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wfnstrategies

Economic, Technical, and Legal Feasibility Study for the Asia-South America Digital Gateway

Final Report

Version 1.3

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Submitted to:

Undersecretariat of Telecommunications of Chile

tmg

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Disclaimer

The information contained in this report is intended solely for the Undersecretariat of Telecommunications of Chile (SUBTEL), who is assumed to have the necessary expertise to determine whether to accept the risks inherent to the investment associated with the 'Asia-South America Digital Gateway' (DGASA) submarine cable system project.

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Acronyms

AAG	Asia—America Gateway
AC	Alternating Current
ACMA	Australian Communications and Media Authority
ACMA	Atlantic Cable Maintenance Agreement
AEE	Assessment of Environmental Effects
AJC	Australia Japan Cable
AMX-1	America Movil—1
AOO	Area of Operations
APMA	Atlantic Private Maintenance Agreement
ASC	Australia Singapore Cable
ASE	Amplified Spontaneous Emission
ASN	Alcatel Submarine Networks
BMH	Beach Manhole
BRUSA	Brazil—USA
BU	Branching Unit
C&MA	Construction and Maintenance Agreement
CAGR	Compound Annual Growth Rate
CapEx	Capital Expenditures
CCM	Contract Coordination Meeting
CDN	Content Delivery Networks
CIF	Cost, Freight and Insurance
CLS	Cable Landing Station
CPA	Cable Protection Area
CPO	Cable Protection Order
CRE	Cable Route Engineering
CRMP	Craft Risk Management Plan
CRMS	Craft Risk Management Standard
CS	Continental Shelf
CSEP	Community and Stakeholder Engagement Plan
DA	Double Armor
DC	Direct Current
DCN	Data Communications Network
DGASA	Digital Gateway Asia – South America
DLS	Digital Line Segment
DOC	Department of Conservation
DP	Desarrollo País
DTS	Desk Top Study
DWDM	Dense Wavelength Division Multiplex
EA	Environmental Assessment
EBIT	Earnings Before Interest and Taxes
EBITDA	Earnings before interest, taxes, depreciation and amortization

EEZ	Exclusive Economic Zone
EIA	Environmental Impact Study
EIS	Environmental Impact Statement
EOW	Engineering Orderwire
EPA	Environmental Protection Authority
EPBC	Environmental Protection of Biodiversity and Conservation Act
EPFI	Equator Principles Financial Institutions
ESRP	Emergency Spill Response Plan
ETSI	European Telecommunications Standards Institute
FP	Fiber Pair
G	Gigabits
Gbps	Gigabits per second
GMSL	Global Marine Systems Ltd
HDD	Horizontal Direction Drill
HKA	Hong Kong-America Cable System
HMN	Huawei Marine Networks
HSE	Local and national Health, Safety and Environment
HVAC	Heating, Ventilation and Air Conditioning
ICC	International Chamber of Commerce
ICPC	International Cable Protection Committee
IEC	International Electrotechnical Commission
IEEE	Institute for Electrical and Electronics Engineers
IFC	International Finance Corporation
IMCA	International Marine Contractors Association
INN	Instituto Nacional de Normalización
IP	Internet Protocol
IP-VPN	Internet Protocol - Virtual Private Network
IRR	Internal Rate of Return
IRU	Indefeasible Rights of Use
ISA	International Seabed Authority
ISO	International Organization for Standardization
Km	Kilometer
LME	Line Monitoring Equipment
LPA	Landing Party Agreement
LW	Lightweight
LWP	Lightweight Protected
MARPOL	International Convention for the Prevention of Pollution from Ships
Mbps	Megabits per second
MIG	Marine Installation Guidelines
MINVU	Ministerio de Vivienda y Urbanismo
MMA	Marine Maintenance Agreement
MMI	Man Machine Interface
MPI	Ministry for Primary Industries
MPLC	Modem Pool Line Card

MPLS	Multi-Protocol Label Switching
ms	Milliseconds
MTTR	Mean Time To Repair
N.A.	Not Applicable
NBI	Northbound Interface
nm	Nanometers
NMS	Network Management System
NOC	Network Operations Center
Non-PZ	Non-Protection Zone
NPV	Net Present Value
NZT	New Zealand Territory
O&M	Operations and Maintenance
OADM	Optical Add/Drop Multiplex
ODF	Optical Distribution Frame
OGB	Ocean Ground Bed
OpCo	Operating Companies
OpEx	Operational Expenditure
OPU	Optical Payload Unit
OSNR	Optical Signal to Noise Ratio
OSP	Outside Plant
OSS	Operations Support System
OTDR	Optical Time Domain Reflectometer
OTN	Open Transport Network
OTT	Over-the-Top
P&L	Profit and Loss
PABX	Private Automatic Branch Exchange
PAC	Pan—American Crossing
PAN—AM	Pan—American
PCCS	Pacific Caribbean Cable System
PFE	Power Feed Equipment
PLCN	Pacific Light Cable Network
PLSE	Pre-Laid Shore End
PMT	Project Management Team
PoP	Point of Presence
POW	Plan of Work
PPP	Public-Private Partnership
PZ	Protection Zone
QC	Quality Control
RCA	Environmental Qualification Resolution
RES	Return Earth System
RFI	Request For Information
RFP	Request for Proposal
RFPA	Ready For Provisional Acceptance
RFS	Ready for Service

RMA	Resource Management Act
ROADM	Reconfigurable Optic Add/Drop Multiplex
ROPs	Remote Operator Positions
ROV	Remote Operated Vehicles
RPL	Route Position List
RTD	Round Trip Delay
SA	Single Armor
SABR	South Africa—Brazil
SAC	South America Crossing
SACS	South Atlantic Cable System
SAEx-1	South Atlantic Express
SAIL	South Atlantic Inter Link
SAm-1	South America—1
SAPL	South America Pacific Link
SDH	Synchronous Digital Hierarchy
SDM	Spatial Division Multiplex
SEA-ME-WE-3	South East Asia-Middle East-Western Europe 3
SEARS	Secretary's Environmental Assessment Requirements
SEA-US	South East Asia—United States
SEC	Superintendencia de Electricidad y Combustibles
SES	Severely Errored Second
SIE	System Interconnection Equipment
SLAs	Service Level Agreements
SLD	Straight Line Diagram
SLLI	Shipboard Load and Lay Instruction
SLTE	Submarine Line Terminal Equipment
SOE	State-Owned Enterprise
SOLAS	Safety of Life at Sea
SOW	Scope of Work
SPMA	South Pacific Maintenance Agreement
SPV	Special Purpose Vehicle
SUBTEL	Undersecretariat of Telecommunications
Tbps	Terabits per second
TMG/WFNS	Telecommunications Management Group, Inc. and WFN Strategies, LLC
UJ	Universal Joint
UPS	Uninterruptible Power Supply
US	United States of America
USD	United States Dollars
VAS	Value Added Service
VPN	Virtual Private Network
WSS	Wavelength Selective Switch

1. Executive Summary

1.1 Introduction

This is the Final Report of the "Economic, technical and legal feasibility study for Asia-South America Digital Gateway" (DGASA or DGASA system) commissioned by the Undersecretariat of Telecommunications of Chile (SUBTEL). This report (1) builds on the demand estimations, regulatory analysis, technical considerations and preliminary route evaluation addressed by the Consortium Telecommunications Management Group, Inc. and WFN Strategies, LLC (TMG/WFNS) in the second report of the project specific to the selected route between Chile and Australia; and (2) presents technical information to help educate and inform the Government of Chile, defines technical requirements recommended for the purpose of procurement and describes the process for implementing a submarine cable system. Further, this report updates the Financial Evaluation Model with more specific details obtained through a formal Request for Information (RFI) and Marine Route Desktop Study, resulting in more precise estimates for Capital Expenditures (CapEx) and Operating Expenditures (OpEx).

Finally, this report aims to provide the Government of Chile with sufficient knowledge and technical information necessary to make key decisions that will undoubtedly be encountered during the implementation of the system. This information is presented in four key areas relating to the implementation of the DGASA system:

1. **System Plan:** A system design plan (design plan) was created in order to establish technical requirements that will be necessary for the procurement of the system. This design plan addresses key decisions associated with System and Route Design, including system capacity, marine cable route, marine cable type and method of installation, just to name a few. The design plan was developed with the support of four of the top submarine cable system suppliers in the world and with the benefit of a Marine Route Desktop Study (DTS), forming the basis for more precise estimates of capital and operating costs associated with the implementation and operation of the system.
2. **Route Plan:** Deciding the route for the submarine cable is the most critical, as this decision sets the basis for defining system performance parameters, has great cost implications and ensures the system is most protected from external aggressions that might cause a system failure event. The DTS includes detailed route information and identifies hazards/special areas to be avoided, as well as proposes submarine cable type, lengths and method of installation. A DTS is the first step in the implementation process which is required by Suppliers in order to develop a route survey plan.
3. **Regulatory & Permitting Plan:** Also Included in the Final Report is a permitting plan, including a permitting matrix to serve as a guide for the Government of Chile and ultimately the System Owner responsible for implementing the DGASA system. It will be important for the System Owner to understand the scope of permitting, which includes local and international regulatory permits. Permits are considered critical path from a project management perspective and will be the primary implementation activity which poses the greatest risk to the implementation effort, in terms of schedule delays and therefore must be managed carefully.
4. **Implementation Plan:** The last area of information outlines specific steps for the implementation of the DGASA system, including planning, procurement, permitting, surveys, manufacturing,

installation, and commissioning of the system. Each phase is described in detail along with suggestions and recommendations based on experience and knowledge. This plan is based on the information available at the time of this report and is time sensitive.

1.2 Technical Requirements

Over the course of this project efforts exploring route options, demand and capacity requirements have culminated in a planned system design with the following general technical requirements:

1. 14,110km System Trunk from Valparaiso, Chile to Sydney, Australia
2. Branching Units (BUs) to Juan Fernández Island, Easter Island, Auckland (New Zealand) and in the vicinity of the Central Zone of the South Pacific for future use
3. Capacity Demand forecast dictates a 16-18 Fiber Pair System
4. Cable system will be open architecture, providing Submarine Line Terminal Equipment (SLTE) selection and procurement flexibility
5. Dense Wavelength Division Multiplex (DWDM) technology to ensure transmission efficiency
6. Active BUs and Reconfigurable Optic Add/Drop Multiplex (ROADM) devices to allow routing changes for optimization and system restoration
7. Active System performance monitoring with automated analysis
8. Deliver 18Tbps per fiber pair capacity
9. Provide transport of bi-directional wavelengths between the Cable Landing Station (CLS) locations
10. Ensure interfaces to the system will comply with either Optical Transport Network (OTN) or Ethernet interface standards, as appropriate
11. Incorporate a Data Communications Network (DCN) for system administration and monitoring
12. Incorporate an Engineering Order Wire (EOW) to permit voice communication between the CLSs plus the Network Operations Centers (NOC)
13. Appropriately mitigate relevant environmental and human risks of external aggression throughout the length of the system
14. Provide an overall Design Life of 25 years for the entire system
15. Provide for future capacity upgrades
16. Ensure that faults affecting one aspect of the system do not impair the operation of the other aspects of the system
17. Provide, at a minimum, industry standard levels of redundancy.

An RFI was conducted involving four major suppliers, which included Alcatel Submarine Networks (ASN), Huawei Marine Networks (HMN), NEC and SubCom. All responded to the RFI, providing a wealth of information to support the proposed design plan, as well as sufficient cost details to establish a sound budget range for SUBTEL's consideration. The information provided also contributed to and helped solidify the technical requirements for this design plan.

These requirements are general and should be used during the development of the eventual Request For Proposal (RFP) document. It must be understood that these requirements help set expectations with the suppliers but are not intended to prevent the suppliers from offering more efficient and cost-effective solutions. In addition, there will be evolving conditions associated with the institutional structure and partnerships formed to deploy the system that may require future decisions that might warrant adjustments to the technical requirements.

1.3 Institutional Model

The selection of an institutional model for the DGASA cable system will depend on various strategic considerations. The Chilean government's role is as promoter and investor in the DGASA cable system and the Fondo de Infraestructura S.A., also known as Desarrollo País (DP), is the state-owned enterprise (SOE) designated to participate as an equity owner in the DGASA project on behalf of the Chilean government. The choice of the institutional model for the project should focus on two layers: (1) institutional model for the DGASA system main cable and (2) institutional model for the Chilean member of the DGASA consortium.

Based on the information available at this time, an unincorporated consortium or shared cost center is deemed the optimal DGASA system main cable institutional model. Structuring the DGASA cable system as a shared cost center will facilitate greater private sector equity participation. The shared cost center structure is widely used in multi-owner submarine cable projects and enables corporate investors to manage risk by limiting investment to their own international connectivity needs while retaining control over how they use their capacity. As additional equity owners beyond the Chilean government are recruited for the project, DGASA consortium members will agree on a final institutional structure for the system which may differ from that proposed herein.

Considering the legal framework applicable to DP, two institutional models may be used for the Chilean member of the DGASA consortium: (1) a shared profit center Public-Private Partnership (PPP); or (2) a shared cost center PPP. These institutional models harness both private and public resources and will create incentives for participation in the DGASA project. In either case, the Government of Chile's participation in the project is assumed to be implemented via a Special Purpose Vehicle (SPV). As project promoters advance in the search for Chilean equity investors for the DGASA system and obtain more information on the commercial and strategic objectives of such potential partners, further review and adjustments to these options will likely be warranted to select the optimal institutional model for the Chilean member of the DGASA consortium.

Relevant for the proposed institutional model is that under any structure that is ultimately chosen by DP and its partners in the future, DP must select an OpCo to implement marketing, operational, maintenance activities on its behalf. As such, the institutional model structure and financial modelling include an OpCo that must be selected by DP following a public tender process.

1.4 Financial Model

The profitability results for the route are set summarized below. The model is attached to this report as Appendix E. Results are presented for five stakeholders or entities: (1) the consortium overall (for the DGASA system main cable); (2) the other consortium parties (as an aggregate); (3) the Chilean SPV, (4) the Chilean SPV investors (aggregate), and (5) the operating company (OpCo).

Where the business case is positive in terms of project net present value (NPV), the payback period for the consortium overall is relatively short, i.e., within a few years. This result arises from the strategy of selling as many indefeasible rights of use (IRUs) in the system as possible early on in the lifetime of the

cable. It is important to note that these figures represent an estimate for potential financial results for the DGASA system overall, not for any individual investor in the cable.

The profitability measures of NPV, internal rate of return (IRR) and payback presented below are calculated on a pre-financing basis. The subsequent figures show the results for the Chilean SPV specifically.

Table 1: Estimated Return to DGASA Stakeholders, USD 000s

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Partners
Project NPV	$131,730	$76,901	$39,712	$37,190	$54,829
Project IRR	28%	28%	13%	N.A.	27%
Payback Period	2.55	2.50	8.59	1.33	2.59
EBIT Ratio	32%	35%	47%	0.4%	28%
Average ROCE	5%	6%	6%	N.A.	4%

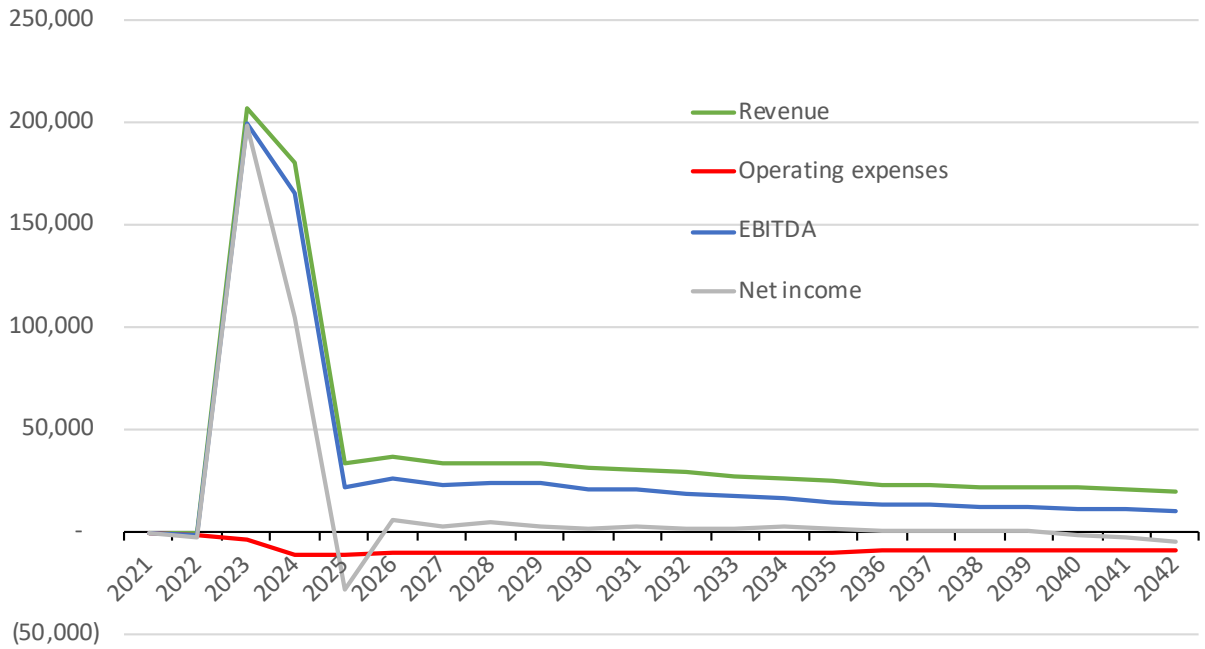


Figure 1: Summary P&L for the Chilean SPV, USD 000s

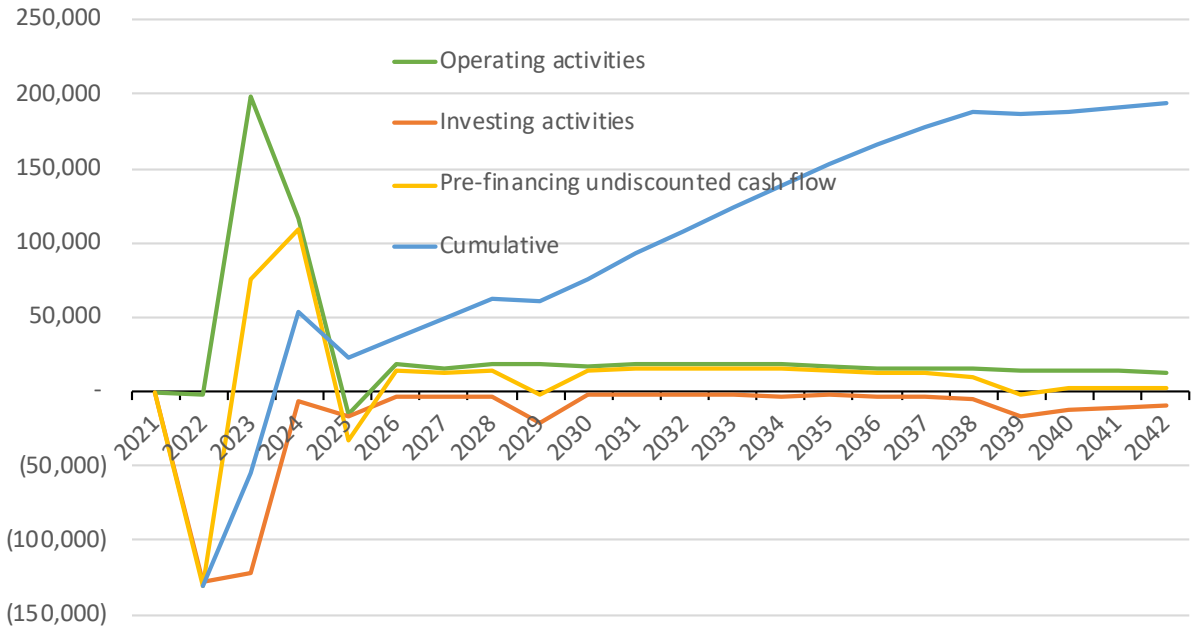


Figure 2: Summary Cash Flow for the Chilean SPV, USD 000s

With respect to the provisioning of Asian onward connectivity from Sydney, it is assumed that capacity between Sydney and Singapore is bought (in upgradeable fiber pairs). Buying fiber pairs offers the advantages of (1) being able to procure capacity on different systems - lending flexibility in sourcing and resilience to the system overall and (2) allowing a more flexible upgrade program. The availability of fiber pairs involves procurement risk, as the SPV is dependent on third parties for making the required capacity available. The handful of systems currently terminating/originating out of Australia are generally 4-fiber pair systems, which may perceive DGASA as a competitive threat or be otherwise disinclined to making capacity available. Currently there is fiber pair capacity available, but, assuming the SPV will capture 50% of the Asia to South America market, the SPV will require a half fiber pair immediately. Requirements will increase for several years until two full fiber pairs are required by 2032. The results are also highly sensitive to the price of the fiber pair for Asian Onward Connectivity. Based on conversations with key industry players, a fiber pair may be available for $50 million, which is the assumption used in the model.

It should also be stressed that the results of business modeling presented in this report are driven by demand modelling estimates undertaken in accordance with the TORs of this project. DGASA promoters should begin the process to validate the business model by gauging actual private interest in equity investment in the DGASA system or pre-sale capacity IRU purchases (i.e., sales that take place pre-Contract in Force (CIF) and pre-Ready for Service (RFS) dates) as soon as possible. This will require multiple rounds of consultations and negotiations across all potential stakeholders, investors and clients. Pre-sales are of prime significance during the deployment phase and the process can be expected to take at least two years before RFS. An accurate assessment of cash-flow will be highly dependent on this early stage of sales activity.

1.5 Recommendations for the DGASA System

This Final Report provides a detailed implementation plan for the DGASA system. It also provides a financial model that outlines financial targets necessary to ensure the DGASA system is a financially viable venture for the Government of Chile. Efforts in the Final Report have been focused on the selected route

known as 2a which connects Chile to Australia utilizing lease facilities onward to various points in Asia, but also provides the opportunity to connect Brazil to Asia via the DGASA system.

The DGASA system, if implemented effectively, will be a disruptive event in the pacific region, impacting market prices and presenting attractive solutions for consumers that desire more economic data transmission routes, lower latency and routing alternatives for system restoration and redundancy. The Government of Chile has already generated interest in the market through this Feasibility Study and recent press release announcing the system to the world and is attracting attention from Suppliers, potential partners, and investors.

TMG/WFNS concludes that this project is technically feasible and within the system capacity means of the Supplier industry, as well as economically viable once partners, investors and customers are properly engaged. As such, DGASA should yield in time a positive return on investment for the Government of Chile and its citizens.

The business case for cable depends crucially on a number of factors including:

1. Selling sufficient capacity up-front before price declines eat away at revenue potential;
2. Ability to acquire a dark fiber for Asian onward connectivity from Sydney to other Asia hubs at the outset of the project at a favorable price; and
3. For the Chilean SPV in particular, an effective sales strategy for Asia demand.

All these elements require of the Chilean SPV effective partnering with other cable owners as well as identifying and contracting a capable and properly incentivized operating company.

2. Project Overview

2.1 Scope of Final Report

The scope of Final Report is to establish a detailed submarine cable system design plan, including marine route plan, and estimated cost of capital and operating expenditures, as well as to offer the Government of Chile suggestions and recommendations for the successful implementation of a submarine cable system between Chile and Asia.

In addition, this report refines the financial model with more detailed system and implementation costs specific to the selected route with the addition of enhanced system and route design details provided by the RFI Supplier responders and ensuing DTS.

2.2 Selected Route

Route 2a was selected by the Government of Chile as the primary route for consideration in the Final Report of the DGASA feasibility study. This route originates in Valparaiso, Chile and terminates in Sydney, Australia forming the main trunk, with branches to Juan Fernández, Easter Island, Auckland, New Zealand and a future branch designated for future service to the Central Zone of the South Pacific. The system will have interconnection points in Valparaiso, Auckland and Sydney. In Valparaiso, the system is planned to extend its presence to Santiago utilizing third party facilities, and anticipated partnerships will onward connect the system to Brazil. The New Zealand interconnection point serves as an option for demand needs that include shorter routes, route redundancy and restoration needs by other providers and consumers. The Sydney interconnection point will be the gateway to Asia, utilizing third party leased facilities for onward service connectivity to numerous points in Asia, including Singapore, China, Hong Kong, Japan and South Korea.

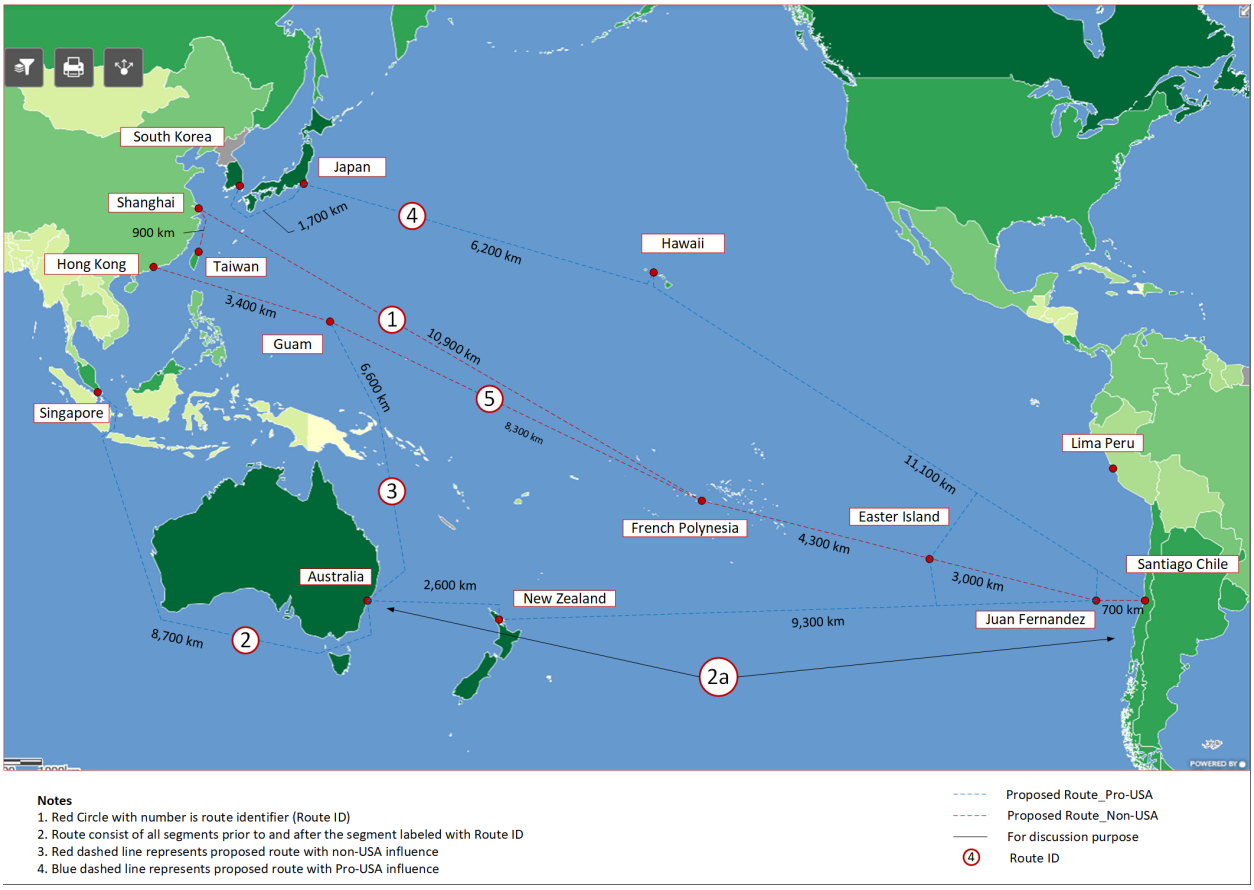


Figure 3: Route 2a, Focus of this Study

3. Submarine Cable System Plan

The purpose of this section is to provide a general understanding of submarine cable systems, explain the functionality of major system components, and describe various decisions/options that will need to be considered at the time of procurement for the implementation of the DGASA system. In addition, this section lays out the system design plan which will serve as the primary blueprint and requirements to which the awarded Supplier will design and install the eventual system.

3.1 System Characteristics

For the purposes of this report, the following terms and definitions will be used:

- Wet Plant: describes portions of the system that are submerged underwater and includes anything supplied under the System Contract between the Beach Manholes (BMHs), which are the demarcation point between Wet and Dry Plant (the BMHs are part of Dry Plant);
- Dry Plant: describes anything supplied under the System Contract from the BMH back to and inside the CLS up to the Optical Distribution Frame (ODF); which includes terrestrial fiber optic facilities that connect the submerged plant to the SLTE;
- Landing Site Facilities: include elements provided by the system owner, such as site acquisition for CLSs, site preparations, utilities, CLS environmental systems, power backup, and any civil work required to facilitate the installation and operation of the CLS stations.

The following drawing shows the relationship between the Wet and Dry Plant elements of the submarine system:

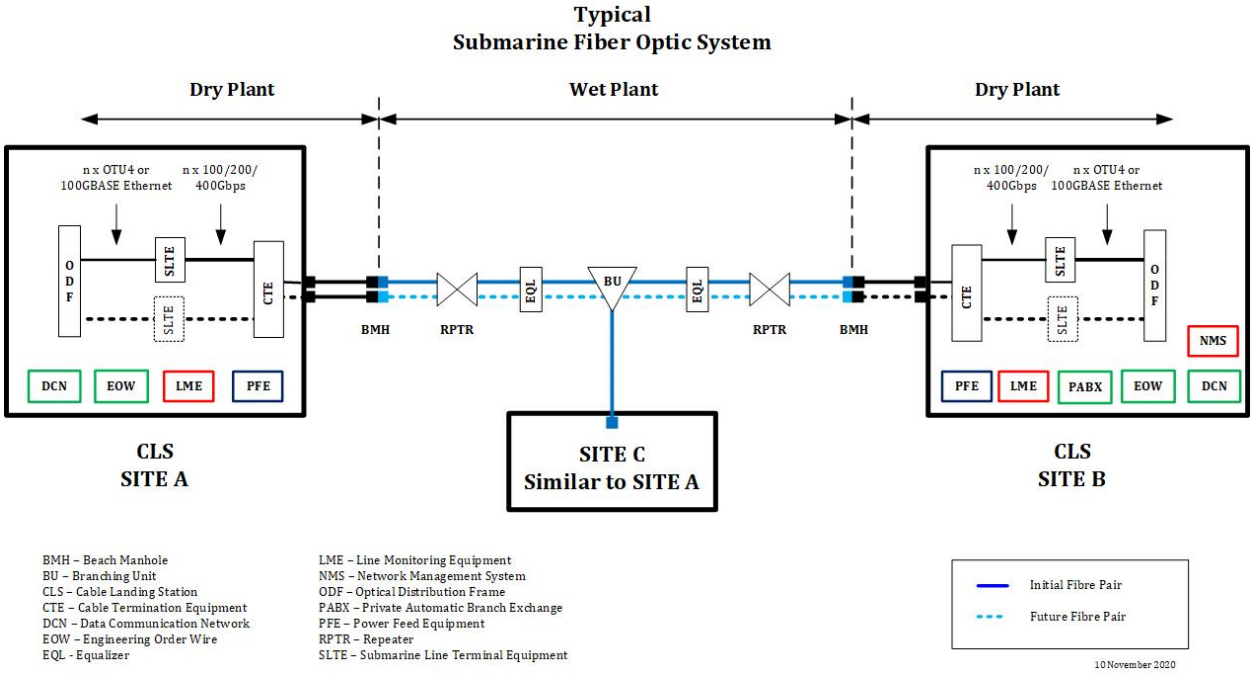


Figure 4: Wet and Dry Plant Elements

Note: The Landing Site Facilities are not identified in the above drawing. Landing Site Facilities are provided by the system owner and consist of duct bank between the BMH and CLS, civil site work, CLS

building, battery plant, site security, Heating, Ventilation and Air Conditioning (HVAC), backup generators and fuel tanks, utility connections, landscaping, lower order traffic equipment. These are normally provided by the system owner through local contractors, because it is more cost effective than including them in the Supply Contract but may be provided by Submarine System Supplier.

The below sub-sections describe general submarine cable system characteristics and the components that make up the system including Wet and Dry Plant components and landing site elements.

3.1.1 Main Trunk

Systems are designed with a main trunk, which consists of the originating and terminating points of the submarine cable. The trunk is the primary route carrying the majority of traffic. The landing points where the submarine cable terminates are usually the main interconnection points to the internet and other countries. System trunks are evolving as technology evolves, where a system used to be comprised of two to four fiber pairs, they are presently capable of 16 fiber pairs with 24 fiber pairs planned in the near future.

3.1.2 Branches

Along the system trunk there may be numerous branches that serve as intermediate points of interconnection and service drops. The branches are limited by system design requirements and technical limitations, but it is possible to have systems with 20 or more branches. Branches usually terminate at landing points, but some are installed with a BU and a tail to await a future need.

3.1.3 Major Components

3.1.3.1 Wet Plant

The Wet Plant consists of submerged system elements including the submarine cable, repeaters, BUs and equalizers between the BMHs at each landing point. Together with various Dry Plant components such as the cable interface equipment, Power Feed Equipment (PFE) and Network Management System (NMS) in the CLS; the Wet Plant and CLS equipment combine to form the submarine cable system. Typically, the implementation of a submarine cable system separates work streams for Wet and Dry Plant installation. The following sections describe the various Wet Plant elements and explain their function.

3.1.3.1.1 Open System

Historically, systems were closed systems, meaning the purchaser was forced to purchase the submarine fiber optic cable and SLTE from a single supplier and which had to be purchased at the same time. Since 2015, systems have become ‘Open Cable’ systems, which means the SLTE equipment is no longer proprietary to the fiber optic cable, resulting in greater flexibility for implementation and allowing system owners to mix-and-match the submarine fiber optic cable with different SLTE provided by different Suppliers. The SLTE can be implemented at a later point in time from the submarine cable in order to optimize then-available technology and pricing. The Open Cable model takes advantage of fundamental characteristics in coherent technology together with transmission properties of high dispersion fibers in undersea systems. These fundamental principles allow the Wet Plant to be optimized regardless of the SLTE supplier. It allows multiple SLTE vendors to interface with a single fiber pair. It also establishes common access to the Wet Plant for upgrades by the SLTE manufacturers.

Note: not all components of the Wet Plant are interchangeable between System Suppliers, e.g., the NMS of one supplier cannot control the BUs of another supplier. Only the SLTE is interchangeable with the Wet Plant. The industry has embraced the Open Cable model, but as yet, there is no industry standardization.

The common submarine cable equipment includes a suite of Dry Plant equipment for Wet Plant operations, maintenance, and troubleshooting, i.e., common equipment needed for fiber interface, powering, line monitoring and management of the undersea network elements. This Dry Plant component includes:

- Open Cable Interface equipment to provide the cable system interface to SLTE, supervisory and control system, BU control, optical spectrum monitor, Amplified Spontaneous Emission (ASE) dummy light source.
- PFE to supply Direct Current (DC) power to the submerged repeaters and BUs. The PFEs are duplicated and the system is designed to have double-ended power feed for greater reliability. Appropriately sized PFEs are installed at both ends of a line segment. In case of a PFE failure or cable shunt fault, the line segment can be fed from a single end.
- NMS for supervisory and control of the system. It has remote operator positions in the NOC. The NMS provides functions such as fault management, performance management, security management, and configuration management. It also performs periodic tasks including fault detection and location. The NMS has northbound interfaces to the purchaser's Operations Support System (OSS).
- Ancillary equipment such as DCN routers and a Private Automatic Branch Exchange (PABX) for Operations and Maintenance (O&M). The DCN and PABX can be carried over the network or off-network, depending upon the choice of SLTE supplier.
- System test equipment for system O&M.

One of the drivers for Open Cables is the development cycle of the SLTE. SLTE technology improvement timeframes are shorter than those to which cable manufacturers can synchronize. For example, it takes over two years to design, manufacture and install a transoceanic fiber system. The purchaser can wait until a year before Ready For Provisional Acceptance (RFPA) to place the order for the SLTE. This allows them to take advantage of any recent SLTE technical and price improvements.

An Open Cable System is designed to operate in an uncertain vendor environment. However, there are issues that must be addressed:

- The cable and SLTE management systems must be compatible; otherwise the system will be difficult to manage.
- System testing must verify the Full Capacity Test on all fibers to ensure that the cable system will perform as expected. This testing is much more complicated than that for previous submarine cable systems.
- Acceptance requires three-way coordination between the SLTE supplier, the system supplier, and the operator to verify all optical performance parameters. It is essential that all parties share acceptance outcomes with one-another and collaboratively agree on the results.

3.1.3.1.2 Optical Technologies

Up until 2018, standard design solutions to meet higher demand capacity in the submarine industry were based on a per-Fiber Pair (FP) optimization, i.e., DWDM using:

- Average of 6 FPs (12 fibers) in the cable
- Effective fiber core area of 150µm²

- Fiber Attenuation of approximately 0.15dB/km
- Very high-power repeaters: > +20dBm
- Power optimization beyond the Beginning of Life optimum.

Recently the system architecture is moving to Space Division Multiplexing (SDM). SDM represents current optical technology impacting several key components of the submarine fiber optic system, including optical fibers, repeaters, BUs and SLTE.

The new SDM solution is based upon:

- Higher FP counts; currently 16 FPs, going to 24 FPs in the future. Essentially more FPs within the cable will bring greater system capacity to customers at a lower price. Note that there will be less capacity per fiber pair.
- The new type of fiber will improve the cost per bit and the number of fiber pairs that can be cabled will have "the right fiber type for the right fiber capacity."
- An innovative repeater architecture based on optical cross-connection allows implementation of pump farming to a bundle of FPs, efficiently delivering the power required.

The SDM solution allows the right cable with the necessary amount of optical power for each fiber, providing greater system flexibility, improved system optimization and a lower cost per bit, including:

- Lower total output power per fiber pair for lower Optical Signal-to-Noise Ratio (OSNR), offering improved power efficiency, but less capacity per fiber pair;
- Allocate resultant savings in electrical power to support additional cable fiber pairs (at least 16 fiber pairs);
- Industry design focus shifts to the total overall cable capacity and away from the traditional goal of maximizing the total per fiber pair capacity. (Pecci & Courtois, 2019).

3.1.3.1.3 Submarine Fiber Optic Cable

As previously stated, the system will follow the "Open Cable" model. The choice of cable type depends upon the results of the DTS and further refined by the Marine Survey and Cable Route Engineering (CRE) working group. CRE is generally defined as the process of ensuring the physical security of the submarine system from natural and man-made hazards through route selection, slack allocation, cable type choice and the use of industry-standard cable burial and protection practices.

A "nominal" cable design would call for:

- Double Armor (DA) from the beach manhole to the 100-meter water depth;
- Single Armor (SA) to the edge of the continental shelf, typically 1,000-meter water depth;
- Lightweight Protected (LWP) also known as Lightweight Screened to the 1,500-meter water depth; and
- Lightweight (LW) for deep water.[1]

[1]"Deep" means water depth over 1,500 meters.

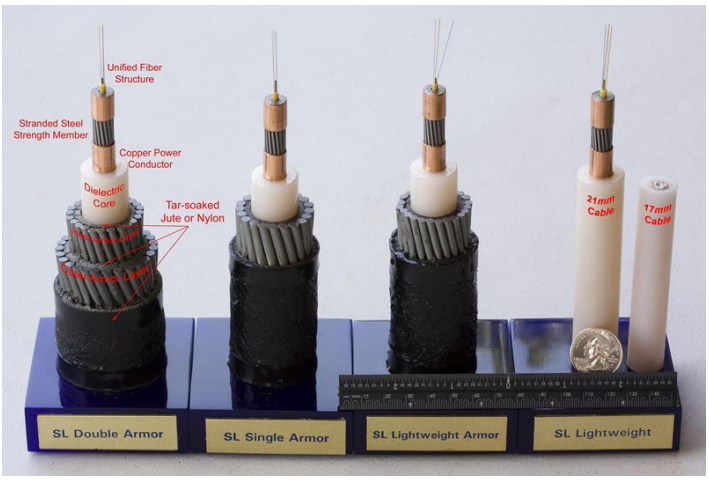


Figure 5: Submarine Cable Types (typical)

Ideally, subject to the seabed profile and shelf edge sediment strength, it is desirable to bury the cable to the 1,500-meter water depth in order to protect the cable from anchors (down to 50m where necessary) and various types of fishing gear. This nominal design will vary depending upon the choice of additional protection; Horizontal Direction Drill (HDD) conduit, split pipe, etc., which will be determined by the seabed conditions and the identified external aggression. HDD and/or split pipe to protect the cable will be used for the shore ends at Valparaiso, Juan Fernández, Easter Island, Auckland and Sydney. Based on a detailed marine survey, there will be economic tradeoffs that are considered by the CRE working group as part of the Supply Contract.

Shore end is a term used to describe the portion of the submarine cable from the BMH to where the cableship begins laying operations, e.g., 15m water depth. The shore end transitions from marine to land at the BMH and is normally more protected as there are greater risks of aggression to the cable. The level of protection on the shore end cable can be reduced from DA to SA for the lengths that will be installed in the HDD pipe, as the steel pipe provides exceptional protection for the cable. A Pre-Lay Shore End (PLSE) is installed where the cableship cannot get close enough to the beach, i.e., within approximately one kilometer of the beach or HDD exit point. A PLSE is installed using a shallow draft vessel to lay the shore end out to the 15m contour, from where the main lay can commence. A PLSE will be installed at Auckland, whereas the other shore ends will be direct landings from the main lay vessel.

3.1.3.1.4 Repeaters

The basic building block of a submarine fiber optic system is the Digital Line Segment (DLS), which represents digital paths for traffic flow in a system. The DLS includes the SLTE and all Wet Plant, i.e., cable, repeaters, BUs, gain and tilt equalizes, and cable joints. The capacity of the DLS depends upon the optical characteristics of all the components. The SLTE and repeaters have a maximum optical output power and a minimum required receive power. The minimum receive power corresponds to a minimum OSNR required by the SLTE and repeaters in order to perform their functions, i.e., faithfully detect the traffic and amplify the optical signals.

The submarine repeater provides amplification of two-way optical digital transmission signals in the erbium-doped amplification window. The repeater is modular in construction and can be equipped for use with cables having from one to 16 fiber pairs. By the end of 2021, repeaters will be able to support 24 fiber pairs (48 fibers).

Repeaters are placed in the cable system so that their "receive" optical signal is greater than their minimum OSNR. In fact, additional allowances are made for nonlinear effects, cable repairs, and end-of-life performance. The higher the system capacity, the higher the minimum OSNR required, which means the repeaters must be placed closer together. A typical span length of 70km to 80km is required for a high capacity system.

Figure 6: Repeater Being Laid

The repeater powering circuitry is compatible with reversible power feed current, i.e., bi-polar. The optical design of the submarine repeater is based on a mechanical arrangement called a double amplifier pair that is composed of four optical amplifiers, a set of 980nm pumps and their powering and control electronics. Repeaters are powered in series from the terminal stations at a constant current of either polarity, and are provided with surge protection devices to prevent the internal circuits being damaged by the large voltage transients that may occur along a cable in the event of a cable fault.

Amplification is provided by an optical fiber whose core is doped with the rare earth element erbium. Optical energy from the 980nm pump laser excites the erbium ions to a higher than normal energy state. Incoming photons of light from a traffic signal within the wavelength range cause the erbium ions to return to their original energy level; in the process stimulating the emission of further photons in phase with the incoming signal and, hence providing gain.

The repeaters are powered by DC power in the submarine cable. The maximum number of repeaters depends upon the power requirements of the repeater and the voltage drop in the cable. The cable is fed by the PFE. Appropriately sized PFEs are installed at both ends of a line segment. In case of a PFE failure or cable shunt fault, the line segment can be fed from a single end. The maximum length of the system is determined by the maximum voltage that can be applied from each CLS. The limit to this is set by the voltage breakdown capability of the different components that make up the Wet Plant, i.e., cable, repeaters, BUs, equalizers, and joints.

For a 14,000km system, approximately 200 repeaters are required. Given a repeater nominally requires 50VDC and the cable has an electrical resistance of about 1.0 ohm per kilometer; two 18kV PFEs are needed to double-end feed the system, each PFE operating at 9kV under normal conditions.

Each repeater contains additional circuitry to the main amplification devices that continuously monitors the health of the repeater. Individual components within the repeater are monitored and these can be

used to predict potential future failures and/or assist in fault location in the event of a cable break between repeaters. This additional circuitry and the equipment in the CLS to manage it are known as a 'Supervisory System'. Each supplier goes about this in a slightly difference way with some providing more information than others. The repeaters are equipped with a passive optical supervisory system that:

- Allows in-service monitoring from both ends;
- Identifies an individual fiber loss impairment;
- Detects a multi-fiber break, i.e., a cable break;
- Detects repeater pump laser degradation.

This supervisory function rides on an out-of-band wavelength just outside of the transmission spectrum.

3.1.3.1.5 Branching Units

There are several types of BUs, depending upon the traffic and power design of the system. The following is a list of the types of BUs from simplest to more complex:

- Fiber pair add/drop (fiber routing), unpowered – used to drop all traffic on specific fiber pairs without DC power switching capabilities;
- Fiber pair add/ drop (fiber routing), powered – used to drop all traffic on specific fiber pairs with the ability to switch the DC power between segments for fault conditions and during marine repairs;
- OADM, powered – used to drop specific (fixed) wavelengths on fiber pairs and switch the DC power between segments for fault repairs;
- ROADM, powered – used to change the dropped wavelengths on fiber pairs and switch the DC power between segments for fault repairs.

Figure 7: Branching Unit Sitting Atop a Transport Frame

The OADM and ROADM functions are located in a separate housing near the BU housing. The OADM and ROADM BUs are controlled by an out-of-band, active optical supervisory system providing in-service command and control. Because the drop channels are broadcast, the OADM and ROADM are equipped with a confidentiality feature that only allows the intended wavelengths to reach the branch terminal.

DGASA will deploy ROADM BUs to accommodate the traffic for Juan Fernández, Easter Island and Auckland. The add/drop wavelengths can be changed over the life of the system as opposed to an OADM BU that fixes the add/drop wavelengths at the beginning-of-life of the system and cannot be changed. The ROADM BU will allow reconfiguration (increase or decrease) of the traffic over the 25-year life of the system.

The Juan Fernández and Easter Island BUs will add/drop traffic on Fiber Pair 1. The Auckland BU will add/drop traffic on Fiber Pairs 1 and 2.

All of the ROADM BU's will have power switching so that in the event of a cable break or shunt fault anywhere in the system, the PFE can be reconfigured to allow the maximum amount of the system to be re-powered and to continue to carry traffic until the fault is repaired.

3.1.3.1.6 Other Elements

3.1.3.1.6.1 Optical Equalizers

Optical Equalizers are passive components that are inserted into the submarine cable to compensate for optical gain and tilt variations over the length of the cable.

Figure 8: Optical Equalizer

The optical gain equalizer equalizes the gain response over the wavelength range (1528nm to 1568nm). It makes the cascading of repeaters possible so that the signal can be transmitted long distances without distorting the optical envelope. The optical tilt equalizer compensates for the gain-tilt due to variances in repeater output and cable loss. The number and locations of the equalizers are determined during system design based upon repeater spans and cable lengths. Optical equalizers are inserted approximately every 1,300 kilometers. It is expected that ten gain equalizers and ten tilt equalizers will be used between Valparaiso and Sydney. The initial branches will probably not need equalizers; however, the future branch to the Central Zone of the South Pacific might need one equalizer. The system supplier will determine how many and where the equalizers will be installed.

3.1.3.1.6.2 Optical Filters

Optical Filters are used with BUs to add and drop optical wavelengths. The filters are in an adjacent OADM or ROADM housing near the BU housing. The filters can be fixed or reconfigurable depending upon the traffic to be added/dropped. The type and size of the filters depends upon the amount of traffic to be

added/dropped. DGASA will use reconfigurable filters in a Wavelength Selective Switch (WSS) housing to allow for traffic flexibility at Juan Fernández, Easter Island and Auckland over the 25-year life of the system. The WSS housing is the same as used for the Optical Equalizer in Figure 8: Optical Equalizer.

3.1.3.1.6.3 Splices (Cable-to-Cable/Cable-to-Housing Joints)

There are two types of splices for a submarine system: factory and field. Factory splices are controlled under the manufacturing Quality Control (QC) procedures. Field splices also have long standing QC procedures.

The factory splices are carried out during the system assembly for connecting repeaters, BUs and equalizers to the cable. Factory splices are also used to produce longer lengths of a single cable type and for transitions between cable types, e.g., splicing DA to SA cable. In-line fiber splices are also used to join lengths of fiber during the cable manufacturing process.

Field splices are carried out during marine installation and include beach joints, initial splices, inter lay splices and final splices. Field splices are also required to install a BU. Field splices may also be needed for installation repairs (if required) and interruptions to laying operations, e.g., unplanned cuts to the cable and buoying-off for bad weather. Except in the Beach Manhole, field splices use the system supplier's proprietary jointing technology. However, the industry standard Universal Joint (UJ) technology may also be used. UJs have been employed since 1990 and are the global standard for marine repair operations.

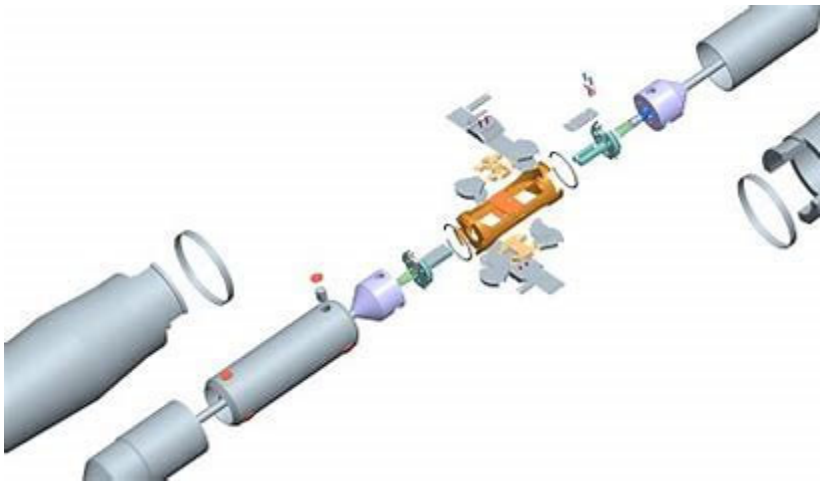


Figure 9: Universal Joint

The BMH Joint requires a special splice kit that joints the marine cable to the terrestrial fiber optic cable and the terrestrial DC power cable. The BMH Joint physically separates the land electrical and optical functions.

In addition to the system's marine spares, UJ piece-parts and consumable kits will be required. These may be purchased by the system owner under the supply contract or can be provided by the marine maintenance service provider. They will be stored on the cable repair ship or at the marine depot of the marine maintenance service provider, and are packaged for 25 years shelf life, to be ready for use in a marine repair.

3.1.3.2 SMART Cables

The fundamental premise of SMART cables is integrating environmental sensors into commercial submarine telecommunications cables. The crucial objectives are: (a) to obtain long-term ocean bottom

measurements of temperature (to measure climate trends), pressure (to capture sea level rise, ocean currents, and tsunamis) and seismic acceleration (for earthquake and tsunami warning, and seismology), (b) to have little or no impact on the operation of the telecommunications system that hosts the sensors, (c) to require no special handling or deployment methods, and (d) to be sufficiently reliable that 95% of all sensors operate for a minimum of 10 years with no maintenance.

SMART cables would make use of the global subsea fiber optic network. More than 1.2 million km of cable and 400 independent subsea cable systems all over the world are operated, maintained, and periodically renewed by the telecommunications industry. Although it is impractical to place sensors into deployed cables, sensors can be introduced during manufacturing into the repeaters on new cables (see Figure) during replacement or expansion operations, which occur on 10-25 year time scales. This provides the opportunity to introduce sensors on new cable systems on this time frame to slowly build an enduring, sustained ocean and earth observing network.

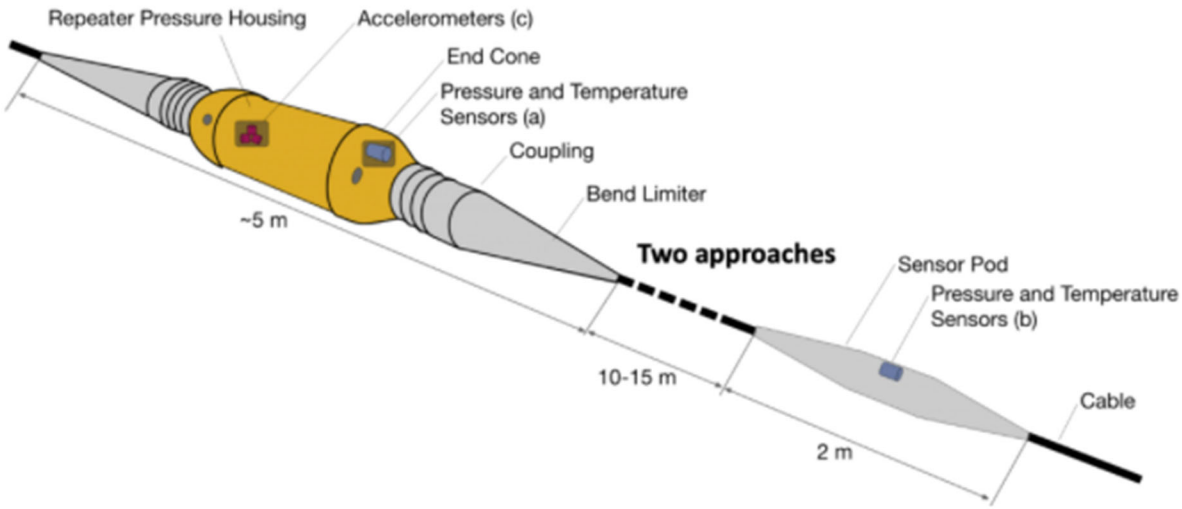


Figure 10: Typical Smart cable design with sensor pod

Figure 10 illustrates a typical configuration with repeater housing showing two possible sensor mounting locations: (a) on the end of repeater housing under the bell housing or (b) in an external pod. Seismic accelerometers are mounted inside the pressure housing (Submarine Telecoms Forum, Inc., 2019).

3.1.3.3 Dry Plant

The Dry Plant consists of all the elements of the system from the BMH to the customer interface point inside the CLS. These elements include the BMH, land cables, cable termination equipment, PFE, SLTE, System Interconnection Equipment (SIE), NMS, distribution frames and battery plant. The following sections describe each element and its function.

3.1.3.3.1 Landing Point (Beach Manhole)

The BMH is the interface point between the Wet Plant and the Dry Plant. The BMH is usually supplied by the purchaser. It can be fabricated onsite or precast and shipped to the site. The size of the BMH is based upon the number of submarine systems that it will support, present and future. Minimum practical size is 1m x 2m x 1m with a removable top. This size does not allow for easy expansion. A more nominal size would be 2m x 3m x 2m. The BMH will have entry ducts from the sea and the land, cable pull attachments,

cable clamps, an earth ground, a wet sump, wall racking for the beach joint, wall racking for submarine and land cable slack, an entrance ladder, and a secure entrance.

The BMH is usually constructed flush with the ground. In some cases, it is actually buried under the surrounding landscape so that it is inconspicuous. It is not uncommon for BMHs to partially fill with water.

Figure 11: Inside a Beach Manhole

Figure 12: Beach Manhole Entrance

3.1.3.3.2 Cable Termination Unit

The Cable Terminating Equipment is the interface between the land cables and the equipment in the CLS. It is the delineation point between the client SLTE and the Open Cable System. Each client SLTE will have access to a defined bandwidth on a fiber pair.

Besides the traffic interface, the Cable Terminating Equipment is the submarine cable interface for:

- Supervisory and control system;
- BU control;
- Optical spectrum monitor;
- ASE dummy light source;
- Electrical measurements on the cable.

3.1.3.3.3 Submarine Line Terminal Equipment

The SLTE will provide point-to-point transmission paths between CLSs and will be interconnected to purchaser owned equipment. The tributary interfaces are standard Ethernet, Synchronous Digital Hierarchy (SDH), or OTN formats. The SLTE performs the conversion between the customers' traffic and the optical signal inserted into the submarine system. The transmit section of the SLTE performs:

- Error correction coding for the tributary traffic signals from the terrestrial networks;
- Wavelength conversions into modulation codes suitable for long-distance transmissions;
- Wavelength dispersion compensations;
- Wavelength-division multiplexing;
- Optical amplification.

The receiver section of the SLTE performs the reception processing operations in order to convert the optical line signal back into the customers' traffic.

The SLTE has the wavelength management function required for adding and dropping wavelengths at intermediate branching points. When combined with OADM and ROADM BUs, it is possible to build an OADM network on a per wavelength basis.

3.1.3.3.4 Power Systems

The PFE comprises the equipment for converting the CLS Alternating Current (AC) power supply into the form required to energize the Wet Plant. The PFE provides a constant current (nominally 1.25A), with a DC voltage that adjusts to compensate to the resistance in the cable, the submerged housings (repeaters, BUs, equalizers and joints) and in the earth potential difference that may exist between landing sites. The size of the PFE is determined by the number of submerged housings plus the length of the submarine cable.

Figure 13: Power Feed Equipment (High Voltage)

The design of the PFE must be consistent with the reliability and availability parameters, e.g., double ended feed is preferable thereby improving the reliability of the system. In a double-end feed, each end feeds ½ of the required power and in the case of a shunt fault at the far end, the PFE will ramp up to feed the entire system. Given that the main trunk will be double-ended fed, the DGASA PFE will operate at 9kV and ramp-up to 18kV if there is a cable fault near the far end of the system. Depending upon the length and number of repeaters in the spur, the spurs may operate with 15kV, 12kV, 9kV, 6kV, 3kV, or no PFE at all. However, to maximize system reliability, the system design may include higher voltage PFEs in the spur CLSs to allow parts of the system to be powered in the event of a cable fault in the main trunk from Sydney to Valparaiso.

Means will be provided to interconnect the power feeding cable, the optical fiber transmission cable and the submarine cable. The design will ensure that no hazardous current or voltage is applied to the cable at any time; either during normal operating conditions or under fault conditions arising from faults external or internal to the equipment.

3.1.3.3.5 Return Earth System

The Return Earth System (RES), also known as Ocean Ground Bed (OGB), provides the return path to ground for the system DC supply. It is designed to sustain a 2.0A current for 25 years. The RES usually consists of an array of electrodes near the BMH. If site conditions warrant it, the RES can be located near the CLS. The size of the array is based upon the local soil resistivity. The resistivity measurements are carried out by the System Supplier as part of the site surveys. The electrodes are metal cylindrical rods, generally 2m in length, vertically buried in a high carbon coke backfill. In some cases, a Sea Earth is required, e.g., at Auckland. The Sea Earth is a massive steel plate that ensures a large surface in contact with seawater. It will be laid out to a suitable water depth, with a four-core armored, electrical cable laid back to the BMH. The System Supplier will provide, install and test the RES.

Additional electrodes or a sea earth plate are usually supplied with the system spares.

3.1.3.3.6 Network Management System

The system will include element managers and network managers for the purpose of providing alarm, configuration, performance, and security management of the system. The system will provide the means to locate faults rapidly and accurately (including shunt faults), cable breaks, individual fiber faults, and terrestrial equipment failures.

The submarine fiber optic cable system will have an NMS that monitors and controls alarms, configuration, performance and security management of all system elements. The NMS is located in one or more of the CLSs. The NMS will interface with third party NOCs in Valparaiso and Sydney. NMS traffic will normally be carried over the DCN. For backup, the System Owner or Purchaser will provide a 2Mbps, off-network circuit between Valparaiso and Sydney. The NMS will have Remote Operator Positions (ROPs) located in the NOCs. The ROPs will communicate with the Network Managers via a Transmission Control Protocol/Internet Protocol data network provided by the owner. The ROPs will have all the features and capabilities of the NMS.

The NMS will have a standards-based Northbound Interface (NBI) by which the NMS will be integrated with the owner's OSS. This OSS is not provided by the System Supplier. The OSS can monitor and provision the system plus capture historical system performance data.

The NMS will provide a user friendly, graphical Man-Machine Interface (MMI) for operation and control of the entire system, including an on-line Help System. The NMS provides a graphical user interface with a system schematic and the means to "drill down" to increasing levels of detail. It maintains and presents alarm and fault logs and allows operator acknowledgement of alarms. It allows fault location in all active components of the system. It allows control of all active components of the system except the PFE (this is for personnel safety considerations). The NMS processes and stores all performance data and allows the operator to retrieve performance data. The NMS permits full backup and restoration of all software, configuration data and performance data. It can store one year's performance data with one day resolution. The NMS allows configuration data, including part number, serial number, unit name, firmware revision, and software revision to be retrieved and displayed. The NMS permits remote inventory management of all system components (except the PFE) and allows download of software and firmware upgrades to the SLTE.

The NMS includes Local Craft Terminal interfaces in order to provide local alarm, configuration and security management of system elements.

The NMS includes Line Monitoring Equipment (LME) in order to monitor the Submerged Plant. Local CLS power, Uninterruptable Power Supply (UPS), and any other ancillary equipment that can be monitored by means of dry contact closures connected to an alarm interface unit. The LME can be controlled from the Network Manager and from the CLS. The LME carries out its in-service measurements without affecting traffic. It autonomously monitors the system in-service and can detect any degradation in the Wet Plant components. The LME localizes faults in the Wet Plant to within one repeater section over any active fiber in the cable. The LME can locate fiber faults with sufficient accuracy for dispatch of marine maintenance vessels, i.e., Coherent Optical Time Domain Reflectometer (OTDR)-like functionality.

3.1.3.3.7 Auxiliary Equipment

The system comes with its own data network, the DCN. The DCN routers connect the LMEs, NMS, Remote Clients, and the various network elements on a system and per CLS basis. The DCN will transport all network management and monitoring information between CLSs using suitable overhead or in-band Data Communications Channels (DCCs) in the SLTE or over an external data link. The system purchaser provides the off-network data link. This link provides backup to protect against a cable fault that disrupts the DCN,

i.e., a cable break. In the case of a cable break, the off-network link allows troubleshooting from both NOCs in order to better isolate and identify the problem.

As an option, an Engineering Order Wire (EOW) system can be provided. The EOW is used for operations and maintenance. It is based on a Voice Over Internet Protocol PABX with handsets at each CLS and in the NOCs. The PABX traffic is carried over the DCN.

3.1.3.4 Traffic Facilities (non-System Supplier)

3.1.3.4.1 Lower Order Service Equipment

The traffic output of the SLTE will be standard, high-speed Ethernet, SDH, or OTN optical signals terminated on an ODF. Depending upon DGASA's customer requirements, these optical signals will be converted to the format that the customer has purchased. The equipment to do that is referred to as SIE, e.g., routers, switches, SDH multiplexers. The SIE can be rack-mounted or in its own cabinet. The SIE is not part of the submarine system contract. The SIE is either supplied by the system owner or the customer, depending upon the customer's contract.

3.1.4 Outside Plant

The Outside Plant (OSP) for the submarine system consists of all the facilities between the BMH and the CLS. The OSP is underground because local construction codes usually do not allow for aerial fiber optic cables and DC power cables on the same pole. Submarine systems will usually require three cables in the duct bank: one fiber optic cable, one DC power cable and one RES cable (depending upon where the RES electrode bed is installed). The OSP is usually a duct bank system with at least two 110mm (nominal) ducts. One of the 110mm ducts will have at least three 33mm sub-ducts in it for the three types of land cables. Since installing a duct bank requires significant civil construction, one or more additional 110mm ducts are usually included for future expansion. While it might be possible to direct bury the cables between the BMH and the CLS, a duct bank system offers better protection, ease of installation and future expansion. Direct buried land cable, where used would be armored and electrical/optical safety tape provided above the cable in the trench.

The OSP, i.e., ducts, sub-ducts, manholes, handholes, route markers, is usually provided by the purchaser. The OSP is built to local telecommunications standards and recommendations. Part of the System Supplier's site survey will be to verify that the OSP meets the system requirements, e.g., duct size, bend radius, length of pull between handholes, size of intermediate jointing manholes, etc. The System Supplier will provide, install and test all the land cables and joints.

Note: The System Supplier is responsible for any additional civil works between the RES electrode bed and the BMH (or CLS).

3.1.5 Cable Landing Stations

The CLSs might be standalone buildings or part of existing buildings, e.g., a caged area in a Data Center or a Point of Presence (POP). All CLSs must meet local building codes and have:

1. Adequate floor space for the initial system capacity with the ability to expand to the ultimate system capacity in the future;
2. Adequate floor loading for the ultimately system capacity.
3. Land cable entrance facilities, also known as the cable vault;
4. Access to local distribution facilities for the customers to connect their traffic;

5. Heating, Ventilation and Air Conditioning (HVAC) to support the initial installation and the ability to be expanded to the ultimate configuration;
6. A fire suppression system;
7. Connectivity to local utilities, e.g., AC power, water, sewer, telephone, internet, cable TV;
8. Adequate DC battery plant that can be expanded in the future;
9. Standby AC power generation with fuel tank(s);
10. A marshalling area with doors sized to receive equipment;
11. Adequate parking for cars and trucks;
12. Adequate workspace and furniture for the local personnel;
13. A break area for the local personnel (if the site is manned);
14. Adequate storage space for spare parts and test equipment;
15. Physical security features, e.g., door locks, guard stations, mantraps, surveillance cameras, building alarms, equipment cages, gates, fencing.

For detailed information on new communications sites, it is recommended to refer to Motorola's *R56, STANDARDS AND GUIDELINES FOR COMMUNICATION SITES* (© Motorola, Inc.). R56 is a widely accepted industry standard that details the requirements and guidelines for the installation of communications infrastructure and facilities. The documentation is maintained by Motorola Solutions but is not proprietary and therefore can be used for any technology, vendor, or application.

The following is an aerial view of a medium sized CLS:

Figure 14: Typical Cable Landing Station

3.1.5.1 Site

CLS sites are typically located near the BMH but can be further from the BMH where more suitable sites are available. Sites are generally large enough to place the CLS building, external generators and provide parking for maintenance personnel, e.g., approximately 0.4 hectare. Site selection requires extensive planning and great care to ensure sites are near viable routes for the OSP cables, have sufficient civil infrastructure to support utility requirements, allow for fuel storage, are not exposed to external aggressions, and have sufficient easements for ingress/egress for all facilities and personal entering and leaving the site.

3.1.5.2 Building

CLSs may be installed in new buildings or existing buildings. New buildings may be constructed from the ground up, may be a repurposed building, or may be a modular building purchased fully fitted and equipment at the factory. Regardless of approach, buildings must meet technical requirements set by the supplier for the certification of the system and must consider growth as the system evolves due to increased demand.

New CLSs are planned for Juan Fernández and Easter Island, which must take into account local sensitives, i.e., match the local architecture, blend into the local culture, contribute to the local community, be considerate of local mores. Ideally, the CLSs should be located near the BMHs with adequate commercial utilities available nearby.

3.1.5.3 Floorplan

CLS buildings typically include various spaces for system equipment, batteries, storage, and office and may include collocation space for third party providers. Each space is sized per the requirements of that particular CLS and usually varies; with larger spaces required for landing points of the main trunk versus smaller space requirements for intermediate branches. Floorplans require separate spaces for system equipment and battery equipment for safety purposes. Other spaces are more flexible and may include other needs by the System Operator.

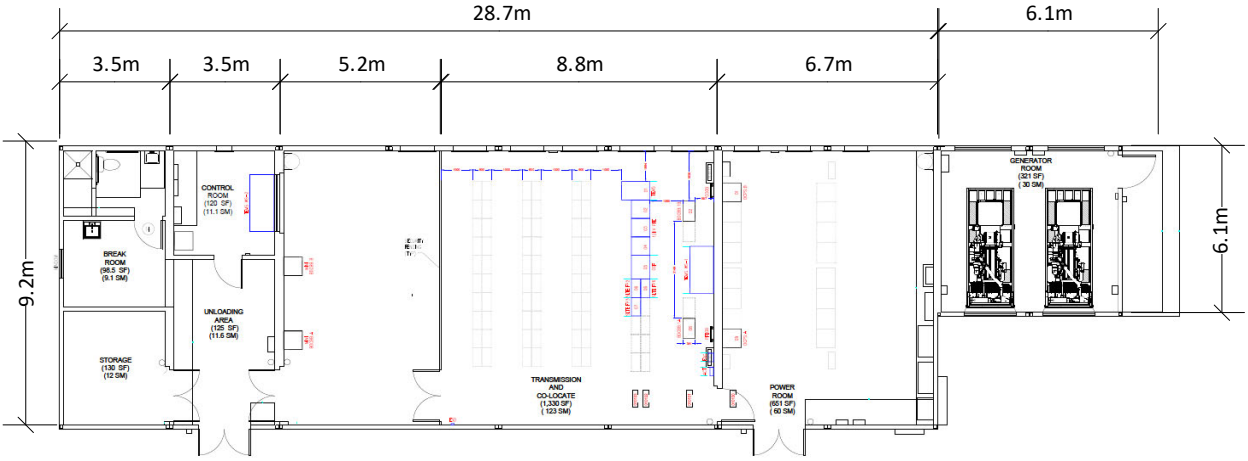


Figure 15: Typical CLS Floorplan

3.1.5.4 Site Electrical Power Systems

The CLS takes commercial AC power and coverts it to DC in order to power the submarine system. There are backup generators to power the CLS incase the commercial AC power is interrupted. The following

drawing is a conceptual layout of the AC and DC power systems for the landing site. It does not address the AC needed for site facilities, e.g., lights, electrical AC outlets, HVAC.

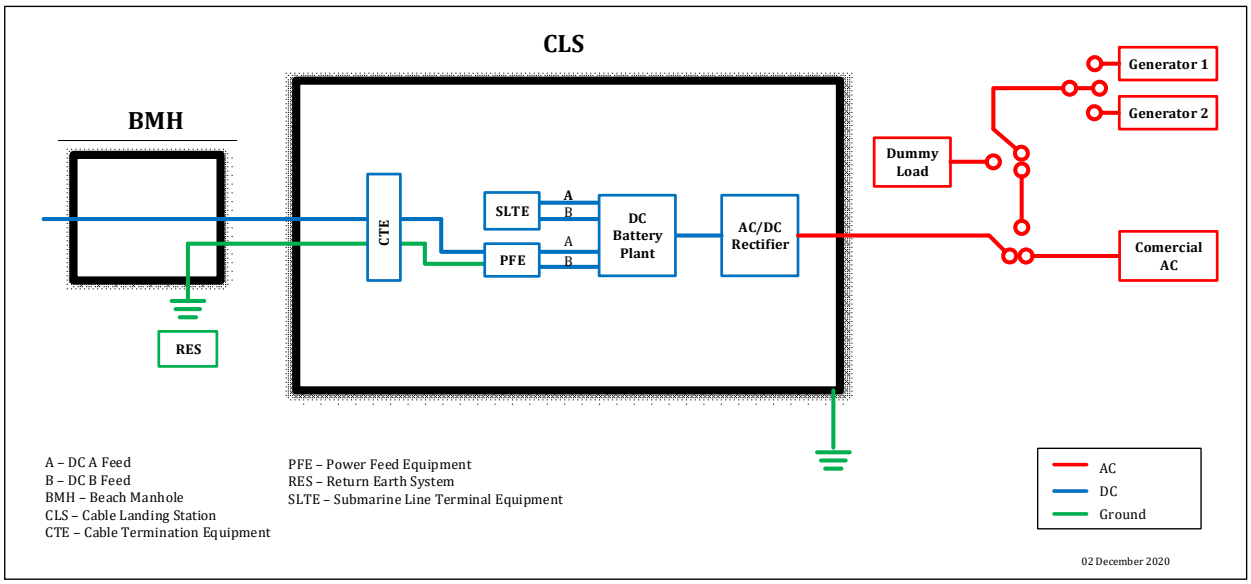


Figure 16: Typical AC and DC Power Systems

3.2 DGASA System Architecture

The previous section described the characteristics of a typical submarine cable system. This section is intended to start defining the specific system architecture for the DGASA system and explains the logic and drivers used to create this design plan and ultimately will serve as the technical requirements to be issued for the RFP/procurement process.

3.2.1 Assumptions

The following assumptions were used when designing the DGASA System:

1. The required 25-year capacity is 270Tbps;
2. Customer traffic input will be 100Gbps, i.e., 100GBASE Ethernet or OTU4;
3. Suitable existing CLS facilities at Valparaiso, Auckland and Sydney will be available to accommodate the DGASA system;
4. Adequate facilities cannot be secured on Juan Fernández and/or Easter Island and new CLS facilities will be provided;
5. The local commercial power at Juan Fernández and Easter Island is not reliable;
6. New 2m x 3m x 2m BMHs will be built at each site:
7. The length of the OSP at each site will be a nominal 3km;
8. NOC functions will be outsourced to third parties at undetermined locations;
9. Owner will provide 2Mbps data circuits from Valparaiso and Sydney to the NOC locations;
10. DGASA will have an OSS outside of the scope of this study.

As new information and opportunities are discovered and the system design evolves, the above assumptions will be either refined or resolved.

3.2.2 System Layout

The DGASA 16 fiber pair, submarine system will provide significant (approximately 270Tbps, total) telecommunications connectivity between South America and Asia.

The DGASA system will connect Valparaiso, Chile and Sydney, Australia. The Valparaiso terminal will support traffic from Chile and other South American markets. The Sydney terminal will support traffic from Chile to Singapore, China and Japan. DGASA will also include three spurs to:

- Juan Fernández
- Easter Island
- Auckland, New Zealand

There will be a fourth BU, designated as "Future", for, as yet undefined, service requirements to the Central Zone of the South Pacific.

The system will be based upon DWDM architecture which maximizes the capacity on a per fiber pair basis. Unfortunately, at this time, a less expensive SDM architecture cannot meet the DGASA 25-year capacity requirement of 270Tbps on 16 fiber pairs. Currently, SDM systems only support 13.4Tbps per fiber pair, i.e., 214Tbps on 16 fiber pairs and may be considered if DGASA capacity requirements are reduced or implementing an additional system is viewed as an option later in time as the system reaches capacity

The DGASA System will be designed, at a minimum, to:

- Deliver 18Tbps per fiber pair capacity;
- Provide transport of bi-directional wavelengths between the CLS locations;
- Ensure interfaces to the system will comply with either OTN or Ethernet interface standards, as appropriate;
- Incorporate a DCN for system administration and monitoring;
- Incorporate an EOW to permit voice communication between the CLSs plus the NOCs;
- Appropriately mitigate relevant environmental and human risks of external aggression throughout the length of the system;
- Provide an overall Design Life of 25 years for the entire system;
- Provide for future capacity upgrades;
- Ensure that faults affecting one aspect of the system do not impair the operation of the other aspects of the system;
- Provide, at a minimum, industry standard levels of redundancy.

DGASA's main trunk is a 14,110km fiber cable with BUs for four spurs. The total installed submerged cable length, including three spurs, is approximately 14,800km. The following figure is the DGASA System Diagram for the basic system. There will be 16 fiber pairs (32 fibers) in the trunk cable for traffic between Valparaiso and Sydney. There will be two or four pairs in the branches. FP 1 will be an omni pair connecting all sites. FP 2 will connect Valparaiso, Auckland and Sydney. FPs 3 to 16 will be express pairs between Valparaiso and Sydney. FPs 17 and 18 are for a potential spur to the Central Zone of the South Pacific and

will be installed between Valparaiso and the "Future" BU. Initially, the "Future" BU will be looped back in an 18km, two fiber pair tail. If implemented, the spur to the Central Zone of the South Pacific will be approximately 1,500km.

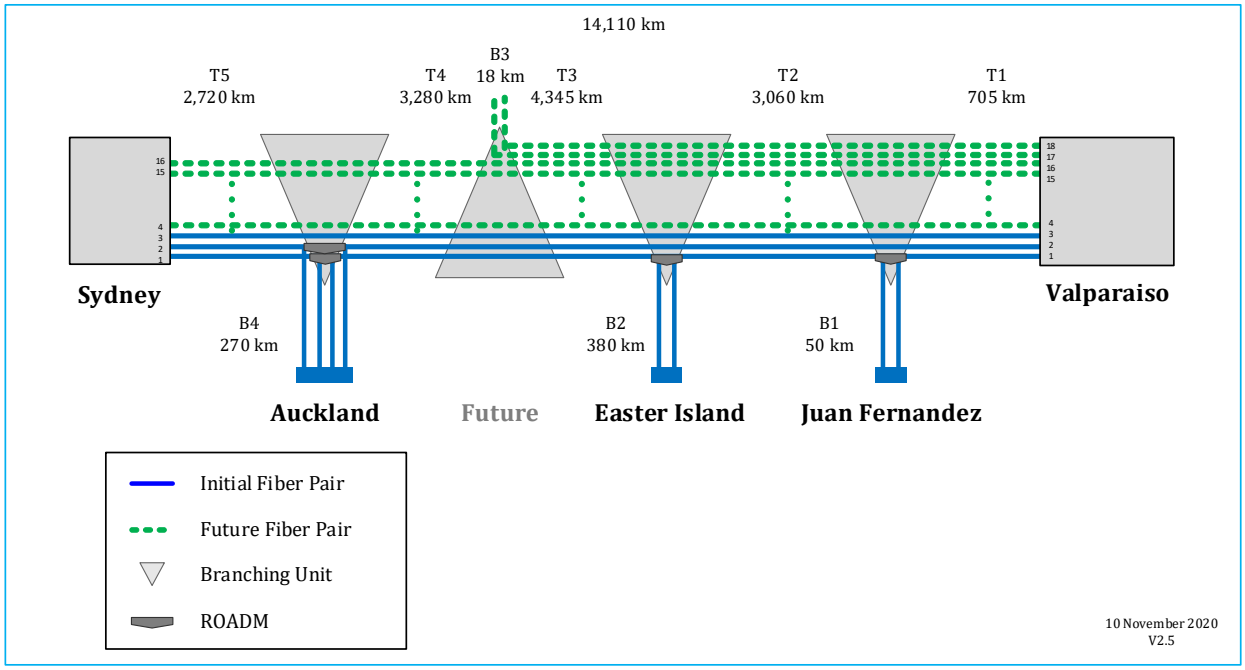


Figure 17: DGASA System Diagram

3.2.3 Route Design

Note that the following route design sections summarize the DTS discussion in Appendix A. In case of any conflict, the DTS takes precedence.

A submarine fiber optic system route is based upon the locations of the landing points and other considerations such as ocean bed geography, natural threats to the system, weather environment, fishing, anchoring activities, and regulatory. The landing sites are chosen based upon traffic requirements. Because the longest DGASA DLS (14,110km) is less than the achievable DLS (>15,000km), the route design will not effect the system architecture and vice versa.

While the exact location of the CLSs are not known at the time of this report, specific landing points were carefully considered and have been chosen for the purpose of this Feasibility Study. It is understood that different landing sites may be selected later in time as new information and opportunities are discovered.

A DTS was performed in order to select the optimal route for the DGASA system, providing a detailed discussion of cable route design and the many considerations required to select the optimal route. Two of the many considerations of the route design are the cost of the cable and the cost of the marine installation. Simply put, the longer the route, the more cost for cable (and possibly additional repeaters) and marine installation.

Therefore, the goal of the DTS is to define the most cost-effective route that offers the greatest level of protection to the cable system. Based on results from the DTS, the planned installation of approximately 14,800km (including the three branches) of submarine cable will link five sites. The main system trunk (14,110km) will cross the South Pacific and proceed through the Tasman Sea linking Valparaiso to Sydney.

There will be three branches to: Juan Fernández (50km), Easter Island (380km) and Auckland (270km). A fourth BU will be for a “Future” spur (18km).

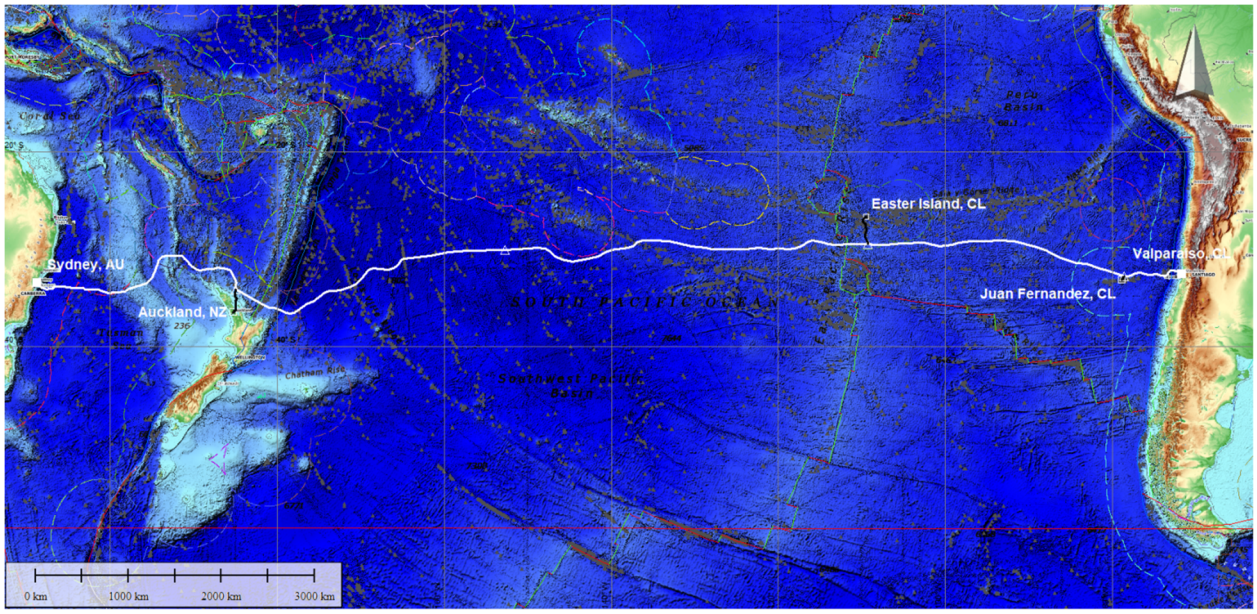


Figure 18: DGASA Geographic Locations

3.2.4 System Segments

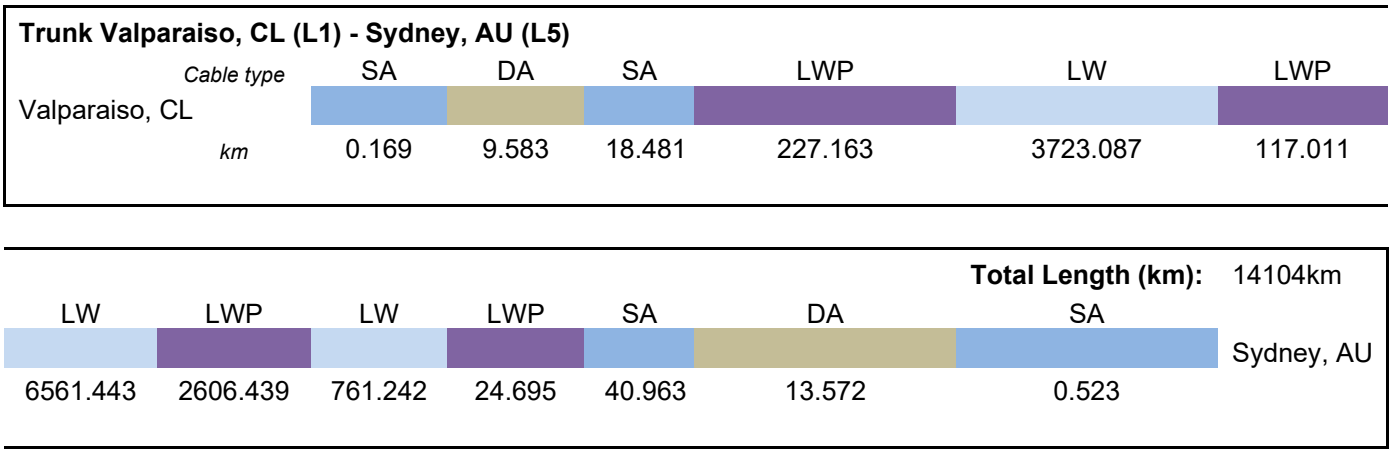
Submarine cable systems are viewed as a series of segments that collectively make up the system. Table 2: List of Segments sets out the designation for each of the segments of the DGASA System. It includes an 18km tail for the “Future” BU. For the lengths of the Digital Line Segments see Table 12: Design Capacity.

Table 2: List of Segments

Cable Segment ID	Length (km)	End 1	End 2	Fiber Pairs
T1	705	Valparaiso BMH	Juan Fernández BU	18
B1	50	Juan Fernández BU	Juan Fernández BMH	2
T2	3,060	Juan Fernández BU	Easter Island BU	18
B2	380	Easter Island BU	Easter Island BMH	2
T3	4,345	Easter Island BU	Future BU	18
B3	18	Future BU	Tail	2
T4	3,280	Future BU	Auckland BU	16
B4	270	Auckland BU	Auckland BMH	4
T5	2,720	Auckland BU	Sydney BMH	16

The estimated total submerged route length is approximately 14,800km. The Route Position Lists (RPLs) are given in the DTS. The Straight Line Diagrams (SLDs) are set out in the table below:

Table 3: DGASA Straight Line Diagrams



Branch (B1) - Juan Fernández, CL (L2) **Total Length (km):** 49.607km

	Cable type	LW	LWP	SA	DA	
BU						JF
	km	34.255	5.025	8.571	1.755	

Branch (B2) - Easter Island, CL (L3) **Total Length (km):** 375.179km

	Cable type	LW	LWP	SA	DA	
BU						Easter Island
	km	368.497	3.087	2.130	1.465	

Branch (B4) - Auckland, NZ (L4) **Total Length (km):** 266.626km

	Cable type	LWP	SA	DA	SA	
BU						Auckland
	km	12.360	241.389	11.695	1.182	

3.2.5 Landing Points

The landing points represent the pre-survey chosen locations based upon preliminary route engineering. At the time of this report, site surveys have not been conducted. Therefore, these locations are subject to change upon completion of the site surveys and when actual site conditions have been confirmed.

At each landing point there will be:

- A BMH where the submarine cable and land cables are joined, see Section 3.1.3.2;
- The RES for the return path for the DC power ground, see Section 3.1.3.2;
- A duct bank between the BMH and the CLS for the land cables, see Section 3.1.4.

The landing points at Valparaiso, Auckland and Sydney are anticipated to be near existing CLSs. These existing CLSs have not been identified. The landing points at Juan Fernández and Easter Island will be greenfield facilities. The locations of the new BMHs are pre-survey and subject to change. The locations of the new CLSs have not been identified, therefore for the purpose of this study; the length of the OSP at each site is a nominal 3km. See Section 3.1.5 for a discussion of the general requirements of the landing sites.

The approximate geographic coordinates of the BMH locations are given in Table 4: Beach Manhole Coordinates.

Table 4: Beach Manhole Coordinates

Landing	Latitude	Longitude
L1, Valparaiso	33º 01.35'S	071º 38.64'W
L2, Juan Fernández	33° 37.97'S	078° 49.76'W
L3, Easter Island	27° 09.45'S	109° 26.42'W
L4, Auckland	36° 46.47'S	174° 46.55'E
L5, Sydney	33° 55.58'S	151° 15.57'E

Proximity to existing Cable Landing Stations and/or Data Centers is illustrated in the next five figures and represented as colored markers. These locations are intended for informational use and are not exact, they are provided purely to help illustrate proximity magnitude and relative distances. The number of units/locations presented are by no means meant to be all inclusive or compressive.

Figure 19: Chile Proximity Map

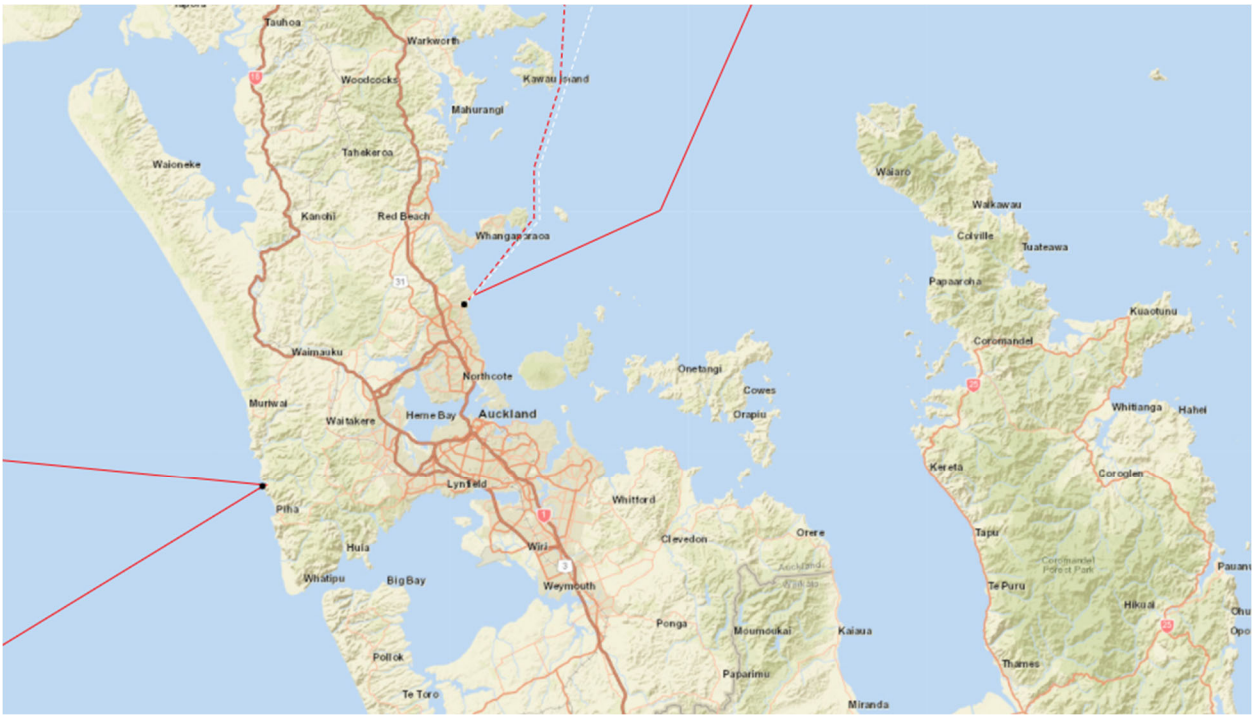


Figure 20: New Zealand Proximity Map

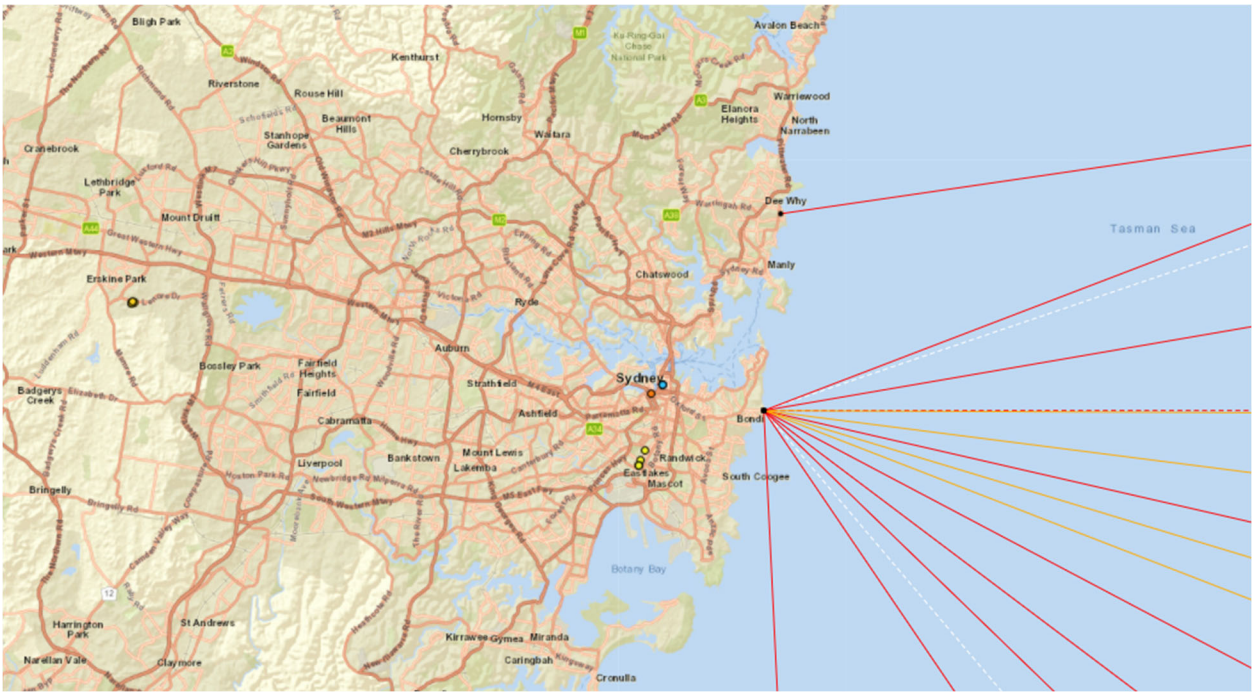


Figure 21: Australia Proximity Map

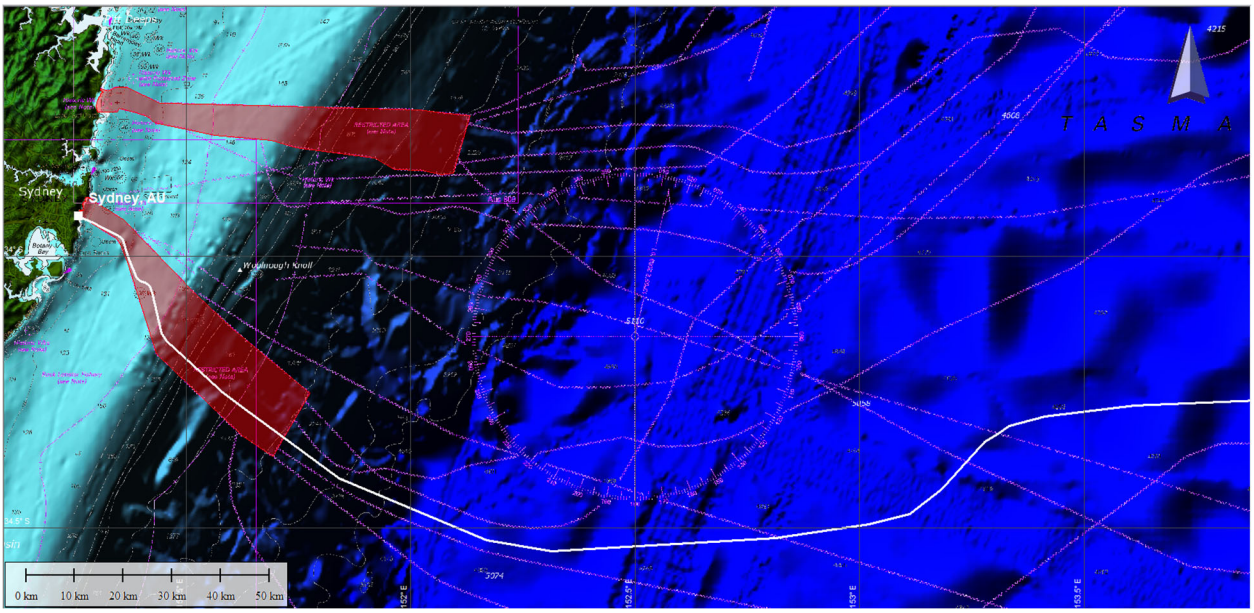


Figure 22: Sydney Cables and Cable Protection Area

Figure 23: Auckland Cables and Cable Protection Area

3.2.6 Cable Landing Stations

3.2.6.1 Existing Cable Landing Stations (Collocation)

Suitable CLS facilities at Valparaiso, Auckland and Sydney have not yet been identified, but it is assumed that existing sites will be available to accommodate the DGASA system. Once the landing parties are ascertained, the appropriate CLSs will be identified. Work will be performed at each of these sites to make them ready for installation of the system equipment. This includes such items as suite entrance work,

overhead iron work, caging, AC and DC power feeds, equipment grounding, HVAC expansion and customer interface equipment.

3.2.6.2 New Cable Landing Station Build

It is assumed that adequate facilities cannot be secured on Juan Fernández and/or Easter Island and new CLS facilities must be provided. If there are adequate facilities, work similar to Section 3.2.6.1 above will be required.

It is assumed that the local commercial power at Juan Fernández and Easter Island is not reliable. This needs to be kept in mind when designing the system backup power at these locations. The CLSs should have enough standby power for one-week autonomous operations, e.g., redundant (1+1) standby generators with a common diesel fuel tank. The redundant generator sets should be sized for the full AC load of the CLS in case one of the generators fails. Each generator set will be 30kW with a common, 2,000-liter diesel fuel tank. The combination of dual-end PFE, battery backup, and standby AC generators should compensate for possible unreliable local utility power.

Modular CLSs are proposed at Juan Fernández and Easter Island. They can either be provided by the System Supplier or the Purchaser. The actual provider is decided based upon economics and local capabilities. It will cost more for the System Supplier to provide the CLS due to administrative markups. If the Purchaser has a local presence in Juan Fernández and/or Easter Island, it will be more cost effective for the Purchaser to provide the modular CLSs. This will require close coordination with the System Supplier to certify that the building meets the Supplier's system requirements and that the Supplier installation activities are not impacted.

The provider will be responsible for all civil work associated with the CLSs. This includes site preparation, drainage, foundations, OSP, utility connectivity, landscaping, paving and fencing. The CLSs must be expandable to support the ultimate system capacity and growth.

3.2.7 Onward Connectivity

3.2.7.1 Chile Onward Connectivity

In order to optimize the DGASA product set and service offering, there is a requirement to include onward network connectivity in Chile, Australia and possibly New Zealand. This onward connectivity is considered within the system capacity forecast and reflected in the design plan.

This section reviews onward connectivity routes from landings on the proposed DGASA route. Based on the review of submarine cable systems in previous reports, a list of four onward connectivity needs shown in Table 5 below was chosen for transit analysis based on (1) transit distance, (2) available capacity, and (3) direct connections to major telecommunications and data center hubs.

The Australia to Asia connectivity options are numerous and only major landings and countries have been listed.

Table 5: DGASA Onward Connectivity Routes – Current Systems

Route	Cables	Landings
Chile – Brazil	terrestrial	Valparaiso, Chile; Fortaleza, Brazil; Rio de Janeiro, Brazil; Buenos Aires, Argentina; Sao Paulo, Brazil;

Route	Cables	Landings
Chile – United States	Curie, PAC, PCCS, SAC, SAM-1	Valparaiso, Chile; Grover Beach, California, United States; Boca Raton, Florida, United States; Jacksonville, Florida, United States
New Zealand – Hawaii	Hawaiki, Southern Cross	Takapuna, New Zealand; Mangawhai Heads, New Zealand; Kapolei, Hawaii, United States; Kahe Point, Hawaii, United States
Australia – Asia	AJC, ASC, Indigo Central, Indigo West, JGA-N, JGA-S, PPC-1, SEA-ME-WE 3	Perth, Australia; Sydney, Australia; Hong Kong, China; Shanghai, China; Guam; Maruyama, Japan; Minami-Boso, Japan; Okinawa, Japan; Shima, Japan; Singapore; South Korea; Taiwan

Source: TMG/WFNS

The following table outlines planned systems that are appropriate to each of the identified onward connectivity options.

Table 6: DGASA Onward Connectivity Routes - Planned Systems

Route	Cables	Landings
Chile – United States	SAPL	Valparaiso, Chile; Naples, Florida

Source: TMG/WFNS

3.2.7.1.1 Chile to Brazil

Several terrestrial fiber network providers offer routes between Santiago and Sao Paulo. Outreach to obtain information directly from these providers and to obtain commercially available datasets on capacity and pricing on these routes has had varied and inconsistent results. The tables below summarize available information obtained from Silica Networks and CenturyLink.

Silica Networks

Silica Networks has one terrestrial route connecting Santiago with Buenos Aires via the Paso Cruz de Piedras border crossing. From Buenos Aires to Sao Paulo, Silica Networks owns another terrestrial fiber path to the Bernardo de Irigoyen/Pato Branco border crossing and hands traffic over to Brazilian carriers for termination in Sao Paulo. Details for this route are as follows.

Table 7: Terrestrial route details for Silica Networks

Segment	Owners	Fiber cables	Available Capacity (Tbps)	Provisioned Capacity (Tbps)
Santiago – Buenos Aires	Silica	2	16	4
Buenos Aires – Sao Paulo	Silica / Third party	-	8	2

Source: Silica Networks information

CenturyLink

CenturyLink routes traffic on a terrestrial fiber network between Santiago and Buenos Aires, with onward submarine connectivity to Sao Paulo (Santos) via the SAC cable. Details for this route are as follows.

Table 8: Terrestrial route details for CenturyLink

Segment	Owners	Fiber cables	Available Capacity (Tbps)	Provisioned Capacity (Tbps)
Santiago – Buenos Aires	CenturyLink	-	25-50	-

Buenos Aires – Sao Paulo (SAC)	CenturyLink	5 (pairs)	8	4.26

Source: TMG/WFNS, CenturyLink

3.2.7.1.2 Chile to United States

Currently, there are 3 primary routes available between Valparaiso and the United States, utilizing the Curie, South American Crossing (SAC), Pan-American Crossing (PAC), South America 1 (SAM-1) and the future South America Pacific Link (SAPL) submarine cable systems. Details for these submarine cable systems are as follows.

Table 9: Submarine Cable System Details for Valparaiso to the United States

System Name	RFS Year	Owners	Fiber Pairs	Available Capacity (Tbps)	Provisioned Capacity (Tbps)
Curie	2019	Google	4	72	-
PAC	2001	CenturyLink	2	3	2
SAC	2001	CenturyLink	5	8	4.26
SAM-1	2001	Telxius	4	19.2	12.5
SAPL	2023	Ocean Networks	3	30	-

Source: TMG/WFNS

3.2.7.1.3 Valparaiso to Los Angeles via Curie

The most direct route between Chile and the United States would make use of the Curie submarine cable system. As of May 6, 2020, Sparkle has purchased a full fiber pair on the cable system, making it available for commercial use. Curie has the advantage of being the newest submarine cable on the west coast of the Americas and landing directly in Los Angeles. Sparkle will have access to fully half of Curie's 72 Tbps available capacity.

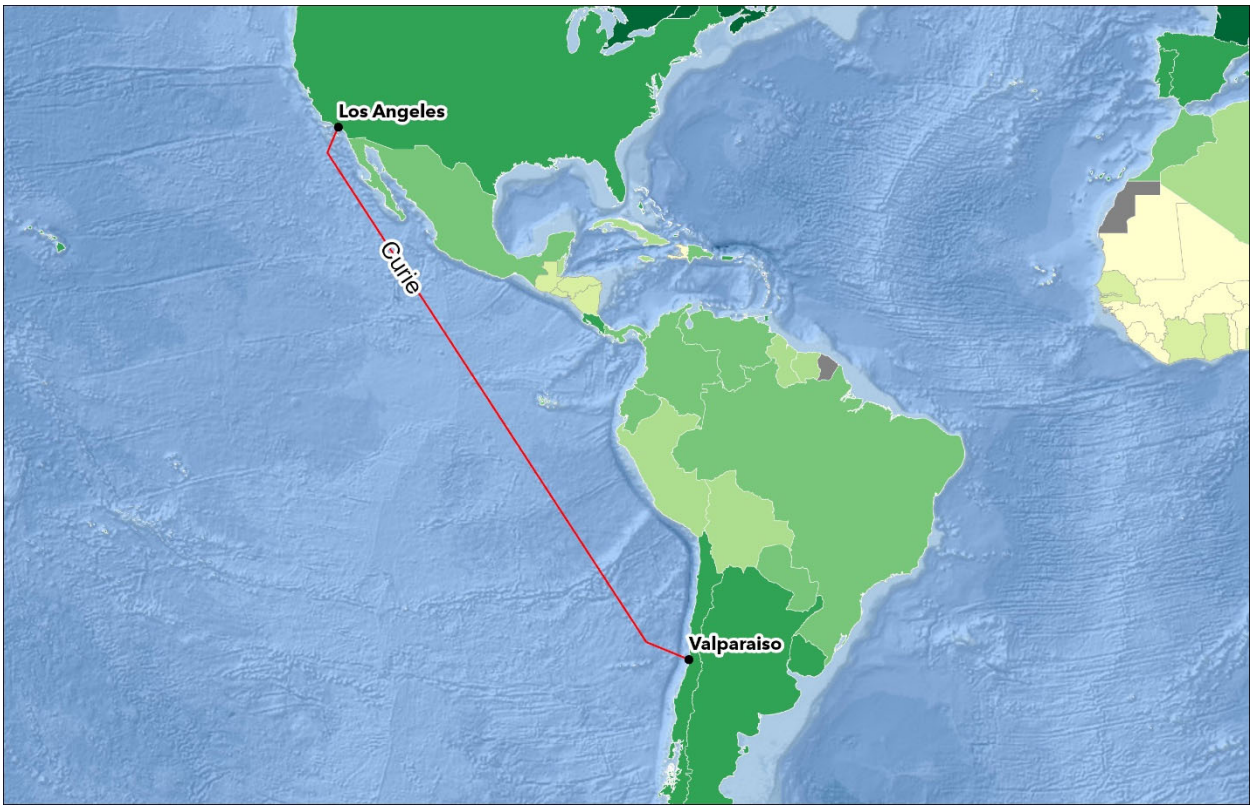


Figure 24: Valparaiso to Los Angeles via Curie Route Map

With an approximate submarine cable transit length of 10,500km between Valparaiso and Grover Beach, latency is estimated to be at 104 milliseconds (ms) assuming perfect network conditions. Network congestion and/or network equipment issues will increase the latency from baseline. This is the lowest latency route between Valparaiso and Grover Beach.

3.2.7.1.4 Valparaiso to Los Angeles via SAC and PAC

The next most direct route utilizes the SAC and PAC cables to get from Valparaiso, Chile to Grover Beach, California. While these cables are significantly older than the Curie cable system, they are part of well-established networks from providers like CenturyLink and Telxius. Unfortunately, the available capacity is significantly lower compared to the new Curie submarine cable.

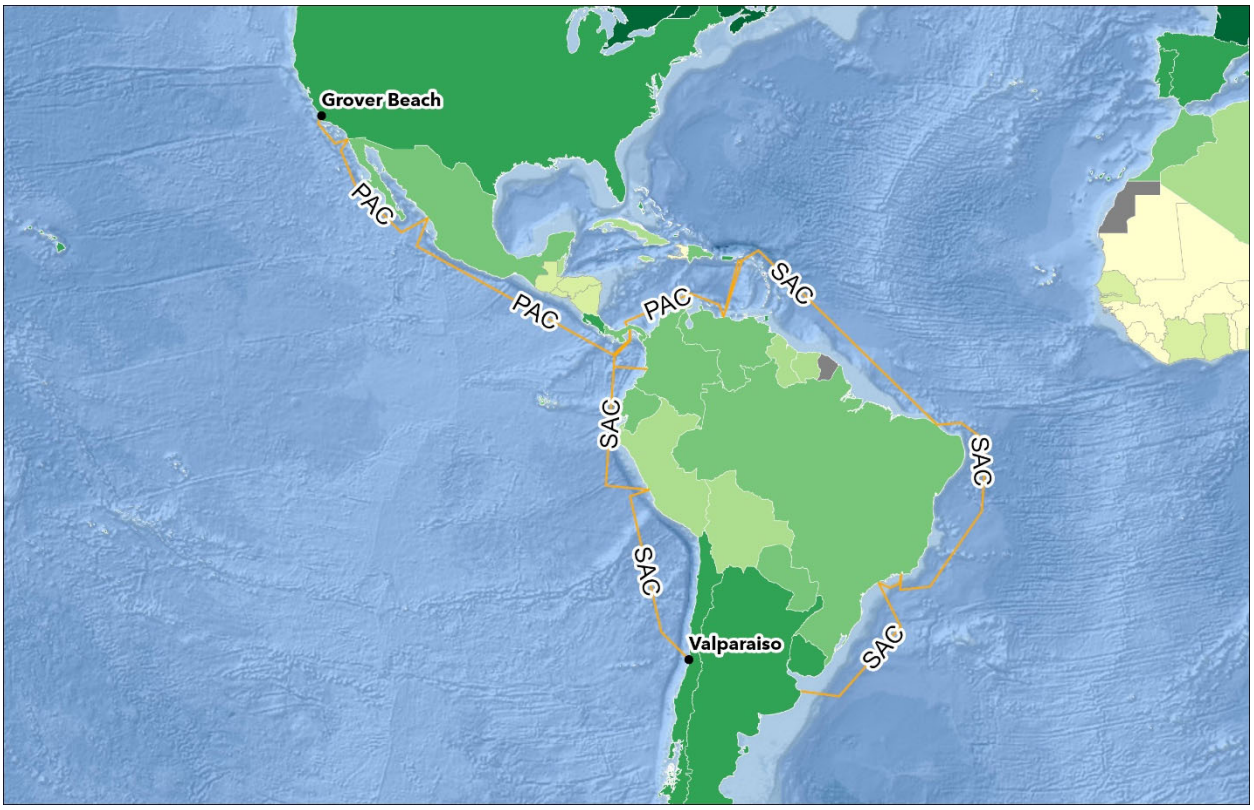


Figure 25: Valparaiso to Grover Beach via SAC and PAC Route Map

With an approximate submarine cable transit length of 12,500km between Valparaiso and Los Angeles, latency is estimated to be at 124ms assuming perfect network conditions. Network congestion and/or network equipment issues will increase the latency from baseline.

However, this route is reliant on the PAC and SAC cables, both of which have a remaining service life of less than seven years and will no longer be commercially viable within five to ten years.

3.2.7.1.5 Valparaiso to Florida via SAM-1

As an alternative path to the United States, the SAM-1 submarine cable system can be utilized to connect to Boca Raton, Florida. This provides route diversity to the United States and a connection to its east coast. The disadvantage of the SAM-1 system is that it connects to many other countries along the way and does not provide a truly direct connection to the United States.

Figure 26: Valparaiso to Boca Raton via SAM-1 Route Map

With an approximate submarine cable transit length of 9,500km between Valparaiso and Boca Raton, latency is estimated to be at 94ms assuming perfect network conditions. Network congestion and/or network equipment issues will increase the latency from baseline.

3.2.7.1.6 Valparaiso to Florida via SAPL

The SAPL submarine cable is currently planned to connect Valparaiso to Florida and could be a future option for onward connectivity to the United States. It has the added benefit of also landing in Hawaii and could serve as an alternate Pacific route in the event of a DGASA cable fault.

Figure 27: Valparaiso to Naples or Makaha via SAPL Route Map

With an approximate submarine cable transit length of 7,500km between Valparaiso and Naples, latency is estimated to be at 74ms assuming perfect network conditions. Network congestion and/or network equipment issues will increase the latency from baseline.

Once SAPL enters service, it will be the lowest latency route from Valparaiso to Florida.

3.2.7.2 New Zealand Onward Connectivity

3.2.7.2.1 New Zealand to Hawaii

Currently, there are two primary routes available between New Zealand and Hawaii, utilizing the Hawaiki and Southern Cross submarine cable systems. Details for these submarine cable systems are as follows.

Table 10: Submarine cable system details for New Zealand to Hawaii, United States

System Name	RFS Year	Owners	Fiber Pairs	Available Capacity (Tbps)	Provisioned Capacity (Tbps)
Hawaiki	2018	Hawaiki Submarine Cable	4	67	5.4
Southern Cross	2000	Southern Cross Cables Limited	3	22	8.4

Source: TMG/WFNS

3.2.7.2.2 New Zealand to Hawaii via Hawaiki

Hawaiki is the most recent and highest capacity option connecting New Zealand to Hawaii. However, it does not provide a direct path. Traffic must travel along the branch from New Zealand to the main trunk before continuing onward to Hawaii.

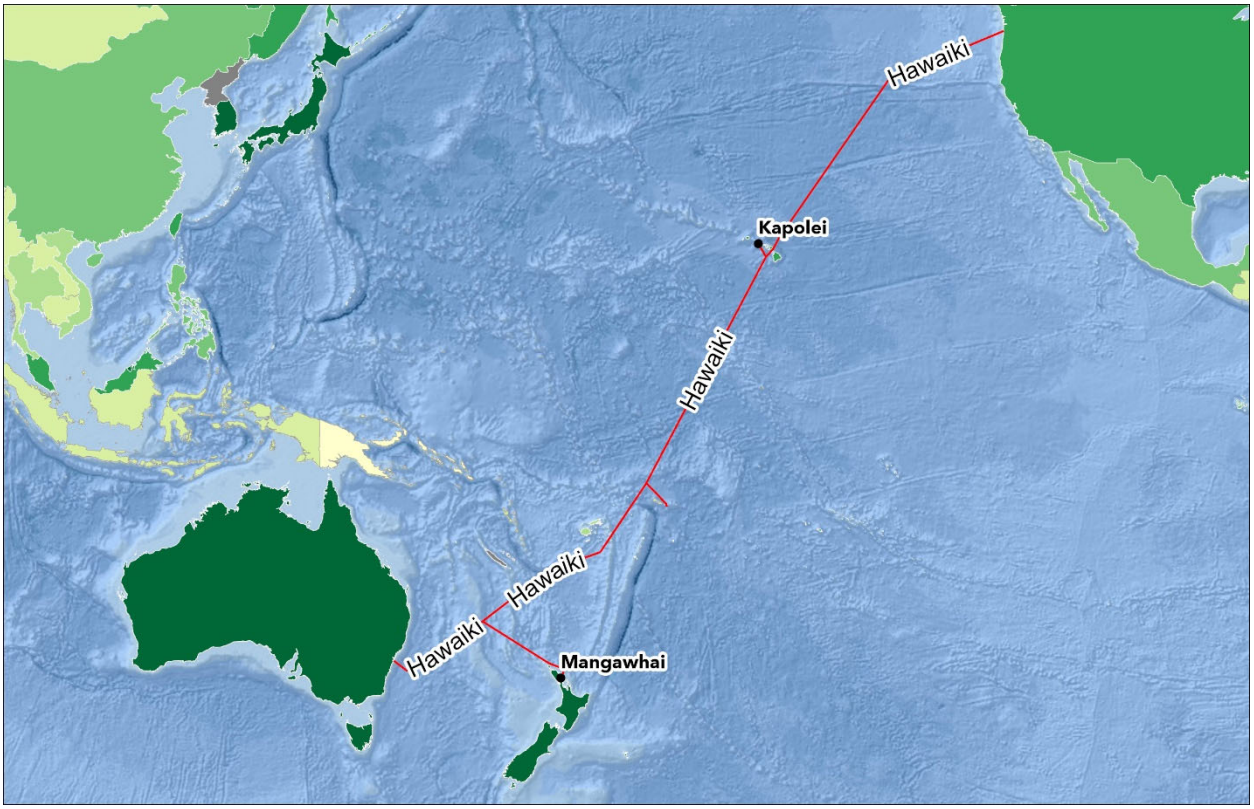


Figure 28: New Zealand to Hawaii via Hawaiki Route Map

With an approximate submarine cable transit length of 8,500km between New Zealand and Hawaii on Hawaiki, latency is estimated to be at 84ms assuming perfect network conditions. Network congestion and/or network equipment issues will increase the latency from baseline.

3.2.7.2.3 New Zealand to Hawaii via Southern Cross

Southern Cross has a well-established and resilient network – due to its older ring design. Unlike Hawaiki, Southern Cross provides a direct connection from New Zealand to Hawaii.

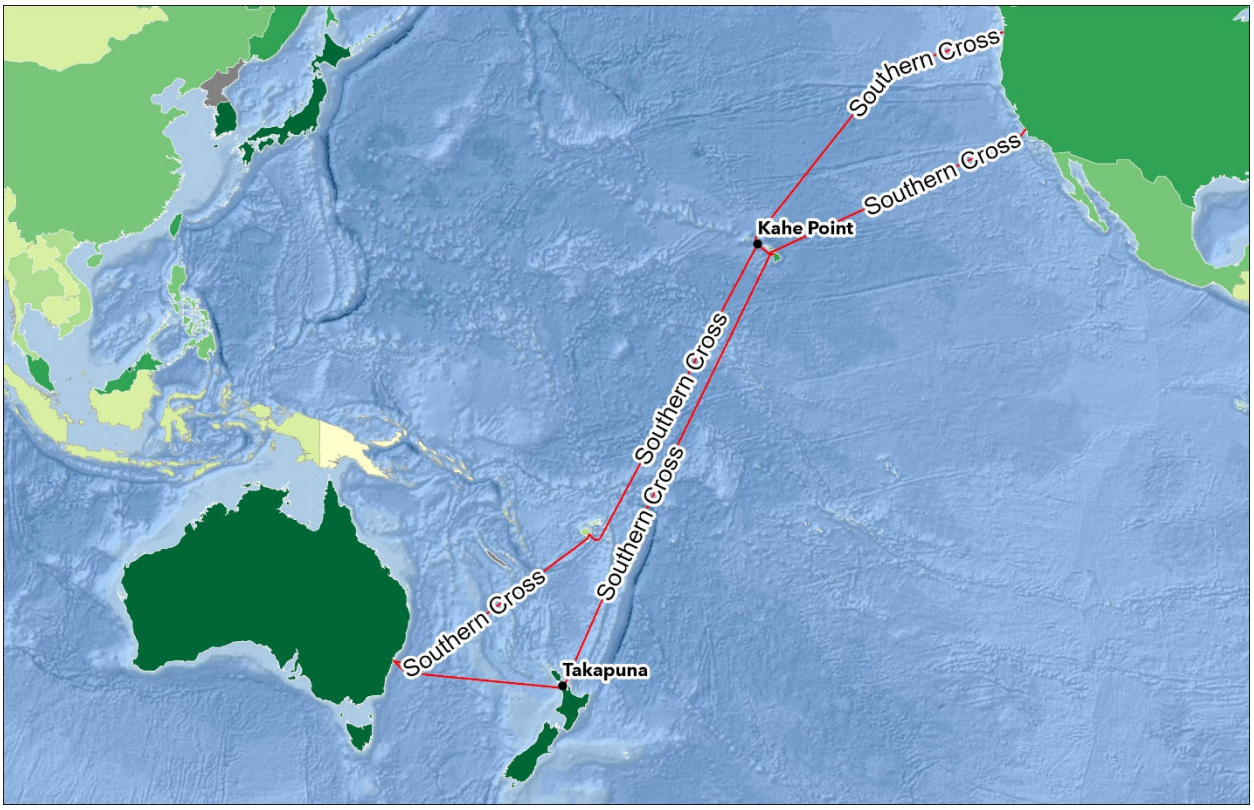


Figure 29: New Zealand to Hawaii via Southern Cross Route Map

With an approximate submarine cable transit length of 7,000km between New Zealand and Hawaii on Southern Cross, latency is estimated to be at 84ms assuming perfect network conditions. Network congestion and/or network equipment issues will increase the latency from baseline. This is the lowest latency route between New Zealand and Hawaii.

There are no currently planned systems that will connect New Zealand to Hawaii.

3.2.7.3 Australia Onward Connectivity

3.2.7.3.1 Australia to Asia

Currently, there are multiple routes available between Australia and Asia utilizing several cables. Details for these submarine cable systems are as follows:

Table 11: Submarine Cable System Details for Australia to Asia

System Name	RFS Year	Owners	Fiber Pairs	Available Capacity (Tbps)	Provisioned Capacity (Tbps)
AJC	2001	Australia Japan Cable Limited, Communications Global Network Services Limited, KDD, SoftBank Telecom Corporation, Telstra Holdings No. 1 Limited, WorldCom Global Networks Limited	4	25.6	9
ASC	2018	Australia-Singapore Cable International Limited, Vocus Communications	4	60	22

System Name	RFS Year	Owners	Fiber Pairs	Available Capacity (Tbps)	Provisioned Capacity (Tbps)
Indigo Central	2019	Google, SubPartners	2	36	12
Indigo West	2019	AARNet, Google, Indosat Ooredoo, Telstra	2	36	12
JGA North	2020	AARNet, Google, RTI Connectivity	2	24	8.5
JGA South	2020	AARNet, Google, RTI Connectivity	2	36	13
PPC-1	2009	PIPE Networks Ltd.	-	2.56	1.6
SEA-ME-WE 3	2000	Southern Cross Cables Limited	3	22	8.4

Source: TMG/WFNS

3.2.7.3.2 Australia to Japan via AJC

The Australia Japan Cable (AJC) connects Sydney, Australia directly to Maruyama and Shima in Japan. As an added benefit, this cable system also lands in Guam and from there can provide Asian onward connectivity to multiple countries in the Pacific and other points in Asia.

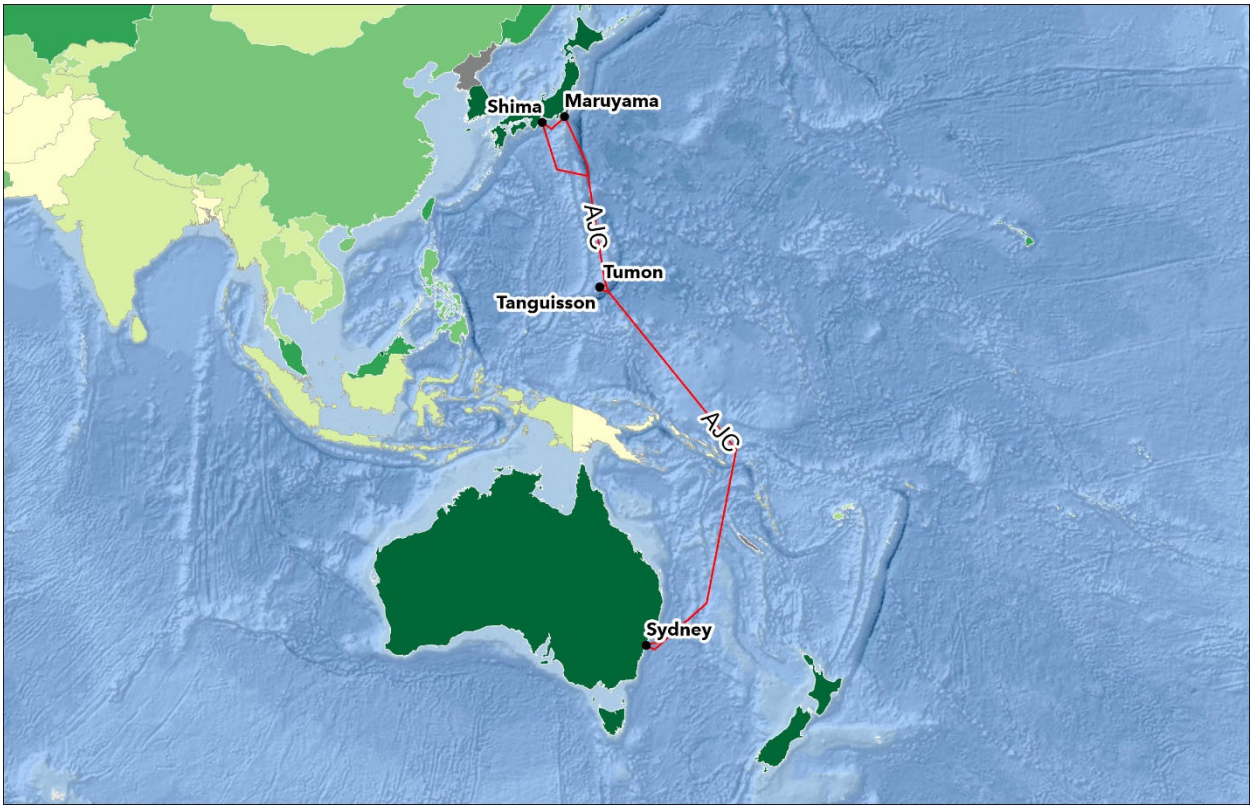


Figure 30: Australia to Japan via AJC Route Map

With an approximate submarine cable transit length of 12,000km between Australia and Japan on AJC, latency is estimated to be at 119ms assuming perfect network conditions. Network congestion and/or network equipment issues will increase the latency from baseline.

3.2.7.3.3 Australia to Japan via JGA North/South

The JGA North and JGA South systems connect Sydney in Australia to Minami-Boso in Japan. As an added benefit, this cable system also lands in Guam and from there can provide Asian onward connectivity to multiple countries in the Pacific and other points in Asia

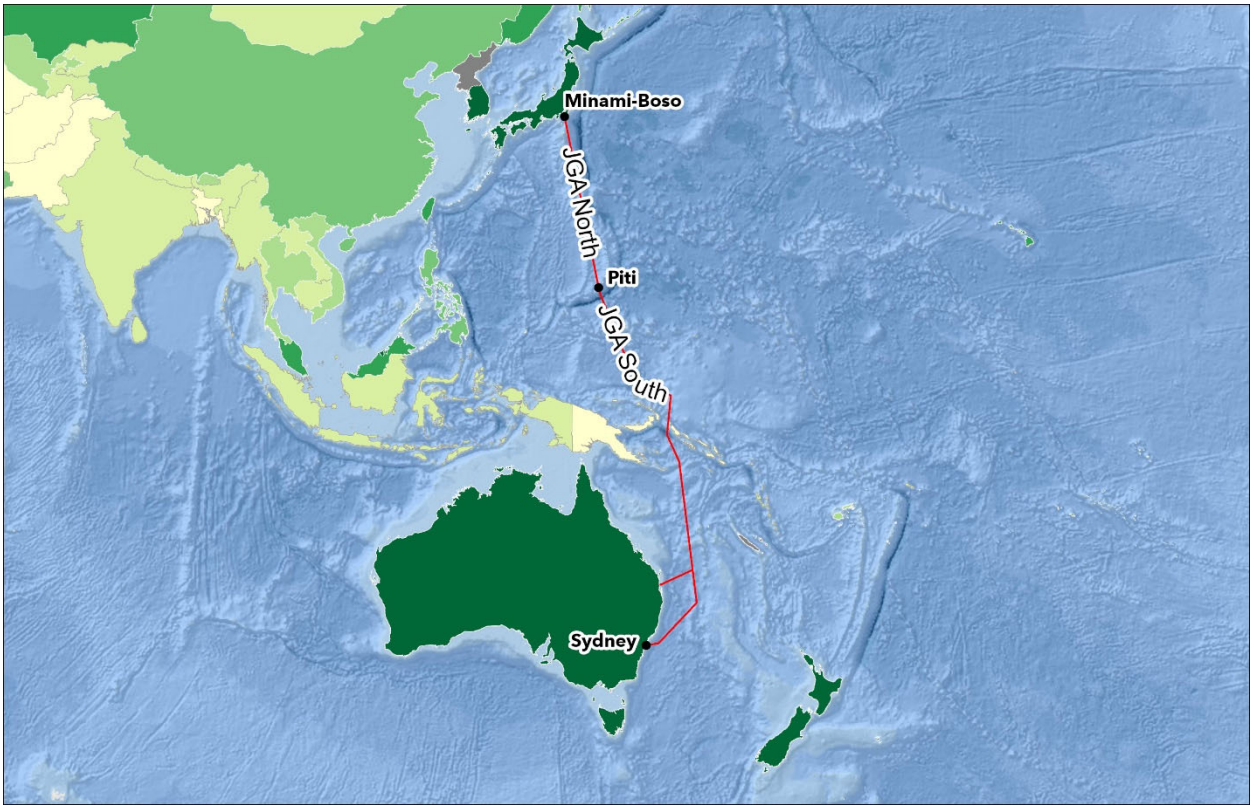


Figure 31: Australia to Japan via JGA North/South Route Map

With an approximate submarine cable transit length of 9,700km between Australia and Japan on AJC, latency is estimated to be at 96ms assuming perfect network conditions. Network congestion and/or network equipment issues will increase the latency from baseline. This is the lowest latency route between Australia and Japan.

3.2.7.3.4 Australia to Singapore via Indigo Central and Indigo West

The Indigo Central and Indigo West systems connect Sydney to Perth in Australia and then onwards to Singapore – one of the biggest telecommunications and data center hubs in the entire Asia-Pacific region. Both systems went into service in 2019 and are part of the same network.

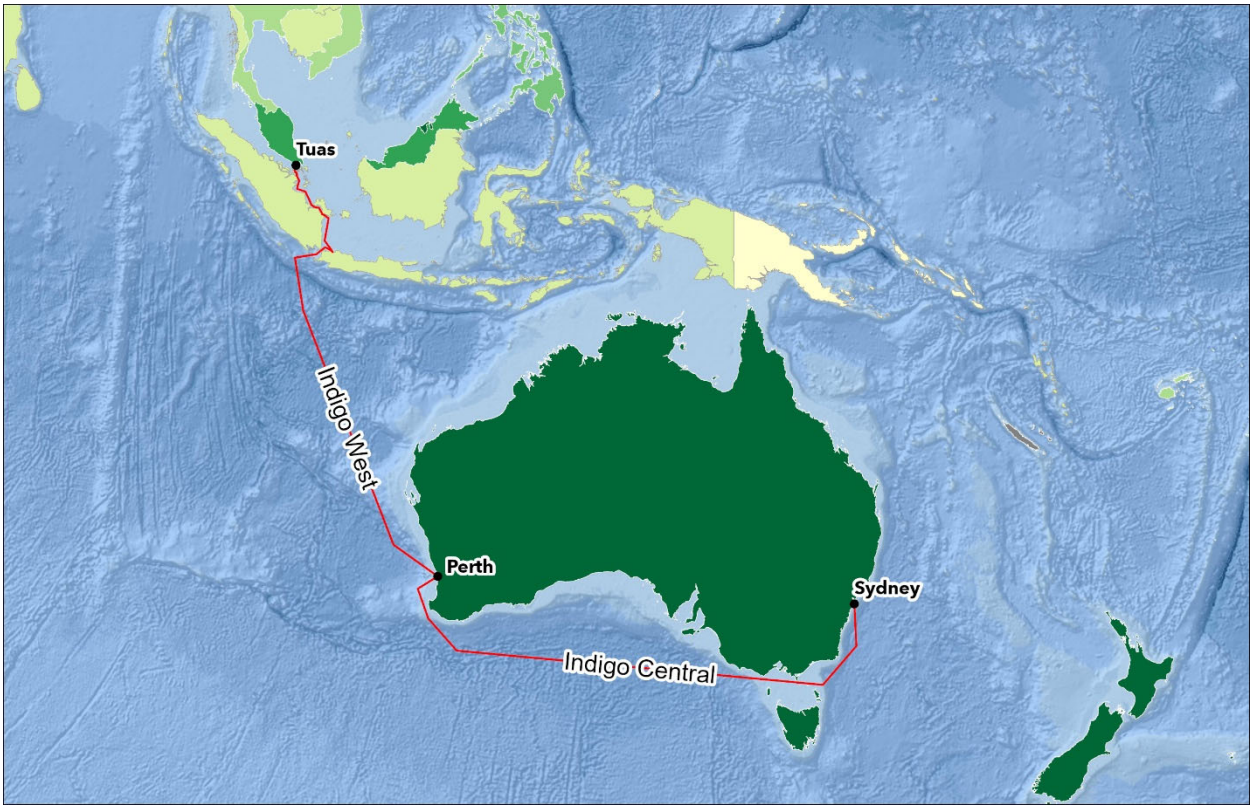


Figure 32: Australia to Singapore via Indigo Central and Indigo West

With an approximate submarine cable transit length of 9,450km between Australia and Singapore on this route, latency is estimated to be at 94ms assuming perfect network conditions. Network congestion and/or network equipment issues will increase the latency from baseline.

3.2.7.3.5 Australia to Singapore via Indigo Central and ASC

The Indigo Central and Australia Singapore Cable (ASC) systems connect Sydney to Perth in Australia and then onwards to Singapore, one of the biggest telecommunications and data center hubs in the entire Asia-Pacific region. Both systems are modern with Indigo Central entering service in 2018 and ASC entering service just last year in 2019.

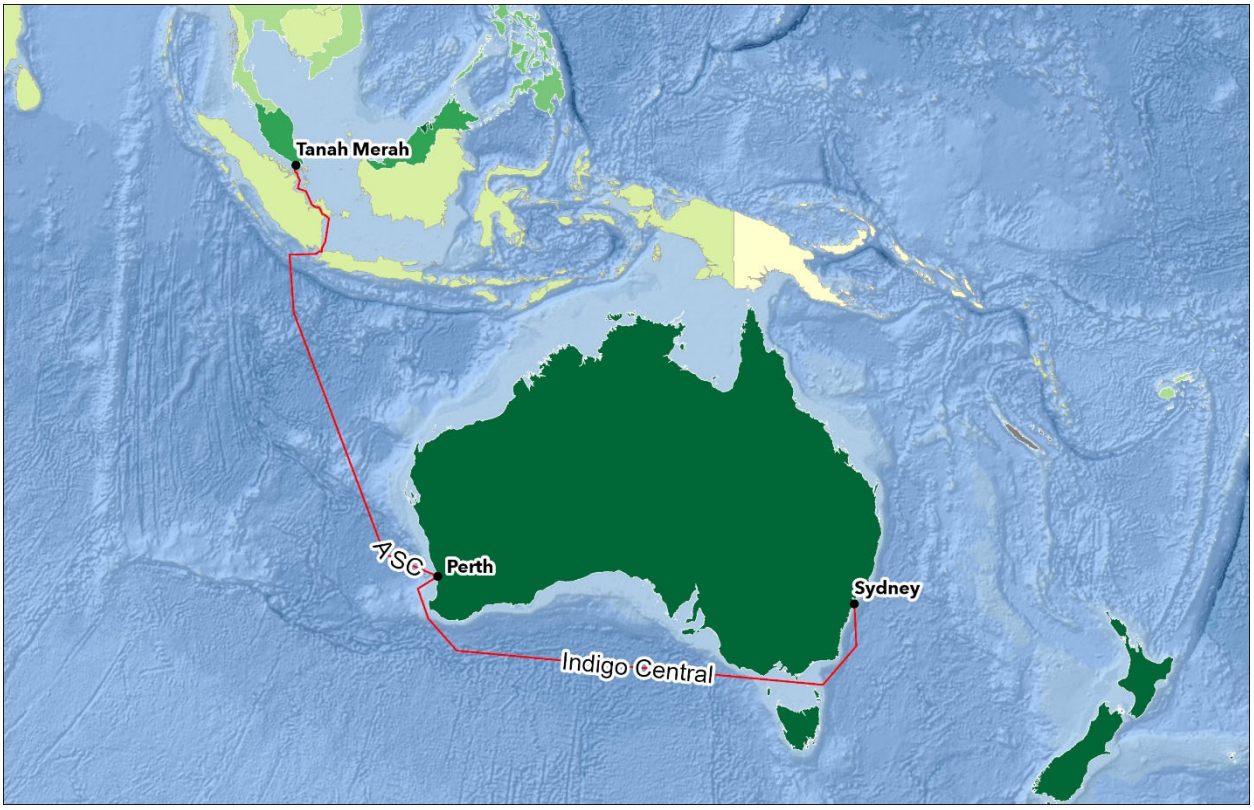


Figure 33: Australia to Singapore via Indigo Central and ASC Route Map

With an approximate submarine cable transit length of 9,450km between Australia and Singapore on this route, latency is estimated to be at 94ms assuming perfect network conditions. Network congestion and/or network equipment issues will increase the latency from baseline.

3.2.7.3.6 Australia to Singapore via Indigo Central and SEA-ME-WE 3

The Indigo Central and South East Asia-Middle East-Western Europe (SEA-ME-WE 3) systems connect Sydney to Perth in Australia and then onwards to Singapore and numerous other landings in Asia. As an added benefit, SEA-ME-WE 3 continues onwards to India, the Middle East and Europe to provide many onward connectivity opportunities. Indigo Central is a modern system entering service in 2019 while SEA-ME-WE 3 is a much older system, having entered service back in 1999.

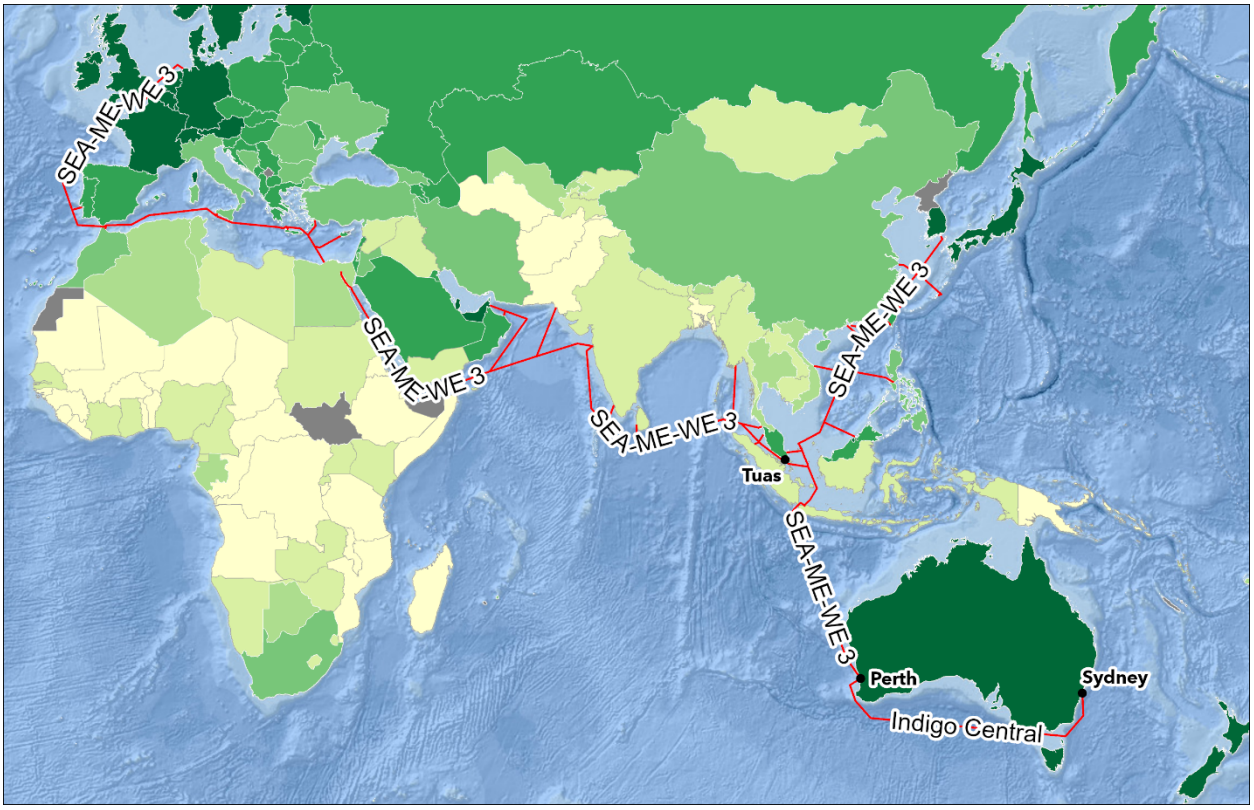


Figure 34: Australia to Singapore via Indigo Central and SEA-ME-WE 3 Route Map

With an approximate submarine cable transit length of 9,200km between Australia and Singapore on this route, latency is estimated to be at 91ms assuming perfect network conditions. Network congestion and/or network equipment issues will increase the latency from baseline.

3.2.7.3.7 Australia to Guam via PPC-1

The PPC-1 system connects Sydney in Australia to Guam. This is an older system with lower available capacity but is part of an established network and provides a diverse connection to Guam, which is a major submarine cable hub in the Pacific.

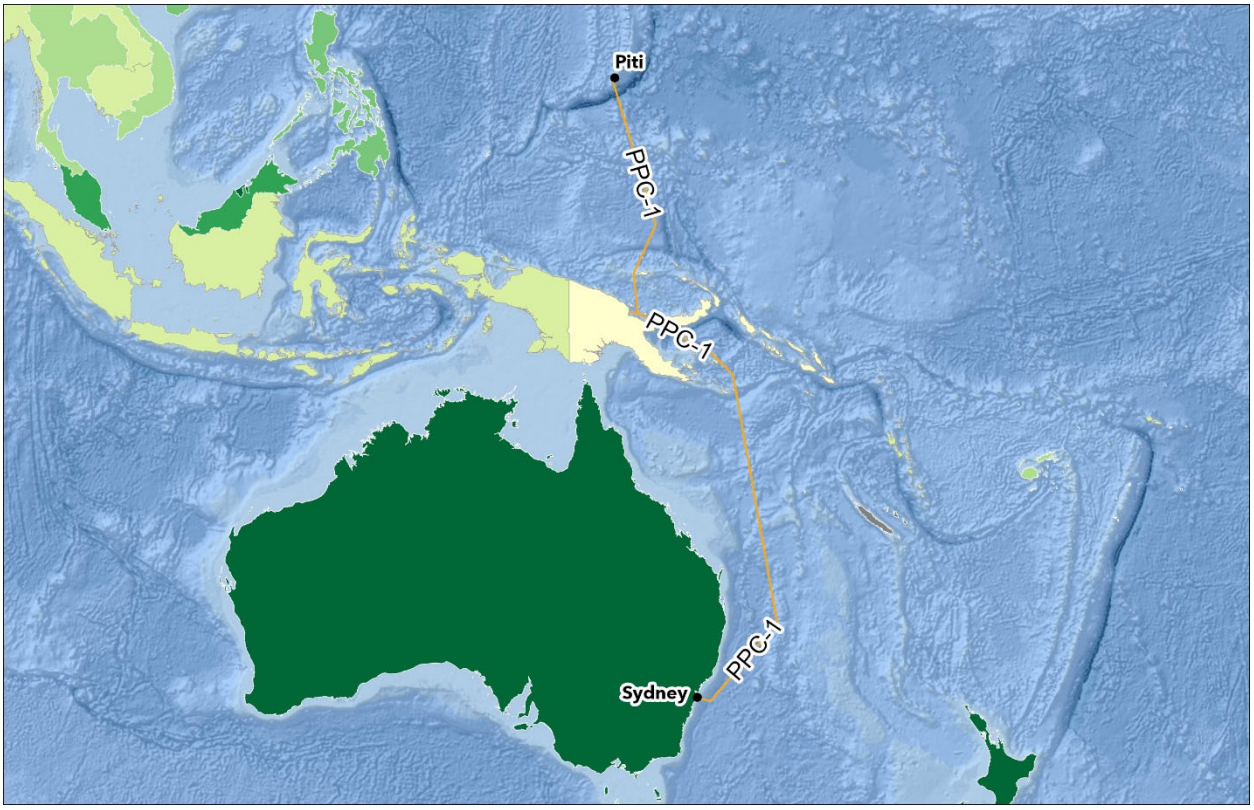


Figure 35: Australia to Guam via PPC-1 Route Map

With an approximate submarine cable transit length of 7,200km between Australia and Guam on this route, latency is estimated to be at 71ms assuming perfect network conditions. Network congestion and/or network equipment issues will increase the latency from baseline

3.3 System Requirements

This section identifies the specific requirements that must be met in order to implement the DGASA system. Based on the DTS and assumptions agreed to for the purpose of this study, the following system requirements have been defined for planning purposes only and are subject to change as new information and opportunities are discovered.

3.3.1 Standards Compliance (Applicable Standards)

All components of the system must comply with the standards and recommendations recognized by the submarine fiber optic system industry. System performance, client interfaces, installation methods and procedures, testing, operational procedures and definitions will conform to international and local standards. All system equipment and components must comply with applicable laws, regulations and requirements of any governmental authority having jurisdiction. Particular attention must be given to protection of intellectual property and traffic/system security.

All workmanship will be performed in accordance with good industry standards and all applicable laws, regulations and requirements of any governmental authority having jurisdiction.

Terms for delivery of goods, including Cost, Insurance and Freight, Delivered Duty Paid and Free on Board should be used and interpreted in accordance with International Chamber of Commerce (ICC) Incoterms 2000 or 2010, as the case may be.

3.3.1.1 International Standards

Standards developed by the following international organizations will impact any submarine cable system design and implementation:

- European Telecommunications Standards Institute (ETSI)
- Institute for Electrical and Electronics Engineers (IEEE) standards
- International Cable Protection Committee (ICPC) recommendations
- International Convention for the Prevention of Pollution from Ships (MARPOL)
- International Electrotechnical Commission (IEC)
- International Marine Contractors Association (IMCA)
- International Organization for Standardization (ISO)
- International Seabed Authority (ISA)
- International Telecommunication Union – Telecommunications Standardization (ITU-T) recommendations
- Safety of Life at Sea (SOLAS)

3.3.1.2 Local Standards

Local standards must be adhered to, such as the following:

- Local and national Health, Safety and Environment (HSE) standards
- Local electrical codes
- Local building codes
- Local and national safety and security directives
- Local, national and international permitting.

Building codes in Chile are published by the Instituto Nacional de Normalización (INN), which is the Chilean member organization of the ISO. Other Chilean standardization bodies are the Superintendencia de Electricidad y Combustibles (SEC) and the Ministerio de Vivienda y Urbanismo (MINVU). Local standards for New Zealand and Australia will be identified at the time of implementation and with the help of the system landing partners.

While Motorola's *R56, Standards and Guidelines for Communication Sites*, is not a required standard, it contains a good deal of practical information that is beneficial to the CLS design.

3.3.2 Overall System

The system will be based upon the Open Cable model and will consist of all the equipment and facilities between the ODFs in the CLSs. These are all assembled into a cohesive system that will function for 25 years.

3.3.2.1 System Capacity Requirements

The DGASA System will be capable of providing standard Ethernet, SDH and OTN interfaces. The System will support standard mappings into optical line signals and Optical Payload Units (OPUs) 2, 3 and 4. Ethernet interfaces could be 100GBASE, 200GBASE, or 400GBASE. SDH interfaces could be OC-192 (10G) or STM-64 (10G). OTN interfaces could be OTU2 (10G) or OTU2e (10G) or OTU4 (100G). Currently, typical interfaces are 100Gbps, but these interfaces can be and should be revisited at the time of procurement.

3.3.2.1.1 Digital Line Segment Capacities

The initial and ultimate capacities of the system are given below in Table 12: Design Capacity. Year 5 and Year 10 capacities are given for CapEx modeling. These capacity requirements were driven by results of the demand study in Report 2 and accepted by SUBTEL for the purpose of this study.

Table 12: Design Capacity

DLS	DLS Length (≈km)	End 1	End 2	Fiber Pair No.	Initial Capacity	Year 5 Capacity	Year 10 Capacity	Design Capacity
1	14,110	Valparaiso	Sydney	1	70 x 200 Gbps	70 x 200 Gbps	70 x 200 Gbps	77 x 200 Gbps
2	11,660	Valparaiso	Auckland	1	1 x 200 Gbps	1 x 200 Gbps	1 x 200 Gbps	1 x 200 Gbps
3	4,145	Valparaiso	Easter Island	1	1 x 200 Gbps	1 x 200 Gbps	1 x 200 Gbps	1 x 200 Gbps
4	760	Valparaiso	Juan Fernández	1	1 x 200 Gbps	1 x 200 Gbps	1 x 200 Gbps	1 x 200 Gbps
5	2,990	Sydney	Auckland	1	1 x 200 Gbps	2 x 200 Gbps	3 x 200 Gbps	5 x 200 Gbps
6	10,725	Sydney	Easter Island	1	1 x 200 Gbps	1 x 200 Gbps	1 x 200 Gbps	1 x 200 Gbps
7	13,455	Sydney	Juan Fernández	1	1 x 200 Gbps	1 x 200 Gbps	1 x 200 Gbps	1 x 200 Gbps
8	8,275	Auckland	Easter Island	1	1 x 200 Gbps	1 x 200 Gbps	1 x 200 Gbps	1 x 200 Gbps
9	11,005	Auckland	Juan Fernández	1	1 x 200 Gbps	1 x 200 Gbps	1 x 200 Gbps	1 x 200 Gbps
10	3,490	Easter Island	Juan Fernández	1	1 x 200 Gbps	1 x 200 Gbps	1 x 200 Gbps	1 x 200 Gbps
11	14,110	Valparaiso	Sydney	2	83 x 200 Gbps	83 x 200 Gbps	83 x 200 Gbps	84 x 200 Gbps
12	11,660	Valparaiso	Auckland	2	1 x 200 Gbps	2 x 200 Gbps	2 x 200 Gbps	3 x 200 Gbps
13	2,990	Sydney	Auckland	2	1 x 200 Gbps	2 x 200 Gbps	2 x 200 Gbps	3 x 200 Gbps
14	14,110	Valparaiso	Sydney	3	90 x 200 Gbps	90 x 200 Gbps	90 x 200 Gbps	90 x 200 Gbps
15	14,110	Valparaiso	Sydney	4	0	90 x 200 Gbps	90 x 200 Gbps	90 x 200 Gbps
16	14,110	Valparaiso	Sydney	5	0	90 x 200 Gbps	90 x 200 Gbps	90 x 200 Gbps
17	14,110	Valparaiso	Sydney	6	0	35 x 200 Gbps	90 x 200 Gbps	90 x 200 Gbps
18	14,110	Valparaiso	Sydney	7	0	0	90 x 200 Gbps	90 x 200 Gbps
19	14,110	Valparaiso	Sydney	8	0	0	90 x 200 Gbps	90 x 200 Gbps

DLS	DLS Length (≈km)	End 1	End 2	Fiber Pair No.	Initial Capacity	Year 5 Capacity	Year 10 Capacity	Design Capacity
20	14,110	Valparaiso	Sydney	9	0	0	35 x 200 Gbps	90 x 200 Gbps
21	14,110	Valparaiso	Sydney	10	0	0	0	90 x 200 Gbps
22	14,110	Valparaiso	Sydney	11	0	0	0	90 x 200 Gbps
23	14,110	Valparaiso	Sydney	12	0	0	0	90 x 200 Gbps
24	14,110	Valparaiso	Sydney	13	0	0	0	90 x 200 Gbps
25	14,110	Valparaiso	Sydney	14	0	0	0	90 x 200 Gbps
26	14,110	Valparaiso	Sydney	15	0	0	0	45 x 200 Gbps
27	14,110	Valparaiso	Sydney	16	0	0	0	0

Note 1: the DLS lengths include 3km land cable at each end and are rounded to the closest 5km.

Note 2: DLS 27 on FP 16 has no identified capacity requirement. DLS 27 is for some undefined, future requirement.

3.3.2.1.2 System Latency

System Latency or Round Trip Delay (RTD) depends upon the speed of light in glass, the length of the glass and the time it takes the SLTE to convert the signal from electrical to optical and back at the other end. An SLTE will add approximately 0.08msec per end (0.15msec roundtrip). System Latency is an important consideration for some customers, e.g., financial markets and 5G cellular content providers. A small percentage, perhaps 5%, of the customers will be interested in the System Latency. By the way of an example, the expected RTD for a 14,000km system is approximately 139ms.

The following table is the expected RTD for the various DGASA DLSs. Note that these estimated RTDs reflect the submarine system latencies including the SLTE latency. The customers' SIE is not included and will add a few milliseconds to the RTD. The latencies were calculated using the following formula:

RTD = Length km ÷ 100.8 km/ms + 0.15 ms ÷ 2.

Table 13: DGASA DLS Latencies

Name	From	To	Route Length (km)	Round Trip (ms)
DLS 1	Valparaiso	Sydney	14,110	140.1
DLS 2	Valparaiso	Auckland	11,660	115.8
DLS 3	Valparaiso	Easter Island	4,145	41.2
DLS 4	Valparaiso	Juan Fernández	760	7.7

Name	From	To	Route Length (km)	Round Trip (ms)
DLS 5	Sydney	Auckland	2,990	29.8
DLS 6	Sydney	Easter Island	10,725	106.5
DLS 7	Sydney	Juan Fernández	13,455	133.6
DLS 8	Auckland	Easter Island	8,275	82.2
DLS 9	Auckland	Juan Fernández	11,005	109.3
DLS 10	Easter Island	Juan Fernández	3,490	34.7

3.3.2.1.3 Wavelengths for Each Optical Fiber

The system will operate in the optical C-band from approximately 1530 nanometers (nm) to 1565nm. This spectrum is divided into wavelengths that will support the SLTE suppliers' modulation format. The number of wavelengths depends upon the modulation and the OSNR of the system. Some typical numbers of wavelengths and bit rates supported on a single fiber pair currently available are:

- 100 λs x 100Gbps = 10.0Tbps
- 90 λs x 200Gbps = 18.0Tbps
- 44 λs x 400Gbps = 17.6Tbps

Other bit rates, e.g., 300Gbps or 800Gbps, are currently supported by some SLTE suppliers. Again, the number of λs depends upon the modulation format and OSNR; and thus, the 800Gbps cannot be transmitted over submarine fiber systems due to OSNR limitations.

For the purposes of this report, the system is based upon 90 λs x 200Gbps (18.0Tbps) per fiber pair which is considered optimal in order to meet the capacity requirements from which this design plan is based. By the time this project is ready for procurement, SLTE suppliers will be offering 44 λs x 400Gbps or higher terminal equipment. Determining the feasibility of higher transmission rates or bit rates is a design exercise best conducted by the supplier at the time of procurement due to the complexity of system design and transmission variables considered at these higher transmission rates. In addition, from a strategic perspective it is recommended that the SLTE choices are made during the installation of the system and at some point closer to the RFS date so that the purchaser benefits from the latest and greatest technology for its investment. The SLTE configuration selected for this study will optimize the number of wavelengths, the modulation format, the OSNR, and the bit rate to give the lowest system cost per bit at the time of this report.

3.3.2.1.4 Initial System Configuration

The Wet Plant is designed and installed based upon the ultimate, 25-year capacity of the system. Therefore, at the outset, the Wet Plant can support at least 270Tbps on the 16 fiber pairs. When the system operates below its design capacity, proper optical loading of the system bandwidth is required. This is achieved either with discrete non-modulated wavelengths or through noise loading of unused parts of the spectrum.

The initial system configuration will light three fiber pairs. FP 1 (15.8Tbps) will be an omni fiber pair supporting all landings. FP 2 (17.0Tbps) will support Valparaiso, Auckland, and Sydney. FP 3 (18.0Tbps)

will be an express fiber pair between Valparaiso and Sydney. The fiber pairs will be equipped with the SLTE to support the initial traffic requirements in Table 12: Design Capacity. The other 13 fiber pairs (234.0Tbps) will be unlit until capacity requirements between Valparaiso and Sydney warrant equipping the fiber pairs.

3.3.2.1.5 Upgrade Model to Expand the System to the Designed Capacity

Capacity expansion is done by adding channels to the existing system. i.e., equipping the SLTE with additional modules. Adding modules is not traffic affecting, i.e., the existing traffic is not interrupted. The modules include amplifiers, multiplexers (when applicable), and transmission cards. The procedure to turn-up the new capacity is:

1. Optical loading adjustment
2. Transmitters switched on and the transmit power increased
3. Pre-emphasis optimization
4. If necessary, adjustment of the transmitter levels for all the existing wavelengths in line
5. Update the NMS (and documentation) to reflect the new capacity.

Capacity expansion is achieved by adding cards to existing SLTE chassis or, if the chassis is full, adding equipped chassis. Care is taken to keep the optical spectrum properly loaded so that the Wet Plant can operate correctly.

3.3.3 Wet Plant

Wet plant will consist of all the equipment and facilities between the BMHs. This includes submarine cable, repeaters, BUs, equalizers and joints.

3.3.3.1 Submarine Cable

Cable types are selected to provide appropriate mechanical protection to the system, noting that there are physical limitations to the installation of, for example, heavy cable in deep water. The table below outlines the general cable types by water depth recommended for the system but may be changed by the CRE working group based on product offerings and results of the future Marine Survey and final design considerations

Table 14: Cable Types and Lengths

Cable Type (km)	Valparaíso to Juan Fernández BU	Juan Fernández BU to Juan Fernández	Juan Fernández BU to Easter Island BU	Easter Island BU to Easter Island	Easter Island BU to Auckland BU[1]	Auckland BU to Auckland	Auckland BU to Sydney
Light Weight (LW)	448.5	34.3	3,058.0	368.5	6,778.0[2]		761.2
Light Weight Protected (LWP)	227.2	5.0		3.1	847.0	12.4	1,901.1

Cable Type (km)	Valparaíso to Juan Fernández BU	Juan Fernández BU to Juan Fernández	Juan Fernández BU to Easter Island BU	Easter Island BU to Easter Island	Easter Island BU to Auckland BU[1]	Auckland BU to Auckland	Auckland BU to Sydney
Single Armored (SA)	18.7	8.6		2.1		242.6	41.5
Double Armored (DA)	9.6	1.8		1.5		1.7	13.6
Pre-Laid Shore End (PLSE)						10.0	
Land Cable	3	3		3		3	3
Total	707.0	52.7	3,058.0	378.2	7,625.0	269.7	2,720.4

[1] Spans T3, T4, and B3 are combined to save space in the table. See the DTS for details.

[2] Includes 18km of LW for the "Future" BU tail (B3).

3.3.3.2 Fiber Pair Requirements (Number of Optical Fibers)

In order to meet the ultimate system capacity requirement (270Tbps), a DWDM system is proposed. This requires using 150µm² premium fiber. Ultimately, 15 fiber pairs are required in the main trunk for the 270Tbps capacity. FP 16 is for unknown requirements or operational considerations (bandwidth). See Table 12: Design Capacity for capacity growth from Day One to the final size.

In Table 2: List of Segments the number of optical fiber pairs is given for each segment. At the outset, three of the 16 main trunk fiber pairs will be lit. Additional pairs between Valparaiso and Sydney will be lit as traffic requires. All of the fiber pairs in the branches will be lit on Day One, i.e., four pairs to Auckland and two pairs each to Juan Fernández and Easter Island. Note that the branches to Auckland, Juan Fernández, and Easter Island never come close to their potential capacity, e.g., one or two wavelengths out of potentially 90 wavelengths.

3.3.3.3 Optical Budget

The optical budget is determined based upon a combination of:

- The optical spectrum (expressed in nm);
- The optical output power of the SLTE and repeaters (expressed in dBm);
- The loss of the optical fibers (expressed in dB/km);
- The loss through BUs, splices and equalizers (expressed in dB);

- Chromatic dispersion of the fiber (expressed in ps/nm/km);
- The optical receive sensitivity of the SLTE and repeaters (OSNR - expressed in dB/0.1nm);
- Propagation impairments (expressed in dB);
- Manufacturing and unallocated margins (expressed in dB);
- Allowances for repairs (expressed in dB); and
- End of Life margin (expressed in dB)
- Customer requirement margin (expressed in dB).

The Open Cable System Supplier will choose the appropriate commercially available fiber to optimize these parameters in order to maximize capacity while minimizing system costs. The fiber(s) will meet the ITU-T recommendations, e.g., G654. The Suppliers use proprietary simulations and testbeds to maximize the system performance. These parameters will be compatible with the SLTE Suppliers' equipment. Each Submarine System Supplier will offer different systems, but the following are some typical values:

Table 15: Some Typical System Parameters

Parameter	Typical Value
Optical Spectrum (C band)	1529nm to 1568nm
Fiber Attenuation	0.155 dB/km
Chromatic Dispersion	22 ps/nm/km
Repeater Output	19 dBm
OSNR	17.2 dB/0.1nm
Propagation Impairments	1.0 dB
Repair Margin	0.5 dB
Aging Margin	0.5 dB
Customer Margin	0.5 dB

3.3.3.4 Repeaters

The length of a system depends directly on the number of repeaters and BUs that can be supported by the PFE. The number of repeaters is dictated by the number and size (Gbps) of the optical wavelengths. The spacing of the repeaters depends upon the OSNR needed to support the optical line rate. The higher the line rate, the shorter the repeater spans must be. Based upon the suppliers' responses to the RFI, the DGASA System repeater spacing projected to be approximately 70km. This equates to a total of about 212 repeaters in all segments.

3.3.3.5 ROADM BU

DGASA will deploy ROADM BUs to accommodate the traffic for Juan Fernández, Easter Island and Auckland. The add/drop wavelengths can be changed over the life of the system as opposed to an OADM BU that fixes the add/drop wavelengths at the beginning of the life of the system and cannot be changed.

The ROADM BU will allow reconfiguration (increase or decrease) of the traffic over the 25-year life of the system. This will provide greater traffic routing flexibility and improved system reliability associated with greater system restoration options.

The "Future" BU for the Central Zone of the South Pacific will be a powered, full-fiber add/drop BU for FPs 17 and 18.

3.3.4 Dry Plant

Dry plant will consist of all the equipment in the CLSs up to the ODF, i.e., cable interface equipment, SLTE, PFE, LME, NMS, ODF. The OSP cables, RES, cable interface equipment, PFE, LME, NMS and ODF are provided by the System Supplier. The SLTE and SIE might be supplied by different equipment suppliers. If so, care must be taken to ensure that the different suppliers' equipment functions together as one system.

3.3.4.1 SLTE Equipment

Most likely, the SLTE will be supplied by a different contractor than the Open Cable system supplier. This allows the purchaser to take advantage of the latest technological advances and price improvements.

The SLTEs will be initially equipped per Table 12: Design Capacity in Section 3.3.2.1. Initial lit capacity will be 50.8Tbps on all DLSs.

3.3.4.2 Power Feed Equipment

The standard trunk powering configuration is dual-end powering, allowing for single-end powering during shunt fault conditions. This is so that traffic can be recovered/restored in the event of a single fault scenario.

Redundancy is included in all PFE designs for high reliability operation. For the Low Voltage (LV) design, two identical and electrically independent power converters are utilized. The High Voltage (HV) design uses an N+1 redundancy design. Three or more active converters provide the power to the undersea system. If one of the converters shuts down, the remaining N converters automatically adjust their outputs to support the load.

The following figure is one of several examples of the possible power configurations proposed by the suppliers in response to the RFI. This will definitely be changed during the RFP process when more information and constraints are known. The power configuration is designed to keep as much as possible of the system operating if there is a cable fault or break anywhere in the system. The PFE is sized for the ultimate capacity of the system and will not need to be expanded in the future.

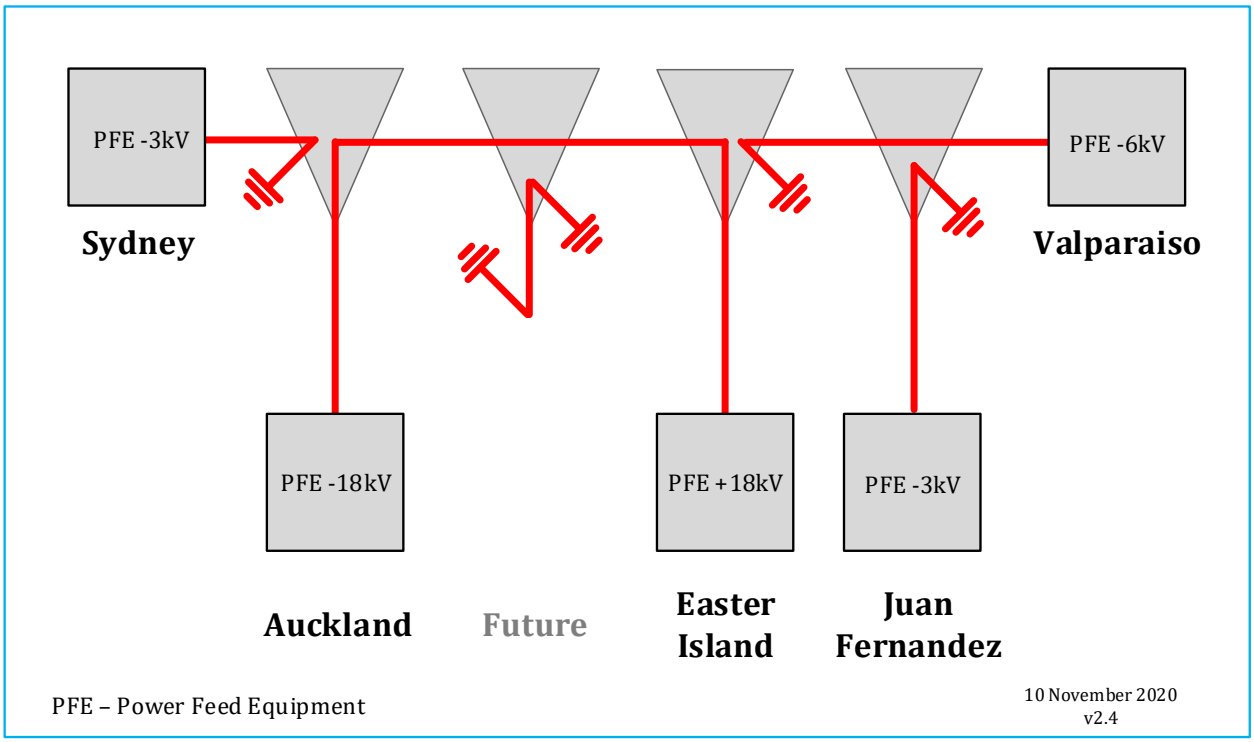


Figure 36: DGASA Power Feed

3.3.4.3 Network Management System

The system will have an NMS for monitoring and control. The NMS is essential for recognizing system faults and troubleshooting problems, e.g., meeting the four-hour Mean-Time-To-Repair (MTTR) assumption. The quicker a system fault is identified, the faster it can be repaired. This NMS system is provided by the System Supplier.

Overall system performance is measured using standard telecommunications parameters such as Bit Error Rate (BER), Errored Second (ES), Severely Errored Second (SES), OSNR, alarms and outages. These parameters are reported to the NMS and displayed in a variety of ways. Data interface points will be connected to the NOCs, where alarms and performance data may be forwarded.

3.3.4.4 Network Operations Center

DGASA will have two NOCs, namely NOC-A and NOC-B. NOC-A will be the primary NOC and NOC-B will be a redundant, backup NOC. The locations of the NOCs can be anywhere in the world that has data connectivity. The NOCs will have NMS Remote Clients so that they can duplicate all the functions of the NMS. For DCN backup, 2Mbps off-system data links will be implemented between the two NOCs. In case of a cable fault, NOC-B can take over the monitoring and management of the system. The two NOCs will be able to work together, over the backup data link, to isolate the fault.

NOC functions can be provided in-house or outsourced to third parties who specialize in NOC services. At this time, the locations and operational model have not been determined. For the purpose of this study it is assumed the NOC will be outsourced. This is subject to change as the institutional structure is defined and these decisions are made by the organization operating the DGASA system.

3.3.4.5 External Data Connections

As mentioned in the previous section, the NMS is connected to the NOCs for external transmission of system performance data via off-network data circuits, which are typically leased 2Mbps circuits from each NMS node to each NOC. This results in monthly recurring expenses reflected in the OpEx cost estimates.

3.3.5 Facilities

3.3.5.1 Beach Manhole

The BMHs will be customized for each location based upon landing point and possible future system landings. Based upon the choice of landing parties, it might be possible to use existing BMHs at Valparaiso, Auckland and/or Sydney. Any new BMHs will be 2m x 3m x 2m to allow for ease of cable installation, maintenance and future systems. For the purpose of this study it is assumed that all BMHs will be new installations and will be sized generically for each site. New BMHs will be provided by the purchaser.

3.3.5.2 Outside Plant (BMH to CLS)

Based upon the choice of landing parties, it might be possible to use existing OSP at Valparaiso, Auckland and/or Sydney. If new OSP is required, it is proposed to be a duct bank system with at least two 110mm (nominal) ducts. One of the 110mm ducts will have at least three 33mm sub-ducts in it for the three types of land cables (fiber optic cable, DC power cable and RES cable). The other 110mm duct is for future expansion. The OSP, i.e., ducts, sub-ducts, manholes, handholes, route markers, will be provided by the purchaser.

For the purpose of this report, the OSP duct bank will be 3km at each site. These lengths will be revised after the site surveys.

Note: The System Supplier is responsible for any additional civil works between the RES electrode bed and BMH (or CLS).

3.3.5.3 Horizontal Directional Drilling

HDD will be needed at all landings except Juan Fernández. Juan Fernández will be a direct landing unless otherwise discovered during the Marine and Site Surveys. Typical HDD lengths are one kilometer seaward from the BMH. The actual required length will be determined during the Marine Survey. HDD is usually the responsibility of the Purchaser and will be performed by local contractors. It is not known if there is a local HDD contractor on Easter Island. This will be determined during the site survey.

3.3.5.4 Cable Landing Station

The new modular CLSs at Juan Fernández and Easter Island will have all the features mentioned in Section 3.1.5.

The system design includes estimated equipment quantities in order to plan for initial and ultimate floor space, DC power and heat dissipation values. They are based upon suppliers' responses to the RFI and are given in the following table. (Common CLS facilities such as battery room, fire suppression system, breakroom, and generator room **are not** included in the table.)

Table 16: CLS Facilities Requirements for Submarine System

	Floor Space (sq. m)		DC Power (kW)		Heat Dissipation (Mcal/h)	
	Initial	**Ultimate**	**Initial**	**Ultimate**	**Initial**	**Ultimate**
Valparaiso	38	77	133.3	488.9	117.1	423.6
Juan Fernández	28	28	6.2	6.2	8.2	6.9
Easter Island	38	38	25.3	25.4	24.7	23.3
Auckland	28	28	8.0	10.3	9.8	10.4
Sydney	38	77	133.3	488.9	117.5	422.0

3.3.5.5 Generator System

Commercial Power backup at Juan Fernández and Easter Island will be two redundant (1+1) standby generators and a common fuel tank at each site. Each generator will be 30kW with a common 2,000-liter diesel fuel tank. The generators and fuel tank will be provided by the purchaser.

Commercial Power backup at Valparaiso, Auckland and Sydney will be part of the existing CLSs. Some costs will be incurred to tie into the existing backup power supply.

3.3.5.6 Security System

Every CLS site must have physical security features, i.e., door locks, guard stations, mantraps, surveillance cameras, building alarms, equipment cages, gates, fencing. At existing, shared CLSs, a security audit must be conducted, and any deficiencies reconciled with the site owner. At new sites, i.e., Juan Fernández and Easter Island, the security features must be part of the site design.

3.3.6 Final Solution Design Considerations

This section summarizes the final design plan and technical requirements proposed for use in the procurement of the DGASA system and offers additional insight and suggestions for consideration.

3.3.6.1 Technical Considerations

The following technologies were considered in the development of the design plan for DGASA:

1. DWDM versus SDM architecture
2. Open Cable System
3. Repeaters
4. BUs with wave and fiber pair switching
5. Transponder Options
6. PFE size.

3.3.6.1.1 Dense Wave Division Multiplexing

There are two architectural approaches to providing capacity on a submarine system: DWDM and SDM. DWDM maximizes the capacity on a fiber pair level while SDM maximizes system efficiency on a system level, i.e., lower optical power on more fiber pairs. The SDM system can reflect a significant price savings over a DWDM system. SDM fiber has an effective core area of 110µm² while the DWDM requires premium fibers with150µm². The SDM fiber is about 20% cheaper than the DWDM fiber (this is fiber cost, not cable cost).

However, given the current submerged plant technology only supports 16 fiber pairs, it is not possible to provide 270Tbps capacity using SDM architecture over transoceanic distances. Currently, the SDM technology can only provide about 214Tbps on 16 fiber pairs, which does not meet the capacity requirement as defined by the Demand Study. Therefore, the DGASA system will use the traditional DWDM architecture.

3.3.6.1.2 Open Cable System

The submarine industry has embraced the Open Cable model and currently is the standard for new system deployments. The Open Cable model allows the Wet Plant to be optimized regardless of the SLTE supplier. It allows multiple SLTE vendors to interface with a single fiber pair. It also establishes common access to the Wet Plant for upgrades by the SLTE manufacturers.

Note: not all components of the Wet Plant are interchangeable between System Suppliers, e.g., the NMS of one supplier cannot control the BUs of another supplier. Only the SLTE is interchangeable with the Wet Plant.

3.3.6.1.3 Branching Units

ROADM BUs allow flexibility to accommodate the traffic for Juan Fernández, Easter Island and Auckland. The add/drop wavelengths can be changed over the life of the system as opposed to an OADM BU that fixes the add/drop wavelengths at the beginning-of-life of the system and cannot be changed. The ROADM BU will allow reconfiguration (increase or decrease) of the traffic over the 25-year life of the system.

3.3.6.1.4 Transponders

The SLTE is capable of providing standard Ethernet, SDH and OTN interfaces. The customer traffic can be mapped into optical line signals and OPUs 2, 3 and 4. Ethernet interfaces could be 100GBASE, 200GBASE, or 400GBASE. SDH interfaces could be OC-192 (10G) or STM-64 (10G). OTN interfaces could be OTU2 (10G) or OTU2e (10G) or OTU4 (100G).

For this report, it is assumed that the customers' traffic is either 100GBASE or OTU4.

3.3.6.1.5 Power Feed Equipment

The PFE system design will be optimized for double-end feed that will allow the most traffic flexibility in case of a cable fault. The design will consider:

- submarine optical system configuration (cable length, numbers of repeaters and BUs)
- known cable fault probabilities
- local commercial power reliability
- ease of power system reconfiguration
- future system expansion to the Central Zone of the South Pacific.

The PFE system configuration given in *Figure 36: DGASA Power Feed* is one suggested by one of the suppliers in their RFI response. It is probably the most complex configuration and will be refined after site surveys and during the RFP process.

3.3.6.2 System Availability

System Availability addresses traffic effecting failures. Non-traffic components, e.g., supervisory system, are not part of the availability analysis.

The submarine fiber optic system will be designed and installed to meet a target of 99.999% availability, i.e., less than 5¼ minutes of outage per year. This excludes damage from external sources, e.g., anchors and fishing gear. It should be noted the availability is based upon statistical values and therefore should be evaluated over a long period, e.g., five years.

Because of the large differences in the MTTR times, there are two aspects of system reliability; (1) the probability of a Dry Plant element failure (MTTR 4 hours) and (2) the probability of a Wet Plant failure (MTTR 25 - 30 days), as detailed below:

1. For the Dry Plant failure, the 99.999% is based upon a MTTR of four hours. Since spares are provided on-site for all cards, the MTTR represents the mean time required to identify and locate the faulty element and replace it with a spare. Unavailability is calculated for all elements and the sum of all the contributions gives the overall unavailability. In the case of a network with

protection, unavailability of the independent paths is multiplied to give the probability of all of them failing at the same time.

2. For a Wet Plant failure, the convention is to quote the expected number of repairs requiring a ship repair during 25 years at the 95% upper confidence level. This covers only repairs due to cable, repeater, equalizer or BU traffic affecting failures and excludes repairs due to damage by external sources (manmade or natural phenomena), which are impossible to estimate. To minimize the number of estimated ship repairs over the system life, a certain amount of redundancy is generally included in the repeaters. To ensure the required amplifier reliability is met, redundant pump laser configurations are employed. Also, the PFE power rectifiers contain multiple serial-parallel redundant configurations to ensure their reliability does not affect the operation of the system. The reliability budget is estimated assuming the submarine link is still within its performance when one of the lasers of some amplifiers is out of service.

The effective failure rate is determined as the sum of failure rates of each component.

As a caveat, System Availability calculations must be evaluated as to business value and end-user expectations. Decisions may require strategic trade-offs with cost, performance and security; and decision makers need to ask questions beyond the system dependability metrics. Careful business evaluation is needed when establishing Service Level Agreements (SLAs) with the customers.

3.3.6.3 Conclusion

The design plan for the DGASA system is considered to be normal with no unusual or special considerations that pose any greater risks than those typically faced with standard implementations. The proposed system design is a modern design, providing the Government of Chile many benefits, including greater capacity, lower latency and greater system reliability and performance. Lastly, Submarine System Suppliers are interested and highly motivated to win this contract and implement the DGASA system.

4. Marine Route Plan

The purpose of this section is to provide a general understanding of submarine cable system route conditions, as well as safety and security of the cable required on the seafloor, and describe various decisions/options that will need to be considered at the time of procurement for the implementation of the DGASA system. In addition, this section lays out a summary of the DTS which will serve as the route details to which the awarded Supplier will design and install the eventual system. Details of the DTS in their entirety are in Appendix A.

4.1 Technical Description

The DGASA submarine cable system, herein referred to as the 'System', spans 14,794 kilometers of complex atmospheric, oceanographic, and geological ocean systems, lands at three major cities and two remote islands, and crosses three tectonic plate boundaries as it navigates some of the Earth's most impressive and recognizable ocean features.

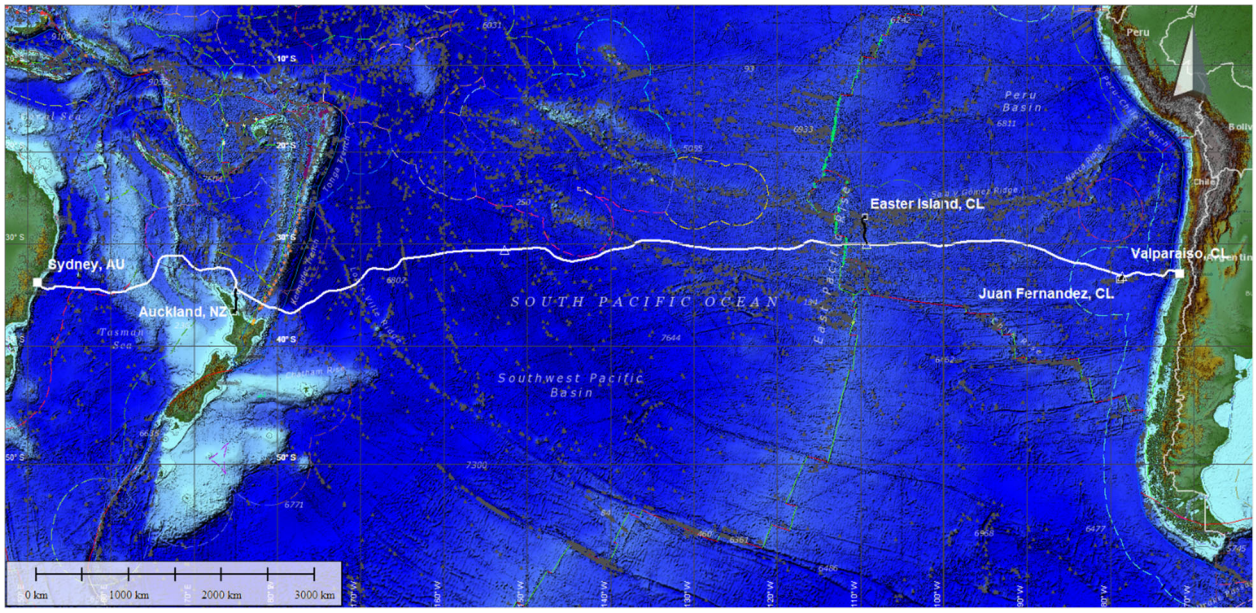


Figure 37: DGASA System Route Overview Map

The System was planned from East to West, starting in Valparaiso, Chile and ending in Sydney, Australia with landings on Robinson Crusoe Island, a part of the Juan Fernández archipelago of Chile, Easter Island, Chile and Auckland, New Zealand. The only two landings not well known to System Suppliers are Juan Fernández and Easter Island. Valparaiso, Auckland, and Sydney all have multiple submarine cable system landings, decreasing the uncertainty around permitting, installation and maintenance risks while increasing the complexity of finding suitable seabed for crossings and landing points.

As with any submarine cable system, planning the safety and security of the cable on the seafloor is fundamentally important and accomplished using well-established route selection and cable protection guidelines published by the ICPC and the decades of experience brought to bear by the cable Supplier and the Supplier's subcontractors and Owner's consultants and representatives. This 'Team' collectively

provides the intellectual and physical resources to safely plan, manufacture, install and maintain a 30-year System.

The DTS provides historical and point-in-time information about the route over which the submarine cable will traverse, used to feed each part of the System design. Prior to finalizing the System design and execution plan, Marine Route Survey (MRS), Land Survey and Supplier-augmented DTS activities are coupled with detailed CRE to provide a least-risk, least-cost effective System that meets or exceeds the Owner's business objectives.

Obstacles for the DGASA System are typical as with any trans-Pacific cable system having multiple landings, but the most notable obstacle for this System is weather, closely followed by tectonic-related events such as underwater volcanoes, hydrothermal vents, and of course earthquakes and resulting tsunamis. The System maintains as high a latitude as possible to provide a best-case weather scenario for survey, installation, and future maintenance. Careful planning of marine operations should prevent excessive weather downtime, a schedule and cost risk. Historically active earthquake-prone areas are avoided as much as possible, but the System's inherent proximity to the Ring of Fire and tectonic plate boundaries mean this System will eventually 'feel' an earthquake during its lifespan. Avoidance of slopes, which can accumulate sediment, is the best singular way to keep the cable from being damaged when sediments break free from the slope face. Tsunamis pose a hazard to all the System's landings. BMH and CLS engineering and strategic placement on shore coupled with strong nearshore cable protection techniques (HDD, split pipe, Uraduct, pinning, etc.) will provide the best chance of survival against tsunami events. These and many other best-practice tactics were employed designing the DTS route.

Suppliers have planned and installed longer and just as technically complex systems around the world in recent years and the DGASA System project risks should be well known and mitigatable by the Supplier. The viability of a successful, on-time and on-budget RFS will depend on strong project management and technical skills of both the Supplier and Owner and less so on the complexities of this System's route design.

The comprehensive DTS stands as a separate document as part of the overall Final Report to provide ease of distribution to relevant parties (See Appendix A).

4.2 Cable System Organization and Description

The following System landings, trunk segments and branches have been organized to include consistent labelling and identification tags, for example, the landing site at Valparaiso, CL has an identifier of L1 and the branch to Easter Island, CL has an identifier of B2. Ordering of the landings, trunk segments and branches are sorted east to west. Refer to Figure 38 for an overview of the route, segments, landings, bathymetry profile and cable lengths.

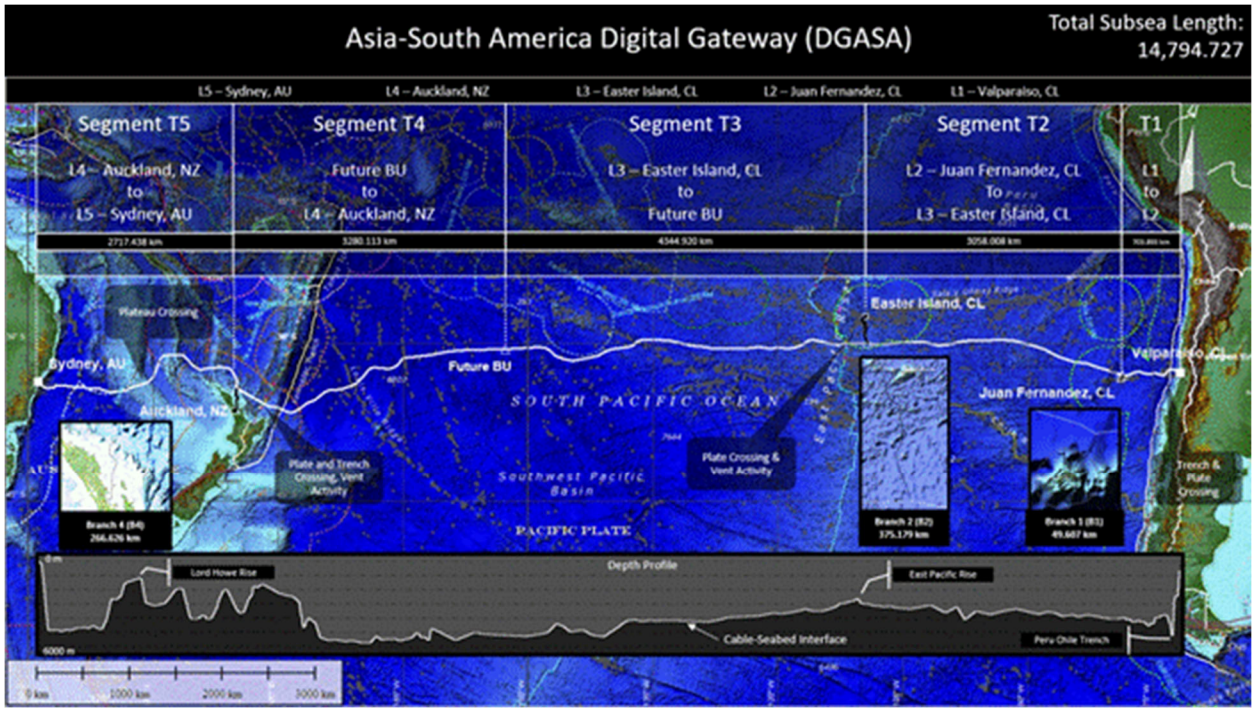


Figure 38: DGASA CRE Overview

It should be noted that the DTS route and proposed installation techniques found herein will likely change prior to cable route survey activities as more technical data and business decisions are obtained, but certainly after the cable route survey and subsequent cable route engineering activities are concluded. This is typical with any cable system and highlights the importance of the organization, identification and classification of each landing, trunk segment and branch to maintain consistency across all project activities and reports. Careful management of identifiers and any future modifications or substitutions will provide consistency between each phase of the project.

The direction of the System route position list and the following description is from East to West, so Valparaiso, Chile to Sydney, Australia.

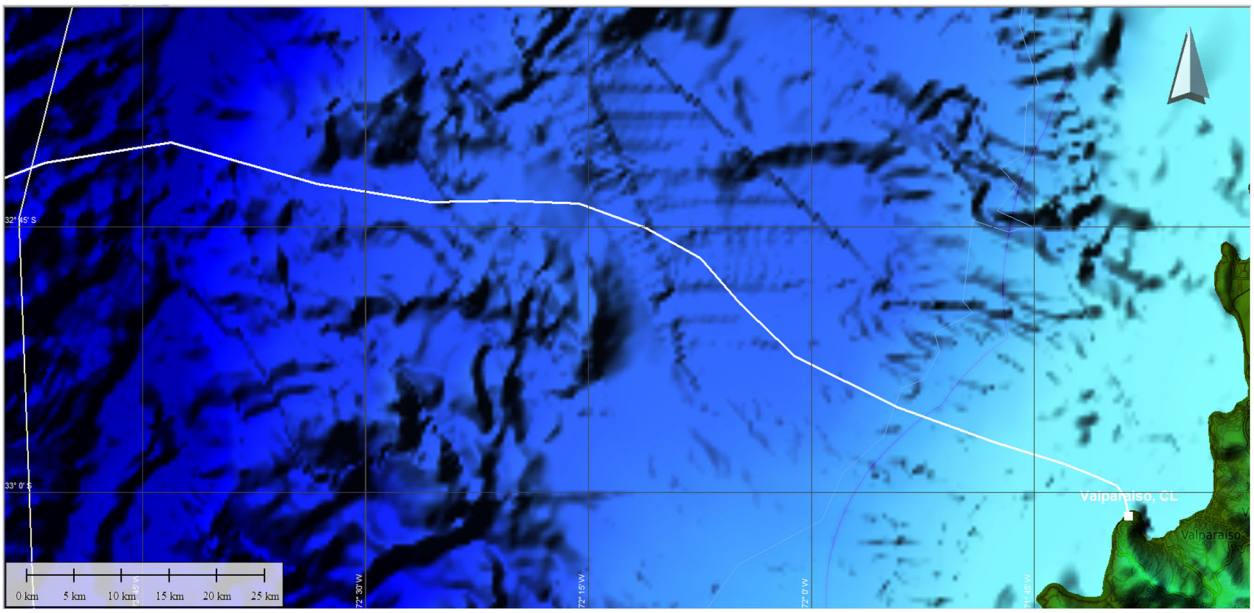


Figure 39: Valparaiso to Peru-Chile Trench

The System trunk starts in the city of Valparaiso, a World Heritage Site and historic seaport, with a proposed BMH located at 33° 01.351' S, 71° 38.640' W near the current Google cable system Curie. The route traverses via HDD to an exit point where it will be buried until reaching the slope of the continental shelf, just before entering the Peru-Chile Trench.

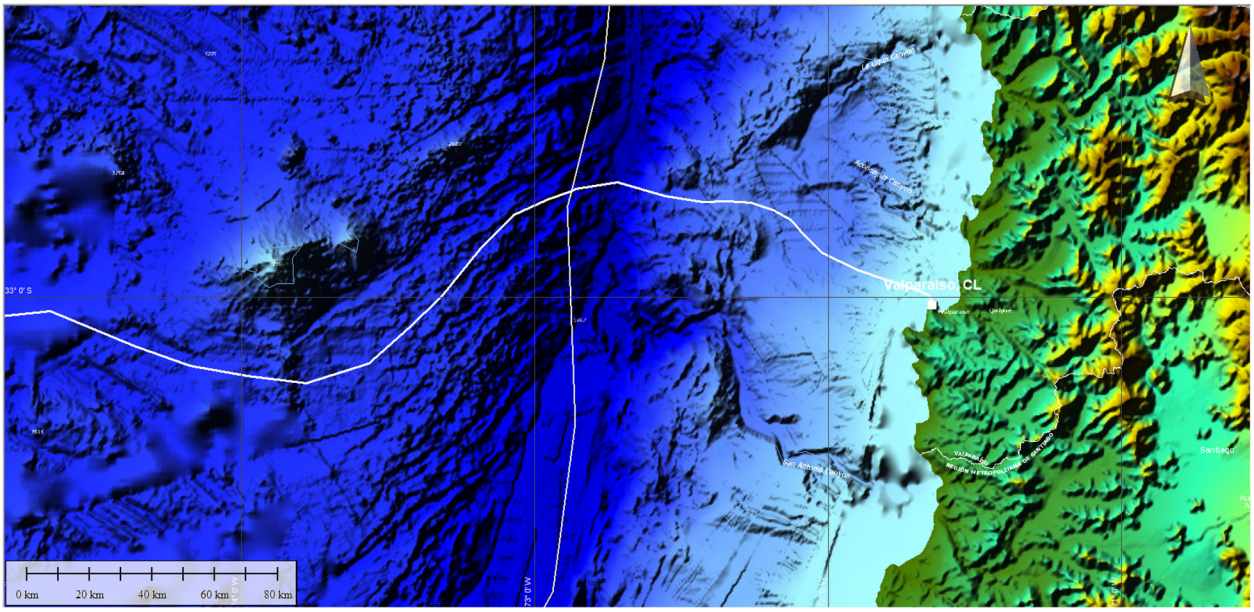


Figure 40: Valparaiso crossing Peru-Chile Trench

The crossing of the Peru-Chile Trench is coincident with the plate transition from the South America Plate to the Nazca Plate at 32° 41.37724' S, 72° 51.54689' W in approximately 5700 meters water depth. The Peru-Chile Trench crossing is relatively standard until the upslope, where the route deviates to the south-west to avoid a set of seamounts before turning due West towards the Juan Fernandez BU located at 33° 16.390' S, 78° 34.278' W in approximately 4000 meters of water.

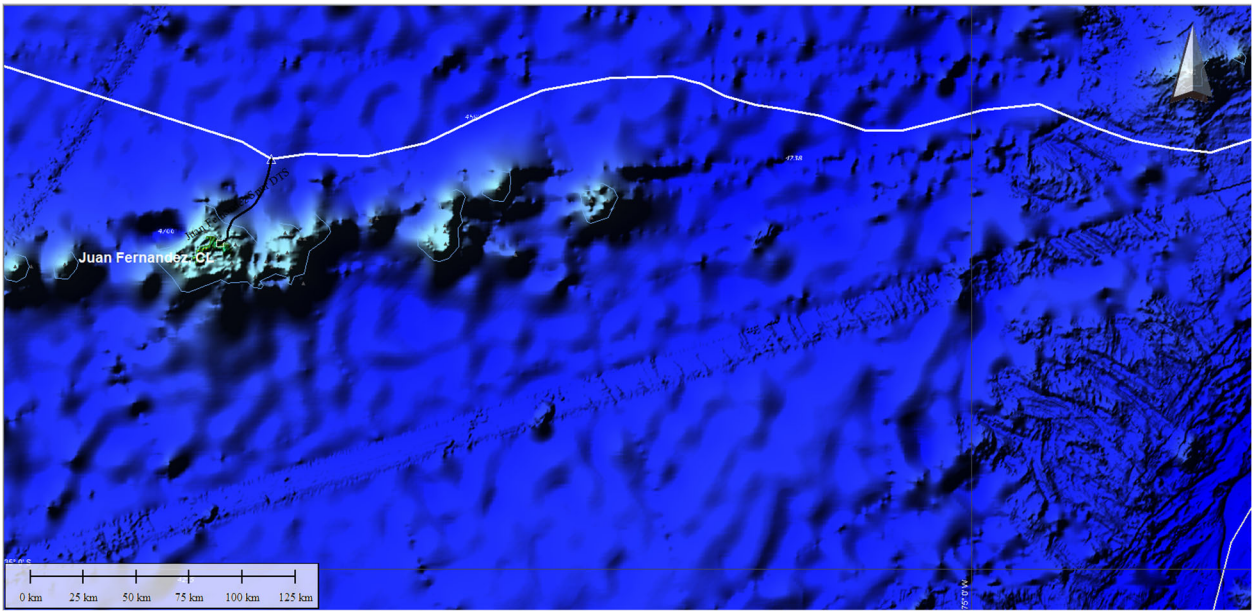


Figure 41: Juan Fernandez Approaches

The route then continues west-north-west towards the Easter Island BU, crossing the Chile EEZ at position 31° 56.68495' S, 84° 10.32648' W, continuing due west until crossing back into the Chile EEZ of Easter Island.

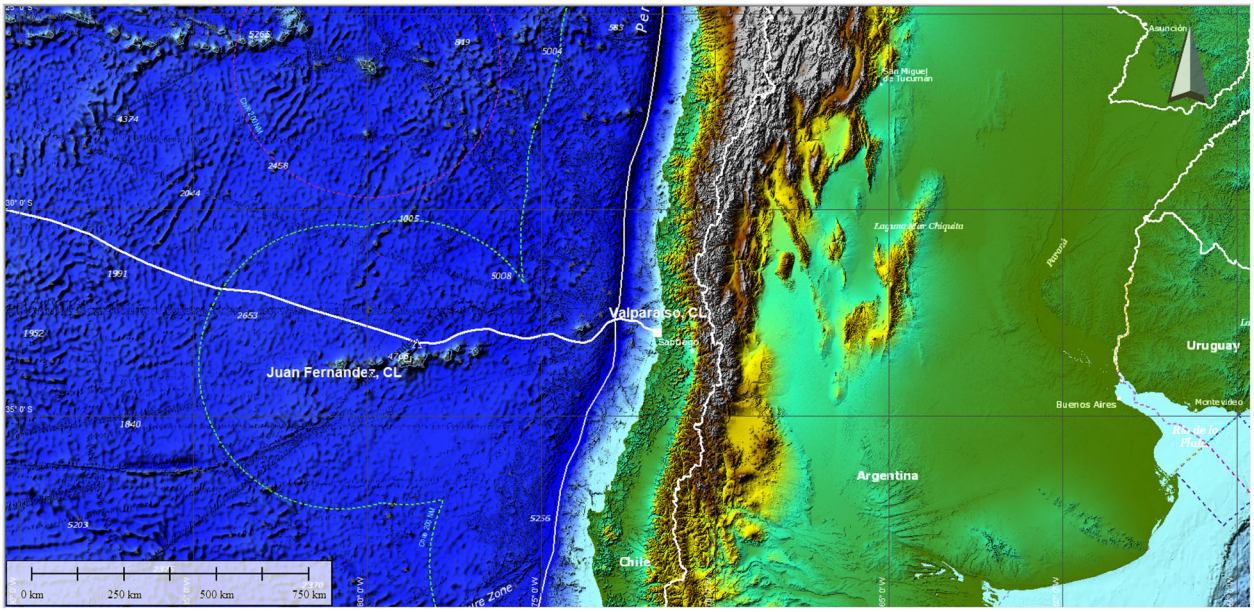


Figure 42: Valparaiso - JF towards EI

The Easter Island BU is located at 29° 58.184' S, 109° 17.138' W in approximately 3200 meters water depth with in the Chile EEZ surrounding Easter Island. The route continues to the East Pacific Rise, located at 30° 1.13458' S, 111° 44.43583' W, where it must cross a vertical structure of seabed surrounded by hydrothermal vents due to the coincident boundary between the Nazca Plate and Pacific Plate.

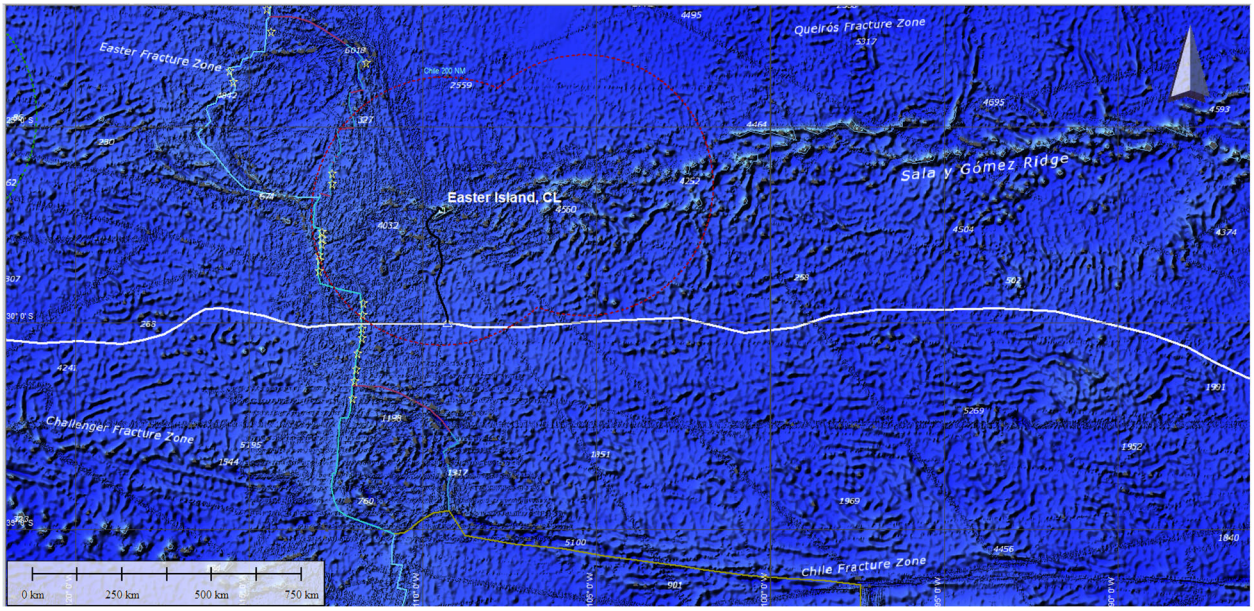


Figure 43: Easter Island BU Route Traversal

From the East Pacific Rise the route continues West towards Auckland navigating around the Austral Seamounts and between the Challenger Fracture Zone and Resolution Fracture Zone while keeping out and South of the French Polynesia (France) EEZ.

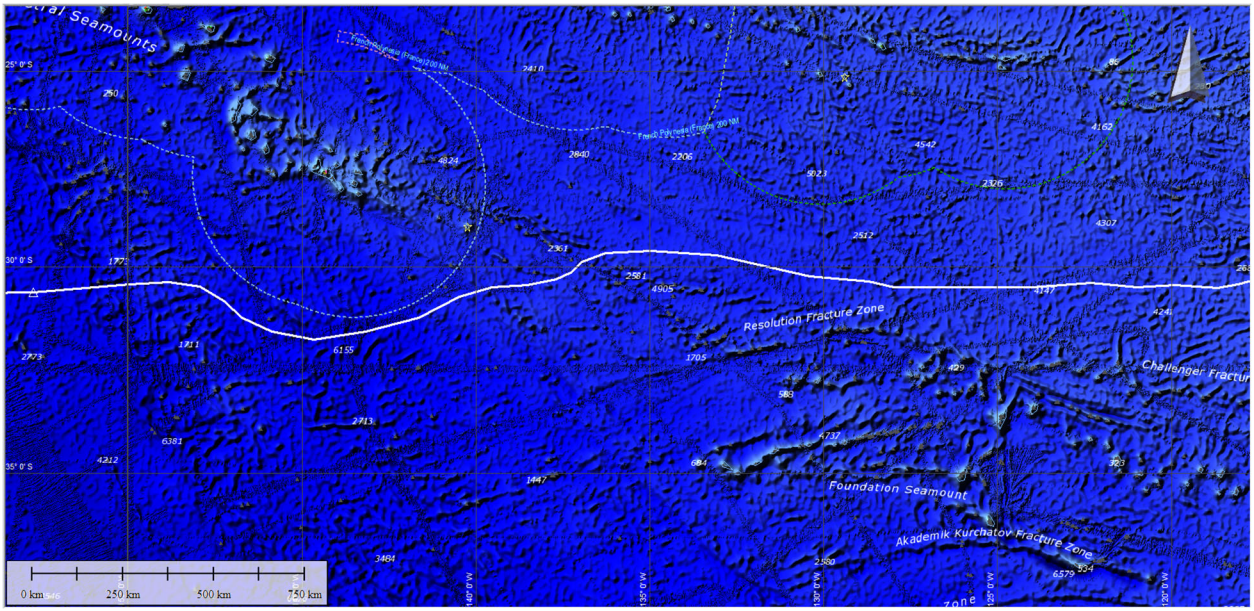


Figure 44: Future BU From EI

Before continuing towards Auckland, a Future BU located at 30° 37.12961' S, 152° 43.84573' W in approximately 5300 meters water depth was placed for the provision of connecting to other islands to the North of the trunk.

The route continues from the Future BU West crossing the Louisville Ridge at 34° 23.17952' S, 171° 20.99691' W and eventually the New Zealand EEZ at 36° 32.96437' S, 177° 29.77971' W.

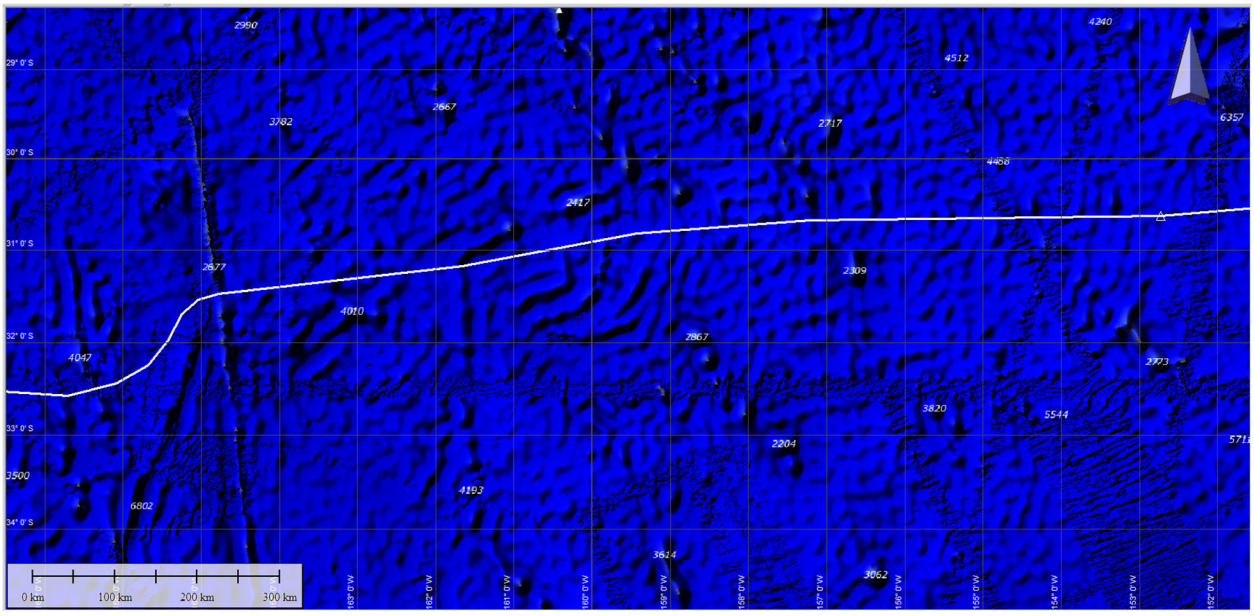


Figure 45: Future BU towards Kermadec Trench

At this point, the route deviates south-west to approach and traverse the Kermadec Trench, which is the boundary for the Pacific Plate and Australian Plate, located at 36° 39.54645' S, 179° 28.81738' W in approximately 5000 meters water depth.

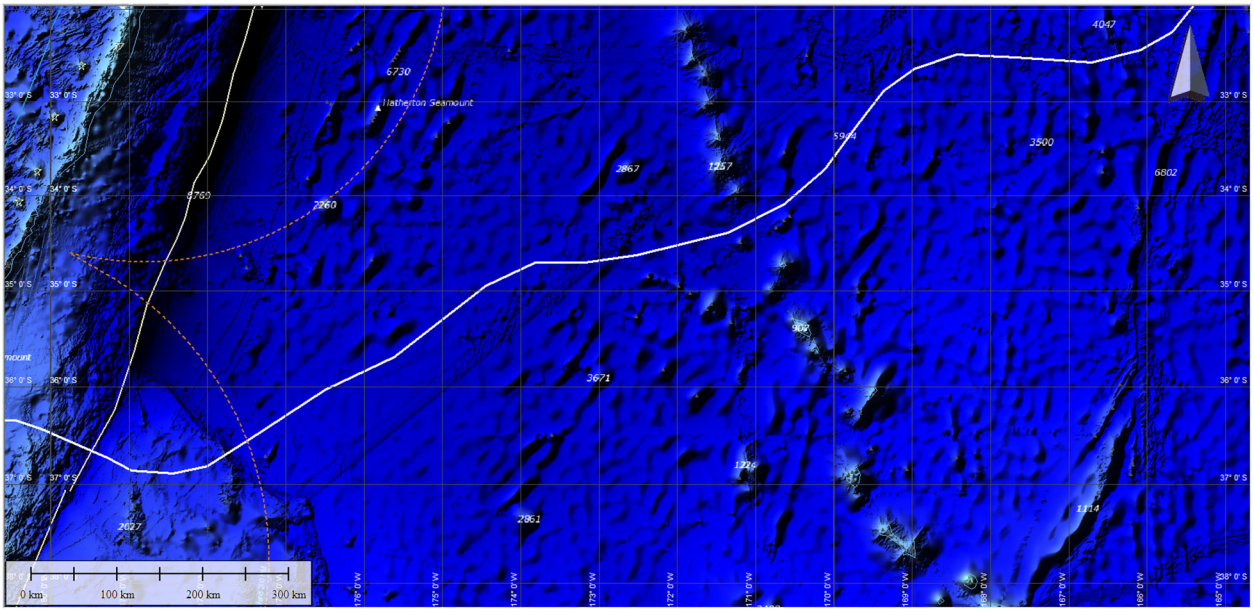


Figure 46: Kermadec Trench Crossing

The route crosses the Kermadec Trench and continues up the continental shelf, crossing the Raukumara Plain south of the Rumble III and Lillie seamounts, and north of Rumble V seamount until reaching the Auckland BU at 34° 36.191' S, 175° 01.496' E in approximately 1850 meters water depth.

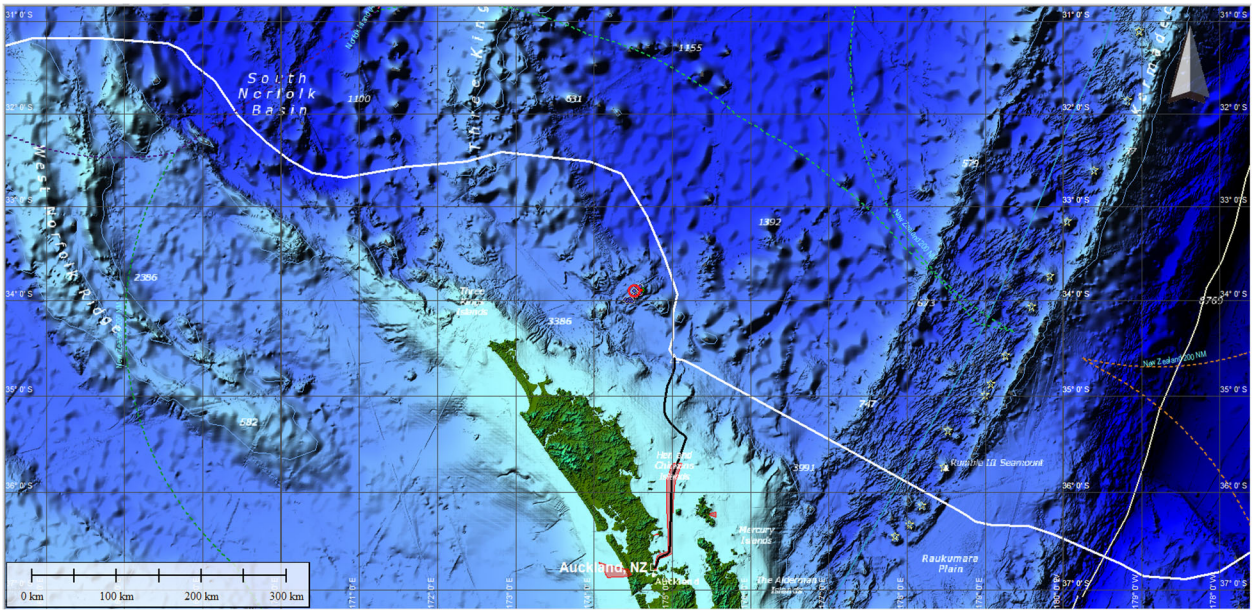


Figure 47: Auckland Route Traversal

The traversal of the route from the Auckland BU to Sydney is complicated by numerous basins and rises that must be crossed. The route leaves the Auckland BU due north, keeping east of the Pururua Seamount, and heads into South Fiji Basin. From there, the route turns west again into South Norfolk Basin and then swings north of Wanganella Bank, crossing into the Australian EEZ at 31° 58.80985' S, 169° 24.93457' E.

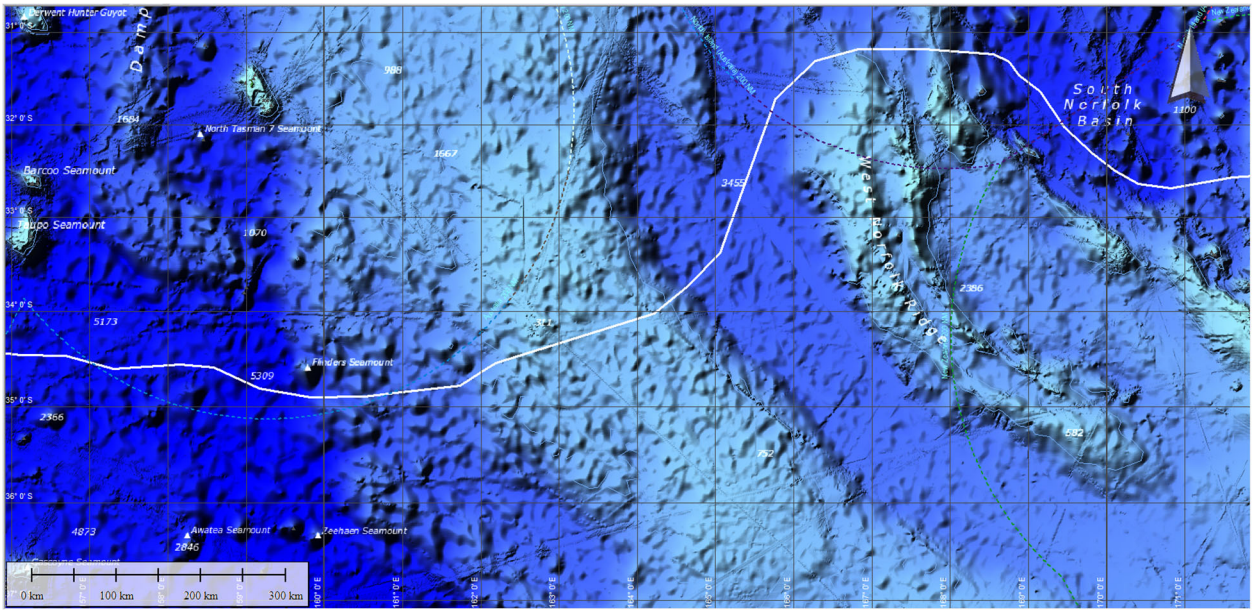


Figure 48: Lord Howe Rise Route Traversal

The route heads south between Wanganella Bank and Lord Howe Rise, crossing back into the New Zealand EEZ at 31° 51.16888' S, 165° 42.67808' E before turning West again to traverse Lord Howe Rise.

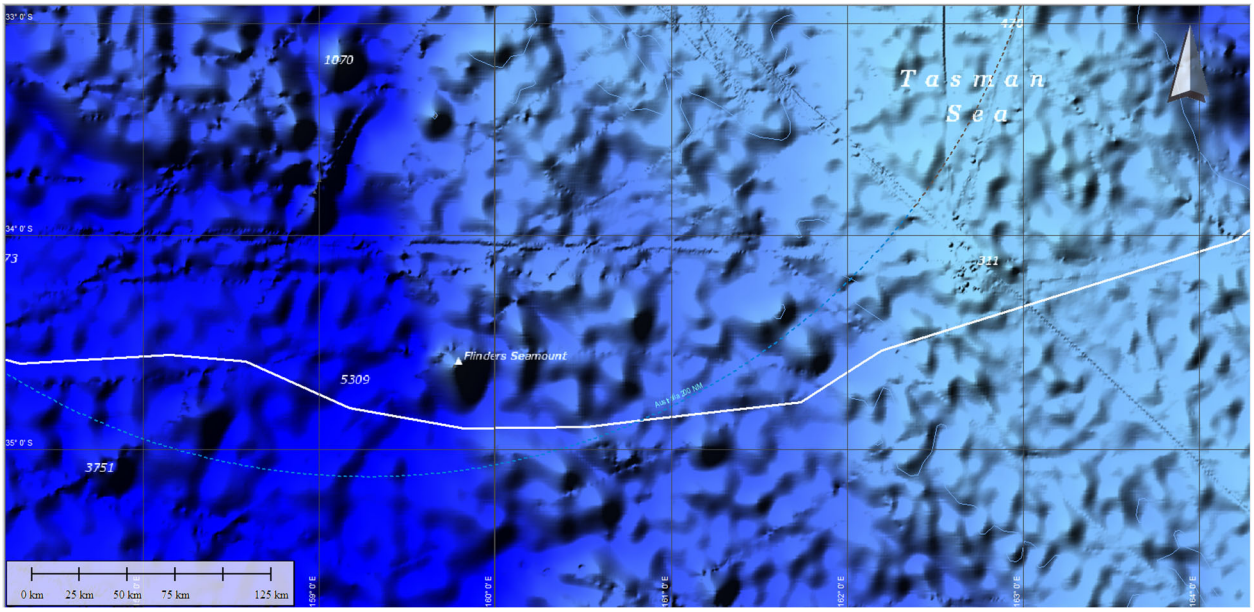


Figure 49: Lord Howe Rise Downslope

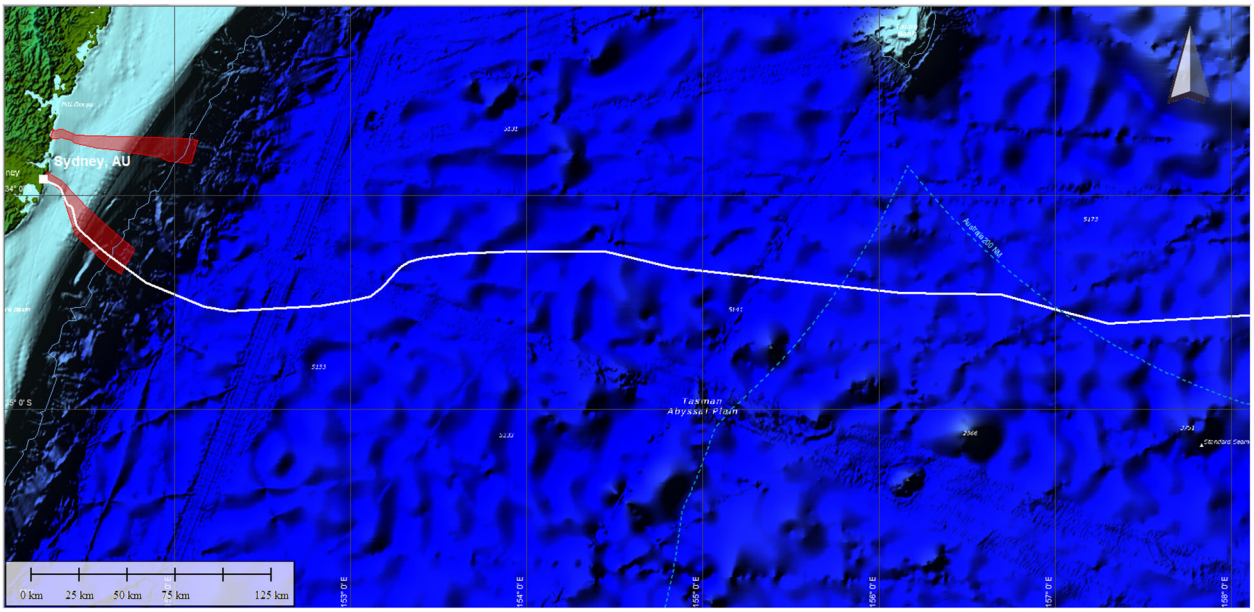


Figure 50: Lord Howe Rise to Sydney

After crossing Lord Howe Rise, the route continues due west towards Sydney, just south of Flinders Seamount, across the Tasman Abyssal Plain of the Tasman Sea.

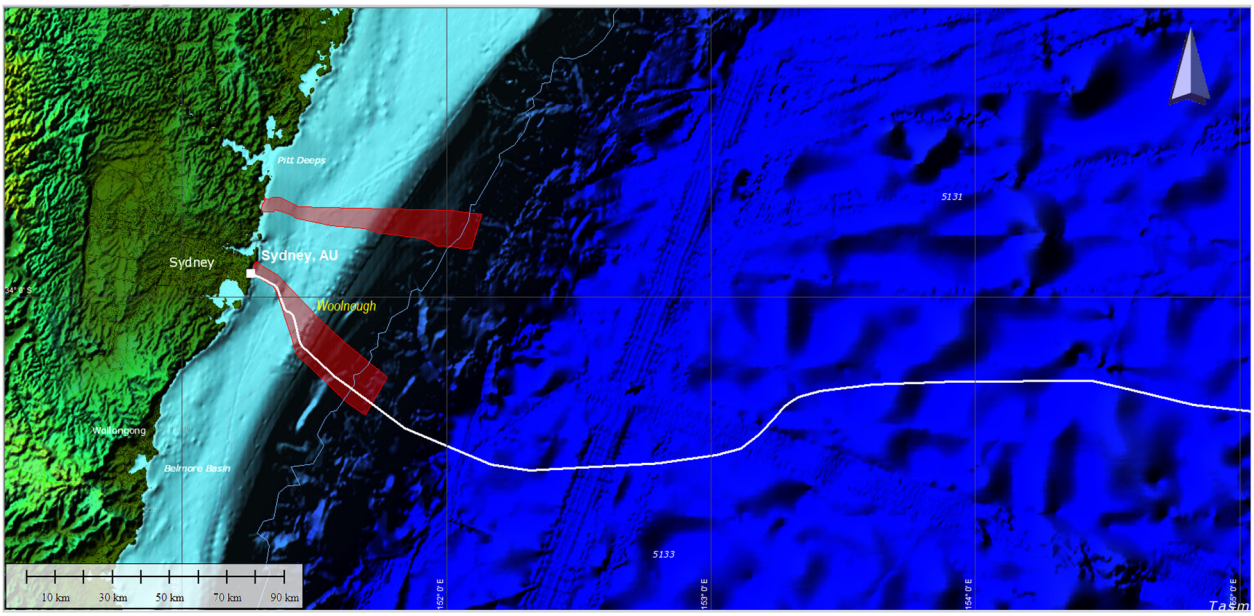


Figure 51: Sydney Route Traversal

The route continues up the Australian continental shelf, south of Woolnough Knoll, into the southern Sydney cable protection corridor, following the other cables into the landing at Sydney located at 33° 55.580' S, 151° 15.571' E.

4.3 Physiography and Geology

The entire System is contained within the Ring of Fire with most of the cable length in deep water with thick South Pacific Ocean sediments. There are notable areas of higher risk to the System, those being the: 1) Peru-Chile Trench, 2) East Pacific Rise, 3) Louisville Ridge, and 4) the South Pacific Ocean – Tasman Sea transition north of New Zealand.

4.4 Regional Geology and Physiography

The Peru-Chile Trench sees a high degree of movement as the Nazca Plate subducts the South American Plate, generating some of the 20th century's largest earthquakes and resulting tsunamis. There is a large amount of sedimentation at the base of the trench with significant canyon fill up-slope, which can lead to mass sediment movement events.

The East Pacific Rise is a mid-ocean ridge and the crust moves away from the center of the ridge on either side. Along the ridge are seamounts, knolls and hydrothermal vents, all of which have newer rock formations, steeper slopes and less sediment to act as natural protection to the cable.

The Louisville Ridge or Louisville Seamount Chain consists of more than 70 seamounts, between which the DGASA System must traverse.

The transition from the South Pacific Ocean deep ocean basin to cross north of New Zealand and back to the deep waters of the Tasman Sea means crossing troughs, plateaus, rises and ridges, all of which are located in a highly active tectonic setting.

4.5 Potential Geohazards and Recommendations to Minimize Risk

There are several geohazards along the System route that will require careful avoidance once the cable route survey results are compiled. The transition of the cable up and down the Peru-Chile Trench will require careful placement and slack management to account for slopes and sediment movement. Traversal over the plate boundaries between the Nazca, Pacific and Australian plates as well as the troughs, basins and plateaus north of New Zealand have cable armoring, slack and slope placement considerations that need to be accounted for prior to survey to find a suitable route. Identification of potential hot spots near known locations of that sort, like the East Pacific Rise, using deep-water towed or autonomous bathymetric and geophysical survey assets would help mitigate identification and placement mitigation CRE techniques.

4.6 Route Seafloor Conditions, Sediment Types and Burial Conditions

Most of the route is in deep water with hundreds of meters of sediment suitable to submarine cable. The landings at Valparaiso, Juan Fernández, Easter Island, Auckland, and Sydney will all have nearshore sediment cover challenges to some degree. Auckland and Sydney may or may not require full burial, depending on the risk profile to be assumed since those landings have their own submarine cable protection zones and well-established cable awareness initiatives. The remote nature of Juan Fernández and Easter Island and the newness of their islands, relative to geological history, means sediment cover will be limited. Offshore Valparaiso, there is enough alluvial sediment transport to both fill the Peru-Chile Trench submarine canyons and its base but nearshore coastal processes, storm events and resulting currents may produce areas of seabed with sparse or no sediment cover.

4.7 Physical Environment

The physical environment for the System is generally homogeneous considering it spans between South America and Australia. The reason being it is generally situated along a common latitude, 30 degrees South. That said, there are specific meteorological and oceanographic situations. There are strong nearshore and offshore winds, waves, and currents that effect Valparaiso and Juan Fernández, mostly in the winter months. Auckland and Sydney experience a similar effect, but much less pronounced.

4.8 Fisheries

Commercial, artisanal, and recreational fishing is active and performed year-round. The cable route is proposed to be surface laid deeper than 1500 meters offshore all landings and thus could be impacted by commercial fishing activities. Chilean, New Zealand, Australian and foreign commercial fishing vessels tend to fish the 500 meter to 1000 meter depth regime; however, this is not always true. If, upon further research with direct contact with relevant government officials, the commercial fishing industry regulations and associated permitting do not allow for strict avoidance of cable areas or particular depth regimes, then 100% cable burial to the limits of allowable or known-to-be-used fishing equipment might be advantageous.

4.9 Marine Activities

The presence of large vessels, such as cruise ships and commercial fishing boats, pose an inherent risk due to accidental grounding, inadvertent anchorage, or fishing activity. There are also scientific and military activities, albeit infrequent, using large vessels capable of damaging a submarine cable. A cable awareness public information campaign should be designed as part of the overall maintenance strategy and implemented prior to marine survey activities.

4.10 Hazards and Obstructions

Hazards to navigation will be encountered in the cable route's vicinity and typically come in the form of geological hazards, wrecks, and other man-made debris. Current nautical charts do not generally have the resolution or are not up to date enough to determine the extent of these hazards along most of the route. Therefore, a cable route survey with seabed classification capabilities should be performed for the cable route corridor in water depths less than 1500 meters.

The largest impact to the cable system would be from encountering uncharted subsea obstructions, wrecks and debris causing the route to be diverted by some unknown number of kilometers. While a cost and schedule risk, this tends to be manageable using industry standard route deviation procedures.

4.11 Cable Route Engineering

CRE is defined as the process to ensure the physical security of the subsea cable system from natural and man-made hazards through route selection, slack allocation, cable type (including armor) choice, and the use of industry-standard cable burial and protection practices. Further, it includes the use of trawl-resistant design practices for all seafloor systems installed in waters that may reasonably be expected to be fished over the lifetime of the Subsea Cable System. In addition, CRE considers the viability of areas identified for the placement of seabed plant components such as nodes, repeaters, and BUs.

CRE will be the responsibility of the chosen supplier of the subsea cable system. However, it is recognized that, the final CRE plan will be subject to the permits obtained from State/Provincial and Federal agencies.

As part of the study, a preliminary level of CRE has been accomplished; however, this has been necessarily limited to the data available. It will be the responsibility of the chosen supplier of the Subsea System to conduct a detailed marine survey of the route and independently research available data to verify or modify the information contained in this Study.

4.12 Marine Maintenance

Please refer to Section 6 of this report for the full details regarding marine maintenance.

4.13 Risks Summary

There are logistical and schedule risks associated with potential adverse weather conditions across the entire System. These risks can be reasonably mitigated by scheduling seagoing operations between November and February and maintaining forecasts and nowcasts during the months leading up to operations.

There are other risks associated with the seabed topography/roughness, seismic events, currents, hydrothermal vents, subsea volcanoes, seamounts and knolls, tectonic plate boundaries and other geophysical and oceanographic processes that will be encountered between Chile and Australia. These types of risks are well known to the submarine cable industry with successful mitigation techniques. The cable route survey will identify and categorize these and other risks to the cable as it lies on the seabed.

4.14 Recommendations

There are several submarine cable crossings offshore Auckland and Sydney; however, this study could only identify the existence of a crossing, not the ownership or name of each crossing. There are other OOS cables that are generally known about but not charted or identified during this study. Offshore Valparaiso, it is expected there to be crossings, but none were specifically identified due to the lack of charted

submarine cables on the nautical charts. Coordination with current and previous cable owners and access to their RPLs would help identify the presence of IS and OOS cables.

Planning the cable route survey should include sub-bottom and magnetometer to help identify cable crossings and seabed suitable for plough burial down to 1500 meters water depth.

If possible, deep water towed or AUV assets should be brought to bear to image high-risk plate boundary crossings and complex continental slope transitions.

A dedicated website should be designed to convey the location of the System from the planning phase through decommissioning.

Local, national, and international nautical charting authorities should be provided the as-laid RPL immediately after RFS for inclusion on relevant nautical charts.

Local and national fishing organizations should be approached as part of the overall permitting process, from planning to RFS. Plan on providing GPS unit compatible RPL position downloads and instructions.

The science community will be extremely interested in the survey results encountered. Providing a version of the CRS data after RFS to an international data clearinghouse has proven to be effective capital during the permitting process.

5. Permitting & Regulations Plan

5.1 Overview

5.1.1 General

The following section generally and then specifically describes the possible permits and regulatory requirements, as well as assesses the risk and environmental concerns and processes for the installation of the DGASA system. As in the case with virtually all submarine cable projects, the permitting process is likely to be in the critical path for the DGASA system and thus, fundamental to its timely and successful implementation. The importance of permitting cannot be overstated. Sufficient time must be allowed to take into account the complexity of the permitting procedures.

5.1.2 Permitting Overview

TMG/WFNS gathered and assembled applicable data of the DGASA system in order to provide a high-level review of the possible permitting process and requirements for the DGASA cable system as presented in this section, as well as a permitting matrix attached to this report as Appendix C. Review of the information provided shows an understanding of the process and requirements for permits and applications. A summary review of the overall permitting process is below, which is meant as a summary/overview table and should not be considered complete. The requirements are based off of pre-chosen landing locations that may be subject to change

5.2 Permitting Requirements by Country

5.2.1 Chile

The following is an assessment of the possible permitting and approval processes needed to install a submarine cable system in 3 locations governed by Chile, which are Valparaíso, Juan Fernández and Easter Island. The Chilean government is a representative democratic republic whereby the President is both head of state and head of government. Though a concrete permitting framework for submarine cable installation is lacking, the main governing bodies that oversee the process are the Ministerio de Transportes y Telecomunicaciones (Ministry of Transport and Telecommunications) and the Ministerio del Medio Ambiente (Ministry of Environment). Consultation with these sectors is imperative to proceed with the permitting process.

Both Easter Island and Juan Fernández are governed by the Valparaíso regional government, which represents the President of Chile in the implementation of public policies according to their government program.

5.2.1.1 Requirements

5.2.1.1.1 Intermediate Telecommunications Service License

Subsecretaría de Telecomunicaciones (Undersecretary of Telecommunications [SUBTEL]), under the organizational structure of the Ministry of Transport and Telecommunications, requires an intermediate Service License for the installation of a submarine cable in Chilean waters. SUBTEL's main functions are to propose national policies on telecommunications matters, in accordance with Government guidelines, exercise direction and control of their implementation, supervise public and private companies in the sector in the country, controlling compliance with the relevant laws, regulations and standards. To obtain

the license direct consultation with these departments is required. The consultation outcome will include the documentation required. The application processing time is anticipated to be between 6-8 months.

5.2.1.1.2 Environmental Qualification Resolution (RCA)

An Environmental Qualification Resolution (RCA) is the Chilean Environmental Permit required for projects and activities for which the law presumes will have an environmental effect (Article 10, Environmental Law 19,300 and Article 3, New Statute for the SEIA [Environmental Impact Assessment System] Executive, Decree No. 40/2012). This is assessed by the corresponding environmental authority. If the activity or project is approved, the RCA will not only contain the environmental permit for the activity itself, but also the environmental permit for all the specific parts and activities that project has by its corresponding RCA.

However, concerning some of the parts or activities involved, a specific sectoral permit will be required, but only for technical purposes, allowing the corresponding sector-specific authority to verify that the analyzed work will comply with the requirements approved by the RCA.

This is called the single window system, as the owner obtains all the environmental approvals a particular project needs in one single document (that is, the RCA).

Under the new statute for the Environmental Impact Assessment System (SEIA), there are two kinds of sectoral permit:

- Permits with only environmental content. The favorable RCA authorizes all sectoral authorities to grant these permits if the requirements and conditions of that RCA are met.
- Permits with both environmental and non-environmental content. The favorable RCA will verify compliance with the environmental requirements. The sectoral authorities will grant the permit if the non-environmental requirements are met, without imposing any additional requirements or conditions not considered within the RCA

Environmental law provides that if a project is subject to the SEIA it will require either an Environmental Impact Declaration (DIA) or an Environmental Impact Study (EIA), depending on the nature of the project.

The DIA is a sworn statement that must include the project, or activity description, an indication of legal framework applicable to the project and an indication of permits that will be required. These permits will be outlined in a discussion with the ministry. The EIA involves a more complex and detailed procedure for a project that falls under Article 11 of the Environmental law.

This is the first permit that should be applied for and requires lengthy consultation with the appropriate government departments. The processing time is dependent on the type of assessment required and is anticipated to be between 2-6 months with the possibility of extension.

5.2.1.2 Risk Mitigation

At this time Chile is considered medium to high risk due to the political issues at hand due to the high level of inequality. The environmental permit has the potential to be lengthy and time consuming. Local agencies will also need to be hired in order to consult on the appropriate permits and approvals required. The lack of an established permitting process also increases risk as it is not as easy to obtain information.

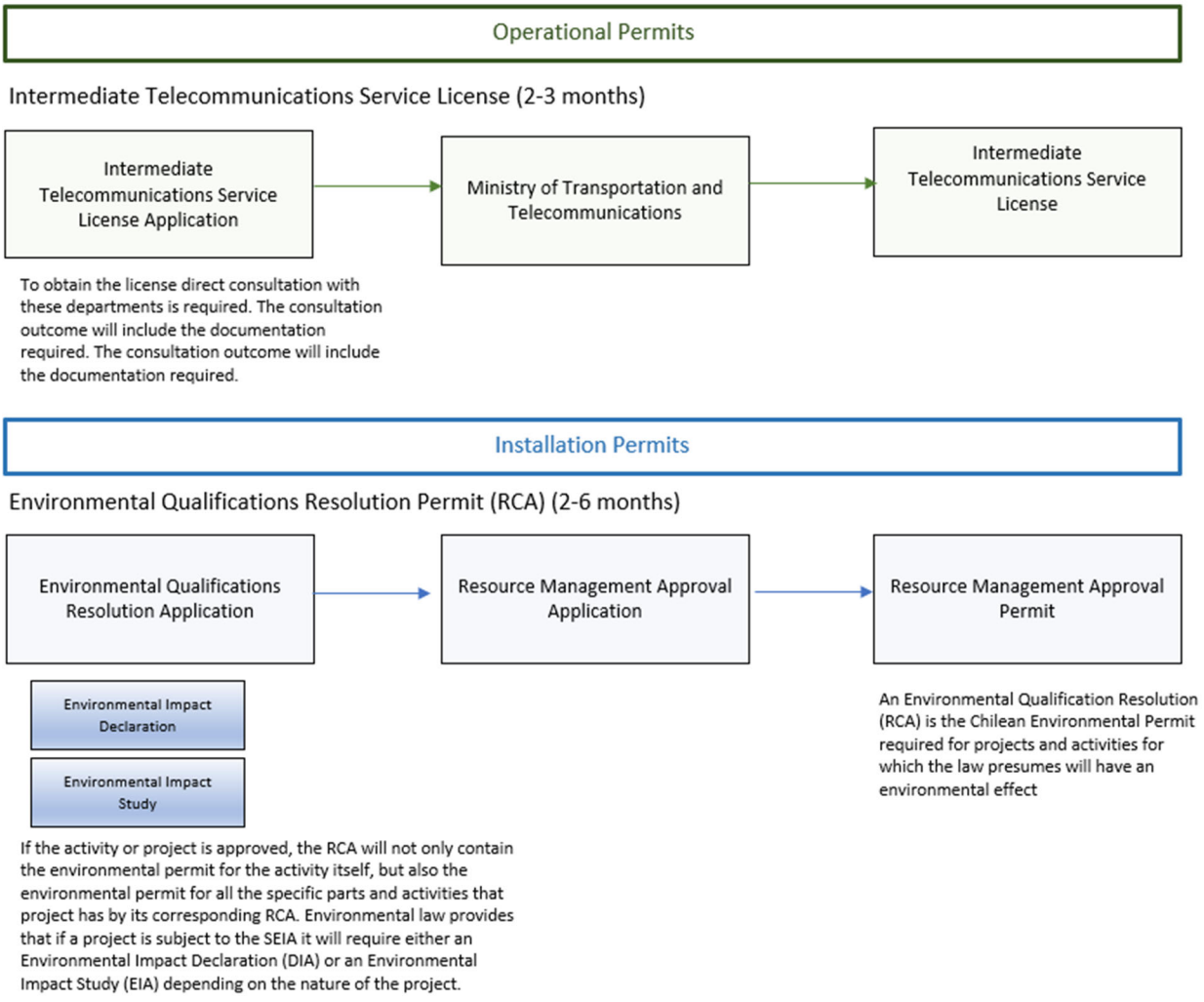


Figure 52: Permitting Flow - Chile

5.2.2 New Zealand

The city of Auckland is located on New Zealand's North Island and is the most populous urban area in the country. New Zealand has a parliamentary form of government based on the British model. Legislative power is vested in the single-chamber House of Representatives (Parliament). Local government bodies consist of elected councils at the regional and city levels together with specialist and Community boards. Those entities have limited powers conferred by statute. The responsibilities of the city councils, in this case Auckland Council, include the provision of community services and local infrastructure and the management of resources and the local environment. Regional councils accomplish larger environmental and infrastructure functions requiring coordination. The Permitting process in Auckland is not a prescribed statutory process for the landing and installation of a subsea cable. There are a number of statutes and local bylaws that will need to be adhered to gain full permitting for New Zealand in addition to possible Māori approval.

The indigenous people of mainland New Zealand are the Māori. Most Māori affiliate with one or more *iwi* (tribe), based on genealogical decent. *Iwi* are usually governed by a governing council or trust board called

a *Rūnanga,* which represents the *iwi* in consultations and negotiations with the New Zealand government. The following are possible permits and permissions needed to install a subsea cable in Auckland.

5.2.2.1 Requirements

5.2.2.1.1 Network Utility Operator License

The first important step in the permitting process is to obtain the New Zealand equivalent of a carrier license which is a network Utility Operator under the Telecommunications Act 2001. This provides special rights of access to land. It allows network operators to access the road reserve to lay or construct telecommunication or broadcasting lines. This process which applies to network operators installing lines along road reserves is much more certain than a process involving private negotiation. The right to lay cables with the road reserve may extend to the beach manhole and allow structure to be placed in the road. Additional land use permits may be required, this is dependent on the local councils.

The application process for obtaining a network utility operator license includes the completion of an information form which should include an explanation as to why operator status is necessary for the applicant, the company's certificate of incorporation, details of the company's history and detailed maps of telecommunications rollout plans. Once the required information is submitted a report from the Minister of Broadcasting, Communications and Digital Media is prepared and the Minister makes a decision. Processing timeframes are anticipated to be between 2-3 months.

5.2.2.1.2 Economic Exclusion Zone and Continental Shelf Act 2013 Approval

The Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (the EEZ Act) was developed to address gaps in the management of New Zealand's marine environment. The Resource Management Act (RMA) 1991 provides for integrated management of the effects of activities within New Zealand's territorial boundary (from the coastline to 12 nautical miles offshore), but, prior to the EEZ Act, only some activities in the exclusive economic zone ("EEZ") and continental shelf (CS) were regulated for their environmental effects. The EEZ Act sets up a management and decision-making framework for managing the effects of activities in the EEZ and CS.

The placement or removal of a submarine cable from the seabed of the EEZ is a permitted activity however, it is required that pre- and post-activity notifications be submitted to the Environmental Protection Authority.

The pre-activity notifications are to be submitted no later than 40 days before the permitted activity commences. The Environmental Protection Authority (EPA) will provide a list of *iwi* to contact within 10 days of notice. The relevant *iwi* should be contacted no later than 25 days prior to activity and proof of contact must be submitted to the EPA no less than 5 days before permitted activity. Both pre-activity submissions should include the details of the person and ship performing permitted activity in addition to a general description of the activity including dates and locations. It may be suggested that an initial Environmental assessment and sensitive environment contingency plan be filed to provide information on any sensitive environments that may be impacted.

Within 60 days of completion of the permitted activity a post-activity notification must be submitted. This should include a general description of activity, details of the environment, an ecological footprint evaluation (which may include an estimation of the volume of material that was removed, and the volume of seabed disturbed) and details of the measures taken to avoid, mitigate, or remedy adverse effects on sensitive environments.

The Applications will be filed and presented at a hearing. A decision and possible mitigation measures will be formulated.

5.2.2.1.3 Marine Dumping Consent

The dumping of waste in the marine environment is an activity that is regulated by the EPA. The EEZ Act controls the waste that can be disposed of or abandoned in the EEZ or on the CS. If any intentional dumping of waste or other materials, including vessels, dredged material or structures, is anticipated a marine dumping consent is required.

The EEZ Act has provided a framework for environmental management in New Zealand's EEZ and CS since 28 June 2013. Its purpose is to promote sustainable management of the natural resources and to protect the environment from pollution in this area. This purpose also aligns the EEZ Act with the 1996 London Protocol (the Protocol), which is an international agreement on how waste may be dumped in the marine environment.

The EPA strongly recommends a pre-lodgment meeting with the EPA before submitting the application to aide in understanding the marine consent process relevant to the operation. Once the pre-lodgment meeting is complete the application can be completed along with the submission of the impact assessment.

An impact statement must accompany the application. It must describe the area, type of environment and type of waste to be dumped, as well as the effects on the human health of the activity, alternative methods of disposal and practical opportunities to reuse, recycle and treat the waste.

Once application is lodged it is considered and may be returned to the applicant with suggested changes. If it is accepted the applicant will be notified. Other government departments or external advisors may be consulted to reach the decision. When accepted a hearing will proceed, this may be public or private depending on the circumstance. If private (non-notified) it is anticipated that the process will take approximately 60 days. If public (notified) the process can take up to 140 days. After the hearing, the applicant is notified of the decision and at that time appeals can be lodged if necessary.

5.2.2.1.4 Marine Discharge Consent

The EEZ Act regulates the discharge of harmful substances into the EEZ and continental shelf from structures, submarine pipelines and ships. Any discharges of harmful substances needs to comply with the Discharge and Dumping Regulations 2015 and may require a marine discharge consent. This is a non-notified process but does require sufficient information about the properties of the hazardous substance for the EPA to assess the environmental impact. Prior to discharging or submitting a consent, contact with the EEZ application team to discuss activities is suggested. When lodging a marine discharge consent application with the EPA, the prescribed form must be filled out, fully describe the proposal and provide an impact assessment.

5.2.2.1.5 Emergency Spill Response Plan Approval

An Emergency Spill Response Plan (ESRP) is the document, or set of documents, that contains the emergency spill response procedures for hazardous substances kept on board an offshore installation and a list of all hazardous substances kept on board an offshore installation, excluding substances classified as oil. An ESRP may be approved by the EPA for a period of up to three years and is used for risk identification, prevention and response to a spill of a hazardous substance(s) while undertaking an offshore operation. This will require a project description and related marine consents and the full description of ESRP.

5.2.2.1.6 Protection Zone Approval

The Ministry of Transport is responsible for administering the Submarine Cables and Pipelines Protection Act 1996 which, provides for protection of submarine cables generally and by virtue of a Cable Protection Area (CPA). The Submarine Cables and Pipelines Protection Act 1996 sets out a process for creating and amending CPA's as well as establishing offenses and penalties. A CPA is created by an order in council which the Governor-general makes on recommendation of the Minister of Transport. Currently there is an existing CPA landing at Takapuna Beach which coincides with the proposed landing location of the DGASA system. Using the current CPA may lead to a less vigorous application process. The Auckland Regional Coastal Plan suggests that new cables should, whenever practicable, be located within existing cable protection zones. The Minister will likely want to reduce public impact.

If the existing CPA is selected for use certain permissions will be needed and the order will need to be amended in order to allow ships to anchor in the area to lay and maintain the new cable system. The actions required to amend a current Cable Protection Order (CPO) are as follows:

- Apply to the Ministry of Transport to amend the current CPO and to lay cable within current CPA
- Confirm that the cable can co-locate within that CPA
- Consult with the Ministry of Transport on proposed application to determine preliminary view and any particular information it would require
- Apply to amend CPO
- Engage with Ministry of Transport during required consultation and submission process with affected parties

If alternative locations are selected a new CPA will be required. This process is much more rigorous, costly and time consuming than the amendment process. The amendment process is estimated to take approximately 12 months in contrast to applying for a new CPA, estimated to take approximately 12 to 24 months.

5.2.2.1.7 Craft Risk Management Plan

The ship may already comply with the standards however, it is important to understand what is required. Craft Risk Management Plans (CRMP) are biosecurity regulations for all craft coming into New Zealand. Craft Risk Management Standards (CRMS) are implemented to manage the biosecurity risks associated with craft such as vessel biofouling. The operator can submit a CRMP for a vessel or fleet of vessels to the Ministry for Primary Industries (MPI) for consideration. Given their unique operational profiles, MPI expects cruise vessels, some fishing vessels and project vessels would be the main type of craft which would require a CRMP. The MPI has developed two standards that aim to manage and/or reduce the presence of biosecurity risks before craft (vessels) arrive in New Zealand Territory (NZT). These are CRMS for Biofouling and CRMP for vessels. Compliance with the CRMSs can be achieved using the following measures:

1. CRMS for Biofouling
    - Ensuring the hull is clean by:
        - Cleaning the hull within a 30-day period prior to arriving in NZT and providing MPI with documentation confirming that cleaning has occurred

- Conducting continual hull maintenance using best practice actions, such as those outlined in the International Maritime Organization biofouling guidelines and providing MPI with documentation that management has occurred
- Conducting an MPI-approved hull and niche area treatment within 24 hours of arriving in NZT and providing MPI with documentation of the scheduled treatment.

2. CRMS for Vessels

- Ensuring that the vessel is as free as possible of pests and potential pest habitats like food waste, soil and standing water.
- Obtaining a Certificate of Freedom for Asian Gypsy Moth if the vessel has been to China, Japan, Korea or the Russian Far East during their spring and summer months.
- Securing all waste on-board the vessel.

Preparing the CRMP proposal is the most important part of the application as it details the specific management actions the vessel has been subjected to in order to manage the risks to an acceptable level. The proposal should outline specific management actions and the timeframes under which each will be performed. The proposal should also indicate what types of records will be retained by the vessel to prove that it has followed the approved CRMP. The processing time for an application is approximately 40 days.

All applications will incur a time-calculated charge of eight hours of work as a deposit for application processing. This will include biosecurity assessment, advice, or the continuation of work previously requested. If the application is complicated and cannot be processed within the eight hours, MPI will contact the applicant to discuss whether they would like MPI to continue processing the application. MPI's application processing deposit will not be refunded should the applicant choose to withdraw the application or should the applicant not be successful. MPI is unable to give an estimate or quote for the final charge of any application due to the variability of time needed to assess each application. Where necessary, MPI will charge per 15-minute increments over and above the initial 8 hours. The Hourly charge is estimated to be $117.61 (including GST).

5.2.2.1.8 Environmental Impact Assessment

Permission is required to interact with wildlife or use public conservation land. The current landing location is not located on public conservation land therefore it is not anticipated that a Department of Conservation (DOC) permit be required or an Environmental Impact Assessment (EIA). In the event that the landing locations are changed to public conservation land and the removal of flora/fauna is necessary an EIA needs to be filed with the DOC. This is an integral part of determining what permit or permissions will be granted. A pre-application meeting with the DOC is strongly suggested to scope out the environmental effects that will need to be considered, this will ensure extra time and money will be reduced. The following are the steps suggested to complete an EIA:

- Describe the environment: The applicant will need to consider the natural, historic, recreational and cultural values of the site and surrounding areas. In order to complete an assessment of the spiritual and cultural values the native people (Tangata Whenua) may need to be contacted. During the pre-application meeting the DOC will provide a list of contacts if necessary.
- Scope the potential effects of the activity: When the concession staff is met in the pre-application meeting both should consider the total environment. All the potential impacts and what adverse effects are likely to be more significant should be noted. These may require more detailed consideration in the application. For very high impact activities this step may involve considerable

work and a field visit. Undertaking this step properly will save time and expense later in the process.

- Identify the effect of the activity: The applicant must determine the direct, indirect and cumulative effects where at all possible. The positive, beneficial or adverse effects should also be mentioned. This should be based on the environmental description the applicant has completed.
- Describe measures to avoid, remedy, or mitigate: List the measures that will be undertaken to ensure that every adverse effect identified will be minimized as far as possible. All adverse effects should if possible be avoided first, then remedied and finally mitigated.
- Identify alternative designs: Alternative designs, locations or timing of activities are fundamental impact mitigation measures and should be considered at the very outset. Alternative locations are a mandatory consideration for applications that require a lease, such as buildings.
- Outline monitoring program: Monitoring simply attempts to test the validity of the predictions made earlier in the EIA process after an operation has been allowed to proceed. Monitoring is a fundamental step that the applicant and the Department will use to determine whether obligations are being met to manage the balance between preservation and use.

Once EIA is submitted a decision will be made on additional information needed and what permits may be required to continue work. Personal consultation with the DOC will commence.

5.2.2.1.9 Resource Management Act Approval

The Resource Management Act of 1991 (RMA) is the primary piece of legislation that outlines how New Zealand should manage the environment. It manages air, soil, freshwater and coastal marine areas as well as regulates land use and the provision of infrastructure. Acquiring approvals and resource consents under the RMA is a complex process that requires the meeting of local and regional authorities, and in this instance, it will be directed to the Auckland council. Some resource consent applications must be decided by a board of inquiry or the Environmental court instead of the local council, specifically those of national significance. These consents may include but are not limited to building consents, land use, environmental and the well-being of those possibly effected by the system. The RMA approval is a 3-stage process beginning with application preparation.

It is imperative that a pre-application meeting with the regional council be conducted before submitting an application as this will reduce time and cost. The pre-application meeting requires a fee of $505. Any further consultation will result in an hourly rate between $111-$206.40. These fees are dependent on the level of consultation required. The pre-application meeting will determine if resource consents are necessary, how the activity is classified and what type of consent is needed. The applicant will also be informed of the required information to be provided, processing timeframe, cost and whether the application for resource consent is needed for both the regional and district/city council. If resource consent is required, the application can be completed with the appropriate information. In order for the Auckland council to obtain a decision on whether the project can commence the RMA approval application must be accompanied by an Assessment of Environmental Effects (AEE).

An AEE should be seen as part of the process of shaping the proposal rather than a task to do once the plans are prepared. It helps to identify the effects of the activity early on in the process and, if necessary, allows measures to be incorporated in order to reduce any adverse effects. It identifies who should be consulted and, if required, from whom a written approval should be obtained. It is used as the basis for the council's decision on whether to notify and grant an application and, if granted, whether to impose any conditions to address any outstanding effects (possible effects to be considered may be but are not

limited to, land, water, flora and fauna, people, infrastructure and traffic and parking). The following criteria should be considered when composing an AEE:

- Identify activity or activities for which consent is sought
- Conduct a site inspection: This will help to determine if there are any environmentally sensitive areas. It is suggested for a local inspector to conduct the inspection. The site surroundings should also be taken into consideration.
- Talk to the regional/and or district council
- Identify effects the project might have on area
- Rank and address the effects: A specialist may need to be consulted
- Re-evaluate the proposal
- Finalize the AEE (include obtaining affected parties' approval)
- Lodge the application

The final outcome of the AEE process is an accurate and objective statement about the effects of the proposal on the environment. This statement will have taken into account whether the proposal has avoided, mitigated or remedied any adverse effects on the environment and people. An AEE should be expected to take a minimum of 45-90 days.

Once the RMA approval application has been lodged along with the AEE the second stage of the process can begin. At this time, the council officer will review the application for completion. The application may be returned with the request for further information or it will be accepted, and outside party notification will be determined. The council may decide the application should be publicly notified (general public), limited notified (affected parties), or non-notified. If submissions are made against the application or the applicant wants to be heard a hearing will be held followed by possible mediation.

The third and final stage of the RMA approval process is the council's decision. It is important to note that if approval is rewarded there may be certain conditions attached. If applicant does not agree on conditions the option to object to council or appeal to the Environmental Count remains. Work can commence after the 15 working day appeal period.

5.2.2.1.10 Coastal Permit

One specific form of resource consent that is anticipated for the installation of a submarine cable system is a coastal permit (coastal consent). This is required for a wide range of activities including:

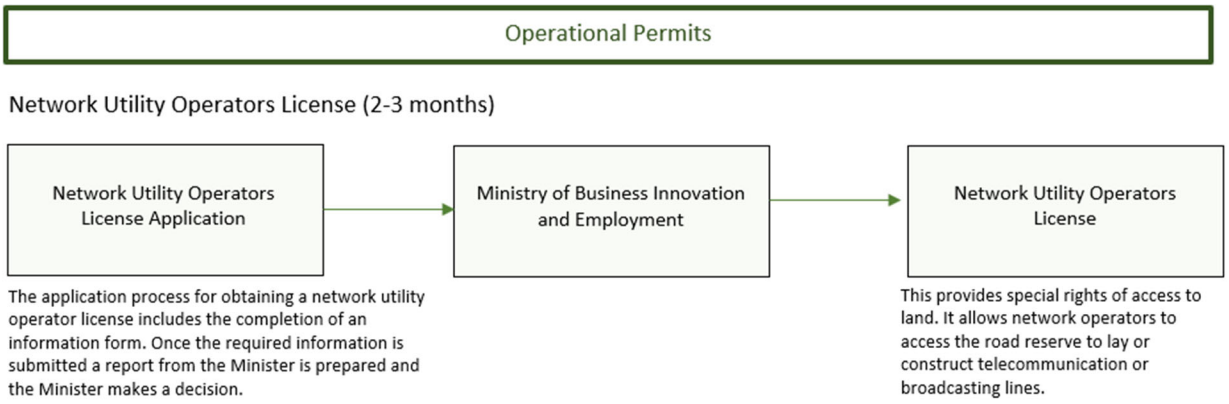
- To reclaim part of the foreshore or seabed
- To construct a structure in, on, under, or over any foreshore or seabed, e.g., to build a jetty, seawall or marina
- To disturb the foreshore or seabed, e.g., by excavation or dredging
- To deposit substances in, on, under, or over any foreshore or seabed
- To plant exotic or introduced plants in, on, under, or over the foreshore or seabed
- To occupy any part of the common marine and coastal area
- To remove sand, shingle, shell or other natural material

- To carry out activities in, on, under, or over any coastal marine area for which a resource consent is required, e.g., the removal of mangroves

When applying for a Coastal Permit it is highly suggested to consult a local agency to help with the application and the construction of an AEE. The coastal permit process follows the same structure as the RMA approval process (see above). It is worth noting that a deposit fee of $7000 may be required for coastal structures and activities. It is likely that this consent would have been discussed during the RMA pre-application so the pre-application fee should not be duplicated.

5.2.2.2 Risk Mitigation

With New Zealand's established submarine cable permitting structure it is anticipated that landing a subsea cable in Auckland will be low to medium risk. The location of the landing is in a pre-established cable protection zone, reducing the risk of establishing a new zone which can be time consuming and costly. Issues are not expected to obtain permissions with using this existing zone. The chosen location is not in an area of concern regarding historically and environmentally sensitive features however, an environmental approval may still be necessary. The complexity of the process will determine the time frames and costs. Consultation with local agencies is highly suggested to get the local community's compliance in regard to possible beach/park closures during the project.



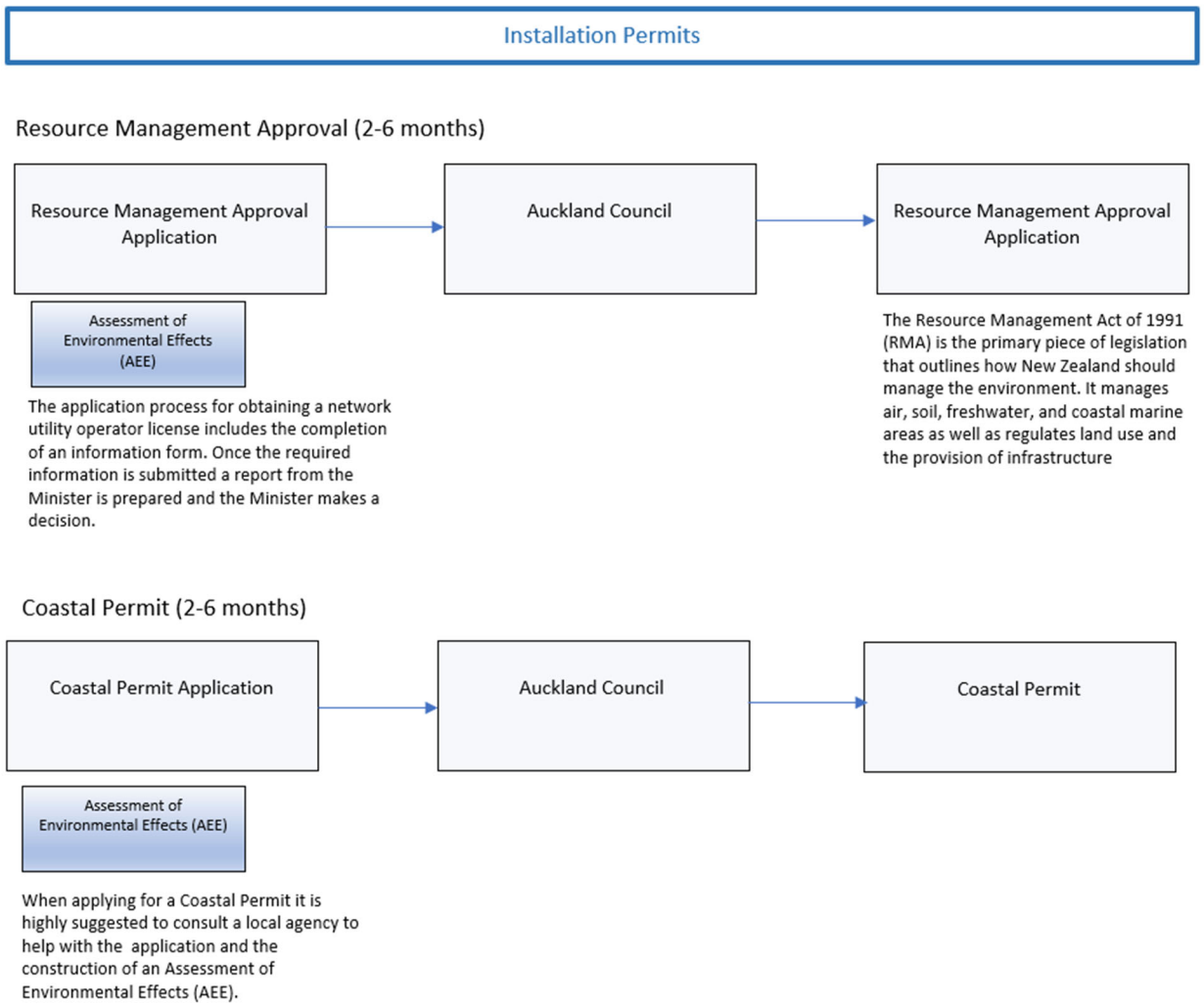


Figure 53: Permitting Flow - New Zealand

5.2.3 Australia

The following is an assessment of the possible permitting and approval process needed to install a submarine cable system in Sydney, Australia. Note that these are general requirements based on the proposed route. Australia is a federal parliamentary constitutional monarchy in which the government consists of 3 branches the Federal (The Commonwealth), state and local. Sydney can be found in New South Wales, one of Australia's six states, located in the southeast region of the continent. Sydney has no distinct local government for its whole urban area; therefore, major projects are the responsibility of the state and commonwealth.

5.2.3.1 Requirements

5.2.3.1.1 Permit to Install Submarine Cable in Australian Waters

The *Telecommunications Act* 1997 is the principal statute that lays out requirements for installation of submarine cables in Australia. Schedule 3A of this Act controls the requirement for carriers to obtain a permit to install a new submarine cable in Australian waters and enables the Australian Communications

and Media Authority (ACMA) to establish protection zones over nationally significant submarine cables. There are two types of Cable Installation Permits issued by the ACMA, Protection Zone (PZ) and Non-protection zone (Non-PZ). Protection zones are intended to stop or restrict activities that have the potential to damage submarine cables as well as to assist with the planning of cable locations.

The Non-protection zone permit is a permit to install one or more international submarine cables in Australian waters that are not in the protection zone and that are not coastal waters of a State or Northern Territory. It is important to note that applying for a non-protection zone permit is both more expensive and time consuming.

Carrier representatives are advised to contact the Networks Section of the ACMA by telephone to discuss a new cable proposal early in the planning phase of the project. This will enable ACMA staff to provide relevant advice about the permit process and check whether the proposed cable route conflicts with routes already permitted by the ACMA. If required, the ACMA will provide the contact details of other permitted cable proponents in the vicinity of a new cable proposal to enable liaison in relation to the cable route.

It is anticipated that a PZ permit will be required based on the suggested route which passes through the Southern Cable Protection Zone. To apply for the permit a fee of AU$4040 must be paid before the application submission. Information required for the application should have been discussed in the pre-lodgment meeting and includes but is not limited to:

- Installation information including desktop or hydrographic survey of the proposed route illustrating the exact location of the proposed cable installation
- Details of ownership and control of submarine cable installation
- Proposed dates
- Technical and economic aspects of installation
- Status of regulatory approvals from other commonwealth bodies that are required to install the cable
- Information about the proximity of proposed installation to other existing submarine cables.

Consultation with the attorney-general's department to ensure that matters of international law, native title and security are appropriately considered may be required when making final decision. Other persons considered relevant such as the Department of Environment, Department of Defense and state government bodies may also be consulted. The decision is generally made within 25-35 days.

5.2.3.1.2 Referral of Proposed Action and Environmental Approval

The *Environmental Protection of Biodiversity and Conservation Act 1999* (EPBC Act) is the main legislative instrument concerned with the environmental impact of cables governed by the Department of Agriculture, Water and the Environment. This approval may include an Environmental Impacts Statement under the Environmental Effects Act 1978. Any approvals, licenses, or permits that fall under the EPBC start with a referral of proposed action. The EPBC Act operates both concurrently and independently of the Telecommunications Act 1997.

The EPBC Act is Australia's national environmental law and it makes sure that nationally significant' animals, plants, habitats and heritage places are identified and any potential negative impacts on them are carefully considered before changes in land use or new developments are approved. This means that landowners, developers, companies, individuals and governments must seek Commonwealth approval in

addition to state and territory or local government approvals if the environment, where actions proposed are on, or will affect Commonwealth land, the environment where Commonwealth agencies are proposing to take an action and if their plans might significantly impact on matters of national significance. Matters of national significance are as follows:

- World Heritage properties
- National heritage places
- Wetlands of international importance (listed under the Ramsar Convention)
- Listed threatened species (except those listed as extinct or conservation dependent) and ecological communities (except those listed as vulnerable)
- Migratory species protected under international agreements
- Commonwealth marine environment
- Great Barrier Reef Marine Park
- Nuclear actions, including uranium mines

The Australian Government continuously updates this list and a common set of processes is used for all applications. It is best to contact the department as early as possible to understand the process and investigate ways that improved environmental outcomes can be built into the project from the start. The purpose of the referral process is to determine whether or not a proposed action will need formal assessment and approval under the EPBC Act. The referral will be the principal basis for the Minister's decision as to whether approval is necessary and, if so, the type of assessment that will be taken. This may include but is not limited to an Environmental Assessment (EA).

The proposed route does not appear to be in the path of an area of National Significance; however, it is suggested that a meeting be held with the Department to ensure no approvals are necessary. If it is decided that an approval is needed the appropriate information will be discussed at meeting and a fee of AU$6577 is required following submission of application.

The application must be filled out electronically. Following the receipt of a valid referral the minister has 20 business days to decide whether the proposed action will require assessment and appeal. Within the 20-day decision period ten days are allotted for public comment. This provides an opportunity for relevant State government ministers and members of the public to comment on the proposed action. The decision of the required assessment can be one of three:

- Controlled action: action is subject to assessment and appeal process under the EPBC
- Not controlled “particular manner” action: approval not required if action is taken in accordance with manner specified
- Not controlled action: approval not required

5.2.3.1.3 Environmental Assessment

Under the EPBC Act, EAs are undertaken to enable environment and heritage protection and biodiversity conservation. Before taking an action that could have a significant impact on a matter protected by the EPBC Act, the proposed action must be referred to the minister to determine whether the proposed action will need formal assessment and approval. Projects that are likely to have significant impacts are required to undergo an environmental assessment. The process of an EA starts with a scoping report in which the

Secretary's Environmental Assessment Requirements (SEARS) are outlined. This is then followed by an Environmental Impact statement (EIS).

An EIS is a publicly available document that provides information on a project, including its environmental impacts and mitigation measures and is used to inform development consent decisions. The structure of the EIS should include the project description, strategic context, engagement approaches and mitigation measures.

The project description of the EIS is very important. The aim of the project description is to provide a clear understanding of the scope of works for which approval is sought and the basis upon which the EIA has been undertaken. It also provides a clearer basis to understand whether project changes which happen following approval are within the terms of the approved project.

The strategic context should identify any relevant policies or plans which demonstrate the strategic planning context and need for the project. It should contain a description of how the project complies with the relevant policies and plans, including an overview of the importance of the project within the strategic planning context.

After the submission of the EIS public exhibition may take place followed by assessment and determination (approval/disapproval). Note that specialist consultation may be required in order to properly assess the impacts and mitigation measures. This will be discussed at the pre-consultation meeting, which is strongly suggested. These meetings can determine a more accurate timeframe.

5.2.3.1.4 Listed Species and Ecological Community Permit

The EPBC Act requires a permit for activities which may kill, injure, take, trade, keep or move a member of a listed threatened species or ecological community, a member of a listed migratory species, or a member of a listed marine species in or on a Commonwealth area.

Permits will only be issued by the Environment Minister if the activity:

- Contributes significantly to the conservation of the listed threatened species or ecological community, the listed migratory species, or the listed marine species concerned, or other listed migratory or marine species or
- The impact of the activity on a member of a listed threatened species or ecological community, a member of a listed migratory species, or a member of a listed marine species concerned is incidental to and not the purpose of, the taking of the activity and
- The taking of the activity will not adversely affect the survival or recovery in nature of the listed threatened species or ecological community or the conservation status or population of the listed migratory species or the listed marine species and
- The taking of the activity will not adversely affect the survival or recovery in nature of the listed threatened species or ecological community or the conservation status or population of the listed migratory species or the listed marine species and
- The taking of the activity is not inconsistent with a recovery plan that is in force for the listed threatened species or ecological community or a wildlife conservation plan that is in force for the listed migratory species or the listed marine species and
- The holder of the permit will take all reasonable steps to minimize the impact of the activity on the listed threatened species or ecological community, the listed migratory species, or the listed marine species or

- The specified activity is of particular significance to indigenous tradition and will not adversely affect the survival or recovery in nature of the conservation status of the listed threatened species or ecological community, the listed migratory species (including any population), or the listed marine species concerned or
- The specified activity is necessary in order to control pathogens and is conducted in a way that will, so far as is practicable, keep to a minimum any impact on the listed threatened species or ecological community, the listed migratory species, or the listed marine species concerned.

The Environment Minister may exempt a person proposing to take an activity from the requirement to obtain a permit provided the person applies in writing. When granting an exemption, the Environment Minister will need to be satisfied that it is in the national interest.

If you are a person who undertakes an activity that results in the unintentional death, injury, trading, taking, keeping or moving of a member of a listed threatened species (except a conservation dependent species), a member of a listed threatened ecological community, all cetacean (whale, dolphin or porpoise) species, a member of a listed migratory species, or a member of a listed marine species in or on a Commonwealth area and your activity was not authorized by a permit, then you must notify the Secretary of the Department within 7 days of becoming aware of the results of your activity. It is not anticipated that this particular permit will be necessary. Avoiding these particular species and protected areas is more cost effective and less time consuming.

5.2.3.1.5 Risk Mitigation

Australia is anticipated to be low to medium risk for submarine cable installation. The selected location is in a pre-established cable protection zone. Gaining access to an established protection zone is less time consuming and costly than implementing a new one, thus reducing risk. The environmental approval/permitting process may be lengthy however, even though the selected landing site is not in an area of high environmental concern. The Southeast region of Australia contains some of Australia's most productive fisheries and one of the fastest growing aquaculture industries in the country. The Commonwealth (Australian Management and Fisheries Authority) and State agencies manage fishing industries. A meeting may be required with the state authorities and appropriate stakeholders to ensure interference is at a minimum or that compensation is made for any disturbance. It is estimated that the process may take approximately one year. The cost is unknown at this time however, an additional fee of $25,000 dollars may be required for third party environmental consultation.

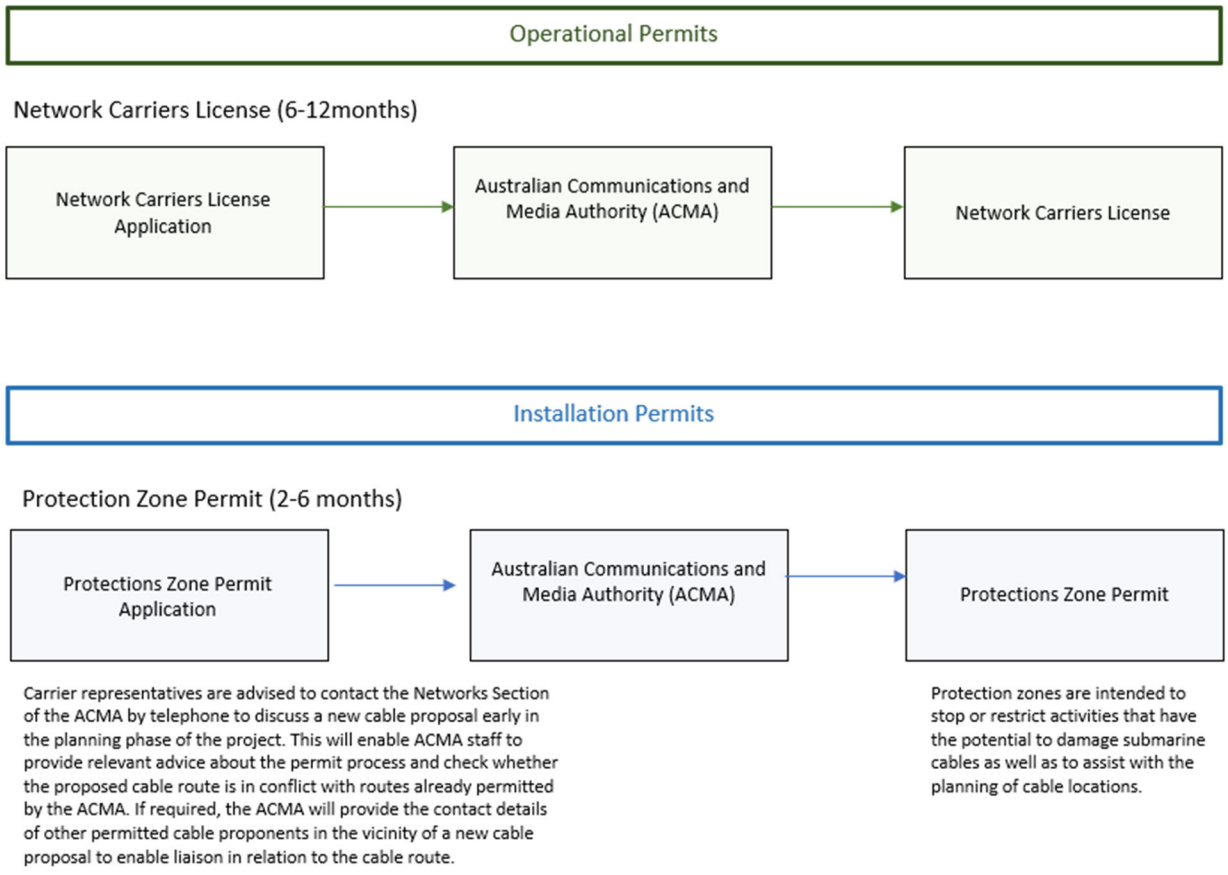


Figure 54: Permitting Flow - Australia

5.3 Equator Principles

The Equator Principles are voluntary standards designed to help banks identify and manage the social and environmental risks associated with the direct financing of large infrastructure projects such as dams, mines, or pipelines. The Equator Principles were established in 2003 by a group of project financing banks, in association with the World Bank's International Finance Corporation (IFC). The Equator Principles were subsequently updated in 2006 (EPII), 2013 (EPIII) and 2019 (EP4). They have been adopted by 78 financial institutions in 35 countries (the Equator Principles Financial Institutions, or EPFIs), covering over 70% of international project finance debt in emerging markets.

The Equator Principles are designed for use primarily in countries with developing legal frameworks. The following sub-sections of the Equator Principles have been considered as they apply to the DGASA project.

5.3.1 Principle 1: Review and Categorization

The Equator Principles are a risk-management framework adopted by financial institutions for determining, assessing, and managing environmental and social risk in projects, and are primarily intended to provide a minimum standard for due diligence to support responsible risk decision-making. These Principles apply globally to all industry sectors and to four financial products: (1) project finance advisory services; (2) project finance; (3) project-related corporate loans; and (4) bridge loans.

The Equator Principles categorize infrastructure projects into the following three categories:

A. Projects with potentially significant adverse social or environmental impacts that are diverse, irreversible, or unprecedented;

B. Projects with potential limited adverse social and environmental impacts that are few, generally site-specific, largely reversible, and readily addressed through mitigation measures; and

C. Projects with minimal or no social or environmental impacts.

5.3.2 Principle 2: Social and Environmental Assessment

For all Category A and Category B Projects, the EPFIs require the cable owner to conduct an assessment process to address, to the Equator Principles Financial Institutions' (EPFI) satisfaction, the relevant environmental and social risks and impacts of the proposed project (examples of which are presented by the EPFIs). The assessment documentation should propose measures to minimize, mitigate, and offset adverse impacts in a manner relevant and appropriate to the nature and scale of the proposed project.

In Category C, the following assessment can be made for the DGASA project:

- DGASA is well below the 100,000 tons of CO2 per year emission threshold requiring annual greenhouse gas emission reports. Even during the construction phase, CO2 emissions from ships are expected to be less than a quarter of that value.
- The project does not have a large carbon footprint beyond the normal usage of electricity.
- The implementation of power feeding from one side to the other limits this further.

The permits require system owners to produce an assessment for the local impact in each landing or territorial area. This needs to be produced and reviewed by each local authority and is a pre-requisite to the system owner obtaining the permits.

5.3.3 Principle 3: Applicable Social and Environmental Standards

The assessment process should, in the first instance, address compliance with relevant host country laws, regulations, and permits that pertain to environmental and social issues.

EPFIs operate in diverse markets: some with robust environmental and social governance, legislation systems, and institutional capacity designed to protect their people and the natural environment (the "designated countries"); and some with evolving technical and institutional capacity to manage environmental and social issues.

As some of the potential investor countries for the DGASA system are on the designated countries list, all activities and construction must be performed in accordance with relevant permits and standards in such countries. Further, the environmental and social impacts of the project must be addressed correctly during the permitting process in each of these countries. The numerous permits required should adequately address any environmental and social concerns.

5.3.4 Principle 4: Action Plan and Management Systems

For all Category A and Category B Projects, the EPFI will require the client to develop or maintain an Environmental and Social Management System (ESMS).

Further, an Environmental and Social Management Plan (ESMP) will be prepared by the client to address issues raised in the Assessment process and incorporate actions required to comply with the applicable standards.

Not Applicable, determined to be a Category C proposal. Based on TMG/WFNS' appraisal of the Equator Principles process, this principle is not applicable to the DGASA project.

5.3.5 Principle 5: Consultation and Disclosure

For all Category A and Category B Projects, the EPFI will require the client to demonstrate effective Stakeholder Engagement as an ongoing process in a structured and culturally appropriate manner with Affected Communities and, where relevant, Other Stakeholders.

Not Applicable, determined to be a Category C proposal. No stakeholder engagement should be required beyond the permitting process, which is a major engagement.

5.3.6 Principle 6: Grievance Mechanisms

For all Category A and, as appropriate, Category B Projects, the EPFI will require the client, as part of the ESMS, to establish a grievance mechanism designed to receive and facilitate resolution of concerns and grievances about the Project's environmental and social performance.

Not Applicable, determined to be a Category C proposal. No grievance mechanism required.

5.3.7 Principle 7: Independent Review

For all Category A and, as appropriate, Category B Projects, an Independent Environmental and Social Consultant, not directly associated with the client, will carry out an Independent Review of the Assessment Documentation including the ESMPs, the ESMS, and the Stakeholder Engagement process documentation in order to assist the EPFI's due diligence, and assess Equator Principles compliance.

Not Applicable, determined to be a Category C proposal. Although there should not be any need for an independent review (mandatory for Category A only), TMG/WFNS has opined on the compliance with Equator Principals. As such, TMG/WFNS has provided its own independent opinion.

5.3.8 Principle 8: Covenants

For all Projects, the client will covenant in the financing documentation to comply with all relevant host country environmental and social laws, regulations and permits in all material respects.

The cable owner should have no objection to this principle, and it should produce the documentation when requested to do so.

5.3.9 Principle 9: Independent Monitoring

To assess Project compliance with the Equator Principles and ensure ongoing monitoring and reporting after Financial Close and over the life of the loan, the EPFI will, for all Category A and, as appropriate, Category B Projects, require the appointment of an Independent Environmental and Social Consultant, or require that the client retain qualified and experienced external experts to verify its monitoring information which would be shared with the EPFI.

Not Applicable, determined to be a Category C proposal. TMG/WFNS believes there should be no need for an independent monitoring.

5.3.10 Principle 10: EPFI Reporting

Not Applicable. No EPFI reporting should be required based on TMG/WFNS' appraisal of the Equator Principles process.

5.3.11 Summary of Equator Principles Findings

TMG/WFNS has reviewed the Equator Principles in their application to the DGASA project and has compiled the following Findings Summary:

Table 17: Equator Principles - Summary of Findings

No.	Principle	Findings
1	Review and Categorization	Categorized as a Category C proposal
2	Social and Environmental Assessment	Social and environmental impacts will be addressed during the permitting process
3	Applicable Social and Environmental Standards	Social and environmental impacts will be addressed during the permitting process
4	Action Plan and Management Systems	Not Applicable
5	Consultation and Disclosure	Not Applicable
6	Grievance Mechanisms	Not Applicable
7	Independent Review	Not Applicable
8	Covenants	Documentation to be produced by the cable owner when requested
9	Independent Monitoring	Not Applicable
10	EPFI Reporting	Not Applicable

There exists no significant environmental risk for the DGASA project, as the cable route selected during the DTS carefully avoids significant "Conservation Zones."

Regarding Social risks, TMG/WFNS has identified that the laying of cable in established "cable protection corridors" in Australia and New Zealand, burying the cable to a target depth of 1.5M down to 1500m sea depth, and working with the OFCC will minimize social risks to fishing activities.

DGASA is compliant with the Equator Principles, as the project presents an insignificant risk to the environment and has very limited potential social impact associated to a plan to be deployed in countries with very strict rules of protection and enforced through a tedious permitting process. Further, DGASA is realistic, achievable, and in-line with current industry practices and situation. Furthermore, the inclusion of Easter Island and Juan Fernández landings into the project indicates that considerable social-economic benefits will result in the deployment of DGASA.

5.4 Environmental Concerns

5.4.1 Chile

As mentioned above, in regard to the RCA, if a project is subject to the SEIA it will require either an Environmental Impact Declaration (DIA) or an Environmental Impact Study (EIA). These processes can be extensive and may raise environmental concerns that can impact or hinder the installation. The main difference between the two relate to the level of detail in the contents, timeframes for assessment and public participation. If both the impacts of the project assessed by the DIA and EIA meet legal standards and fulfill legal requirements an RCA will be issued which authorizes execution of project approval. The following describes the processes involved with these systems in addition to other environmental concerns that should be considered.

A DIA is suggested for projects that are expected to have smaller environmental impacts. This can take up to 90 days to obtain, requires no indigenous consultation and only requires citizen participation if requested due to the project generating significant environmental changes. Other requirements associated with a DIA include:

- A project description
- General description, determination and justification of the area of influence
- Background that justifies the non-existence of environmental impacts outlined in Article 11 of the Environmental Law which include,
    - health risks for the population, due to the amount and quality of the streams, emissions or wastes
    - significant adverse effects on the amount or quality of renewable natural resources, including soil, water and air
    - the relocation of human communities, or significant alteration to the living systems or customs of human groups
    - location in or next to populations, resources or protected areas, priority sites for conservation, protected swamps and glaciers that could be affected, as well as the environmental value of the territory where the project is intended to be settled
    - significant alteration of the scenic or touristic value of an area, in terms of magnitude and duration; and
    - alteration of monuments, sites with anthropologic, archeological or historical value and, in general, every site belonging to the cultural heritage
- Contingency prevention plan and emergency plan, when applicable
- Compliance plan for applicable environmental legislation
- Description of voluntary environmental commitments, if contemplated

In contrast to a DIA an EIA involves a more complex and detailed procedure for a project that does fall under Article 11 of the Environmental Law. In addition to the requirements listed above for a DIA an EIA should include:

- A detailed description of the area of influence
- Prediction and evaluation of environmental impacts
- Description of the effects of article 11 law that gave rise to the EIA

- Mitigation, repair or compensation measures plan
- Monitoring plan for environmental variables

This process can take up to 180 days, requires citizen participation and may require indigenous consultation if significant impact on human groups belonging to indigenous peoples is expected. The review process officially begins when an excerpt from the EIA is published in the gazette and regional newspaper. The environmental authority will then distribute the full EIA to relevant state agencies and local municipalities who then have 120 days to review and submit comments. The authority is then expected to convene with the state agencies and make a decision.

Juan Fernández belongs to the region of Valparaíso meaning that the same permitting structure applies. Though no specific conservation laws are available a few environmental concerns should be recognized before consultation for the RCA. As a world biosphere reserve Juan Fernández has been considered of maximum importance because of the endemic species of flora and fauna. The critically endangered species on the island are to be noted as destruction of their habitat can have significant environmental impact and may cause issues as far as cable installation is concerned including increased time frame and the requirement of an EIA.

It is also worth noting that the main source of income is fishing, specifically lobster. Discussion on ways to avoid interference is suggested. The main fishing season is between October 1st and May 15th. Another form of income is the tourism industry with special interest in diving. Avoiding the impact on the reef systems is highly suggested.

Similar to Juan Fernández, Easter Island belongs to the region of Valparaíso also adhering to the same permitting structure. Though the selected landing location is not located within the park it is worth noting that 40% of Easter Island is composed of Rapa Nui (the Polynesian name for Easter Island) National Park, a national park and UNESCO World Heritage Site regulated by the National Forest Service of Chile (CONAF) and the entire park is declared a National monument. It is important to avoid disruption within the park's parameters.

5.4.2 New Zealand

As previously mentioned, the RMA is the primary piece of legislation that outlines how NZ manages the environment. Approval is likely to carry out a project no matter how small or great in size. If resource consent is needed the Auckland council will need an AEE. This should be seen as a task to shape the resource consent proposal. Taking the time to prepare a good and thorough AEE will save time and money.

The following criteria should be considered when composing an AEE:

- Identify activity or activities for which consent is sought
    - These activities need to be clearly described in detail. If they are not on the form, then they may not be included in the consent.
- Conduct a site inspection: This will help to determine if there are any environmentally sensitive areas. It is suggested for a local inspector to conduct the inspection.
    - The natural, adjacent and physical features should be considered
- Talk to the regional/and or district council
- Identify effects the project might have on area
- Rank and address the effects: A specialist may need to be consulted
    - Consider if the potential effect can be avoided, mitigated, or remedied

- Re-evaluate the proposal
- Finalize the AEE (include obtaining affected parties' approval)
- Lodge the application

The final outcome of the AEE process is an accurate and objective statement about the effects of the proposal on the environment. This statement will have taken into account whether the proposal has avoided, mitigated or remedied any adverse effects on the environment and people. An AEE should be expected take a minimum of 45 to 90 days.

Permission is required to interact with wildlife or use public conservation land. The current landing location is not located on public conservation land therefore it is not anticipated that a DOC permit be required, in which an Environmental Impact Assessment (EIA) would be required. If the landing locations were to be changed to public conservation land an Environmental Impact Assessment needs to be filed with the DOC. This is an integral part of determining what permit or permissions will be granted. A pre-application meeting with the DOC is strongly suggested to scope out the environmental effects that will need to be considered, this will ensure extra time and money will be reduced. The following are the steps suggested to complete an EIA:

- Describe the environment: The applicant will need to consider the natural, historic, recreational and cultural values of the site and surrounding areas. In order to complete an assessment of the cultural, spiritual and cultural values the native people (Tangata Whenua) may need to be contacted. During the pre-application meeting the DOC will provide a list of contacts if necessary.
- Scope the potential effects of the activity: When the concession staff is met in the pre-application meeting both should consider the total environment. All the potential impacts and what adverse effects are likely to be more significant should be noted. These may require more detailed consideration in the application. For very high impact activities this step may involve considerable work and a field visit. Undertaking this step properly will save time and expense later in the process.
- Identify the effect of the activity: The applicant must determine the direct, indirect and cumulative effects where at all possible. The positive, beneficial of adverse effects should also be mentioned. This should be based on the environmental description the applicant has completed.
- Describe measures to avoid, remedy, or mitigate: List the measures that will be undertaken to ensure that every adverse effect identified will be minimized as far as possible. All adverse effects should if possible be avoided first, then remedied and finally mitigated.
- Identify alternative designs: Alternative designs, locations or timing of activities are fundamental impact mitigation measures and should be considered at the very outset. Alternative locations are a mandatory consideration for applications that require a lease, such as buildings.
- Outline monitoring program: Monitoring simply attempts to test the validity of the predictions made earlier in the EIA process after an operation has been allowed to proceed. Monitoring is a fundamental step that the applicant and the Department will use to determine whether obligations are being met to manage the balance between preservation and use.

Once EIA is submitted a decision will be made on additional information needed and what permits may be required to continue work. Personal consultation with the DOC will commence.

5.4.3 Australia

As stated above, the EPBC Act is the Australian Governments key piece of environmental legislature. Approval is required from the Australian Government Minister for any proposed action likely to have an impact on a matter proposed in the EPBC Act (mentioned above). There are two key stages in the environmental assessment process required by the EPBC Act, referral and assessment/decision.

The purpose of the referral stage is to determine whether or not a proposed action requires approval under the Act and is outlined in the following five steps:

- Submission: a referral form must be completed submitted via the department for consideration
- Decision process: following receipt of a valid referral the minister has 20 business days to decide whether the approval action will require assessment and approval under the act.
- Public comment: as part of the total 20 business days taken for the referral process, there is a 10-business day public comment period. This provides an opportunity for relevant Australian, state and territory government ministers and members of the public to comment on the proposed action.
- Decision if an action requires assessment and approval: Within the 20-business day timeframe, the minister will decide whether a proposed action is likely to have a significant impact on one or more matters protected by the EPBC Act. If a significant impact is likely the action will need to be assessed and approved under the EPBC Act before it can proceed. This is called a 'controlled action'.
- Ministers explanation of how the proposed action will be assessed (this is the second stage in the process and may include an EIS).

It is essential that all available information be provided about the proposed action as well as measures that will be put in place to reduce adverse impacts. Not all projects will need extensive approval, and this will reduce unnecessary steps.

The EIS plays a critical role in the process of identifying, predicting, assessing, evaluating and mitigating the environmental, social, economic and other relevant effects of development proposals. When constructing an EIS document the following must be included:

- Declaration
- Glossary and abbreviations
- Executive summary
- Introduction
- Project description
- Strategic and statutory context
- Engagement
- Environmental impact assessment
- Mitigation measures
- Evaluation and conclusion

The project description chapter of the EIS is very important. The aim of the project description should be to provide a clear understanding of the scopes of work for which approval is sought. It should also provide a clearer basis in understanding whether project changes which happen following approval are within the terms of the approved project. It should also include existing plans, figures and images relevant to the project.

The strategic and statutory context chapter should identify any relevant policies or plans which demonstrate the strategic planning context and need for the project. It should contain a description of how the project complies with the relevant policies and plans, including an overview of the importance of the project within the strategic planning context.

Brief descriptions, preferably in table format, of how the project aligns with statutory approval requirements should also be included. The statutory context describes the approvals framework relevant to the project by considering two question, is the proposal permissible? And are there any other statutory approval factors to be considered?

Proponents are responsible for engaging with the community and other stakeholders throughout all phases of the EIA, including during the preparation of the EIS. Engagement approaches may include:

- Engagement as part of scoping, including establishing the level of engagement and participation outcomes during the preparation of the EIS
- Preparation of a Community and Stakeholder Engagement Plan (CSEP) to demonstrate how the participation outcomes will be met during preparation of the EIS
- Implementation of the CSEP during the preparation of the EIS.

In the environmental impact assessment chapter proponents must describe how the matters identified in the SEARs have been assessed and how any potential impacts have been avoided, minimized or offset. In addition, proponents must identify any residual impacts. The proponent's Scoping Report and the SEARs issued by the Department will identify the level of assessment for each matter. Each matter will require either a Key Issue Assessment requiring the preparation of a specialist report to assess impacts and design project specific mitigation measures, typically attached as an appendix to the EIS, or an Other Issue Assessment where the impacts are reported in the EIS and which can typically be managed through routine mitigation and management measures.

The Department has developed an assessment and mitigation framework as part of the Approach to Setting Conditions Guidelines. The framework sets out the preferred hierarchy of approaches for managing impacts. Mitigation measures should be presented in a manner that is consistent with the Department's conditioning framework. The Department has set out three main ways an impact may be conditioned:

- Performance-based conditions identify performance criteria that must be complied with to achieve an appropriate environmental outcome but do not specify how the outcome is to be achieved
- Prescriptive conditions require action to be taken or specify something that must not be done
- Management-based conditions identify one or more management objectives that must be achieved through the implementation of a management plan.

When proposing a performance-based or management-based approach to mitigation, the proponent needs to demonstrate how the nominated performance criteria or management objectives will be achieved and maintained.

Once the document is complete and has been submitted and reviewed by the department the documents are made available for public exhibition and comment. Taking into account the public comments the report may be revised by the proponent and resubmitted to the minister who then makes a decision to approve, approve with conditions, or not approve the proposed action. This decision must be made within 40 days of the final document.

The Australian government has bilateral agreements with all state and territory governments to accredit environment assessment processes that meet set standards. It is possible to do a single assessment, avoiding disruption if both EPBC and state approval are needed. In order to take advantage of this, making a referral to the minister early is essential. This can reduce cost and time constraints.

5.5 Permitting Conclusion

The permitting process involved for the DGASA installation is not expected to be of particular concern. Each location has a unique legislative structure; however, some form of operator's license/approval and some form of environmental permit/approval is universal. New Zealand and Australia have the most structured permitting framework compared to Chile which will require more personal consultation with the government. Regardless of the location pre-application meetings are suggested to cut down on cost and time. These meetings will produce a more accurate scope of information needed and will reduce unnecessary steps.

The lack of structure in terms of permitting increases the risk of the process in Chile. Both New Zealand and Australia are considered to be low to moderate risk depending on the level of environmental assessment and approvals required. Currently all landing locations are found in areas of low environmental risk meaning they are not in areas of environmental significance. In the event this changes extensive environmental assessments and impact statements may be required. It is also worth noting that Juan Fernández and Easter Island both contain significant flora/fauna and heritage sites that should be avoided. Again, the landing locations do not appear to pose a threat. The importance of permitting cannot be overstated. Careful attention to the governing legislation and processes will be an effective strategy in moving forward.

6. Marine Maintenance and Restoration Plan

6.1 Overview

As explained in Section 5.5.3 of Report 2, the system owners will need to consider how best to cover the risk of faults to the submerged plant over the design life of the system. Now that a single route has been chosen, this important consideration can be looked at in more detail. The standard approach is to enter the system in to one or more maintenance agreements and Section 5.5.3 of Report 2 identified the maintenance zones that currently exist in the Atlantic and Pacific Oceans. These comprise the more traditional 'Club' Maintenance Zones and the global coverage of these is in Figure 55: Global Zone Maintenance Agreements.

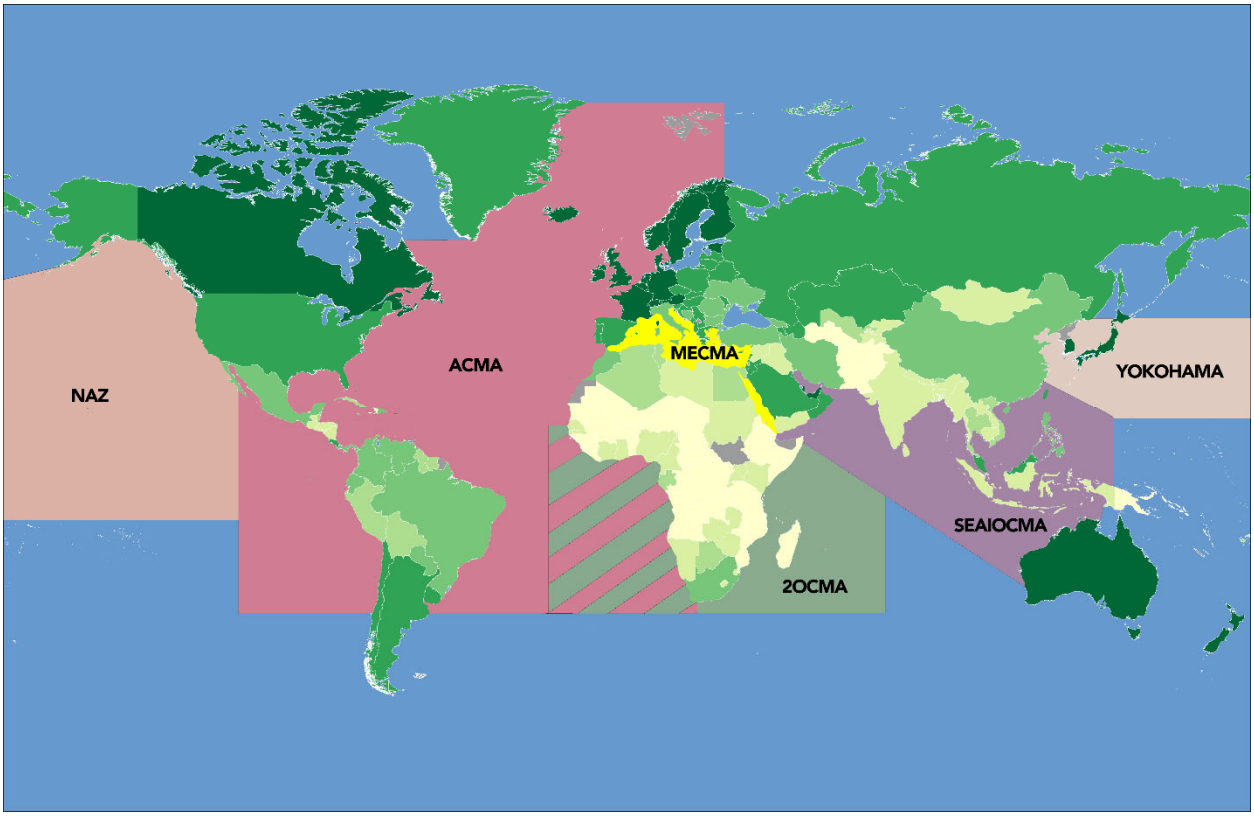


Figure 55: Global Zone Maintenance Agreements

The oldest of these 'Club Zones' is the Atlantic Cable Maintenance Agreement (ACMA), https://www.acma2017.com/. ACMA was founded in 1965 and the other Zones, formed later, are modelled on the ACMA agreement. In addition to these Zone agreements, a number of alternative Private Maintenance Agreements have been set up to complement and, in some cases, compete with the Zones. The global coverage of these is shown in Figure 56: Global Private Maintenance Agreements below.

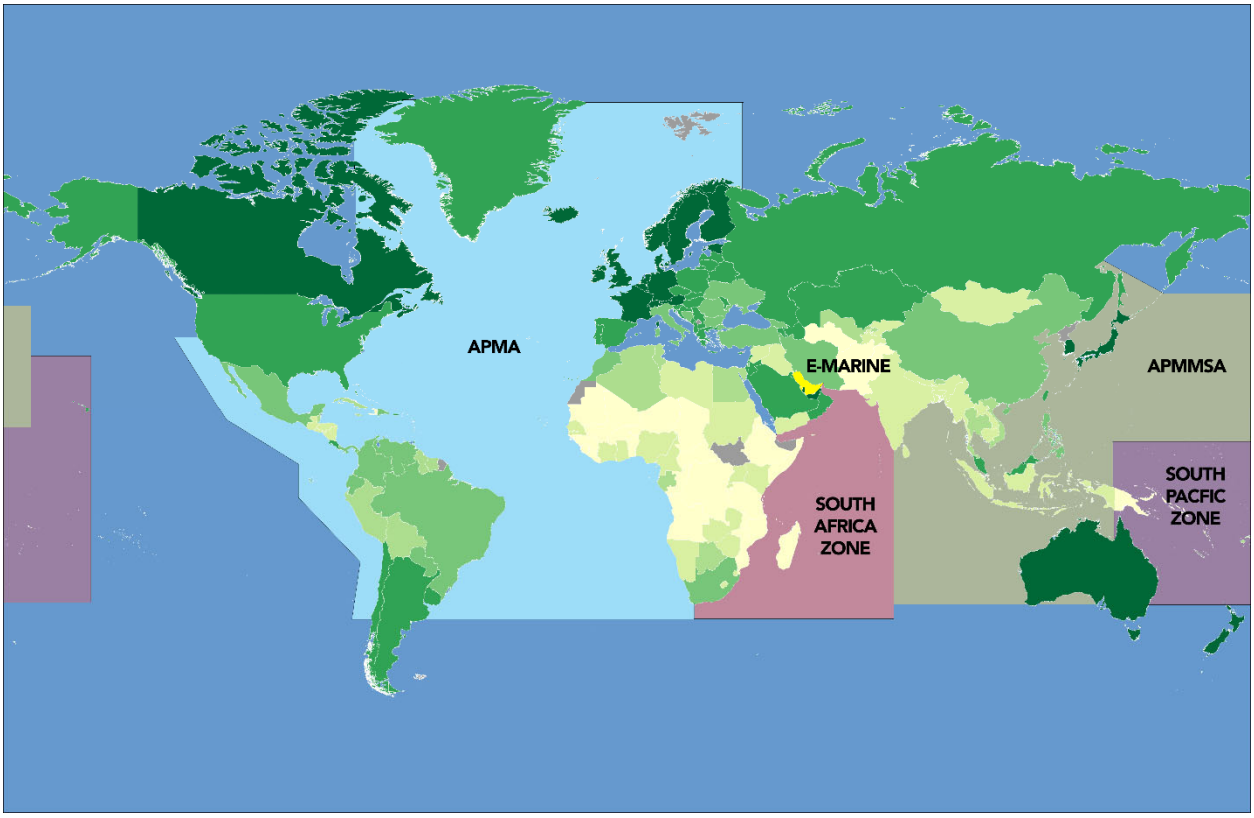


Figure 56: Global Private Maintenance Agreements

As can be seen, the proposed DGASA route falls within the South Pacific Maintenance Agreement (SPMA) to the west. Since 10 March 2017, this agreement has been serviced by SubCom under a five-year contract. They operate a depot on Upolu Island Samoa and the station ship CS *Reliance.*

In the east Pacific, there is no ship based in South or Central America and the existing cables are serviced by ACMA. Since 2017, the service providers to ACMA have been Global Marine Systems Limited (GMSL) and Orange (previously France Telecom Marine). Their contracts will run until December 2021. The station ships are all deployed in the Atlantic with the nearest based in Curaçao, which accesses the Pacific via the Panama Canal. In addition, the Atlantic Private Maintenance Agreement (APMA) has a station ship based in Curaçao, under a five-year contract which came into force on 1 January 2017. While providing a service to the existing Pacific cables, these services are predominantly funded by Atlantic Ocean cable owners and they will take priority over Pacific cables if two owners call for the repair ship at the same time. This could lead to significant delay in repairing a cable fault in the DGASA system.

There are two alternative approaches to marine maintenance, other than entering it into an existing marine maintenance agreement (Zone or Private): a) negotiate a private contract with a single marine service provider, but this would probably be prohibitively expensive; b) wait for a cable fault and then go to the spot market to find a repair ship. Given the high traffic carrying capacity of DGASA, no ship's operator currently offers this approach as a formal service, so the system downtime that would result in the event of a fault would probably be too great for capacity purchasers to have confidence in the system if this was the marine maintenance regimen. Therefore, neither of these alternatives will be considered further.

At the time of writing this report, the existing maintenance agreements that would cover DGASA are SPMA with a ship based in Upolu, Samoa and ACMA/APMA with the nearest ship based in Willemstad, Curaçao;

however, it should be noted that all these service contracts will come to an end before DGASA goes into service. What might happen when these contracts are renewed is a matter of speculation, which suppliers will be successful in the next round of contract negotiations and what the terms of the new service contracts may comprise is beyond the scope of this report. So, for the purposes of this report, the existing services only will be analyzed.

6.2 Risk of System Faults

As explained in the DTS, a process of CRE will be undertaken as part of the development of the DGASA system. This starts at the DTS stage and is carried on through the marine route survey into system design and manufacture and finally the installation methodology. The CRE process will involve investigations into known and potential risks of external aggression faults, both from natural phenomena and manmade. These risks will, as far as is practicable, be mitigated through route selection, choice of cable type, cable burial and where appropriate, additional protection, plus the allocation of cable slack allowances throughout the route.

All System Suppliers responding to the RFI have extensive experience in identifying risks to submarine systems and using the CRE process to mitigate them. One of these responders will become the DGASA system supplier. Properly carried out, CRE will take into consideration all the known/identified risks and should result in a system protected, as far as is economically practicable, from these identified risks. However, it is impossible to guarantee that all the potential risks to the system that may occur over the 25-year design life of the system will be identified. Also, there are some types of faults, e.g., random anchor faults, which are uneconomical to protect against.

As part of the CRE process, the fault history of the overall region and that of similar cable routes will be considered. The vast majority of cable faults are caused by manmade external aggression and occur in shallow water (<1500m), so landing points and continental shelves will be the most at risk. DGASA will be the first cable ever to be laid across the South Pacific from Chile to Australasia; so, there is no historical information of faults on this deep-water route. With regard to the continental shelves, there is good fault history data for Sydney and Auckland and limited data for Valparaiso, but as cables have never landed in Easter Island and Juan Fernández, there is no historical data to call on. Based on the historical data available for the Pacific region as a whole, the potential fault incidence can be assessed as on the order of one fault every five years.

In the event of a system fault, traffic will be lost on the DLS(s) affected by the fault and with it, revenue, while increased O&M cost will be incurred to carry out the repair. It is important to consider the timescales involved in system outage in order to get an understanding of the financial implications and the impact on customer confidence relating to the service provided. To do this the timescales involved in a repair operation are considered in two separate parts: a) response time to the area of the fault; b) time on the cable grounds to reinstate the system.

6.3 Response to System Faults

Report 2 presented a broad estimate that a typical system outage, due to a submerged plant system fault, could be on the order of 10-15 days. Now, on the basis of a single route (2a) this can be considered in more detail.

When a fault occurs on a submarine system, the first indications are alarms at the CLSs and the NOCs. The alarms that go off will depend on the type of system fault that has occurred, but they should initiate a process of fault location. This could include the use of the system supervisory, PFE voltages, OTDR/ Coherent Optical Time Domain Reflectometer techniques and low current DC electrical tests. Once a good

approximation of the fault location has been determined, the system owner can notify the appropriate repair ship to mobilize for the repair, giving the service provider the fault type and approximate location. Once this notification has been sent, the system owner is committed to paying the 'Running Costs' of the repair ship. The first process is to develop a repair plan and agree what spare submersible plant should be used to carry it out. Under most maintenance agreements the ship is required to mobilize, load the appropriate spare submerged plant, if stored in a shore-based depot and then commence passage within 24 hours of notification. Therefore, by the time the ship is underway to fault area, the system could already have been down for up to 48 hours. It should be noted for some marine maintenance agreements, depot storage is not included, and the system owner will need to enter a separate agreement with the depot owner. These depot agreements typically include submerged plant storage, periodic testing, handling between depot and repair ship and scrapping of recovered submerged plant.

The next phase of the operation is the transit to the Area of Operation (AOO). This will commence from the base port/depot directly to the AOO if the fault is in international waters. However, if it is within territorial waters, the vessel will need to clear into that country before it can commence operations unless it has special dispensations. For the purposes of the analysis we will assume the vessel must clear-in and that a typical passage speed of 12 knots, in good weather, will be used.

Table 18: Repair Ship Transit Times

Willemstad, Curaçao		**ACMA**		
Port of Entry	**Distance (km)**	**Distance (nm)**	**Duration @ 12 knots (days)**	**Plus, Panama Canal Transit**
Valparaiso	6,6520	3,370	11.7	13.7
Juan Fernández	6,093	3,248	11.4	13.4
Easter Island	6.783	3,656	12.7	14.7
Upolu, Samoa		**SPMA**		
Port of Entry	**Distance (km)**	**Distance (nm)**		**Duration @ 12 knots (days)**
Sydney	4,533	2,443		8.5
Auckland	3,004	1,619		5.6
Easter Island	6,607	3,561		12.4
Juan Fernández	9,446	5,091		17.8

As can be seen from Table 18: Repair Ship Transit Times, due to the Panama Canal passage time, the response time to Easter Island from Upolu is marginally better than that of the ACMA/APMA ship and would suggest that Easter Island should be included in SPMA and Juan Fernández in either the ACMA or APMA agreement. Therefore, the coverage of the deep-water sections of the main transoceanic span should be split at a convenient point between the two chosen agreements.

After the transit, the clear-in process should take no more than 24 hours and the vessel will then be able to transit to the AOO. As already stated, the most likely fault area is in shallow water on the continental shelf. For this analysis it will be assumed that the fault is somewhere in that area and so will occur between the landing point, i.e., BMH and the transition from LWP to LW cable on the edge of the continental shelf, as defined by the RPLs. The approximate distances from the Beach Joint to this transition are as follows:

a. Auckland = 267km (144nm)
b. Sydney = 80km (43nm)
c. Valparaiso = 255km (138nm)
d. Easter Island = 7km (4nm)
e. Juan Fernández = 13km (7nm)

As can be seen, with the exception of Auckland, all of the landings have a very short continental shelf. As a repair ship can passage at 12 knots in good weather, in the worst-case scenario when the fault is near the continental shelf edge, the AOO for all faults will be within 24 hours passage of the port of entry. For the purposes of this analysis we will assume that repair operations will commence within 24 hours of leaving the port of entry (48 hours after arrival).

6.4 Repair Operation

There are a range of repair operations that could be required:

1. Cable break deep water (unburied)
2. Cable break shallow water (buried)
3. Shunt fault/fiber break deep water (unburied)
4. Shunt fault/fiber break shallow water (buried)
5. Repeater replacement
6. Branching Unit replacement
7. Shore end repair/replacement.

The duration of each repair will depend on a number of factors, including but not limited to type of fault, the cable type the fault is in, the length of cable damaged, water depth, whether the cable is buried or surfaced laid and the prevailing weather conditions.

As previously explained in Section 3.1.3.1 Wet Plant under Splices, the DGASA system will be installed using the chosen system supplier's proprietary jointing technology, however, repair operations will be carried out using UJ technology. The current UJ can accommodate up to 96 fibers and is qualified to a breakdown voltage of 15KV. The cables that will be offered for DGASA are currently under development and to supply a 16/18 fiber pair cable design will require qualification programs for both the supplier's proprietary jointing technology and UJ technology. In some of the RFI responses the Supplier's system designs includes PFE that are required to deliver a voltage of 18KV; therefore, the UJ for these suppliers' cable designs will need to be qualified to a higher voltage breakdown than it has been in the past. TMG/WFNS believes that all the necessary qualification programs can be accomplished within the DGASA project timescale.

A minimum of two cable-to-cable joints will be required to complete any repair. The number of fibers in the cable to be spliced will be the major factor in the jointing times, with an average of 10 minutes required for splicing and reinstating the protective coating. DGASA is planned be a high fiber count cable (34/36 fibers); so, to complete the minimum of two cable joints for any repair, more than half a day on just fiber splicing will be required. Testing each splice will be carried in parallel with splicing and will be followed by wrapping the fibers into the central housing, re-instating the insulation through molding and closing the joint. The insertion loss of the splices will be checked at each stage of assembly. This testing is relatively simple for the initial repair splice as the splices can be tested from the end of the stock cable onboard the repair ship. However, for the final repair splice, the ship will have no access to the fibers and

the insertion loss of the slices must be measured from the appropriate CLSs. This will require the CLSs to power the system with the cable still onboard the ship. To do this power safety must be handed back from the ship to the CLSs and ship-to-shore communication will have to be by satellite phone. This will add significantly to the time required to complete the final splice compared with the initial splice. As can be seen, the initial and final splices make up a significant part of the critical path to completion of the repair and the fiber count in the cable is major factor in this timing.

Without working through the details of each type of repair, for the purposes of this analysis, is assumed that the fault requires the simplest repair (least time consuming) operation of a single cable break in shallow water, buried cable and that the complete repair operations will be completed, assuming no rework or weather delay, in seven days. Obviously more complex repairs will require longer in the AOO before the final splice can be slipped and the system put back in traffic. Any rework and weather conditions that prevent the repair ship from working will add to the duration, and will increase the overall cost of the repair. In addition, weather conditions are a significant consideration for the DGASA route. (See 0)

In summary, the timescale required for the completion of a single, simple system fault, up to the slipping of the final repair splice, would result in a system downtime a as follows:

Operation	**Days**
Identify and locate fault	1
Mobilize Repair Vessel and Load spare Plant	1
Transit to Port of Entry	X
Clear-in	1
Passage to AOO	1
Carry out repair and slip Final Splice	7

As shown, the system downtime for a simple fault on the continental shelves will be, assuming no rework or weather downtime, a minimum of 11 days plus X, the outward transit from the Base Port/Depot to the Port of Entry. For faults on each continental shelf of the DGASA system, the minimum downtime using the existing maintenance agreement repair ships would therefore be on the order of:

ACMA/APMA ship:

Valparaiso = 24.7days
Juan Fernández = 24.3 days
Easter Island = 25.7 days

SPMA Ship:

Sydney = 19.5 days
Auckland =16.6 days
Juan Fernández = 28.8 days
Easter Island = 23.4 days

It should be noted that the system owner will continue to pay for the Running Costs of the repair vessel until it has returned to its base port and discharged the unused submerged plant and recovered scrap into the depot. This may or may not involve clearing out of the country in which the repair has taken place.

It can be clearly seen that even for a simple fault on any of the continental shelves, the downtime for the part(s) of the DGASA system affected by the fault will be on the order of 20-30 days. Therefore, traffic restoration is a major consideration.

6.5 Restoration

The normal PFE configuration for the DGASA system require the main route from Valparaiso to Sydney being double-end fed, one CLS applying negative voltage to line and the other positive voltage to line with a null point of zero voltage relative to earth in mid ocean. The spurs from Auckland and Easter Island will have PFEs feeding to earths at the BUs. The spur to Juan Fernández will have no repeaters in it, but as part of the system design, a PFE will probably be provided to power part of the system during fault conditions. In the event of cable faults (breaks or shunt faults) some reconfiguring of the PFE can be built into the design so that it will be possible to re-power the system and restore some if not all the traffic. Depending on the location of a shunt fault in the system, the power circuits in the BUs could be switched such that two PFEs could be used to power to the shunt fault and the other PFEs used to power to earth at the BUs and so maintain some if not all of the system in traffic. This would allow the system to maintain revenue earning traffic until the repair ship has reached the AOO, minimizing system downtime.

In the event of a complete cable break, the system could still be powered, but traffic would be lost in the DSL(s) where the break is. If there were to be a cable break in the spurs to either Juan Fernández or Easter Island, traffic between Valparaiso, Sydney and Auckland would be unaffected, but there would be no alternative fiber path for traffic to and from the island with the cable fault in its spur. Therefore, traffic would be lost until the repair was completed. In the event of a cable fault in the main link from Sydney to the Auckland BU, the PFE could be re-configured so that Auckland and Valparaiso power the main system, but due to the system architecture only a small portion of the Sydney traffic could be restored over one or more of the other cable systems between Sydney and Auckland, then from Auckland over the main route to Valparaiso, with an increase in RTD. The only available restoration path currently available for the majority of the Sydney traffic would be on cable systems to Los Angeles and/or Hawaii then back down the west coast of the Americas to Valparaiso, with a significant increase in RTD. Traffic from Sydney and Auckland to Easter Island and Juan Fernández would then be carried west to east from Valparaiso over DGASA, with additional increase in RTD.

For a cable fault in the Auckland spur no power re-configuration would be necessary and traffic from to and from Auckland could be restored via Sydney over an alternative cable. For a cable fault between Valparaiso and the Juan Fernández BU the situation is more complex. A PFE can be provided at the Juan Fernández CLS so that the main system can be powered between Sydney and Juan Fernández, so the traffic between Sydney, Auckland, Easter Island and Juan Fernández could be restored to normal, but traffic between Valparaiso and the other CLSs will be significantly affected. As with Sydney, the only existing restoration path currently available for this traffic, would be on cable systems up the west coast of America to Los Angeles and/or Hawaii then back across the Pacific to Sydney and Auckland. Traffic to Easter Island and Juan Fernández would then have to be carried east to west over DGASA. This would add significant RTD to all this traffic when compared to the normal DGASA traffic configuration.

6.6 Valparaiso Based Repair Ship

Based on entering DGASA into the SPMA and ACMA/APMA agreements, the system will be most vulnerable to cable faults in the eastern Pacific. Easter Island and Juan Fernández will have no restoration in the event of any fault in their spurs, and in the event of a fault on the Chilean continental shelf, the main traffic from Chile to Australasia could only be restorable through a lengthy re-routing via the United States. Using the ACMA/APMA repair ship, the best possible system outage would be as demonstrated in

Section 6.4. During any outage, DGASA will not be earning revenue and will be incurring additional O&M expenses for the cost of the repair. This situation is independent of whether or not the DGASA owners are offering protected traffic. However, if the DGASA owners sell protected traffic, they will also be covering the additional cost of restoration until the repair is complete. Therefore, it would be sensible to consider an alternative to ACMA/APMA for cable faults in the eastern Pacific.

If a repair vessel were to be based in Valparaiso, then typical repair programs for these locations would be significantly shorter and, as Juan Fernández and Easter Island are Chilean territories, customs clearance (required for an ACMA/APMA ship) would probably be reduced if not deemed unnecessary for repairs on their continental shelves.

The passage distances to the AOO for a Valparaiso based repair ship would be as follows:

Table 19: Transits from Valparaiso

Valparaiso	**West South America Marine Maintenance Agreement**		
Port of Entry	**Distance (km)**	**Distance (nm)**	**Duration @ 12 knots (days)**
Valparaiso	103	55	4--5 hours
Juan Fernández	672	382	1.3
Easter Island	3.688	1.188	6.9

The operational program would also be reduced.

Operation	**Days**
Identify and locate fault	1
Mobilize Repair Vessel and Load spare Plant	1
Transit to AOO	X
Carry out repair and slip Final Splice	7

Assuming no rework or weather down time, the repair time and system outage would be reduced as follows:

Valparaiso = 9.5 days
Juan Fernández = 10.3 days
Easter Island = 15.9 days

This would be a significant improvement over an ACMA/APMA repair and for Eastern Island a SPMA repair. It would probably not be economically viable to establish what we will call, for the purposes of Final Report, a West South American Marine Maintenance Agreement for the DGASA system alone. However, there are currently three existing submarine systems; Curie, SAC and SAM-1, that land in Valparaiso, plus two others that are planned to land at that locale, including SAPL and the South Pacific Subsea Cable. These five cables will have the same issues as DGASA with regard to the response time from ACMA/APMA with their Atlantic based repair ship and the fact that Atlantic cable owners will have priority call on their services. So, for the DGASA project and with its Government support, this would be an excellent time to promote interest in a new maintenance zone with a base port in Valparaiso.

Having a repair ship in Valparaiso would not be a new thing. From 1881 well into the 20th century the Central & South America Telegraphy Company had a station ship based in Valparaiso to look after its

telegraph systems. Subject to the number of cables system owners interested in such a zone, this would probably also need a shore-based depot for the storage of spare submerged plant.

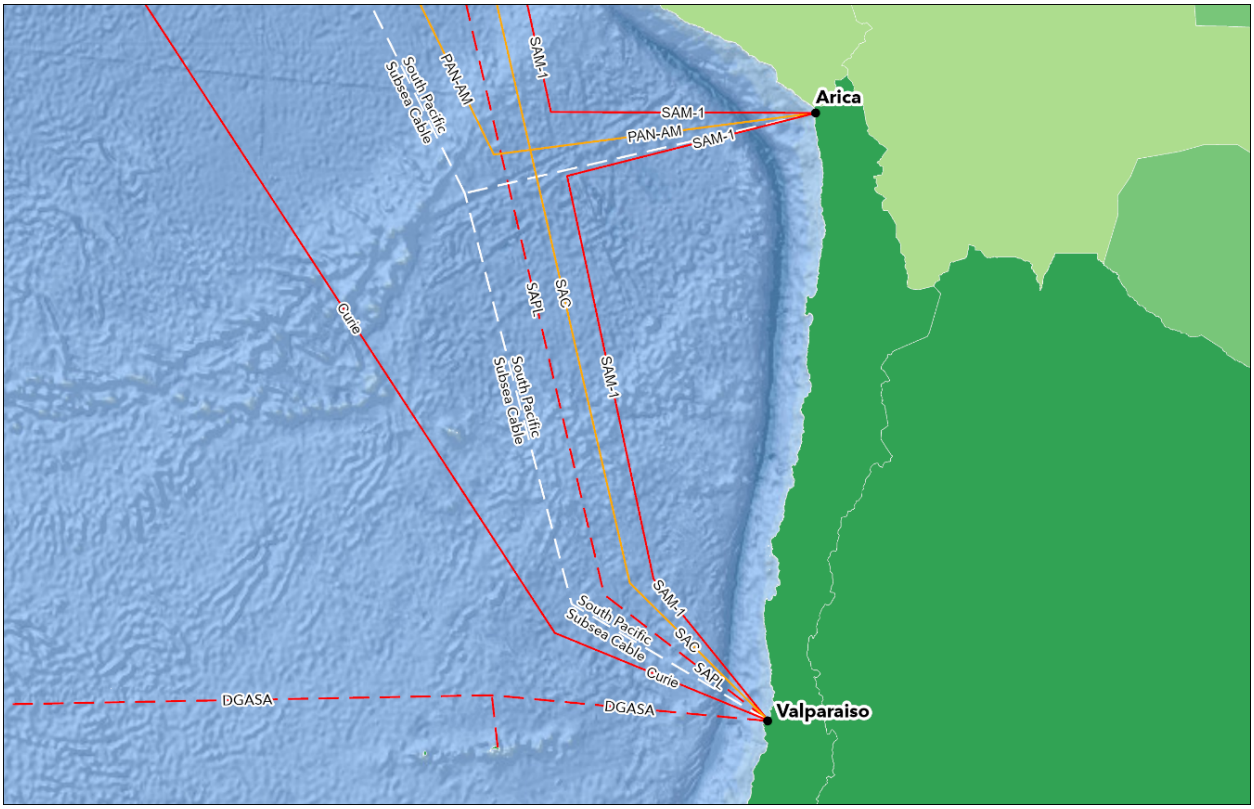


Figure 57: Existing & Planned System landing in Valparaiso, Chile

6.7 Cable Awareness and Third-Party Liaison

Given the amount of traffic that the DGASA system will carry and the duration of downtime in the event of any cable fault, it is essential that the purchasers take every opportunity to reduce the risk of cable faults. System owners normally invest in a program of 'Cable Awareness' to make sure that all other seabed users and other relevant commercial marine entities are aware of the submarine system, its location and purpose. This will involve, but may not be limited to, ensuring the cable route is published on all the major international charts that are likely to be used in the area, as well as pilot books published by these organizations coupled with the printing and distributing of charts and brochure targeted at fishing organizations and regular liaison meetings with bodies representing commercial marine entities and/or companies developing seabed mineral resources.

The organizations to engage with, under such a program, are likely to be different for each landing and continental shelf. The list of organizations for Sydney and Auckland are already well established and for Valparaiso, existing submarine cable owners will have already started this process. The owners of systems landing in these locations should be contacted by the DGASA owner and discussions initiated as to whether there is any benefit for the DGASA owners in becoming part of existing Cable Awareness Programs. For Easter Island and Juan Fernández, new programs will need to be established. These activities can be carried out in parallel with the supply contract for the DGASA system, once the DGASA route is finalized, so that they are in place by the time DGASA goes into service.

6.8 Conclusion

The DGASA system will be installed along a new route that is not established and does not fall under any existing maintenance zones. Therefore, a major challenge for the Government of Chile or the System Owner will be to establish a maintenance agreement with terms that reduces the time to repair. Three options have been presented; 1) enter into agreement with an existing maintenance zone 2) establish a private zone with potential partners or other system operators or 3) secure a dedicated repair vessel to be based out of Valparaiso, which would require the establishment of an agreement with other System Operators in the region.

In any case, the Government of Chile or the System Owner will need to seek a remedy that reduces the time to repair or establish back up routes to be used in times of a system failure, which based on this study could last as long as 30 days. It is not uncommon for systems to be out of service for weeks and in some cases longer, but the goal for any system owner is to avoid or minimize service outages as much as possible in order to ensure quality service and a pleasant experience for the consumers.

7. Implementation Plan

This section is intended to provide the framework for implementing a submarine cable system. The implementation plan is based on information available at the time of this report and is subject to change as the Government of Chile continues to seek potential partnerships and investors, which will undoubtedly influence decisions as the project draws nearer to the procurement phase. This plan outlines each phase of the implementation process and serves as a guide to help the Government of Chile or System Owner as it implements the DGASA system.

7.1 Plan of Work

The process of implementing a submarine cable system includes the following:

1. Planning
2. Procurement
3. Route Survey (Route Design)
4. System Design
5. Manufacture
6. Installation
7. Commissioning

7.1.1 Planning

Typical Duration: 3-6 Months

Work Streams:

- Define Requirements
- Develop Design Plan

The planning phase of any project is the most important as it outlines the scope of work, identifies key requirements, establishes a timeline and sets the required CapEx and OpEx budget targets necessary for the project. SUBTEL is currently in the planning phase utilizing this Feasibility Study to establish a sound business case and implementation plan for the DGASA system. This effort includes a system design plan, technical requirements and a high-level timeline or Plan of Work (POW) to illustrate the expected duration to install and make the system RFS. At the conclusion of this report, SUBTEL will have a good understanding of what makes up a submarine cable system and a strong plan to ensure a successful implementation.

Report 2 assessed and recommended a primary route, which consists of a trunk from Chile to Australia with branches to Juan Fernández, Easter Island, New Zealand and a future branch to interconnect with the Central Zone of the South Pacific. This implementation plan is specifically designed to this route and includes a route plan developed through a DTS and is based on capacity requirements developed based on Report 1 demand assessment and working with SUBTEL and DP, which is the infrastructure funding entity under the Government of Chile and responsible for securing funding for this project.

Planning durations may be as short as several months or as long as a couple of years or more.

7.1.2 Procurement

Typical Duration: 2-3 Months

Work Streams:

- Develop Technical Requirements
- Develop Commercial Agreement
- Procurement Process Administration

Once DP has identified potential partners and have secured funding, they may proceed to the procurement phase. This phase includes the preparation and management of a tender package (RFP) for the marine route survey and installation of the DGASA system. The RFP process includes the administration of the process itself, including development of the RFP package, assessment of the responses from each Supplier and through adjudication and award of the contract. This RFP will be the instrument used to convey technical requirements and other goals from which the participating suppliers will develop a design solution. This process will also allow the system owner or purchaser (in procurement terms) an opportunity to negotiate final terms and cost for the proposed design solution.

Included in this procurement process are the following:

1. Develop Technical Requirements
2. Define Terms & Conditions
3. Determine Proper Tender Process
4. Prepare Tender Package, including Desktop Study
5. Release Tender and Manage Responses (Administration)
6. Assess Supplier Responses
7. Propose Adjudication and Award

The technical requirements typically include route design (route survey), system design, cable/equipment manufacturing, submarine cable installation, BMH installation, OSP installation (fiber from BMH to CLS) and the CLS including site, building, utilities and all equipment required for the system and its operation.

The submarine industry separates this work into two types, marine work versus terrestrial work. Marine work, also referred to as submerged plant or Wet Plant, includes the submarine cable, components like Branching Units and repeaters that are submerged under the water, beginning and ending at the BMH. Terrestrial work, also referred to as Dry Plant includes all other work from the BMH to the CLS.

There are two approaches for procuring a system, one is a turnkey approach which includes all aspects of the system installation, including route survey, Wet Plant and Dry Plant. The other approach is non-turnkey, which seeks to lower cost by parsing the system installation work to numerous suppliers, typically separating route survey, Wet Plant and Dry Plant.

In some circumstances a non-turnkey approach may seem favorable, especially if there are local or known resources available to install the Dry Plant. However, while this approach may reduce costs, it increases the risk to the client or purchaser of the system by taking on more liability and increasing the work to be managed internally. Some components of the submarine system suggest themselves to the non-turnkey approach, e.g., SLTE, OSP, BMH, CLS facilities. A turnkey solution may be more costly but reduces the risk by reducing the Purchaser's liability and placing the risks squarely on the supplier.

DP and its partners may procure a system at any time it feels ready but must ensure funding is available at the time of procurement or have a high degree of confidence that funding will be available to execute a submarine cable system installation contract. Attempting to procure a system without establishing funds will be counterproductive and dilute the system's credibility, which may undermine DP's resolve to implement this system. This will not doom a system, but will make efforts to procure the system more difficult and could risk the project with respect to timing.

Procurement is typically a three to six month process.

7.1.3 Route Survey (Route Design)

Typical Duration: 4-6 Months

Work Streams:

- Mobilization
- Survey Work
- Demobilization
- Review & Accept Final Survey Report

The installation of the DGASA system will include a route survey, as well as the actual installation of the system. Route surveys are typically conducted in advance of the installation and are used to confirm the proposed route identified in the DTS, identify obstacles (i.e., geophysical, manmade, environmental, etc.) to be avoided and provide data necessary to determine what portion of the cable will be laid versus buried, as well as what type of cable armoring will be required for each portion of the route. The supplier will mobilize vessel(s) to conduct the route survey, which is typically done a year in advance of the installation. The data collected during the route survey will determine installation methods and type of cable, and will allow the supplier to estimate more precisely how much cable will be needed and ultimately allow for the final design of the system.

Route surveys are negotiated as part of the procurement process and can be costly if not carefully negotiated, as they include high costs for mobilization and delays attributed to weather. The route survey process includes the following steps:

1. Provide Supplier DTS (proposed route)
2. Development of the route survey plan
3. Mobilization of the survey vessels
4. Route survey work consisting of sonar mapping and physical coring
5. Route Working Group to assess route survey data and make final routing decisions
6. Final route survey report, including all route data collected

The route survey is a key step of the implementation process and necessary in order to finalize the route and system design. Route survey durations are dependent on the length of the route and weather conditions that define workable windows of time. Typically route survey durations are anywhere from three to six months and may carry over to an additional work season if there are complications and delays.

7.1.4 System Design

Typical Duration: 2-3 Months

Work Streams:

- Initial Design Review
- Final Design Review

Design effort begins once the contract is awarded to a supplier and is finalized when the route survey has been concluded. Data gathered from the route survey defines the final technical specifications for submerged cable length and type, and installation methods. Once these parameters are defined the system design calculations may be processed and final system design solution developed for the system.

System design includes number of fiber pairs, transmission capacity per fiber pair, repeater spacing, BU specifications, optical drop/add multiplexers specifications and power feed specifications. It also includes network monitoring and management equipment, as well as ancillary equipment necessary to support the system and services drops

System design is performed by the supplier awarded the contract and the duration for this work ranges from two to three months, depending on the size and complexity of the system.

7.1.5 Manufacturing

Typical Duration: 4-15 Months

Work Streams:

- Cable Manufacturing
- Component Manufacturing

After the system design has been completed and transmission specifications have been defined, the supplier will begin manufacturing cable and electronic equipment. The following components are manufactured after design and in advance of installation.

Cable Manufacturing

1. Cable segments – by type and size
2. Repeaters
3. Branch segments
4. BUs
5. OADM
6. Equalizers
7. Splice boxes

System Manufacturing

1. SLTE
2. PFE
3. Network management elements

Manufacturing durations are typically four to fifteen months, depending on length and diversity of cable types, as well as the supplier's capacity schedule.

7.1.6 Installation

Typical Duration: 4-12 Months

Work Streams:

- Mobilization
- Load Cable
- Install Shore Ends
- Lay Main Cable
- Test and Accept
- Demobilization
- Full System Commissioning

Submarine cable system installations are broken down into two types of work, Wet Plant and Dry Plant. The Wet Plant is started first, where all submerged cable, including BUs, repeaters and OADM devices are installed. This includes burial of some segments in shallow water where the threat to the cable is high and laying cable on the seabed in deep water installation where the threat is low. As the Wet Plant is being installed and tested, all Dry Plant facilities are installed to complete the system

7.1.6.1 Wet Plant

Wet plant Installation includes the trunk (or main lay) and branches plus repeaters, BUs, and equalizers. Shore end refer to operations necessary to land the submarine cable and connect to the land cables in the BMH. Most shore ends are “direct landings” where the cable is pulled from the cableship to the beach or to the start of the HDD pipe. This distance should be less than 1km and depends upon how close the cableship can get to the shore. For cableship operations, the minimum water depth is 15m. If the water is shallow, i.e., < 15m, for cable lengths greater than 1km, a PLSE is installed out to where it is safe for the cableship. The PLSE is a separate marine operation done well in advance of the arrival of the cableship so as not to be on the critical path. At that point the submarine cable is spliced to the PLSE and the cableship begins installation operations.

7.1.6.2 Dry Plant

As the Wet Plant is installed, the supplier will install the land fiber cable, CLS and system components (SLTE) as the final steps in the installation process. The installation of the Dry Plant facilities can be done in parallel, in advance of or after the Wet Plant is installed depending on specific circumstances and is usually dictated by the supplier, but may be dictated by the System Owner as special needs are identified.

7.1.7 Commissioning

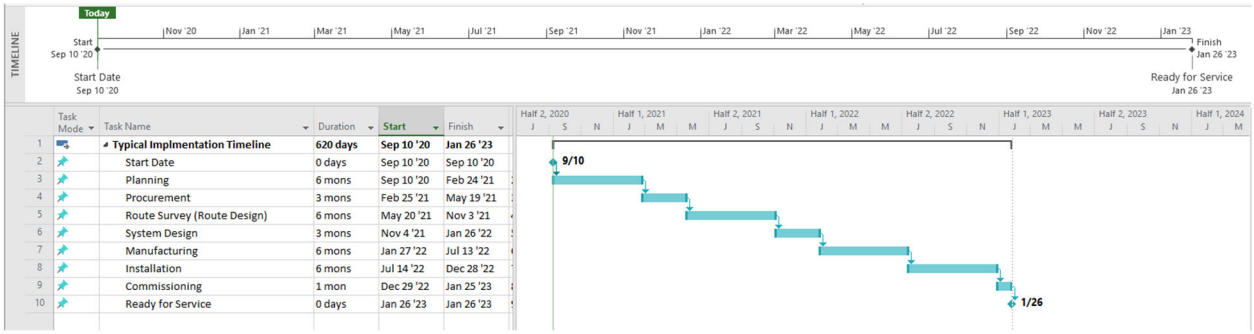
Upon completion of the system installation, all system components assembled and integrated will be commissioned. This process means the system will be tested end-to-end to ensure connectivity, measure transmission rates and confirm the system operates and performs as designed.

The Client or purchaser typically works with the Supplier to determine an agreeable test and acceptance plan for commissioning. Once the system is commissioned, the system is declared RFS. Keep in mind that there are situations where the system is conditionally accepted and placed into service with a hand full of minor issues remaining. Once the system is commissioned, it is considered formally accepted by the System Owner and represents the point at which the Supplier’s obligations for the installation of the system are concluded. There maybe scenarios where the purchaser may choose to conditionally accept the system while efforts to complete installation punch list items is concluded and most supplier’s offer 2 – 5 year warranty.

At this point it is recommended that the purchaser conduct a burn-in period to continue testing and ensuring the organization is ready to operate and manage the system. Commissioning is typically a one to two month duration with a three-month burn-in period.

7.2 Gantt Chart

The Gantt Chart in Figure 58 provides a reasonable high-level schedule that could be realized. However, the primary purpose of this plan of work is to provide a general understanding of the durations of work that could be expected for each phase of the project and is presented solely to help SUBTEL understand general timelines for consideration. The Supplier will develop the primary Plan of Work (POW), which will be integrated into the System Owners project POW.



	Task Mode	Task Name	Duration	Start	Finish
1		**Typical Implmentation Timeline**	**620 days**	**Sep 10 '20**	**Jan 26 '23**
2		Start Date	0 days	Sep 10 '20	Sep 10 '20
3		Planning	6 mons	Sep 10 '20	Feb 24 '21
4		Procurement	3 mons	Feb 25 '21	May 19 '21
5		Route Survey (Route Design)	6 mons	May 20 '21	Nov 3 '21
6		System Design	3 mons	Nov 4 '21	Jan 26 '22
7		Manufacturing	6 mons	Jan 27 '22	Jul 13 '22
8		Installation	6 mons	Jul 14 '22	Dec 28 '22
9		Commissioning	1 mon	Dec 29 '22	Jan 25 '23
10		Ready for Service	0 days	Jan 26 '23	Jan 26 '23

Figure 58: Project Gantt Chart

8. Projected Implementation Costs

8.1 Projected CapEx Costs (Projected Implementation Cost)

This section provides estimated capital costs for the DGASA system and its installation, which are based on the system design plan developed per the technical requirements set forth in Section 3.3. These estimated costs are provided for the purpose of financial modeling and ultimately to serve as a budgetary target for the implementation of the DGASA system. The following sections describe all cost elements, explain the purpose and provide additional suggestions or recommendations for SUBTEL's consideration.

Please note the following:

- 10% Contingency for the DGASA project is included
- All costs and prices are stated in real terms, i.e., inflation has not been addressed
- All pricing is 2020 US Dollars
- System Costs does not include any costs for financing the project, e.g., financing origination fees, legal fees, interest payments.

As a general note, normally the System Supplier will offer a five-year warrantee on the submerged plant and a two-year warrantee on the Dry Plant. Other timeframes can be negotiated. Other elements of the system, e.g., CLS, OSP, BMH, backup generator, will have their own warrantees.

8.1.1 Permitting

8.1.1.1 Operational Permits

Operational permits are required for all work associated with the installation of the system, including Marine and Terrestrial installation work, including shore ends, BMH, OSP facilities and the CLSs. These permits are the responsibility of the Suppliers and it is standard for Suppliers to include this scope of work in the Installation Contract. Therefore, pricing for operational permits is not specifically identified as a cost element.

8.1.1.1.1 Chile

The main operational permit in Chile is the RCA. This will determine and outline all other all other permits and approvals that may be necessary for the installation, including but not limited to the environmental requirements. Chile does not have a well-developed submarine cable regulatory framework; therefore, further consultation with the local authorities is required. No cost estimate can be provided at this time.

8.1.1.1.2 New Zealand

The operational permits required in the New Zealand cannot all be estimated, however, the ones that can are the RMA and coastal permit. For the RMA, a pre-application meeting will cost $505. After that, there is an hourly consultation fee of $111-206.40 (since it is not known how many hours of consultation will be required it is hard to estimate the cost). If a coastal structure is required a deposit fee of $7000 might be required. As for the coastal permit, it can be approximated that is will cost between $2243-$4050. In short, minimum estimate for the operational permits that can be provided is $2748. It can be expected that this number will be much higher as this does not include all of the required operational permits. The cost of other permits is circumstantial and cannot be estimated at this time.

8.1.1.1.3 Australia

The operational permits required for Australia include, but are not limited to, the proposed action referral (application fee of $6577) and sea dumping permit ($10,000-$23,000). In total the minimum cost will be $6577. It is expected that this estimate will increase depending on the circumstances and pre-application meeting.

8.1.1.2 Environmental Studies

There will be numerous permits that include requirements for environmental studies. These studies are intended to demonstrate proper care will be taken to preserve and minimize impact to the environment/people and are the responsibility of the System Owner. Cost estimates provided in this report are based on TMG/WFNS' experience and knowledge and are subject to change once the system is procured and all aspects of the system installation have been finalized.

8.1.1.2.1 Chile

An Environmental Qualification Resolution is the Chilean Environment permit required for projects and activities for which the law presumes will have an environmental effect. In general, there are no fees for processing an environmental or sectoral permit. If an Environmental Assessment is required the specifics will also be discussed in direct meetings, these may include, a DIA or EIA based on the circumstances. An EIA tends to be more time consuming and costly. At this time, the specific requirements are unknown; therefore, an effective cost estimate cannot be provided. Pre-lodgment meetings are mandatory and will provide further detail requirements.

8.1.1.2.2 New Zealand

The Resource Management Act is the piece of legislation that governs how New Zealand manages their environment. An Assessment of Environmental Effects is a requirement as well as an EIA. If an EIA is required, it is expected to increase cost. This is circumstantial and further cost analysis can be obtained in the pre-application meeting.

8.1.1.2.3 Australia

A referral of proposed action and some form of environmental assessment is required for the installation of a submarine cable system in Australia. The environmental assessment is circumstantial, and cost will be determined depending on what kind of assessment is needed, however, if a conservation management plan is needed it can cost between $2000-$4000 and this includes a desk-top review and possible site visits. This process may also require an EIS which can be costly. It is important to note that this estimate of $2000-$4000 does not include other measures that need to be taken. Further costs and fees will be discussed in the pre-application meeting.

8.1.1.3 Principle Permits

Principle permits include operating licenses and other permits specific to the ownership and operation of the submarine cable system. Cost estimates for these permits were derived from TMG/WFNS subject Matter Expert (SME) and from suppliers as part of their response to the RFI.

8.1.1.3.1 Chile

The principal permit required in Chile is the Intermediate Telecommunications Service license which requires direct consultation with the appropriate agencies. These consultation meetings will provide

further information on the cost requirements. At this stage it is difficult to provide an accurate cost estimate.

8.1.1.3.2 New Zealand

New Zealand requires a network utility operator's license. Similar to Chile the cost will be determined during a pre-application meeting with the appropriate authorities. At this stage in the project an estimate of operational permit costs provided are provisional and subject to change.

8.1.1.3.3 Australia

A permit for installation is the principle permit required for cable installation in Australia. Currently the route has the cable being installed in a protection zone which will require a fee of $4,040 to obtain the permit. This is the minimum cost and there are other costs that cannot be identified until the time the System Owner applies and engages with the Government of Australia.

8.1.2 Marine Route Survey

Marine route surveys are typically conducted by the Supplier awarded the contract to install the submarine cable system. The data collected by the route survey feeds route and system design efforts, which is a critical to the project. There are circumstances that might push a System Owner to seek this work from a separate supplier, but this increases risk to the System Owner and is not recommended. For the purpose of this report the marine route survey is assumed to be provided by the installation supplier.

8.1.3 Wet Plant

System Costs includes costs for all elements of the submarine cable system, Wet Plant. These cost elements include the costs of the main system (Wet & Dry Plant components) and does not include permitting, local civil works, CLSs, BMHs, OSP, project logistical expenses, purchaser's project management and administration, NOCs, backup NMS traffic route.

8.1.3.1 Cable

Submarine and terrestrial fiber optic cables are available in various sizes, types and performance ratings, which are determined during the route and system design efforts. The suppliers as part of the RFI process provided budgetary costs based on their recommendations for cable size, type and performance parameters. These costs are budgetary and subject to change during the route and system design process.

Optical fibers are not priced separately, and Suppliers do not share their manufacturing material cost data.

8.1.3.2 Repeaters

Repeaters are integral elements of the System, supporting 2, 4, 16, or 18 fiber pairs depending upon design and Supplier source.

8.1.3.3 Branching Units

BUs allow access to the submarine cable system and are decided by the System Owner. The design plan for the DGASA system includes four BUs, which are proposed to be the ROADM type, allowing greater flexibility and reliability.

8.1.4 Spare Submerged Plant

8.1.4.1 Spare Cable

The suppliers will recommend spare cable types and lengths based on the route and system design. These spare cables will be stored in two separate spares depots. Spares cost are identified separately.

8.1.4.2 Spare Splicing Kits (Universal Jointing)

Junctions, or fiber splices, are part of the Wet Plant. They join repeaters, BUs and equalizers to the cable and splice segments together. They are used when repairing the cable and are essential elements for sparing. Splices are not priced separately as they are considered part of the cable. However, the spare fiber repair splice kits are priced separately. They are stored with the submerged plant spares in the cable depots.

8.1.4.3 Spare Repeaters with Tails

Repeater spares have been included per standard practice and in quantities recommended by the Supplier. Spare repeaters will support 18 fiber pairs (maximum fiber count) and have 100m tails. The spares will be stored at the cable depots. Costs provided reflect these specific elements separately and in quantities as recommended by the supplier's design. Spare quantities can be increased if there are circumstances and known risks that justify the increased costs.

8.1.4.4 Spare Branching Units with Tails

Two spare BUs will support 18 fiber pairs (maximum fiber count) and have 100m tails. The spares will be stored at the cable depots.

8.1.4.5 Suggested Spares Quantities

The following spares list have been suggested by suppliers and are subject to change at final system design and may also be influenced by the purchaser's level of concern and/or confidence in the system protection plan.

Estimated ROM cost for spares of $8,379 m has been included in the total implementation costs.

Table 20: Suggested Spares Quantities

Depot 1	**Units**	**Qty**
Special Application (SPA)	Km	29.00
Light Weight Armored (LWA)	Km	11.00
Double Armored (DA)	Km	1.00
Repeater Spares	Each	1
Non-Integrated GEJ Spares	Each	1
Non-Integrated GEJ-S Spares	Each	1
OADM Unit - 2FP	Each	1
Depot 1 - Total Cost ($1000 USD)	$ 4,370	

Depot 2		**Qty**

Special Application (SPA)	Km	29.00
Light Weight Armored (LWA)	Km	11.00
Double Armored (DA)	Km	1.00
Repeater Spares	Each	1
Non-Integrated GEJ Spares	Each	1
Non-Integrated GEJ-S Spares	Each	1
OADM Unit - 1FP	Each	1
Depot 2 - Total Cost ($1000 USD)	$ 4,009	

8.1.5 Marine Operations (Installation)

8.1.5.1 Main Lay

Installation of the submarine cable is comprised of surface lay, burial and a post installation inspection with additional burial work as required. Suppliers will provide detailed pricing for each of these work streams, but this work is typically not negotiable at this level.

8.1.5.1.1 Surface Lay

Laying the submarine cable on the surface is done in marine depths greater than 1500m along the route designed, which take into account all obstacles and risks to the cable. The cable used for this segment of the system is typically Lightweight cable. This installation methodology is decided by the Supplier with collaboration with the System Owner during the Route Working Group sessions. All Suppliers responding to the RFI provided great detail in their pricing estimates.

8.1.5.1.2 Burial Operations

Where there are greater risks of aggression to the cable it is buried, which is usually closer to the shore ends at depths less than 1500m or where there is known aggression risk to the cable. Submarine cables are buried by means of a plow that is pulled by the vessel as it feeds the cable to the plow. Typical burial depth is 1.5m, but there are circumstances that might require greater depth. All suppliers provide pricing for burial work based on the preliminary route data from the DTS work being conducted as part of this project.

8.1.5.1.3 Post-Lay Inspection & Burial

Once the cable has been installed the supplier will use Remote Operated Vehicles (ROVs) to visually inspect portions of the cable. These ROV platforms are capable of burying the cable as determined via the inspection. These costs are were also provide by the suppliers and included in the marine installation cost element. Once again, the marine cost estimate is subject to change after the route survey and route design are completed. However, because a DTS was conducted during this study, the risk of this cost estimate changing dramatically has been reduced.

8.1.5.2 Shore Ends

8.1.5.2.1 Horizontal Directional Drilling

HDD describes a method of drilling, but more importantly in the submarine cable system industry, it means that a steel pipe has been installed under the surface from a point near the BMH to a point offshore along the route. This pipe is usually a 10cm-15cm diameter steel pipe, which can be up to 30cm in diameter, providing the greatest level of protection to the cable. HDD is usually determined during the marine and site surveys in areas where there is a risk of aggression to the cable and can vary in length with the longest approximately 1500m. This report assumes HDD will be required at all landing points except Juan Fernández and is included in the responses from the Suppliers.

8.1.5.2.2 Pre-Laid Shore End

Also, at the shore end, there are two types of shore end installations. Once is where the cable is directly landed at the landing point. This means the same cable that is installed along the route is landed and secured at the BMH, then the vessel begins the marine installation. PLSEs are a segment of cable that is installed in advance of the main lay. This cable is installed from the BMH to a point just offshore where the main cable is jointed or spliced at some later point in time. The supplier determines the methodology and was included in the RFI responses.

8.1.6 Terrestrial Plant

8.1.6.1 Land Fiber Cable

Cost estimates for OSP fiber cable are based on the assumption that each landing site will require 3km of fiber cable from the BMH to the CLS. These costs are subject to change as the actual fiber cable route and CLS locations are identified.

8.1.6.2 Land Electrical Cable

The electrical cable is typically installed in parallel with the fiber cable between the BMH and the CLS. Therefore, the same assumption of 3km is assumed and these costs are also subject to change as the actual fiber cable route and CLS locations are identified.

8.1.6.3 Terrestrial Spares

Spares for terrestrial plant include a section of cable that might be needed to replace a section of cable damaged by aggression to the cable. The length of this cable is determined by the specific terrestrial route design and distances between cable enclosures or housing. Because this cost is minor, it is included in the terrestrial fiber cable cost and not detailed separately.

8.1.7 Terrestrial Installation

As previously mentioned, all Suppliers provided cost for the terrestrial plant and its installation. However, it must be noted once again that because the location of the CLS locations are unknown, an assumption was made for the purpose of this study, that all terrestrial cable segments would be priced out for 3km at all landing sites. Therefore, it must be understood that this cost is subject to change once the final locations are determined.

8.1.7.1 Civil Works

Construction and civil works include electrical, sewage and water service-related work necessary to supply the CLS and system. The scope of these cost elements can vary drastically by site, and at the time of this report specific site locations are unknown. However, “Allowance” pricing for civil works has been included but will need to be refined as more site information is identified.

8.1.7.2 Beach Manhole

The size of the BMH depends upon the number of submarine systems that will land at that location. The BMH can either be prefabricated or cast in place. It is usually less expensive for the purchaser to supply the BMH versus the System Supplier. Generally, the purchaser will have a better understanding of local conditions. For the purpose of this study cost for BMH installations were included as part of the RFI responses.

8.1.7.3 Duct Bank

Conduits are part of the OSP. They interface to the CLSs in a cable vault next to the CLS as described in section 3.1.3.3.1. The cables between the BMH and the CLS will be underground. They can be direct buried or pulled through a duct bank. The duct bank is more expensive but is preferred due to cable protection, ease of installation and future expandability. The duct bank is usually provided by the purchaser under a separate contract. Generally, the purchaser will have a better understanding of local conditions. Cost estimates for installing the duct bank have been provided by the suppliers, but once again are subject to change as the exact location of the CLSs and OSP cable routes are determined.

8.1.7.4 Return Earth Ground System

There are several different grounds in the system. The RES is part of the submarine system provided by the System Supplier. The BMH ground will be part of the BMH construction. CLS grounds will be supplied with the building and both have been included in the cost estimate. (See Motorola's R56 for details on station grounding.)

8.1.8 Cable Landing Station

CLS costs include site acquisition, site preparation, building, fencing and parking area. The actual size of the CLS will be determined partly by requirements set by the system design, but also influenced by system partner needs and other considerations by the System Owner. For the purpose of this study CLS costs are based on minimal space requirements and do not reflect other space requirements as they are unknown at this time.

8.1.8.1 Building

In order to establish property or dependency, it is necessary to have information about the local real estate and commercial leasing markets at each of the landing sites. This information will be developed in the future once the landing parties are identified.

The CLSs will be furnished with personnel amenities to suit the local requirements, e.g., work areas, furniture, breakroom, hygiene facilities, storage space.

All local facilities are the responsibility of the purchaser.

8.1.8.1.1 HVAC

The Air Conditioning is part of the HVAC system and will be sized for the initial capacity. Future expansions will be funded under the traffic capacity upgrades. The system cost is based on the supplier's recommendation and are typically included when purchasing a new building.

8.1.8.1.2 Fire Suppression

CLS buildings require fire suppression systems, which are typically provided by separate suppliers, not the system supplier and may be included in building cost, if for example a modular building is purchased. For the purpose of this report fire suppression cost are provided per the Supplier's recommendation and only consider the system needs.

8.1.8.1.3 Security System

Physical security features will be incorporated into the CLS site, e.g., door locks, guard stations, mantraps, surveillance cameras, building alarms, equipment cages, gates, fencing.

8.1.8.1.4 Battery Plant (with UPS)

Every CLS building includes a battery plant to run the system in time of commercial power failure. These batteries are stored and maintained in the CLS building in a space near the system equipment. Cost for these elements has been provided by the supplier based on the design requirements as set forth in the RFI.

8.1.8.1.5 Fencing and Paving

CLS sites also require fencing for security and parking for operations personnel. The cost for these elements is based on specific site locations and size, which are unknown at the time of this report. However, the cost for CLS building includes fencing and paving and is subject to change as the size and location of the CLS changes.

8.1.8.1.6 Grounding

Grounding systems are required by design and can vary in cost based on location and ground resistance. Cost for providing grounding systems is also included in the CLS building cost.

8.1.8.1.7 Racking

Cable racking systems are typically included in the CLS cost element and are not separately priced in feasibility studies as they are not major cost elements.

8.1.8.1.8 Electrical Service

Normally, the local power company builds its electrical substations. The system Purchaser will pay for the drop from the electric company's nearest connection point (e.g., a transformer on a pole) to the CLS. This will only be at Juan Fernández and Easter Island. Without knowing the status of the local electrical grid, in a worst case the local power company may ask for financial assistance to supply power to the CLS.

At Valparaiso, Auckland and Sydney, the CLSs already exist and it is not expected that the new AC load will require expansion to the local power company's substations.

8.1.8.2 Backup Generator

Commercial Power backup at Juan Fernández and Easter Island will be two redundant standby generators and fuel tanks at each site. Each generator will be 30kW with a common 2,000-liter diesel fuel tank.

Power backup at Valparaiso, Auckland and Sydney will be part of the existing CLSs. Some costs will be incurred to tie into the existing backup power supply.

UPSs will be supplied for the NMS monitors, routers and switches. Nominally the UPS will supply 20 minutes of power until the CLS backup AC generators ramp-up to full output. (At that time, the equipment on UPS will switch back to the station AC supply.)

8.1.9 Dry Plant

8.1.9.1 Submarine Line Terminal Equipment

SLTE are installed at each termination point in the system, typically at the CLS and/or collocation space in an existing CLS, building or data center. The submarine fibers are terminated to the SLTE which provides digital ingress/egress of data traffic to the submerged plant. These elements are primary components included in the Suppliers RFI response.

8.1.9.2 Terminal Points

The SLTE will terminate on an ODF. The SIE will terminate on either an ODF or a Main Distribution Frame depending upon the input/output traffic format. The SIE is where the customers access the submarine system and are also included in the Suppliers cost.

8.1.9.3 System Interface Equipment

Separate from the SLTE, but connected to the SLTE, there is SIE used to provide service side digital interfaces for distribution of lower level traffic (e.g., 10Gbps, 100Gbps) to end-users or consumers.

Past systems were closed system requiring the purchase of a complete system, Wet Plant and Dry Plant. Current strategy trends, enabled by an open system architecture, separates the purchase of Wet Plant and Dry Plant as discussed in section 3.1.3.1. This allows the purchaser to delay the purchase of SLTE equipment, typically a year later just before the system is RFS, allowing technical development cycles to mature and ensure purchase of the latest technology at improved price points.

SLTE and SIE equipment have been sized per the planned design requirements driven by the Capacity Forecast and input from submarine system installation Suppliers.

8.1.9.4 Network Management System (Administration System)

The customer usually has a separate OSS that is above the submarine system's NMS. The OSS handles the network's administration including billing, trouble tickets and SLAs monitoring. The NMS feeds its information to the OSS via northbound interfaces. The OSS is not supplied by the System Supplier and is usually a separate system developed for the purchaser by a third party. The OSS is not part of this report.

Each CLS has LME that feeds CLS and segment alarm and status information to the NMS. The NMS will have Remote Operator Terminals in the NOCs. There will also be Local Craft Terminals in the CLSs for local personnel.

8.1.9.5 Power Feed Equipment

The power equipment consists of the PFE and the DC Battery Plant for the terminal equipment. The DC Battery Plant will be sized for 8-hour backup.

8.1.9.6 Ancillary Equipment

There will be miscellaneous equipment such as racks, equipment cabinets, fuse panels, iron work, distribution frames, fiber jumper cables, pan duct, ground bars and storage cabinets. At each location, a set of spares for each piece of equipment will be required.

8.1.9.7 Spare Submarine Line Terminal Equipment

Spare SLTE cards will be necessary in failure events that include SLTE components, typically optical transponder cards. While the SLTEs are redundant the System Owner should maintain adequate spare numbers in order to avoid prolonged system outages

8.1.9.8 PFE Spares

PFE elements are just as critical as the SLTE elements and therefore warrant the same level of necessity and importance. The supplier will recommend a spares plan, which the System Owner may adjust once the system is in operation.

8.1.10 System Test and Commissioning

8.1.10.1 Test Equipment

Test equipment utilized in day-to-day operations of the system are recommended by Suppliers and included as part of the Supplier's proposed solution.

8.1.10.2 System Test and Acceptance

The System supplier will perform in-station acceptance tests to ensure that each site has been installed correctly. These site tests are witnessed and accepted by the purchaser.

8.1.11 Network Operations Center Equipment

The System Owner has the choice to install and operate a NOC or outsource the NOC to service providers. It is recommended that the system owner outsource the NOC, and it is further assumed for this study. While the NOC is outsourced, there is equipment that will need to be purchased to support the connections to the NOC. This equipment has been included in the supplier's responses to the RFI and embedded in this cost element.

8.1.12 Project Services

8.1.12.1 Engineering and Project Management (Supplier)

Engineering and project management services are standard cost elements included in every supplier's proposal. These costs vary from supplier to supplier and are not negotiable. Each supplier provided a cost for these services and this cost has been included.

8.1.12.2 Project Management Cost

Project management services are included in submarine cable system installation contracts and provided by the Supplier awarded the contract to install the system. However, there may be a need for third party Project management resources for quality assurance purposes, which are not included in these cost estimates. Cost provided in CapEx summary table only cover System Supplier's project management, which includes such items as: the Supplier's Project Management team, required customer reporting, monthly meetings, Supplier's travel, etc.

8.1.13 Other Related Costs

8.1.13.1 Training

When the system is near RFPA, the Supplier will train purchaser personnel using the actual system equipment. The Supplier can also give high level, system training to the purchaser's administration personnel. The Supplier will offer various training options:

- Type A is mainly academic in nature so that the trainees are able to understand the design philosophy of the system and analyze network alarms/performances.
- Type B training is primarily intended for operations and maintenance staff.
- Type C is for the land joints that are used in the land part of the system.

8.1.13.2 Documentation

Documentation includes system specifications, as built, route survey data and user manuals that the System Owner will need to properly operate the system and especially for the event of a system failure. This cost element is standard in all supplier proposals and was obtained from the Supplier's responses to this RFI.

8.1.14 Capital Cost Summary

Cost elements as described throughout the previous sections were gathered from the RFI responses submitted by all four suppliers and assimilated to produce an estimated cost estimate based on the design plan and technical requirement set forth in this report. Cost elements not provided by the suppliers, such as civil works, CLSs and permitting cost associated with environmental studies were estimated by TMG/WFNS, which are based upon experience with similar transoceanic submarine fiber optic systems. Some "Allowances" are made for items not addressed by the July 2020 RFI or known to TMG/WFNS and are so noted.

Table 21: Capital Cost Summary

Estimated Capital Expenses		**($1000) US**
Permitting	$	2,625
Marine Route Survey	$	8,148
Submerged Plant	$	338,552
Spare Submerged Plant	$	8,379
Marine Operations	$	50,011
Civil Works	$	1,084
Land Cable Installation	$	2,003
Cable Landing Station	$	2,430
Station Landing Terminal Equipment	$	42,559
Spare SLTE	$	1,039
Engineering & Project Management Services	$	13,541

System Test & Commissioning	$	480
Training	$	432
Documentation	$	246
Test Equipment	$	405
Permits*	$	1,500
Land Acquisition *	$	2,000
Project Management*	$	1,000
Subtotal	$	476,434
Contingency (10%)	$	47,643
Grand Total	**$**	**524,077**

* Purchaser direct costs

Cost estimates provided are considered Rough Order of Magnitude level estimates with a +/-25% margin of error, which is the industry standard. Appendix D includes a cost table that details these costs by segment and branches.

TMG/WFNS is confident that the system cost can further be negotiated downward during the formal procurement process. In addition, the cable owner should use the financial model to establish a target for the CapEx budget then work to meet this target. Outside the scope of this feasibility study, there are other options and strategies that may also be employed to meet the CapEx target. However, due to the amount of information that is unknown at the time of this report and in light of the remaining activities and decisions associated with the structure of the Special Purpose Vehicle (SPV), potential partnerships and investor requirements, capital investment required to implement the DGASA system is anticipated to fall within a range between $404,969M (25% less than the RFI figures) and $524M (0% less than the RFI figures).

8.2 Projected OpEx Costs (Cost of Operation and Maintenance)

8.2.1 Overview

In Report 2 Section 5.5.3 we provided an overview of typical O&M and that these costs can be split into system administration, landing site and marine maintenance costs. It was explained that, how these costs were incurred, and which parties will bear them, will depend on the business model chosen for the procurement of the DGASA system. If an incorporated consortium or SPV model is adopted, then all O&M costs will be budgeted within the business plan of the Special Purpose Vehicle (SPV). For an un incorporated consortium model governed under the Construction & Maintenance Agreement (C&MA) or similar arrangement, some of the costs may be borne by the individual consortium members and others may be shared in proportion to the individual signatory's investment in DGASA. Also, under either model the DGASA owners will have the option to outsource the necessary services through commercial contracts or cover the requirement though their own in-house resources.

Now that a single route has been chosen, this may be considered in more detail, however, little or no information has been provided in the responses to the RFI for these costs. Therefore, only the marine

maintenance costs can be refined from the Report 2 estimates, in which all costs have been developed in a broad gauge fashion, based on input from four of the top suppliers (ASN, SubCom, NEC and Huawei) and WFNS' knowledge and recent hands on experience with other system in the region. It should be noted that the vast majority of the Landing Party O&M costs are not those that the responders to the RFI typically provide; they will be either in-house costs or commercial contracts negotiated by the owners with local suppliers and will be different for each of the landings.

TMG/WFNS believes figures provided are reasonable for initial project budgeting, but will need to be refined as the DGASA project moves forward. For Easter Island and Juan Fernández, the infrastructure will require new builds, but for Auckland, Sydney and Valparaiso, the DGASA system is expected to share existing facilities. This will have a bearing on the annual costs incurred. Once the locations of landing points and the CLSs have been determined, it will be up to the DGASA purchasers, based on the selected business model and the choice of in-house or out sourced cost, to develop detailed budgets based on in-house costings or tenders from third party service providers. The work on this can be scheduled to take place in parallel with the RFP process for the supply of the DGASA system.

The following sub-sections provide a more detail list of the items that will need to be included in the budgets.

8.2.2 System Administration

System administration annual costs will be incurred by a SPV and shared or divided among signatories to a C&MA in the proportions defined in that document. They can include but may not be limited to: general administration, accounting, billing, contract administration, financing, human resource (for an SPV), information technology, legal, Marine Maintenance Authority (MMA) [see Section 8.2.4], marketing, Public Relations, NOC management, purchasing, sales and system engineering including system upgrade and network expansion planning. The total annual cost of system administration will depend on the model of ownership of DGASA, so it is unreasonable to provide an estimate for budgeting until the decisions on ownership model and landing parties are determined. For financial modelling purposes, technical, sales, G&A staffing and office OpEx have been agreed with SUBTEL.

8.2.3 Landing Sites

Landing site annual costs will be incurred for the CLS at each landing point. This will include the general maintenance of the building and grounds, primary utility services, generator maintenance and refueling, battery maintenance, HVAC and security system maintenance. If DGASA choses to own and operate its own NOC, some, if not all of these costs, will apply to that facility as well.

Although the DGASA system equipment will be designed to work without regular routine maintenance, an annual budget should be included for the DGASA equipment and backhaul equipment, in each CLS, to be regularly checked. No additional information has been made available at the time of writing this Final Report, as such an annual budget figure of $1,300,000, for each CLS has been retained from earlier estimation in which all costs have been developed in a broad gauge fashion, based on input from four of the top suppliers (ASN, SubCom, NEC and Huawei) and WFNS' knowledge and recent hands on experience with other system in the region. In addition, to the CLS maintenance, it is assumed that DGASA will have a NOC at each end of the main system so an annual budget of $60,000 should be allowed for each.

At each landing site, annual budgets will need to be established for the maintenance and repair of the OSP. This will include but may not be limited to; the duct route from the CLS to the BMH and the BMH, as well as the land cable and the RES (OGB). This will include the storage of the spare cable drums, jointing kits and electrodes, with testing as appropriate, plus the capability to carry out cable-to-cable joints in the

fiber and electrical cables (including the beach joint), plus the replacement of RES (OGB) electrodes, if required. The DGASA land routes are nominally 3km in length so a nominal annual budget of $100,000 is reasonable.

These components of Landing Sites OpEx are referred to as OSP Maintenance, CLS Maintenance Charges and NOC Charges respectively in Table 22: Annual OpEx Budget Estimate.

8.2.4 Marine Maintenance

As already discussed in Section 6.1, the DGASA system will have to be entered into two marine maintenance agreements. For the purposes of this analysis, we will assume that these will be ACMA in the east and SPMMA in the west. The DGASA system owners will need to nominate what is called the 'System Maintenance Authority'. This will be an individual or a group of people responsible for administering the marine maintenance agreements, plus any depot agreement(s) and most importantly directing repair operations and replacing consumed spare plant. The MMA will be an employee of a SPV or will usually be provided by one signatory under a C&MA. The role of the MMA is normally budgeted as a general administration cost, as it is ongoing with or without the need for repairs.

The cost of marine maintenance is the dominant O&M cost for a submarine system. It will be split into five main categories:

1. Annual Standing Charges for the Maintenance Agreement
2. Depot Charges (if applicable)
3. Running Costs for any repair
4. Replacement of consumed spare submerged plant
5. Third party liaison and cable awareness (this is sometimes included in general administration).

The DGASA system is nominally 14.795km long so based on an estimate of the current ACMA/APMA and SPMA charges, being currently on the order of $300/km, it will attract an annual Standing Charges of on the order of $4,438,500.

It is almost certain that DGASA spare submerged plant will be stored in a depot at each base port, so a separate Depot contract will be required. Generally, the depot owner will offer a range of services: storage of cable, costed by volume, storage of housings (repeaters, BUs, equalizers), storage of jointing kits, periodic testing, cable and housing handling i.e., transfers within the depot loading and discharge plus scraping of recovered submerged plant. The nominal spare for the DGASA System 740km of spare cable so an annual Deport Charge of on the order of $110,000 should be budgeted for the two depots

Running Costs under the ACMA/APMA and SPMMA agreements are currently on the order of $30,000 per day. As explained in Section 6.4 the duration of a repair operation will depend on a wide range of factors. For this analysis we will consider a simple repair on the Easter Island continental shelf repaired by the SPMA ship and a simple repair on the Valparaiso continental shelf repaired by the ACMA/APMA ship.

From the analysis carried out in Section 6.4, the repair at Easter Island will take 23.4 days from notification to completion of the final splice. The repair vessel must then clear out, passage back to the base port, discharge spares and scrap and then demobilize. This will take an additional 15.4 days making a total of 38.8 days. For Budgeting purposes and additional a weather contingency of say 20%, for winter repairs giving a total of 46.5 days, which equates to a Running Cost of $1,395,000. For the repair off Valparaiso by the ACMA/APMA repair vessel, based on the Section 6.4 analysis, the duration from notification to completion of final splice would be 27.4 days. To complete this repair an additional 16.7 days will be required before the repair ship is demobilized, making a total of 44.1 days, plus a 20% weather

contingency gives a total of 53 days, which equates to a Running Cost of $1,590,000. On top of the repair vessel Running Costs the DGASA owners will incur depot costs for handling submerged plant and disposing of recovered scrap. Smaller costs should also be budgeted for representative travel and system testing support from the CLSs and the NOC.

Based on the average fault rate in the Pacific region a fault rate for the DGASA system can be expected to be on the order of one fault every five years, and the total cost of a single repair is $1,750,000, which should be covered by an annual budgeted of $350,000.

For replacement spare plant, the DGASA owners will probably be able to retain the unit pricing under the supply contract for all the submerged plant for the warranty period (typically 5 years), but after that unit pricing and perhaps more importantly, delivery timescales will be subject to market forces. If systems suppliers have full order books, small orders of replacement spares will have low priority so lead times can be extremely long.

8.2.5 OpEx Cost Summary

Table 22: Annual OpEx Budget Estimate

US$ (thousands)	Valparaiso	Juan Fernández	Easter Island	Auckland	Sydney	System	Total
Marine Maintenance - Standing Charges						$4,439	$4,439
Deport Charges						$110	$110
Marine Maintenance - Running Costs						$350	$350
OSP Maintenance	$100	$100	$100	$100	$100		$500
CLS Maintenance Charges	$1,300	$1,300	$1,300	$1,300	$1,300		$6,500
NOC Charges						$120	$120
Total	**$1,400**	**$1,400**	**$1,400**	**$1,400**	**$1,400**	**$5,019**	**$12,019**

8.2.6 Final Implementation Recommendations

TMG/WFNS have concluded that the implementation of the DGASA system can be successfully achieved and that at the time of this report there are no high or unusual risks to this proposed system from the perspective of installation. The data gathered and assessed indicates this effort would fall within typical implementation parameters with typical project risks and considerations. The route selected mitigates geopolitical risks and with the system expected to be well received and generate interest from potential partners and consumers looking for alternative and more economical route options.

9. Economic Evaluation

9.1 Institutional Model assessment

9.1.1 Introduction

The selection of an institutional model for this project will depend on various strategic considerations.

Institutional model considerations for the DGASA main cable and Chilean landing party considerations for DGASA participation are addressed in the following sections. Each subsection includes an institutional model risk assessment. Further consideration of alternative institutional models is elaborated in Appendix C of Report 2.

9.1.2 Institutional Model Considerations

There are two main institutional models used internationally to organize and operate submarine cable networks: (1) an incorporated entity or consortium and (2) an unincorporated consortium.

An **incorporated entity or group of related incorporated entities** remains a preferred option for a single-owner submarine cable system or a multi-owner system in which equity participants intend to operate the cable system as a single for-profit enterprise. In recent years, single-owner cables by international content providers, such as Google, have favorably embraced the incorporated structure, which was once the exclusive province of international network operators like Cable & Wireless.

In contrast, the **unincorporated consortium**, with the relationship among consortium members governed by a C&MA, has proved to be a flexible and resilient institutional model for submarine cable systems operated as shared cost centers. The unincorporated consortium structure has adapted for modern and dynamic markets to include participation by domestic and international network operators and content providers.

Table 23: Comparisons of Typical Characteristics of Incorporated and Unincorporated Institutional Models compares the key ownership features, governance features and the landing party arrangements typically employed under both institutional models.

Table 23: Comparisons of Typical Characteristics of Incorporated and Unincorporated Institutional Models

	Key Ownership Features	Key Governance Features	Landing Parties
Incorporated Consortium	The sole interest of each ordinary equity investor is ordinary shares of the parent entity of the cable system group of entities. Such shares are held with the prospect of receiving dividends as the sole return on investment.	Governance follows the applicable principles of the entity law for the parent entity. Typically, the affairs of the group are managed by the parent entity's board of directors (or similar body), which has fiduciary duties to shareholders and creditors under applicable law.	Equity owners may or may not serve as a landing party in one or more countries. Equity owners may use an unrelated landing party.

	Key Ownership Features	Key Governance Features	Landing Parties
Unincorporated Consortium	Requires two or more ordinary equity owners of a cable system. Typically structured so that it is not recognized as a separate person from its members for regulatory, tax, or other purposes. Principal economic interest of each ordinary equity investor is capacity rights in the shared infrastructure.	Governance follows the principles established in the C&MA, which is the governing contract for the consortium. Management committee functions similar to a board of directors of an incorporated entity except that each management committee member only has fiduciary duties to the consortium member he or she represents (unless otherwise provided in the C&MA).	Members may or may not serve as a landing party in one or more countries. Unlike the incorporated structure, the consortium members generally would not establish their own jointly owned landing party in any landing country where no consortium member will serve as landing party. Instead, a third party will typically serve as landing party.

Source: TMG/WFNS

Of the 28 cable systems examined in the case studies in Appendix A of Report 2, 16 adopted an incorporated enterprise model and 12 adopted an unincorporated consortium model. The 16 cable systems with an incorporated enterprise model include 14 single-owner cables and two multi-owner cable (both owned by the same equity investors). Of note, all but two of the multi-owner systems opted for an unincorporated consortium model. These results are summarized in Table 24: Summary of Institutional Models Employed by Case Study Cable Systems.

Table 24: Summary of Institutional Models Employed by Case Study Cable Systems

Institutional Design	Incorporated Enterprise		Unincorporated Consortium
	Single-Owner	Multi-Owner	
Names of Cable Systems	AMX-1, BRUSA, Curie, Deep Blue, EllaLink, GlobeNet, Hawaiki,[2] PAC, SABR, SACS, Sam-1, SAPL, Seabras-1, SAEx-1	Southern Cross and Southern Cross Next	AAG, Americas-II, Monet, PAN-AM, PCCS, PLCN, SAC, SAIL, SEA-US, Tannat, Unity, HKA
Number of Cable Systems	14	2	12

Source: TMG/WFNS

In addition, it should be noted, that the capacity Indefeasible Right of Use (IRU) is the preferred mechanism to sell enduring non-equity capacity interests in cable systems with incorporated or unincorporated ownership structures.

[2] Hawaiki Submarine Cable LP owns all capacity on main cable. Capacity IRU purchaser American Samoa Telecommunications Authority owns a branching unit installed on the main cable.

9.1.3 Primary Drivers of Institutional Model Selection and Design

Institutional model (incorporated or unincorporated) and design (entities, roles and relationships) reflect three primary factors, as follows: (1) accommodating the desired common enterprise among equity participants; (2) mitigating regulatory burdens and (3) mitigating tax burdens.

A single-owner cable system has no choice but to adopt an incorporated structure. However, a multi-owner system (as is expected to be the case of DGASA) can adopt either an incorporated or unincorporated structure. The driver of whether or not to incorporate will be the desired common enterprise among the owners. However, many aspects of both incorporated and unincorporated institutional models are designed to mitigate extraterritorial reach of regulation and taxation.

As the total number of ordinary equity participants and the diversity of their business models, geographic locations and intended capacity uses for a submarine cable system increase, it becomes more likely that they can only align their interests by limiting their joint activities to sharing infrastructure costs rather than conducting a common for-profit enterprise. Though details vary, the number of entities involved in either an incorporated or unincorporated model tends to increase with the number of landing countries and equity owners. Both institutional models can have a relatively elaborate structure involving a separate entity in each landing country.

Table 25: Scenarios to Favor Shared Profit Center Versus Shared Cost Center and Potential Benefits summarizes the main scenarios that typically favor one or another of these objectives and their potential benefits.

Table 25: Scenarios to Favor Shared Profit Center Versus Shared Cost Center and Potential Benefits

	Scenario	Benefits
Shared Profit Center	1. Single entrepreneur or network operator sponsors the cable project as an ordinary equity investor and the remaining ordinary equity participants are institutional or public investors who will rely on the efforts of the project sponsor to ensure a positive return on their investment. 2. Multiple operators want to attract institutional equity and debt investment in their common venture 3. Retail network operators who compete want to develop a shared cable project likely to have capacity in excess of their combined needs and want to collaborate in commercializing the excess capacity	Institutional investors can acquire ordinary and preferred equity at the enterprise level. Institutional lenders (commercial and concessionary) can lend at the enterprise level. All ordinary equity investors are aligned in common pursuit of profit.
Shared Cost Center	1. Retail network operators who generally operate in different geographic or service markets want to develop a shared cable project to meet their own capacity needs but would prefer to commercialize any excess capacity independently of each other. 2. A wholesale network operator wants to participate in a cable project as an ordinary equity owner.	Enables participants better to manage risk by limiting their investment to inputs to their businesses, i.e., the capacity they believe they can profitably exploit and providing them with exclusive control over how they exploit it. Avoids the need to develop, pursue and evolve a common vision for profit.

	3. A content provider wants to participate in a cable project as an ordinary equity owner	Enables equity participants in the retail and content businesses to procure the capacity they need (in a role which gives them more governance rights than a capacity IRU purchase) without having to participate in the risks of establishing a separate wholesale IP transit business in the highly competitive global markets

Source: TMG/WFNS

Submarine cable system owners also tend to structure their ownership arrangements around limiting extraterritorial application of telecom regulation and national taxation and fiscal impositions. When an entity is subject to a country's telecom regulatory framework by reason of having been issued a license or otherwise based on its ownership of assets or provision of services in the country, the sector regulator typically has the authority to impose various obligations on that entity that may burden operations of the cable system outside the territory. Such burdens may include, for example, local incorporation requirements, foreign ownership restrictions and regulation of access to capacity in the cable system. Similarly, for taxation purposes, submarine cable owners usually employ country-specific entities. Each such entity must comply with national tax laws of the country(ies) in which it is incorporated, domiciled and/or has a physical presence. Other entities are generally beyond reach of a country's tax laws to the extent contractual arrangements among separate cable system ownership entities are at arm's length.

The main impacts and institutional options typically implemented to limit extraterritorial application of regulation and taxation are summarized in Table 27: Risk Assessment of DGASA Main Cable Institutional Models.

Table 26: Summary of Impacts and Institutional Options to Address Extraterritorial Regulation and Taxation

Driver of Institutional Design	Impact	Institutional Options
Limiting Extraterritorial Telecom Regulation	Cable system and its owners may be subject to unnecessary financial and other burdens associated with telecom regulation. Cable system and its owners may be subject to conflicting obligations in different landing countries	Structuring the cable owner group so that all assets and activities in each jurisdiction are owned and operated by a locally incorporated entity that does not own assets or do business outside the landing country's territory.
Limiting Extraterritorial Taxation	Increase cable owners tax liability and tax compliance requirements	Employ country-specific entities that must comply with national tax laws of the country(ies) in which it is incorporated, domiciled and/or has a physical presence.

Source: TMG/WFNS

9.1.4 Proposed Institutional Model for the DGASA System Main Cable

Based on the information available at this time, an unincorporated consortium is the optimal DGASA main cable system institutional model.[3] Structuring the DGASA cable system as a shared cost center will facilitate greater private sector equity participation. The shared cost center structure enables corporate investors to manage risk by limiting investment to their own international connectivity needs and retaining control over how they use their capacity.

The case studies discussed in Appendix A of Report 2 underscore this point. As the number of equity participants and diversity of their businesses and geographic locations increase, they usually can only align their interests by limiting joint activities to infrastructure and cost sharing rather than establishing a common for-profit enterprise.

The C&MA is the primary governance document for an unincorporated consortium. It addresses:

- Design and procurement
- Operation, maintenance and upgrading
- Ownership and capacity use rights
- Decommissioning and liquidation

The principal economic interest of each equity investor in an unincorporated consortium is capacity rights in shared infrastructure. Corporate finance is usually at *consortium member level* rather than *consortium level*. Each consortium member commits to pay an agreed share of cable system costs. A consortium member can fund its commitment from cash reserves or by issuing ordinary or preference shares, incurring funded debt and/or preselling capacity IRUs in the cable system.

Governance of an unincorporated consortium follows the principles established in the C&MA. Consortium affairs are usually directed by a management committee, which is similar to a board of directors, but each committee member only has fiduciary duties to one consortium member. The flexibility of a contractual relationship enables consortium members to have weighted voting rights in proportion to ownership. The C&MA may also require supermajority approval of certain matters.

The subsections below discuss the potential (1) cable system ownership and governance structure, (2) consortium member roles in procurement of the cable system, (3) consortium member roles in operation and maintenance of the cable system and (4) consortium member independence in commercializing DGASA cable system capacity

9.1.4.1 Potential DGASA Cable System Ownership and Governance Structure

Based on the information available at this time, it is anticipated that the DGASA main cable will likely include four groups of ordinary equity investors.[4] These will be formed by key investors in each of the three landing countries and a fourth category formed by content or Over-the-Top (OTT) provider(s). As noted, it is expected that this diverse group of potential equity owners will likely have different commercial objectives, making the unincorporated cost center a more attractive institutional approach

[3] It should be noted that, at this time, additional equity owners beyond the Chilean Government have yet to be identified. Accordingly, once all potential consortium members of the DGASA system are recruited, recommendations included in this report regarding the institutional structure may need to be revised.

[4] It is possible that the Australian and New Zealand groups are formed by the same equity investor or group of equity investors. In that case, the proposed institutional model would be reduced to three groups of investors.

to incentivize participation in the project at this time. Should this situation change, then it could be justified to revisit this issue.

As noted, the C&MA will determine the ownership and exploitation rights of each of the consortium members of the DGASA system. At a high level and taking account that negotiations between Chilean government promoters of the DGASA system and other potential equity investors should take place in the near future, the following ownership and governance issues will need to be addressed within the DGASA consortium:

- The main cable route from Valparaiso to Sydney will be comprised by 16/18 fiber pairs. It can be expected that each group of equity investors will own a specific number of fiber pairs on the main route.
- The New Zealand branch comprises 4 fiber pairs. It is unclear at this time how ownership over these fiber pairs will be allocated between consortium members.
- The Juan Fernández and Easter Island branches comprise 2 fiber pairs. It can be expected that the Chilean group will own such fiber pair.
- Each consortium member will likely be responsible for procuring its own SLTE for activating and using its dark fiber pairs and may select its own SLTE supplier.
- The submarine cable (excluding the individually owned fiber pairs), the BU, all repeaters and all other common plant and equipment on each segment (excluding any components owned by the cable landing party and made available for use by the consortium members under a Landing Party Agreement (LPA)) will likely be owned by the consortium members in common in proportion to their ownership of fiber pairs in the relevant segment.
- Each consortium member can be expected to have exclusive right to use its fiber pairs in the DGASA cable system and to commercialize all capacity activated on those fiber pairs using its SLTE installed in the three CLSs (excluding Juan Fernández and Easter Island, which are expected to be owned and used exclusively by the Chilean group).

The C&MA will also establish the DGASA consortium's governance framework. It can be expected that the principal governing body will be an executive committee or similar structure likely comprising one member appointed by each consortium member. Each consortium member's voting rights (exercised through its representative on the executive committee) should be proportionate to its relative ownership of fiber in the relevant segment. Voting rights can be expected to differ on the main cable and the New Zealand, Juan Fernández and Easter Island branches, as discussed above

In addition, DGASA members will likely enter into LPAs governing the deployment, operation and use of CLS in the system. The members of an unincorporated consortium in each of the landing countries may or may not serve as landing parties for the cable system. In any landing country where no consortium member will serve as landing party, it is typical for a third party serve as landing party and enter into an LPA. Where the consortium members act as landing parties, they will enter into LPAs making them contractually responsible to the other consortium members for the CLS(s).

The following graphic illustrates the potential institutional structure of the DGASA consortium.

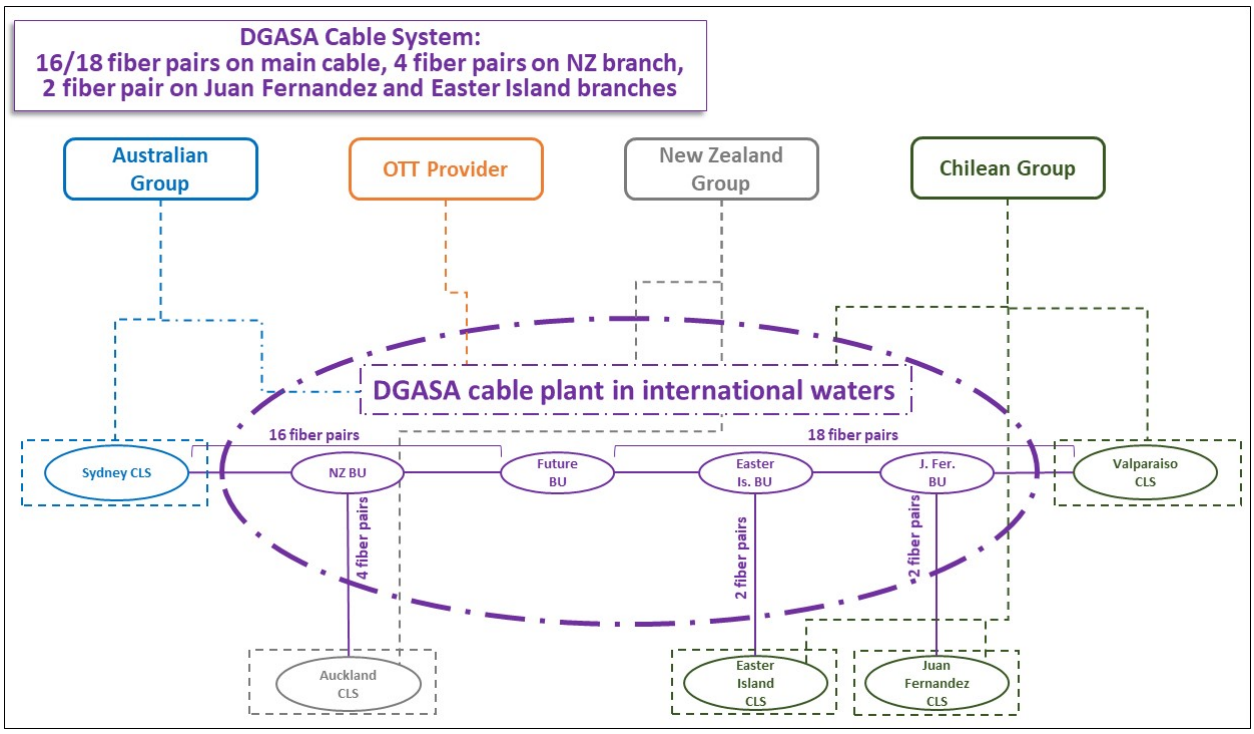


Figure 59: Proposed DGASA Main Cable Institutional Structure

Source: TMG/WFNS

9.1.4.2 Potential Consortium Member Roles in Procurement of the DGASA System

After entering into the C&MA, the DGASA consortium members will need to procure the supply and construction of the main cable system, their separate SLTE and the CLSs and associated terrestrial works. This will likely include the following primary elements:

- Each consortium member, directly or via the legal entities designated to this end, will enter into a supply contract with a recognized supplier to procure the main cable system.
- Each consortium member will enter into a supply contract to procure its SLTE.
- Consortium member that serve as landing parties will enter into contracts to procure and/or make ready the CLSs for which they were separately responsible. It is expected that the DGASA system will leverage existing CLSs in Valparaiso, Chile, Auckland, New Zealand and Sydney, Australia, since these are existing demand-aggregation points with existing infrastructure, hence these structures will not need to be constructed. Instead, potential updates and other investments may be needed to make them ready for DGASA. Conversely, CLSs in Juan Fernández and Easter Island must be procured.

These activities are depicted in the following diagram.

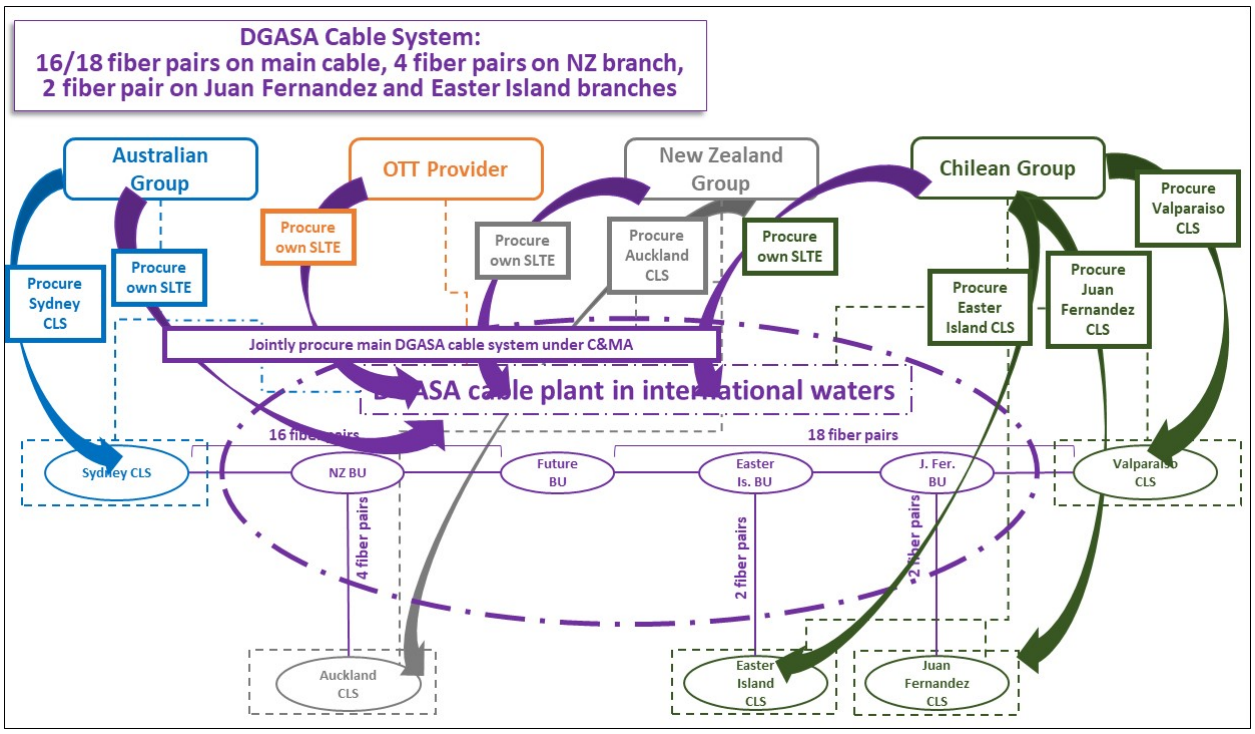


Figure 60: Proposed DGASA Consortium Procurement Responsibilities by Entity

Source: TMG/WFNS

During the procurement stage, the consortium members would need to invest cash to pay suppliers to cover their own and their portion of shared CapEx and pre-RFS OpEx. These payments are typically paid directly by each consortium member to the relevant suppliers. For accounting purposes, they are usually treated as capital expenditures by the individual consortium members for procurement of their respective ownership and rights of use in the shared and individual elements of the cable system.

In addition, each cable landing party would also need to fund the CapEx and pre-RFS OpEx for the CLSs for which it is responsible. These amounts are also usually paid directly by the cable landing party. These expenses may be fully absorbed by the respective cable landing parties. Or they may qualify for reimbursement by other consortium members so as to distribute the local landing party costs in an agreed proportion. It is not known how the DGASA consortium members will handle these matters.

Each DGASA consortium member is expected to be responsible for sourcing its own capital to invest in the DGASA cable system CapEx and pre-RFS OpEx.

9.1.4.3 Consortium Member Potential Roles in Operation And Maintenance of the DGASA System

After the cable system is RFS and has been handed over by the main supplier, the consortium members would undertake operations and maintenance of the completed cable system through the contractual structure they establish in the C&MA. This could include the following primary elements:

- Consortium members or their affiliates would likely enter into joint contracts with suppliers for operations and maintenance of the main DGASA cable system.
- Each consortium member or its affiliates would enter into a separate contract for O&M of its SLTE equipment.

- Each landing party (or the third party to whom it had outsourced such responsibility) would operate and maintain the CLSs for which it is responsible.

These activities are depicted in the following diagram.

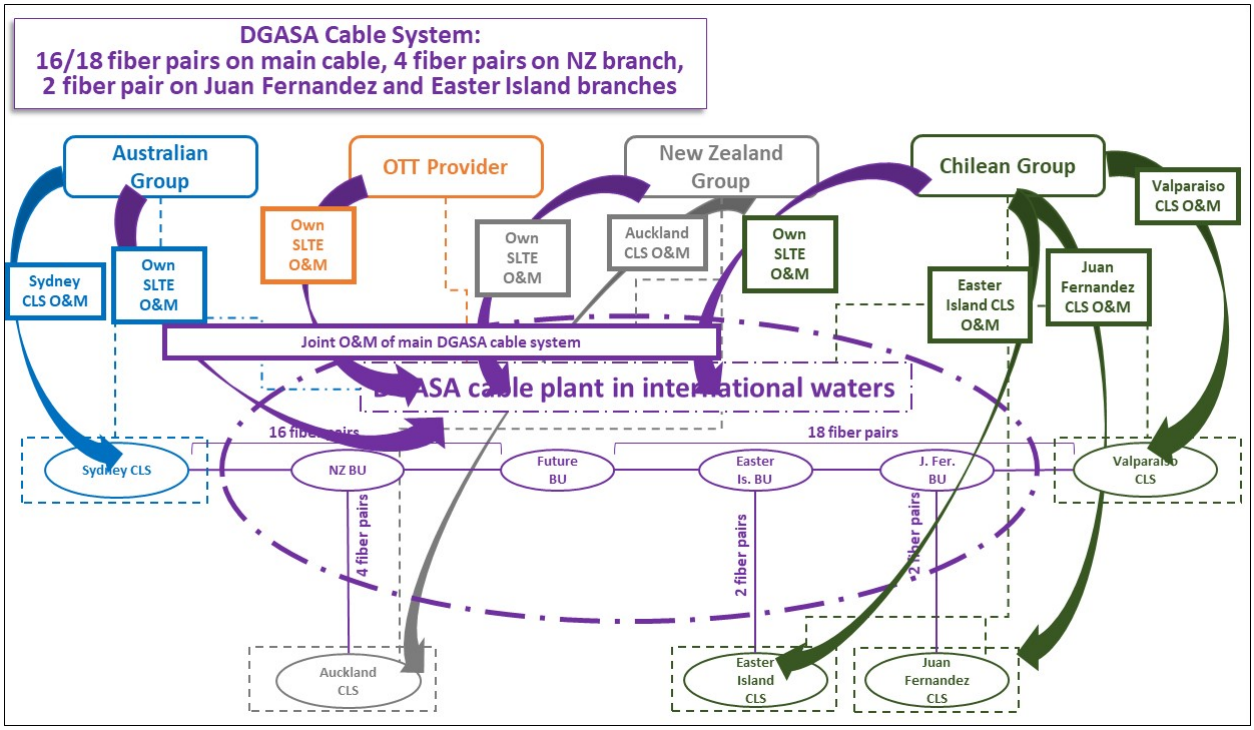


Figure 61: Proposed DGASA System Operations and Maintenance Responsibilities by Entity

Source: TMG/WFNS

9.1.4.4 Consortium Member Independence in Commercializing DGASA System Capacity

As a shared cost center, the objective of the unincorporated consortium is to procure capacity for use by its members. All capacity on the DGASA is expected to be owned by the individual consortium members. Each consortium member and its affiliates will commercialize its capacity allocation independently according to its own business model in the geographic and service markets in which it conducts business.

Capacity may typically be commercialized by a member of an unincorporated consortium in one of two ways: (1) as a self-provisioned input to the consortium member's other retail and wholesale offerings; or (2) as a separate wholesale offering through capacity IRU sales and/or the provision of capacity services.

Each DGASA consortium member may employ different affiliates within its group to self-provision or sell capacity rights and services depending on the local regulatory or tax regime of a particular landing country. The following is a typical approach adopted by unincorporated consortium members to limit their extraterritorial regulatory and tax obligations:

- Self-provisioned capacity will be used by the relevant member of the consortium member's group, including local entities and/or foreign entities, depending on the nature of the integrated service.
- The local group entity will make all sales of capacity services and leases to customers in a country in which it does business.

- Sales of capacity IRUs or leases to customers within a country may be made by another entity if those sales will be considered casual sales that do not constitute a permanent establishment and/or the provision of services within that country by the other group entity.
- Otherwise, sales of capacity IRUs to customers within a country will be made by the local group entity.
- All sales to customers who do not have a permanent establishment and are not doing business in any landing country (such as transit services which form part of a traffic route that transcends the landing countries), including sales of capacity IRUs and capacity services, may be made by any group entity, depending on its regulatory and tax structure.

These potentially diverse arrangements for independent commercialization of capacity on a submarine cable system by members of an unincorporated consortium are boundless. These will depend on the commercial objectives of each DGASA member. For example:

- Large content or OTT providers typically use submarine cable systems in which they invest for carriage of internal telecommunications traffic to support their global content and information services business.
- National/international telecommunications carriers typically use submarine cable systems in which they invest as a self-provisioned input to its retail offerings. In addition, they typically commercialize excess capacity to develop or expand their wholesale international capacity businesses.

9.1.4.5 Risk Assessment of DGASA Main Cable Institutional Model

The key institutional model project risk is failure to attract private sector equity participation in the DGASA system. Private participation is essential to success. The risk of the institutional model dissuading private investment is compared in Table 27: Risk Assessment of DGASA Main Cable Institutional Models below.

Table 27: Risk Assessment of DGASA Main Cable Institutional Models

Key Project Risk	Issue	Potential Adverse Financial Impact	Possibility Risk Occurs	Mitigation Measure	
Failure to enlist private network operator or content provider investment in DGASA ordinary equity	Private investor participation is essential to reduce public financial burden and ensure the DGASA system will benefit from industry knowhow and downstream commitments to the cable system	High	High, if institutional model chosen is not fit-for-purpose	Selecting an institutional model that is fit-for-purpose can mitigate the likelihood of this risk materializing:	
					Mitigates risk
				Adopting an unincorporated consortium operated as shared cost center	Yes
				Adopting an incorporated entity operated as shared profit center	No

Source: TMG/WFNS

When a cable system equity investment is structured as a for-profit commercial enterprise (e.g., an incorporated consortium), institutional investors can acquire ordinary and preferred equity at the

enterprise level. Institutional lenders (commercial and concessionary) can lend at the enterprise level. All ordinary equity investors are aligned in common pursuit of profit.

On the other hand, when cable system equity investment is structured as an interest in shared infrastructure or cost center (i.e., an unincorporated consortium), corporate participants can more easily navigate internal and external restrictions on investments in businesses they cannot control. The shared cost center structure enables them to better manage risk by limiting their investment to inputs to their businesses (i.e., the capacity they believe they can profitably exploit) and providing them with exclusive control over how they exploit it. It avoids the need to develop, pursue and evolve a common vision for profit. Importantly, it enables equity participants in the retail and content businesses to procure the capacity they need (in a role that gives them more governance rights than a capacity IRU purchase) without having to risk establishing a separate wholesale Internet Protocol (IP) transit business in the highly competitive global markets.

9.1.5 Proposed Institutional Model for the Chilean Member of the DGASA Consortium

In selecting and recruiting an existing entity to serve as a country's DGASA consortium member, a public sponsor will have little or no control over that entity's own institutional structure. However, in the case of the DGASA system, at present it has become clear that the Chilean government, as key sponsor of the project, will be required to establish an entity to serve as Chile's DGASA consortium member. Accordingly, the Chilean government, through its instrumentalities, will have more control over the local consortium member's own institutional structure. The institutional model chosen for the Chile's DGASA consortium member has significant implications for potential equity investors and therefore requires thoughtful planning and effective advocacy with prospective participants.

The Chilean government has chosen to participate in the DGASA system via the Fondo de Infraestructura S.A., also known as DP. Based on the information available at this time, two potential institutional models are identified for the Chilean member of the DGASA consortium: (1) a shared profit center Public-Private Partnership (PPP); or (2) a shared cost center PPP.[5] These institutional models harness both private and public resources. As project promoters, including SUBTEL and DP, advance in the search for Chilean equity investors for the project and obtain more information on the commercial and strategic objectives of such potential partners, further review and adjustments to these options will likely be warranted to select the optimal institutional model for the Chilean member for the DGASA consortium.

The following subsections discuss the legal framework governing DP as well as each institutional model identified above. A comparative risk assessment of the alternative institutional models is then presented.

9.1.5.1 Overview of the Legal Framework Governing DP

The Chilean government has chosen to participate in the DGASA system via DP. DP is a 100% SOE created to serve as the Chilean government´s vehicle to finance and invest in infrastructure projects. The Chilean state owns 99% of DP and the *Corporación de Fomento de la Producción* owns the remaining 1%. Governed

[5] This report does not discuss three additional potential institutional models that could be used to set up the Chilean member of the DGASA consortium. First, a 100% private-owned entity was discarded as work undertaken during the demand study phase of this project found that public participation will be required to implement the project in Chile. Second, a 100% state-owned entity (SOE) is not discussed as an option for the Chilean consortium member as it has been discarded by the Government of Chile because DP does not have the expertise to independently enter into the submarine cable market and is seeking a private strategic partner with industry know-how for this venture. Third, a hybrid shared cost center and shared profit center model does not initially appear to accommodate DP's objectives to seek a partnership with a strategic investor. These additional institutional models are nevertheless discussed at length in Annex C of Report 2 of this project.

under Law Nº 21.082 of 2018, DP formally began operating on January 4th, 2019 when it held its first shareholders meeting. The DGASA system is expected to be the first project in which DP will participate.

Importantly, Law Nº 21.082 defines the legal framework under which DP must operate. This has a direct impact on how the Chilean government will be able to participate in the DGASA system and, as a consequence, on the institutional structure of the Chilean member of the DGASA consortium in particular. At least the following key characteristics of this framework are relevant to this assessment:

- **Financing of DGASA**: DP may participate in the project via an equity investment as a shareholder in the DGASA main cable consortium. It may do so by directly investing in the project or indirectly through subsidiaries (50% or higher ownership) or affiliates (10% ownership or higher). DP may directly or indirectly hold equity ownership over an infrastructure company (InfraCo) or other entity that in turn will hold equity layer ownership rights over the DGASA system.
- **Build, Operate and Commercialize DGASA**: DP must use unrelated third parties to undertake so-called "ancillary services" over infrastructure it finances.[6] In the case of the DGASA system, these services include, at least, building, operating and commercializing submarine cable capacity on the system. DP must in turn select one or more third party operating companies (OpCo) to supply such ancillary services via a "public tender" process.[7] DP may design and implement an *ad hoc* "public tender" process consistent Law Nº 21.082 to select the OpCo.[8]
- **Profitability of DGASA and government guarantees**: DP may only invest in projects that are deemed profitable and can thus not subsidize infrastructure projects.[9] Similarly, DP cannot obtain any form of government guarantees to back its investments. [10]

It should be noted that this framework does not predetermine the choice of institutional model for the Chilean member of the consortium in which DP will participate. It does however create restrictions on which projects DP may invest in (only profitable projects), activities DP may engage in directly or indirectly (no operational activities are allowed) and the financing options available to DP (no government backing nor sovereign guarantees would be available).

Relevant for the proposed institutional model is that under any structure that is ultimately chosen by DP and its partners in the future, DP must select an OpCo to implement marketing, operational, maintenance activities on its behalf. As such, the institutional model structures discussed below include an OpCo that must be selected by DP following a "public tender" process compliant with Law Nº 21.082. Section 9.2 discusses the specific arrangements and compensation options for the OpCo.

9.1.5.2 Shared Profit Center PPP

Where DP is able to enlist private participation in Chile's DGASA consortium member alongside its participation, a shared profit center PPP is one of the models that should considered to structure this entity. Selection of this institutional model implies that participants in the PPP want to establish the local DGASA consortium member as a for-profit enterprise rather than a shared cost center. This would take the form of a SPV incorporated under Chilean law.

It is not uncommon for public sponsors of PPPs to push for establishing a shared profit center. The Chilean government and DP in particular, is not in the telecommunications or content business and therefore (1) does not have experience or know-how in this market and (2) does not have direct use for cable system

[6] Law Nº 21.082, arts. 2 and 5. This assumes that DP will have an ownership stake in the DGASA system above 5%.
[7] Law Nº 21.082, arts. 2 and 5.
[8] Law Nº 21.082, arts. 2 and 5.
[9] Law Nº 21.082, arts. 2 and 5.
[10] Law Nº 21.082, art. 27.

capacity (although public institutions are often significant users of international capacity). Establishing a shared profit center may thus offer DP a mechanism to recoup its public investment through future dividends and earn a profit.

For the case of DGASA, the shared profit center PPP is likely the optimal institutional model where DP is only able to recruit one private sector equity investor in the PPP (excluding the strategic partner). Even under these circumstances, however, DP may need to provide some or all of its share of capital expenditures with the possibility of not obtaining any return on or of the investment.

The following graphic illustrates the potential institutional structure of the shared profit PPP for the Chilean consortium member.

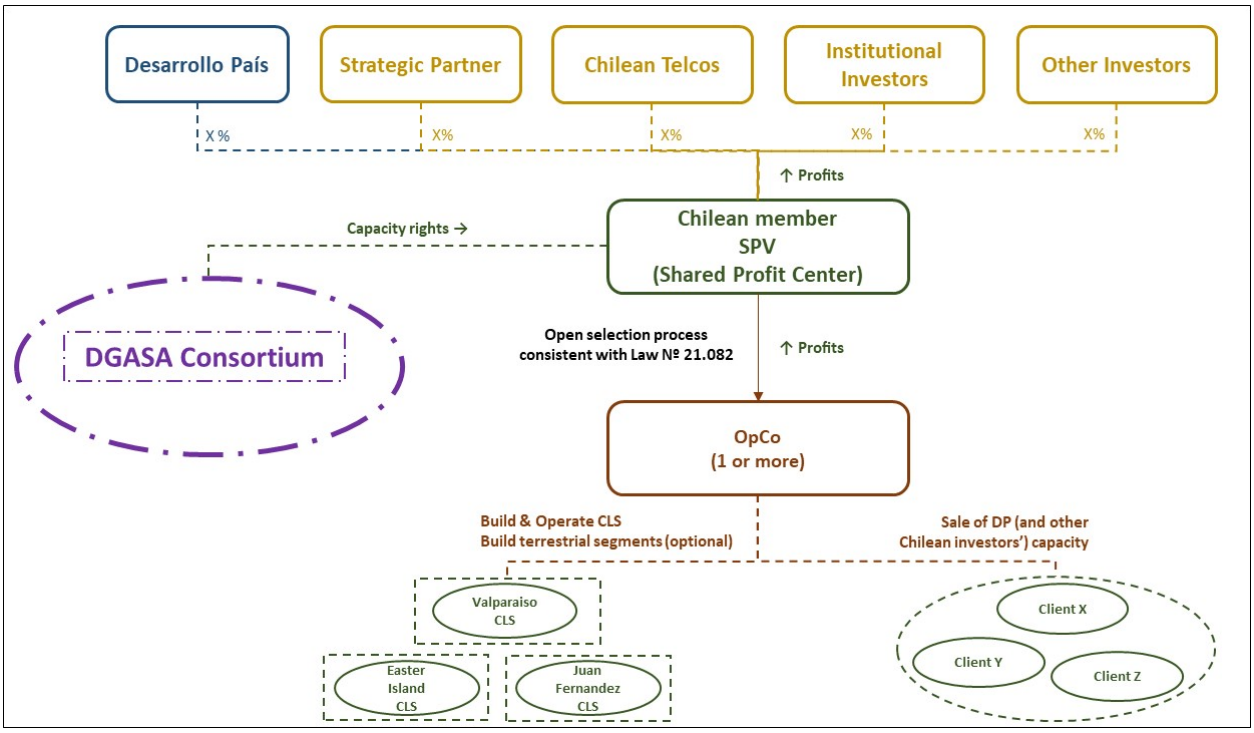


Figure 62: Chilean Member Institutional Structure as a Shared Profit Center PPP

Source: TMG/WFNS

It should be noted that where more than one private participant expresses interest in equity participation in a PPP that will serve as the Chilean member of the DGASA consortium a shared profit center is only an optimal institutional model if it aligns with private investor desires for the common enterprise. Because industry investors often prefer to share costs rather than profits, there are few examples of for-profit PPPs formed to serve as national members of a cable consortium.

Accordingly, a for-profit enterprise PPP (or SPV as shown in Figure 62: Chilean Member Institutional Structure as a Shared Profit Center PPP) is typically not an optimal institutional model for the local member of an unincorporated cable consortium. Establishing the Chilean DGASA consortium member as a separate profit center may chill or suppress the level of private investment for some of the same reasons network operators and content providers seldom establish submarine cable consortia as shared profit centers (i.e., as an incorporated consortium). In particular, retail telecommunication network operators and content providers may see no advantage in being ordinary equity investors in the PPP and may instead opt to purchase capacity IRUs. Wholesale network operators may view the PPP as a potential competitor

and would not want to support its entry into the market. This could explain (at least in part) the lack of interest in participating as investors in the DGASA system expressed to date by Chilean retail telecommunications network operators (such as Telefonica or Entel) and by wholesale network operators (such as Telxius).[11]

A for-profit PPP also straddles two countervailing risks that make private sector investors wary. One is commercial risk typical in any submarine cable business venture. This is the risk that demand on the route is insufficient to ensure financial viability and investments may be stranded and unprofitable. The other is regulatory risk. This is the risk that demand is sufficient to ensure financial viability, but the PPP's dominance on the route leads the sector regulator to regulate wholesale prices provided by the PPP. Private network operators can better hedge both risks by purchasing capacity IRUs for their own use, at a level which aligns with their own demand estimates, rather than investing in the PPP. This may occur where the Government's choice of institutional model for the consortium member PPP as a separate profit center confers a *de facto* monopoly on the routes. This can later lead to monopoly rents, which will either suppress performance of the domestic telecom market or require intervention by the sector regulator to regulate prices. For example, a recent study determined that average 2019 prices charged by Angola Cables (whose prices are currently not regulated) for IP transit to Europe over WACS were four to twelve times higher than prices charged for IP transit to Europe over WACS in Ghana (5X), Nigeria (8X), Senegal (4X) and South Africa (12X).[12]

9.1.5.3 Shared Cost Center PPP

Another PPP model that should be considered for the Chilean member of the DGASA consortium is the shared cost center. This PPP model is similar to the shared cost center model recommended for the main DGASA cable consortium (i.e., the unincorporated consortium model). Each PPP member receives capacity rights and is obligated to contribute to capital expenditures and operating expenses in proportion to its specified ownership interest as determined in the PPP agreement and the DGASA consortium C&MA. However, in most cases, an entity must be established to serve as a member of the cable consortium.

In establishing a PPP as a shared cost center, the parties typically face the same entity law issues discussed in the context of submarine cable equity owners. However, because all members of a cooperative PPP are expected to be located in Chile and an instrumentality of the Chilean Government (DP) will directly participate in the PPP, the parties can often find a way to overcome the entity law issues with less risk than for an international consortium. Further assessment of Chilean corporate law will be warranted to determine the optimal structure of a shared cost center PPP should this be the preferred model of Chilean equity investors in the DGASA system.

The following graphic illustrates the potential institutional structure of the shared profit PPP for the Chilean consortium member. In this scenario, DP together with potential institutional investors and a strategic partner(s) would incorporate a shared profit center depicted as SPV 1, which would in turn hold equity in the shared cost PPP depicted as SPV 2 and receive capacity rights on DGASA in return for capital contributions and operating expenses. SPV 1 would in turn commercialize these capacity rights via an OpCo as required by the legal framework governing DP. Chilean retail network operators, wholesale network operators and other investors would participate in the project via SPV 2 and exclusively share in the costs of the DGASA system. This would allow them to independently commercialize their capacity rights on the DGASA cable. SPV 1 and the other members of SPV 2 would subsequently enter into non-compete agreements. This structure could create additional incentives for multiple private sector

[11] See discussion in section 4.3 of Report 2 of this project.
[12] World Bank Group. 2019. Digital Reform Roadmap Baseline Assessment for Angola. Washington, DC.

participants in the Chilean member of the DGASA, as it would likely address the commercial and regulatory risks discussed above.

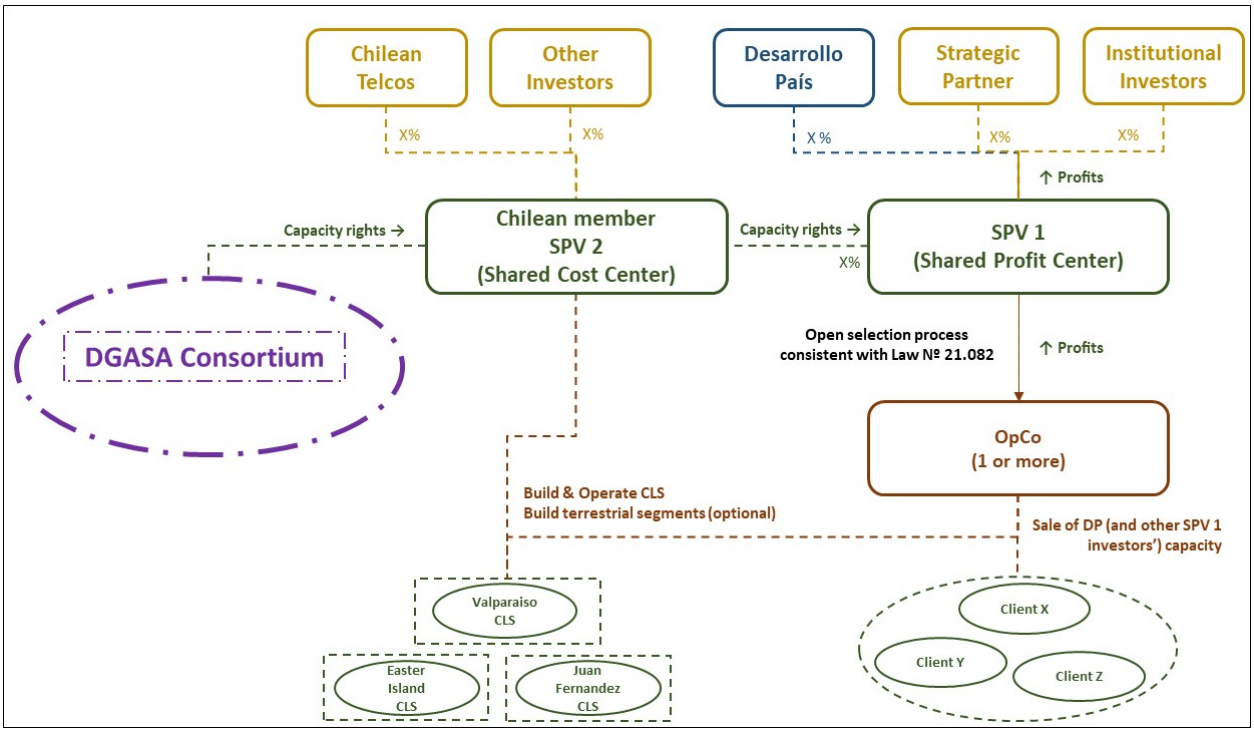


Figure 63: Chilean Member Institutional Structure as a Shared Cost Center PPP

Source: TMG/WFNS

9.1.5.4 Relative Risk Assessment of DGASA Consortium Member Institutional Models

A relative risk assessment of the alternative DGASA consortium member institutional models is summarized in Table 28: Risk Assessment of DGASA Consortium Member Institutional Models below. The "possibility of occurrence" as used in the table refers to the possibility that the institutional model adopted will dissuade private investment rather than the broader risk that some other factor, such as low demand, will dissuade private investment.

Table 28: Risk Assessment of DGASA Consortium Member Institutional Models

Key Project Risk	Issue	Potential Adverse Financial Impact	Possibility Risk Occurs	Mitigation Measure	
No private network operator or content provider invests in ordinary equity of a Chile's DGASA consortium member	Private investment is necessary to reduce the public investment required and ensure consortium member will benefit from private capital, industry know-how	High	High, if institutional model chosen is not fit-for-purpose	Selecting an institutional model that is fit-for-purpose can mitigate the likelihood of this risk materializing:	
					Mitigates risk
				Shared profit center PPP	Medium

Key Project Risk	Issue	Potential Adverse Financial Impact	Possibility Risk Occurs	Mitigation Measure	
	and downstream commitment to cable system			Shared cost center PPP	Yes

Source: TMG/WFNS

9.1.6 Conclusions

The selection of an institutional model for the DGASA cable system will depend on various strategic considerations. Taking account of the Chilean government's role as promoter of and investor in the DGASA cable system and the legal framework governing DP, the choice of the institutional model for the project should focus on two layers: (1) institutional model for the DGASA system main cable and (2) institutional model for the Chilean member of the DGASA consortium.

Based on the information available at this time, an unincorporated consortium or shared cost center is deemed the optimal DGASA system main cable institutional model. Structuring the DGASA cable system as a shared cost center will facilitate greater private sector equity participation. The shared cost center structure is widely used in multi-owner submarine cable projects and enables corporate investors to manage risk by limiting investment to their own international connectivity needs and retaining control over how they use their capacity. As additional equity owners beyond the Chilean Government are recruited for the project, DGASA consortium members will agree on a final institutional structure for the system which may differ from that proposed here.

Considering the legal framework applicable to DP, a Chilean SOE designated to participate as an equity owner in the DGASA project, two institutional models may be used for the Chilean member of the DGASA consortium: (1) a shared profit center Public-Private Partnership (PPP); or (2) a shared cost center PPP. These institutional models harness both private and public resources and will create incentives for participation in the DGASA project. As project promoters, advance in the search for Chilean equity investors for the DGASA system and obtain more information on the commercial and strategic objectives of such potential partners, further review and adjustments to these options will likely be warranted to select the optimal institutional model for the Chilean member for the DGASA consortium.

9.2 Business Model

9.2.1 Introduction

The section describes the business model for the DGASA cable system. The business model is the set of tactics and strategies defining how DGASA will deliver and sell its offerings. The primary components of the business model discussed in the section are presented in Table 29: Primary Components of the Business Model. The business model must be understood within the context of the institutional model chosen. The institutional model will determine, among other things, whether various potential stakeholders are interested in joining as customers or owners and how they perceive the value proposition of the system.

Table 29: Primary Components of the Business Model

Component	Description
Customer segments	Customer types that will be targeted to sell capacity on the system
Value proposition	Factors making DGASA services compelling to customers
Customer relationships	Arrangements made to acquire, maintain and grow the customers base
Key activities and resources	Actions and strategies to create, deliver and capture value
Financials	Revenue streams and cost of service delivery
Key partners	External parties for making the business happen, including investors, consortium partners and suppliers

Source: TMG/WFNS

9.2.2 Customer Segments

If one simplifies the world of the Internet into a mechanism of connecting eye-balls (end-users) to the location of content, one can identify the potential customer base for a submarine cable—the primary means of international Internet connectivity—as those entities providing the international link between the two. In the past, the primary deliveries of international connectivity, were major telecommunications operators or transit carriers. Some of these transit carriers were access providers to the end-users themselves while others were specialized firms, especially in the major international routes. These carriers tended to dominate the market for submarine cables, often creating consortia to do so.

More recently, content providers have been obviating transit carriers. As content volumes have increased, these content providers have no longer needed to purchase directly or indirectly capacity on multi-carrier systems. They have become owners, often sole owners, on cable systems.

To a far less extent, enterprise customers also purchase cable capacity to meet specialized needs. In relative terms, their share of the market, like that of carriers is decreasing vis-à-vis content providers. The figures below summarize these trends in terms of customer segments for submarine cable capacity. Figure 64: Evolution of Share of Used Capacity by Customer Type in Submarine Cables (2009-2019) illustrates the global increase in the relative size of content provider capacity acquisition.

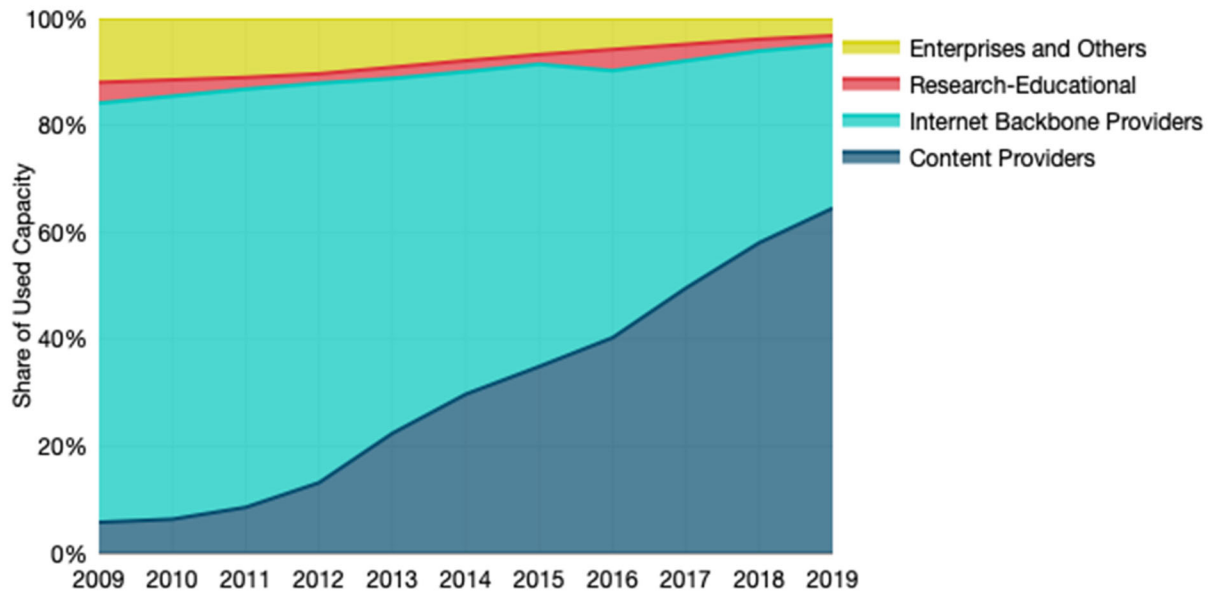


Figure 64: Evolution of Share of Used Capacity by Customer Type in Submarine Cables (2009-2019)

Source: TeleGeography

Consistent with the above trend, Figure 65: Share of Capacity by Customer Types for Major Routes (2019) illustrates that content providers already dominate capacity holdings of the systems in the large trans-Atlantic, transpacific and intra-Asia routes.

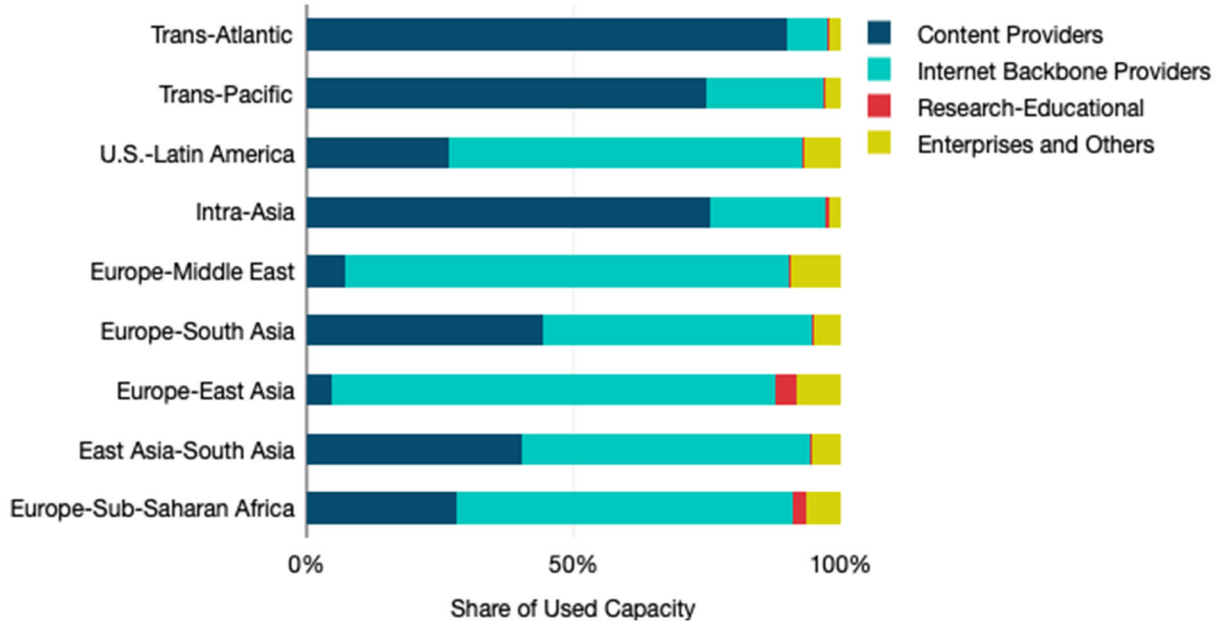


Figure 65: Share of Capacity by Customer Types for Major Routes (2019)

Source: TeleGeography

Considering these market trends, it is just a matter of time before content providers dominate most major routes, as their demand growth rates are substantially higher than that of other customer segments as shown in Figure 66: Compound Annual Growth Rates by Customer Type and Region (2015-19) below.

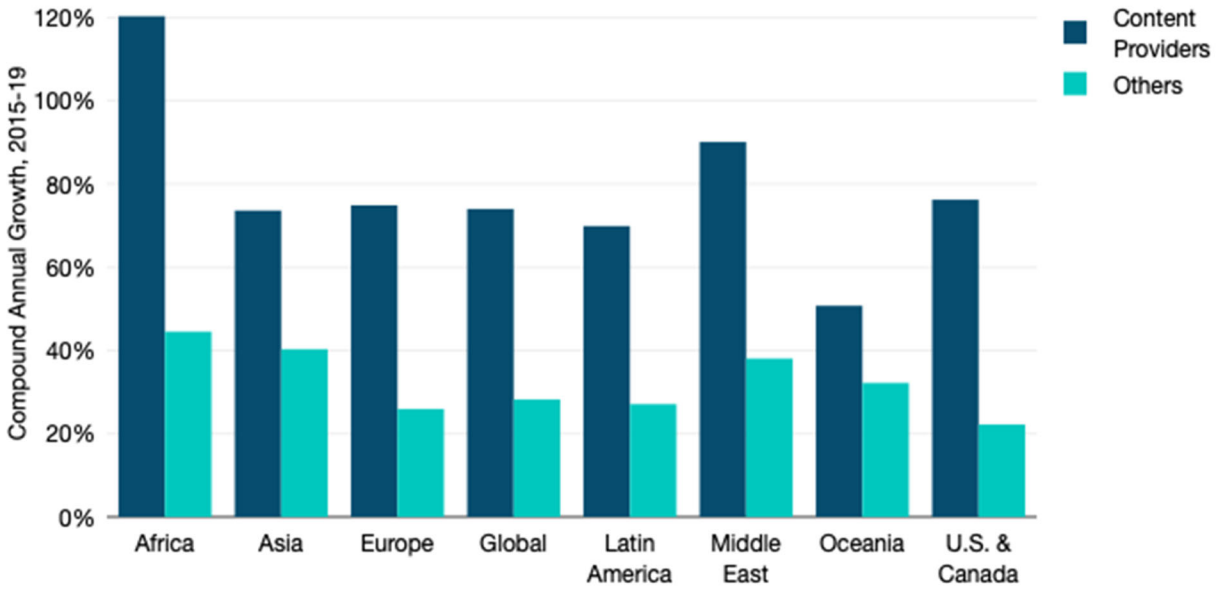


Figure 66: Compound Annual Growth Rates by Customer Type and Region (2015-19)

Source: TeleGeography

Based on the discussion above, the major potential customer segments for the DGASA cable are identified in in Table 30: Potential Customer Segments for the DGASA System. As has been address in Section 4.3 of Report 2, several of these potential customers have expressed some level of interest in the DGASA project.

Table 30: Potential Customer Segments for the DGASA System

Potential Customer Segments	
Americas-based carriers	Century Link, Entel, America Movil, Liberty Global, Telxius, Telecom Italia Sparkle
Americas-based content providers	Microsoft, Facebook, Amazon, Google, Netflix
Americas-based "others"	Enterprise and other minor players
Asia-based carriers	NTT, China Telecom, China Mobile, China Unicom, Korea Telecom, PCCW, COLT (and other international carriers with hubs/networks in Asia), Telstra
Asia-based content providers	Alibaba, Tencent, Rakuten
Asia-based others	Enterprise and other minor players

Source: TMG/WFN

It is important to recognize, again, that there is a degree of fluidity between the roles of owner and customer, which is related to the institutional model, the business mode and market circumstance. Depending on these factors, any given player may be interested in acquiring capacity on the cable through ownership rather than purchase, vice versa or a combination of both.

9.2.3 Value Proposition

There are essentially seven elements of value that DGASA will likely offer to its potential customers (Table 31: Elements of Value That DGASA Will Likely Offer).

Table 31: Elements of Value That DGASA Will Likely Offer

Value Proposition	Remarks
Increased capacity where constrained	Generally speaking, available capacity on most systems currently greatly exceeds lit or used capacity, so this may not be a relevant selling point. However, availability of an entire fiber pair is often constrained on older systems. There are a few very large players that may be interested in DGASA for the fiber pair availability.
Ownership opportunity	Several large players may be keen to own rather than lease capacity. Owning capacity means acquiring effectively at cost, it also means that they acquire large amounts of capacity and fiber pairs directly.
Improvement in service quality	The DGASA system is a *unique* value proposition for the South America to Asia route. Currently traffic between these two regions run at 300+ milliseconds. The DGASA system will at least halve the latency. Low latency will be a primary selling point and could justify prices at a significant price premium, depending on the relative latency differential and the service that it is being used for.
Route diversity	Large players buy capacity on multiple submarine systems to ensure network availability should one or more other cables go down. The DGASA system can serve as an option to ensure redundancy of traffic for such players.
Geographic diversity	Related to the above, service providers will be interested in back-up routes that are in geographically different places as geography-specific events can take out multiple cables in one area. This is a unique value proposition for the DGASA cable as it traverses uncovered territory in the Pacific. In addition, depending on the route chosen, the system could provide connectivity between South America and Asia without landing in the United States. This could also be an attractive proposition for certain potential customers.
Price	South America and Asia service providers will be able to send their inter-regional traffic at lower cost than the indirect routes.
Industry-specific/regional-specific requirements	There may be some specific requirements for certain industries or firms that will be much better met through the DGASA cable. For example, certain multinational mining operations have

Value Proposition	Remarks
	been identified that would benefit from direct connections among subsidiaries.

Source: TMG/WFNS

The customer segments are likely to be differentiated somewhat by these value propositions. Table 32: Relevance of Value Propositions for Different Customer Segments below summarizes that differentiation. It can be expected that at least some content providers will have the scale and more keen interest in fiber acquisition and ownership.

Table 32: Relevance of Value Propositions for Different Customer Segments

Customer Segment	Capacity Where Constrained	Ownership Opportunity	Improved Service Quality	Route/ Geographic Diversity	Price	Industry/ Region Requirements
Americas-based carriers			+	++	++	
Americas-based content providers	++	++	+	+	++	
Americas-based others			++		++	++
Asia-based carriers			+	+	++	
Asia-based content providers	++	++	+	++	++	
Asia-based others			++		++	++

Source: TMG/WFNS

9.2.4 Customer Relationships

The nature of the relationship with DGASA customers will depend on a number of factors beyond the type of customer described above. The following four key factors and their impact on the nature of the relationship are discussed below: (1) product and pricing; (2) landing market structure; (2) access point for the cable; and (4) specific needs.

9.2.4.1 Product and Pricing

Submarine cable product offerings and pricing are naturally a central feature of the customer relationship. As alluded to above, customers may be attracted to opportunities to invest or purchase products that have features of investment in order to get better pricing for capacity. Products are significantly defined by the sales arrangements that the customer chooses. Specific products and pricing for the DGASA system are discussed in more detail in section 9.3.3.2.

It is important to note that the price of terrestrial capacity between Santiago and other South American cities (particularly in Brazil and Argentina) is a central issue to the success of DGASA. Efforts must be

undertaken to ensure that the market delivers reasonably priced capacity so that the large markets, particularly on the Atlantic coast of South America, can utilize DGASA economically. Should market forces not deliver these results, then governments of South America may need to consider coordinated regulatory actions as discussed in section 4.6.8 of Report 2.

Similarly, it will be vital that fiber is secured from another submarine between Sydney and an Asia hub (e.g., Singapore) to allow capacity upgrades at a reasonable price over time.

9.2.4.2 Landing Market Structure

The diversity and nature of the customer relationships may be significantly impacted by the terms on which they gain access to the cable. Historically, the dominant telecommunications provider was typically the landing party for a submarine cable and would accordingly be the intermediary between a large variety of customers. As markets liberalized, the types of landing parties became more diverse. Still, the nature of the landing party may significantly determine whether DGASA will have a direct relationship with wholesale customers in any country. If the landing party is an integrated service provider, that offers end-user and wholesale connectivity services, it may discriminate against its competitors even in a liberalized market.

If the landing party is *carrier-neutral*, then the DGASA system may deal directly or indirectly with wholesale customers but will have some expectation that the whole market is open to its services. If the landing party operates on an *open access* basis, then not only can DGASA expect to have the opportunity to serve the entire wholesale market, but the terms on which each service provider access the market will be roughly equivalent.

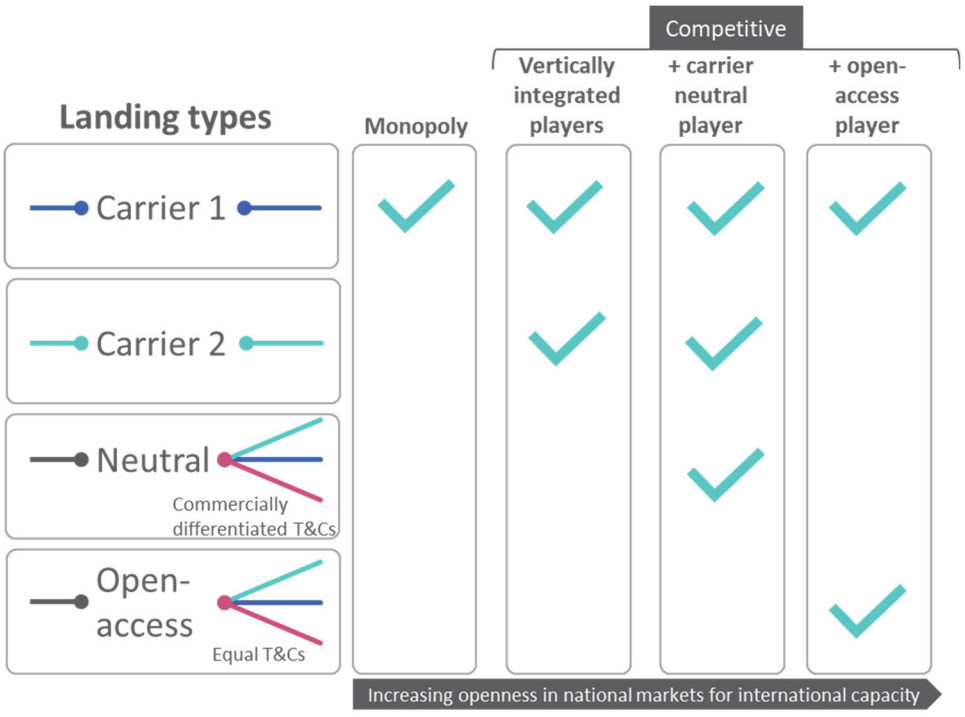


Figure 67: Varying Market Structures in Landing Countries

Source: TMG/WFNS

From the perspective of a submarine cable business, although there are benefits to having more direct, broader access to the market in any given country, there may be some disadvantages. For example, where

the landing party enjoys market power, it is a more likely to be motivated to invest in the cable as it would enjoy above-market returns. Such landing parties also have more leverage within the country to make deployment of the cable happen more rapidly than open access landing parties.

At this point, it is not recommended that the DGASA system set pre-conditions for what type of landing is obtained in landing countries. Instead, the DGASA system should be opportunistic and seek the most viable termination in target markets. This may be working with carrier-neutral, open access or, in some cases, vertically integrated players.[13]

9.2.4.3 Cable Landing Points

Related to the above is the issue of the location of where the cable lands. DGASA will be landing at five locations. Two of these are specific to the objective of establishing lower cost connectivity to Easter Island and Juan Fernández. The quality of location and significant elements of the customer relationship will be answered with the following questions for the remaining three locations (Valparaiso, Auckland and Sydney).

- Are there other cable systems landing at the cable station to relevant destinations and thus increasing the attractiveness of not just a terminating location but also for onward routing of transit traffic? As discussed in Section 3.2.7, these locations are sites of multiple cable landings.
- Are there large customers located in the landing country with high potential traffic demands/source of traffic? Among the benefits of these locations are potential partners that have chosen these locations because they are sources of existing and growing traffic demand. Again, please refer to Section 3.2.7.
- Is the location well connected, both domestically and internationally, to act as a traffic hub to interconnect and serve neighboring countries and connected countries? Australia and New Zealand are not yet widely recognized as major hubs the way that Singapore and Hong Kong are, but Sydney already has all the attributes of a growing hub[14] and with declining transpacific costs offered by DGASA can be expected to further significantly upgrade their status.
- Are the connecting cable and domestic networks sufficiently dimensioned and priced to be able to accommodate and support the system to make it competitive and attractive? This is the case for all three existing cable landing stations. Sections 5.6.2 and Section 5.7.2 of Report No. 1 of this project fully explored the presence of digital infrastructure and demand in the countries served by these locations. Particular issues dealing with regional pricing for Valparaiso are discussed in Section 9.3.4.1.
- Is the landing station already an existing hub for co-location, data centers or Internet exchanges? This is the case for all three: Valparaiso; Auckland and Sydney. See Section 5.4 of Report No. 1 for more details.

All other things equal, the DGASA cable should attempt to land with least-cost access to the sources of traffic and leverage hubbing as much as possible.

9.2.4.4 Specific Needs of Customers

Customers will likely have specific needs regarding the cable service that will greatly influence the customer relationship. Among these specific needs are: (1) SLAs; (2) expansion/ upgrade capabilities and

[13] For further review of potential landing party institutional analysis see Section 9.1.4.

[14] See, for example, "Chasing Opportunity in the Interconnection Market", a presentation given by Jon Hjembo of Telegeography at the Pacific Telecommunications Council, 19 January 2020.

(3) redundancy arrangements, as discussed in Table 33: Expected Specific Needs of Customers of the DGASA System below.

Table 33: Expected Specific Needs of Customers of the DGASA System

	Description
SLAs	SLAs are generally a factor in sales contracts and may impact, inter alia, the level of pricing: a premium may be charged for high service level agreement conditions or a lower price may be charged for lower service levels or there may be penalties clauses if such SLAs provisions are not met.
Expansion/ Upgrade Capabilities	A key driver for some customers is the potential of on-demand or in-step changes to incrementally increase capacity. DGASA's ability to respond will depend on the terminating equipment and/or associated connected network equipment that has flexibility or adaptable provisioning capabilities to increase capacity on demand or with relatively short-lead times. System upgrades are generally a relatively low incremental cost so this can provide a significant driver on unit cost and price that could affect the price proposition or competitive price pressure if other competing systems upgrade and thus reduce that market price. However, it could also be part of the sales proposition if upgrade options are potentially available. Related to this is DGASA strategy to increase capacity in the system in relation to *actua*l demand vs *purchased* capacity. Customers will purchase capacity in excess of their actual needs. This is particularly true of multi-year IRU purchases. Moreover, they certainly will have the *right* to capacity up to the amount purchased even if they do not practically need it. However, DGASA will have the scope to economize on capacity provisioning (e.g., purchasing fewer cards than necessary to cater for total *purchased* capacity), so long as it continues to deliver on customer SLAs.
Redundancy Arrangements	This element is expected to be a significant factor in demand for the cable, particularly at the start-up phase. The arrangement set up to achieve this offering depends on who the customer is, and type of redundancy or restoration required. The type of restoration and redundancy will impact the system design, costs to set aside capacity or purchases to acquire capacity on other systems. • *Mutual Restoration*: This is where a cable system collaborates with other systems on a mutual basis to set aside capacity to be available to restore one another's systems in the event of partial or complete failure (e.g., fiber issues or cable breaks). • *In-Service Restoration*: This is where there are some fiber pairs set aside to offer restoration and automatic protection switching in the event of a failure in the fiber or terminating equipment of one fiber pair to another fiber pair. This would not assist in the event of a failure of an entire segment of the cable. • *Network Restoration*: This is now a common form of restoration adopted by larger carriers and content providers. They provision for multiple routes to which their network centers are connected and manage their networks to consider potential single or multiple failures. There is, thus, no dependence on any particular submarine cable to provide the required level of restoration/redundancy itself and all of this network provisioning risk is borne "in-house". This can result in cheaper individual purchases as there is no requirement to rely on protected wavelengths or other premiums for other restoration requirements. However, it requires a more extensive and autonomous infrastructure and network architecture.

Source: TMG/WFNS

9.2.5 Key Activities and Resources

The activities associated with DGASA service delivery are diverse and will vary over the lifetime of the cable. The lifetime of the cable can be broken down into four basic phases as show in Figure 68: Phases of Submarine Cable Lifetime.[15]

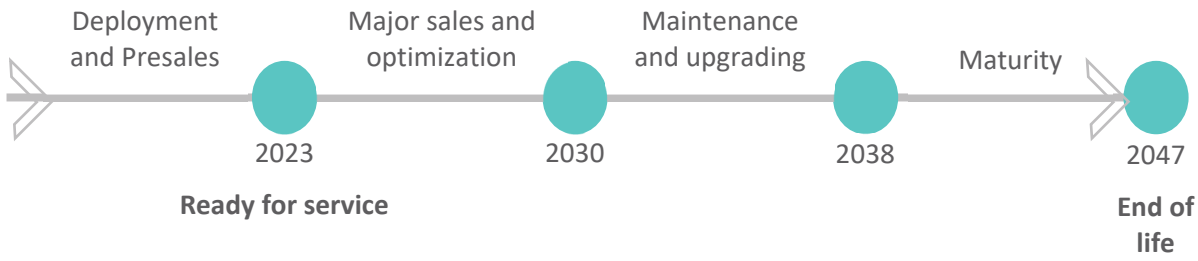


Figure 68: Phases of Submarine Cable Lifetime

Source: TMG/WFNS

During the initial deployment phase, likely to run over a two-year period, DGASA will be focused on arranging for the manufacture, deployment and testing of the submarine cable, as well as a pre-sales campaign. This is of course the period where the majority of the CapEx of the project is incurred. The main activities include project management and support, Wet Plant, Dry Plant, marine operations (deployment), as well the set-up of network operations and administration, permitting activity, test equipment and testing, set-up of financial and sales functions. Pre-sales are of prime significance during this phase. The pre-sales process takes at least two years before contract signing for these types of systems. Overall cash-flow is highly dependent on this early stage of sales activity. The deployment activities are all outsourced, so during this period, the consortium partners operating activity will be limited to contracting, supervision, pre-sales activity and financial management.

Sales channels and customer service for the cable are highly simplified. As the product offering is limited, there will be no need to differentiate various sales channels. The international capacity industry is a relatively small community where deals are made directly often at one of the numerous capacity conferences that occur throughout the year.

Customer service is highly technical, effectively carried out between the respective technical staffs of DGASA and the customer. Interaction with the customer will center around daily technical issues, maintenance and restoration, as necessary. Relationships, contacts and escalation procedures tend to be set out in operations documentation and SLAs. Contract renewals will be handled by the sales team.

During the first years of operation, the organization will be focused on demonstrating delivery, becoming known in the market, additional sales and operations maintenance. In this period, the organization should focus on getting as much sales commitment as possible. With respect to operations, there are a number of ways to organize the maintenance of the system. This includes outsourcing such activities as (1) performance monitoring to landing parties and (2) repair and restoration to specialized firms. This would also be where the commercial arrangements around ownership are implemented, pricing strategy is refined, and sales activity is stepped up.

In the third phase of the business, the focus will be on ensuring continuing performance with appropriate maintenance and upgrading electronics to meet moderate sales growth.

[15] To meet the schedule described in this figure, it is assumed that the DGASA consortium and Chilean SPV will be created in 2021.

In the final phase, the business will have significantly less sales and will have to plan ultimately for the end of life. This will include, for example, engaging in decommissioning, or recycling of assets.

These key activities can be delivered to the enterprise in a variety of ways. For illustrative purposes, Table 34: Key Activities Identified and Assumption of the Business Model lists some of the main activities, how they might be delivered, and the assumptions made by TMG/WFNS for purpose of the business model.

Table 34: Key Activities Identified and Assumption of the Business Model

#	Activity	Options	Assumption for Model
1	Landing	New build-third party; New build-own construction; Existing station	Existing landing station
2	Permitting	Outsource, In-house	Outsource[#]
3	Route Extension to other landings	Buy or Build	Build
4	Deployment of Wet Plant, Marine Operations	Outsource, In-house	Outsource[#]
5	Sales	Outsource, In-house	Outsource*
6	Network Operations Monitoring and Trouble- Shooting	Outsource, In-house	Outsource*
7	Repair and Restoration	Outsource, In-house	Outsource[#]
8	Layer 1 (wavelengths) service provision	In scope/out of scope	In scope
	Layer 2 and above (ethernet-based solutions, IP Transit, IP node and cloud) service provision	In scope/out of scope	Out of scope
9	Decommissioning	Outsource, In-house	Outsource

Notes: [#] Outsource assumed to be undertaken by the consortium through competitive tender processes. Three separate tenders could be expected: one for the permitting and deployment of Wet Plant/marine operations; another for repair and restoration and a third for decommissioning. [*]Outsource assumed to be undertaken by the Chilean SPV through a competitive tender as required by the Chilean legal framework.

Source: TMG/WFNS

In terms of compensation schemes for the resources involved, it is noted that in the case of outsourced work, the labor compensations are arranged by the firm to which the activity is outsourced. DGASA (or its members individually--see note to table above)will conduct tenders for these outsourced services and can expect to pay competitive rates that are typical for the international submarine cable market. For in-house resources, the compensation will reflect the market conditions and legal requirements of the relevant nation. In this case this, we assume that this will be Chile.

For the Chilean entity, as mentioned above in Section 9.1.5.1, some of these activities (e.g., Chilean SPV sales and Chilean specific network operations monitoring and trouble-shooting) will be outsourced to one or more OpCos. There are potentially many options for structuring the relationship between the Chilean SPV owners and the OpCo(s), including variants for the scope of activity, responsibility for different types of costs incurred, the term of the concession, the payment for the concession, etc. For discussion and modelling purposes, it is assumed that there is only one Chilean OpCo. It has also been agreed, for modelling purposes, that the OpCo will be fully in charge of operating the Chilean assets in the cable, sales and managing customer relationships. The OpCo's revenues are the sales of capacity, out of which it must cover all non-CapEx costs of the Chilean SPV and the concession fee. The concession fee is composed of

two parts: (1) a one-time upfront payment made at the time of concession contract award equivalent to 10% of the Chilean SPV's share of the cable CapEx; and (2) a recurring annual fee of the maximum of either 150% of the SPV's debt payment or 65% of the annual revenue for the given year.

9.2.6 Financials

There are three basic elements of the financial dimension of the business model: (1) revenue streams; (2) cost structure and (3) debt financing. These are depicted in Figure 69: Key Financial Components of Business Model below.

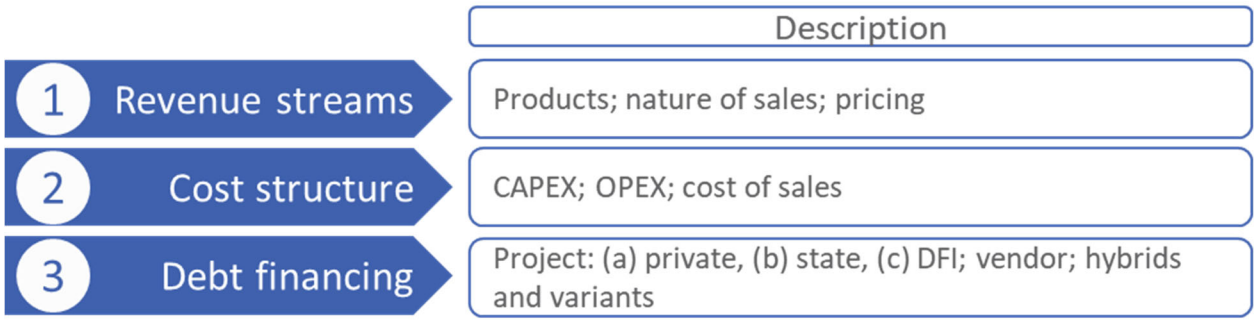


Figure 69: Key Financial Components of Business Model

Source: TMG/WFNS

With respect to the revenue streams, these are a function of the product mix and the nature and timing of sales and pricing. These issues are discussed in detail in Section 9.3. It is important to note that not all owners of the system will be "selling" capacity, e.g., content providers will generally be using capacity for their own internal needs. However, even in these cases, there is, of course, value to the asset, and, to calculate financial results, it is assumed that the value created is implicitly equal to the price at which the capacity would be sold on the market.

Regarding the cost structure, almost any activity of a submarine cable may be undertaken in a variety of ways, which may appear as different types of costs—CapEx, OpEx, or costs of sales. Table 35: Key Activities Identified and Their Relation to Cost Structure below presents the key activities identified above and list how they are expressed in the cost structure.

Table 35: Key Activities Identified and Their Relation to Cost Structure

#	Activity	Option Assumed for Model	Cost Type
1	Landing	Existing landing station	CapEx for Dry Plant to Landing Station and in-building facilities (etc.)
2	Permitting	Outsource	OpEx
3	Route Extension	Build	CapEx
4	Deployment of Wet Plant, Marine Operations	Outsource	CapEx
5	Sales	In-house	OpEx + Cost of Sales in Commissions
6	Network Operations Monitoring and Trouble- Shooting	In-house	OpEx
7	Repair and Restoration	Outsource	OpEx

8	Layer 1 (wavelengths) service provision	In scope	CapEx, OpEx
	Layer 2 and above (ethernet, IP Transit, IP node and cloud) service provision	Out of scope	Not applicable
9	Decommissioning	Outsource	OpEx

Source: TMG/WFNS

Debt financing refers to non-equity financing that appears as a medium or long-term liability on the balance sheet. Business models usually involve a combination of approaches. Using private debt to fund telecommunications infrastructure is the overwhelmingly most typical case in well-functioning markets. However, where the business cases are built on a narrower basis of profit opportunity, private funding may be problematic. In these cases, the government, which tends to have different assessments of risk and required return than private investors, may have a role to play. Development Financial Institution funding can be key in markets where capital of any type (private or public) is scarce.

Vendor financing may be key where more favorable terms are offered with the capital equipment purchase itself. In the context of submarine cables, where large upfront CapEx is followed by revenues and related cash inflows only after the first phase of deployment, there is an opportunity for the vendor to improve its offer through allowing installment payments, postponing cash outflows. Vendor financing may cost more than other forms of financing due to a number of reasons, including that the vendor acts as an intermediary because it ultimately must back its financing through a bank and also must subscribe to some form of insurance. These additional costs effectively transfer the burden of the unpaid revenues to the cable.

Various hybrid and variants of these forms of financing exist. Documentary credit, for example, is project-specific debt instruments raised from a bank or a financial institution. The credit is a three-way arrangement—with the vendor, the buyer and the bank—all signing a joint credit agreement. Under this arrangement, once the cable has been certified by the vendor as deployed, the buyer's bank settles the invoice to the vendor and the submarine cable company introduces the liability to its balance sheet.

9.2.7 Key Potential Partners

In the submarine cable context, key partners include significant, non-customer relationships that are undertaken for the purposes of:

- Delivery of the deployment of the cable (vendors);
- Purchase of network to extend service reach beyond the cable (network partners);
- Landing parties;
- Outsource (operations) partners; and
- Equity partners.

As mentioned in Section 9.2.2, It is important to recognize that there is a degree of fluidity between the roles of owner and customer, which is related to the institutional model, the business model and market circumstances. Depending on these factors, any given player may be interested in acquiring capacity on the cable through ownership rather than purchase, vice versa or a combination of both.

While it is still too early to identify specific partners/investors for the DGASA project, section 4.3 of Report 2 presented an initial list of companies interviewed that have expressed a potential willingness or interest in the system. From a broader perspective, for purpose of business modeling, Table 36: Potential Partners

for the DGASA System below provides a framework of the possible nature of the partners/investors and an example of entities that might be brought into the project.

Table 36: Potential Partners for the DGASA System

Partnership Type	Nature of Partnership	Examples of Partner
Vendor	Cable	NEC, Huawei, Alcatel, SubCom
Vendor	OSS	Centina
Vendor	Transmission	Xtera, Cisco
Vendor	NOC	TATA
Network Partners	Purchase or lease of capacity	Service providers, other submarine cable systems
Landing Parties	Space, installation of equipment (e.g., SLTE)	National service providers, Equinix, Telxius
Operations	Repair and restoration	eMarine
Equity partners	Ownership interest	Content providers, service providers, other private investors, national government and state-owned entities.

Source: TMG/WFNS

9.2.8 SWOT Analysis

The discussion of the business model is concluded by conducting a SWOT analysis on the project based on the information available in relation to the opportunity to date. This analysis is summarized in Table 37: SWOT Analysis. These are attributes that further iterations of the business model will need to leverage (strengths), address (weaknesses), exploit (opportunities) and mitigate (threats).

Table 37: SWOT Analysis

Strengths	Weaknesses
• Latest technologies • Scalable 16-fiber pair cable • Low latency for SA-Asia route • Leverages robust Asian intra-regional connectivity • Will be perceived as complementary, not competitive with customer base • Close ties with government of Chile • Early days of business model development=flexibility	• No existing infrastructure to leverage • No resilient, ring topology • Lack of direct connectivity to U.S. content • Lack of Asian Onward Connectivity • South America intra-regional connectivity still developing • No existing customer base • Some elements of business case as yet unclear • Existing cable contract lock-in
Opportunities	**Threats**
• First cable on proposed route • Trade between Asia and South America increasing • All landings, well placed for interconnecting with other systems	• Copy-cat cable likely in near future; historic pattern of new cable every five years • Inter-regional traffic likely to be 5% or less (South America to Asia) of total and under 1% (Asia to South America) of total

• Landing in dynamic, developing markets • Markets on the cusp disruptive demand phenomenon. • Possibility of a non-US landing is attractive to some players • South America to United States routes still relatively high cost • Commercially and legally willing to contract with China • Potential competitor for US to Australia/NZ traffic • Restoration/diversity partner	• Traffic continues to migrate "to the edge" via CDNs and caching, i.e., share international traffic to total dropping • Growth rates of disruptive demand by nature speculative • Price reductions may be greater than anticipated

Source: TMG/WFNS

9.2.9 Conclusions

In this section the main aspects of the business model have been discussed. The business model described is a high-level overview, pending the review and selection of a recommended route for the DGASA system. Once the route is selected, more details of the business model will emerge as potential customers and investors will have a better idea of what is on offer. That said, a number of important features of the business model can already be identified.

In terms of customer segments, the main customers are expected to be:

- Americas-based carriers;
- Americas-based content providers;
- Asia-based carriers;
- Asia-based content providers; and
- Various enterprise and smaller niche players on both sides of the Pacific.

The value proposition of the DGASA to these customer segments includes features that are not specific to the route, such as offering additional capacity for those service and content providers that are bandwidth constrained, an opportunity for those seeking lower costs through capacity ownership and generic route diversity to achieve resilience objectives.

There are DGASA-specific aspects to the value proposition as well, including:

- ***Improvement in service quality***, e.g., fewer hops and lower latency. This value proposition is unique to the DGASA system for the South America to Asia route.
- ***Geographic diversity***. Related to the above, service providers will be interested in back-up routes that are in geographically different places as geography-specific events can stop service on multiple cables in one area. This is a unique value proposition for DGASA as it traverses uncovered territory in the Pacific.
- ***Price***. South America and Asia service providers will be able to send their inter-regional traffic at lower cost than the indirect routes.
- ***Industry-specific/regional-specific requirements***. There may be some specific requirements of particular industries or firms that will be much better met through the DGASA cable. For example, additional connectivity to the Easter Islands or French Polynesia.

The relationships that will be developed for the DGASA customers to leverage this value proposition include the product offerings and pricing discussed in Section 9.3.3.2 and various arrangements that the DGASA system will make in terms of SLAs, capacity upgrades and redundancy for service reliability. The DGASA cable alone may not determine how customers might make use of the proposition as it depends on access conditions as well.

The activity and resources needed to deploy and maintain the cable will evolve over the lifetime of the cable. The activities that DGASA chooses to undertake in-house or outsource will depend on a number of factors related in part on the institutional model selected, as described in Section 9.1.2.

The financials that underlie the business model can be specified in terms of revenue streams, costs and financing. Financial analysis for the DGASA system is included in Section 9.3.

The key partners for DGASA are the various equipment vendors involved in the deployment of the cable and the investment partners that will play a role in financing the cable. The potential institutional model under which these investment partners will take part in the cable is discussed in section 9.1.

9.3 Financial Analysis

9.3.1 Introduction

This chapter presents the results of the financial modeling for the business case. It first discusses the revenue estimates, then the cost estimates. The section concludes with a presentation of the profitability results of the base, optimistic and pessimistic scenarios. Results are presented for:

- The “Consortium” as a whole;
- The “Chilean SPV” investing in Asian Onward Connectivity from Sydney to Other Asia countries (in addition to the DGASA cable itself) – its financial results are split between the “Chilean SPV Investors” and the “OpCo”;
- The “Other Consortium Partners”, which are the other consortium members (treated as a whole) besides the “Chile SPV”;
- The “Chilean SPV Investors”, who are equity owners of the Chilean SPV; and
- The “OpCo” contracted by the Chilean SPV to operate and maintain the Chilean SPV’s assets and sell capacity on DGASA on behalf of the Chilean SPV.

In this chapter, revenue, CapEx and OpEx are discussed. These sections are followed by discussions of results of the stakeholders. Section 9.2.6 describes the structure of the financial models that generate the results.

It should also be stressed that the results of business modeling presented in this chapter are driven by demand modelling estimates undertaken in accordance with the Terms of Reference. DGASA promoters will have to begin the process to validate the business model by gauging actual private interest in equity investment in the DGASA system and pre-sale capacity IRU purchases (i.e., sales that take place pre-CIF and pre-RFS dates). This will require multiple rounds of consultations and negotiations across all potential stakeholders, investors and clients. Pre-sales are of prime significance during the deployment phase and the process can be expected to take at least two years before RFS. An accurate assessment of cash-flow will be highly dependent on this early stage of sales activity.

The analysis for the business involves both the DGASA cable itself and the Asian Onward Connectivity contracted by DGASA consortium partners to deliver traffic to and from Sydney and other Asian hubs.

The Asian Onward Connectivity is a proposal that 1) adds value to the DGASA route and 2) provides flexibility to provision for accessing various destinations in Asia.

In order to maximize the value of this Asian Onward Connectivity, DGASA will likely want to a) acquire a fiber pair as quickly as possible to an existing hub in Asia and b) remain flexible about sourcing additional fiber pairs in order to be opportunistic regarding where demand migrates and where fiber pairs become available and at what price. The model provides the opportunity to specific various parameters for Asian Onward Connectivity that may be adjusted as more information becomes available on options for connectivity to other Asian hubs.

9.3.2 Revenue

The pricing for the routes is discussed in section 9.3.4 below. The underlying demand quantities have been explored extensively in Section 5 of Report 1 of this project. The bottom-up demand estimates calculated in the DGASA demand model and described in Section 5 of Report 1 are reasonable.

A bottom-up estimate demand is not the only way to measure demand, however, particularly in the short-run. Discussions with potential buyers and investors suggest that demand may be on the order of 50-75% of what the demand model is predicting. Accordingly, we take this to inform a pessimistic case. On the other hand, Section 5 of Report 1 also indicates a potential uplift of some 20% in the event of a significant anchor tenant and that the opinions expressed in the interviews referenced above are necessarily preliminary.

Therefore, the following scenarios are designed around the demand model results:

- +20% as the optimistic case
- +0% for the base case
- -50% for the pessimistic case.

As mentioned in Section 9.2.6 above, it is important to note that not all owners of the system will be "selling" capacity, e.g., content providers will generally be using capacity for their own internal needs. However, even in these cases, there is, of course, value to the asset, and, to calculate financial results, it is assumed that the value created is implicitly equal to the price at which the capacity would be sold on the market.

9.3.3 Products

9.3.3.1 Connectivity Supply Chain

In order to define the product set for the DGASA system and Asian Onward Connectivity, it is necessary to identify DGASA's activity scope with a discussion of the supply chain for international connectivity. This supply chain is schematically represented in the Figure 70 below. Cable demand will be originated from end users, data centers or other aggregating points, e.g., internet exchanges, colocation centers and carrier hotels. These end-user or aggregation sites are linked to the CLS in which the cable terminates. These links between end-user sites and landing station may be international networks, national links or local backhaul connections.

The landing stations contain the electronics, power and associated equipment necessary to transmit communications across the cable itself. The landing stations need not be self-standing facilities but can be co-located with an aggregation point or other network PoPs. The landing stations provide the "meet-

me" location for service and content providers to interconnect with the cable and with one another and often to cross-connect cable systems.

The submarine cable (in this case, DGASA and Asian Onward Connectivity) is comprised of all the undersea cable elements--repeaters, BUs, cable—as well as and generally, for pricing and costing purposes, shore plant to the landing station and the SLTE and other equipment dedicated to this part of the system DWDM equipment, protection equipment, etc., within the landing station. Services provided by the CLS itself—space and facilities to allow service and content providers to connect to the cable equipment are not within the scope of DGASA.

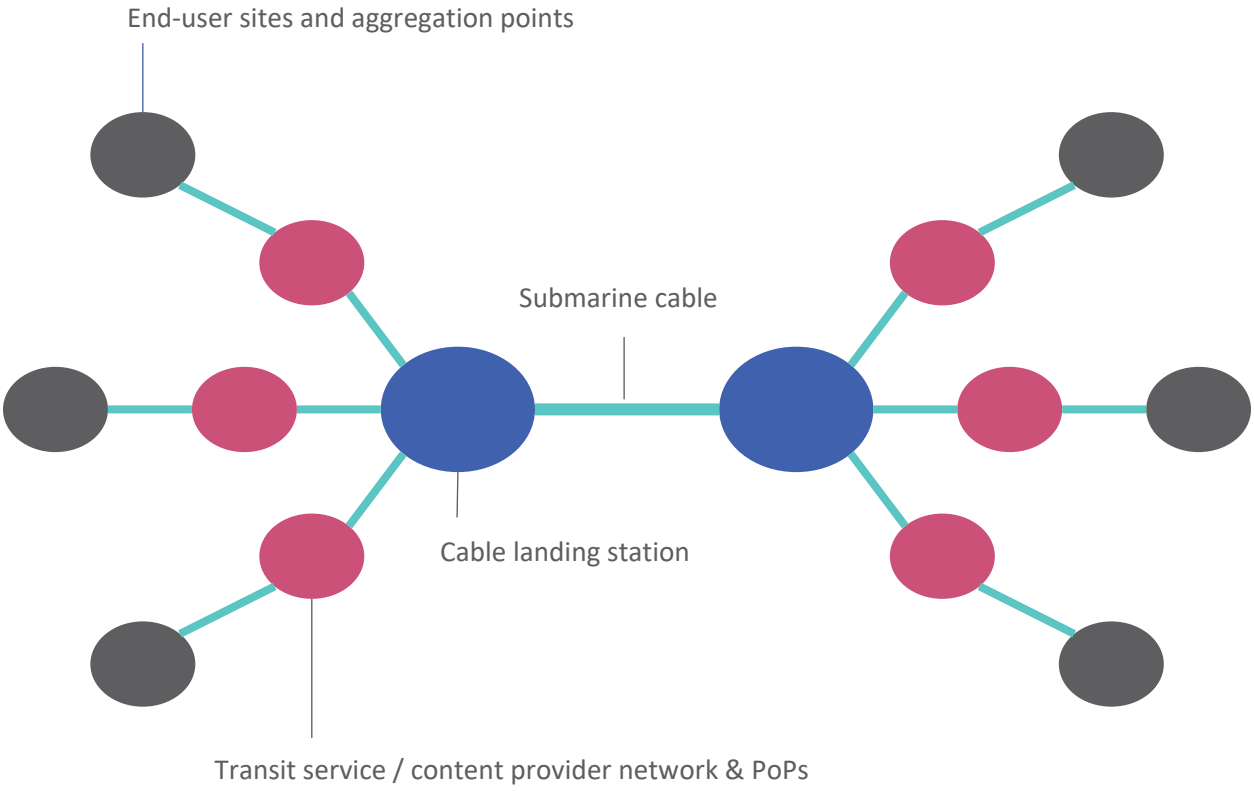


Figure 70: Supply Chain of International Connectivity

Source: TMG/WFNS

Although each of these elements in the supply chain are providing a connectivity service, the products are differentiated by the network and cost elements underlying them and, of course, the customers for the products offered. Table 38 summarizes these distinctions while Appendix C of Report 2 provides further description of non-submarine cable system products identified in the table below.

Table 38: Summary of Distinctions Between Components of the Supply Chain for the DGASA System and Asian Onward Connectivity

Component	End-user Sites and Aggregation Points	Service/Content Provider Network and PoP	Cable Landing Station	Submarine Cable System
Major Product Cost Elements	End-user/VAS, local network	Backhaul, core network facilities and services	Space, Power, Cross-connect facilities and services	International Capacity, electronics

	equipment & services			equipment and services
Products	VAS, MPLS, IP-VPN, Data Center Services	Domestic and International Transit connections	Co-location, interconnection and cross-connection	Wavelength capacity under IRU or lease
Customers served	ISPs, Corporate Customers	Primary Wholesale: Owners; Landing Parties; Large OTTs, Medium-Large Carriers (buying IRU and large capacity leases)		
		Second Wholesale: Small/medium carriers; ISPs smaller OTTs (smaller capacity purchases)		

Source: TMG/WFNS

In terms of products, corporate enterprises and ISPs, data center users and small or medium carriers are served at end-user sites and aggregation points serve those who are offered international connectivity bundled services. These customers typically do not "see" or pay for individual components that make up the supply chain.

Furthermore, it is worth noting that the ISPs served at end-user sites and aggregation points are providing a retail service to their own customers. The retail business is very different from the wholesale service. A retail service will have a mix of traffic, is primarily a shared and contended service (end users share bandwidth) and will be served through both domestically and internationally sourced content.

Wholesale transit service and backhaul capacity are offered by domestic service and content providers to intermediary domestic distribution points and, in the case of international traffic, to international PoPs or directly to the landing station.

The landing station will offer right of access to the cable station (usually in the form of an upfront or an annual charge, or a combination of both), interconnection (to connect to carriers' own networks with the cable system), cross-connection (to access other cable systems) and in the case of co-location space, i.e., common equipment areas.

The customers that purchase international connectivity on a wholesale basis, whether bundled (combining domestic connectivity, landing station services and international connectivity, say, in an IP Transit service) or an unbundled basis can be thought of in two tiers:

- ***Primary purchasers***: Larger players, who may be owners or investors in the submarine cable system, system and landing parties, including large carriers and increasingly OTTs. These purchasers would typically take a significant investment in the system upfront with large capacity purchases.
- ***Secondary purchasers***: This would typically be small/medium carriers or other carriers using the system as an alternative diverse route for their products.

9.3.3.2 DGASA (and Asian Onward Connectivity) Products

In this section we describe the major products that could be offered on the DGASA system and the Asian Onward Connectivity provided by the Chilean SPV contracting for additional capacity to other Asian markets. In principle, the same products sold on DGASA could be sold on the Asian Onward Connectivity portion. However, in practice, as mentioned below, it is unlikely that dark fiber will be sold on the Asian Onward Connectivity.

The two potential types of products could be offered by the DGASA cable system include:

- ***Dark fiber***, which are effectively dedicated and terminated to specific carriers, who then decide independently when to upgrade capacity on the fiber. Dark fiber tends not to be among the main products offered on long-haul (repeatered) submarine cable systems due to the limited number of fibers on the system. There are, of course, counter examples, especially where a major anchor client or investor is involved. As the Chilean SPV will be a customer itself for dark fiber for the Asian Onward Connectivity component, it is unlikely that it will be selling dark fiber for Asian Onward Connectivity.
- ***Wavelengths***, which are provisioned on systems via the SLTE and the use of DWDM, which allow the provisioning, or "lighting," of many wavelengths over a limited number of fibers. Wavelengths have typically been delivered using 10 Gbit Ethernet transport protocols, but now there are 100 Gbit, 150 Gbit, 200 Gbit and future plans to implement 400 Gbit.

In addition, the DGASA system must consider what level resiliency for the capacity sold:

- ***Protected/unprotected capacity****:* Capacity may be sold either protected or unprotected depending on the system configuration or restoration network architecture. Historically, submarine cable systems have been configured such that there is the option to sell capacity either protected or unprotected. For this to be an option, the system needs to be able to offer a duplicate level of capacity that can be used in the event of the failure. As described in section 9.3.3.2, in order to have some form of protected capacity product offering, the system configuration must have:
    - Self-Healing ring (multiple routes to the same destinations with automatic protection switching;
    - In-System restoration (this would only cover individual fiber or components not catastrophic cable breaks; or
    - Mutual restoration (capacity set aside on an alternative system).

If the network configuration has the capability of offering alternatives, then the products can be developed as a marketing and differential selling point compared to other systems or different products on the system depending on the customer requirements. The products could range from unprotected (no dedicated restoration) to protected. If a protected capacity product is offered these could potentially be offered on a dedicated (permanently configured or capacity set aside to be switched to automatically) or pre-emptible (where there is no guarantee that all capacity will be restored and would require some level of restoration prioritization and associated product segmentation).

Section 9.3.4.2 also refers to mutual restoration being more common now with larger carriers and OTTs. In this case they would purchase their own capacity on multiple routes and then bring all this back to their own network centers and manage themselves such that they may not require or be willing to pay a premium for protected capacity as they could do this within their own network architecture.

Furthermore, these products can be differentiated on the basis of the sales agreement, which come in two basic forms:

Table 39: Types of Sales Agreements for Products on DGASA (and Asian Onward Connectivity)

Product	Description
IRU sale	Under an IRU arrangement, the purchaser is given the right to use some capacity on a telecommunications cable system over its useful lifetime. Under an IRU, the purchaser often has the right to lease capacity to a third party. An IRU incurs an obligation to pay a proportion of the costs of

	operating and maintaining the cable, including any costs incurred repairing the cable after mishaps.
Annual Lease sale	Under a lease arrangement, the purchaser is given the right to use the capacity on the specified circuit for a shorter period without ownership-type rights. For many capacity customers, one-year leases have become the industry standard. Leases allow buyers to exploit rapidly declining prices and remain a primary approach for capacity procurement for this reason. Longer lease terms of more than one year are available and involve lower price buy-ins, as the seller can lock in a value that is still greater than the year-on-year changing price.

Source: TMG/WFNS

This report focuses on products that would be offered on the cable system as defined within its scope above and considering the capacity needs of various sizes of customers. The products that the carriers or OTT providers would offer to their customers (i.e., other carriers and small and large business customers consisting of Modem Pool Line Card (MPLC), IPVPN, IP Transit, Cloud based services, IP solutions, lower capacity Ethernet and IP services) are not considered.

A limited number of dark fiber sales are included as the cable is likely to have more than enough fiber pairs for the early years of operation. Also, discussions with potential customers indicated there may be interest in fiber pairs or partial pairs.

Therefore, for the purpose of this report, in advance of detailed discussions with potential clients about more specific offerings and the final system configuration, five products are specified for the DGASA[16] business case:

1. 100G unprotected wavelength purchased on an IRU basis;
2. 10G unprotected wavelength purchased on an IRU basis;
3. 100G unprotected wavelength purchased on an annual lease basis;
4. 10G unprotected wavelength purchased on an annual lease basis;
5. Fiber pair purchased on an IRU basis; and
6. Quarter fiber pair purchased on an IRU basis.

IRU purchases carry with them an annual charge for operations and maintenance. For IRU *sales*, the O&M fees are calculated in the revenues as a separate line. For IRU *purchases*, for Asian Onward Connectivity, associated O&M fees appear in operating expenditures as a separate line.

9.3.3.3 Product Mix Over Time

The product mix is determined by the customer mix. Customers are differentiated, not only by their capacity needs but by their investment risk profile. Investors, carriers, operators and OTT providers face "buy-or-build" decisions when considering involvement in the deployment of a new submarine cable capacity. Their decision comes down to the evaluation of the following options:

- Do they become one of the owners or main investors to be involved in the initial purchase of the system?

[16] For Asian Onward Connectivity, only wavelength products are assumed to be offered, i.e., no fiber products.

- Do they defer initial investment and join at a later stage, risking a price premium for the capacity, having circumvented the level of investment risk as the initial owners/investors?
- Do they defer and/or decide to just lease capacity on the system?

The key factors that would influence the build-or-buy decision are indicated in the table below:

Table 40: Factors That Influence the Build-or-Buy Decision

Decision Factor	Upfront Involvement (Own)	Late (Delay Own or Lease)
Cost of Capital	Low	High
Demand Confidence	High	Low
Technology Change	Low to moderate	Rapid
Market Position	Established	New

Source: TMG/WFNS

A number of alternatives allow for some variations on the standard options discussed, including capitalized leases, short term leases and long-term leases.

Initially, the product mix is dominated by purchases made by those customers interested in an ownership or IRU arrangement. The needs of the supplier and purchaser are accommodated by this initial mix. By purchasing large amounts of capacity upfront, the buyer can negotiate a better deal and have a long-term plan in place for their facilities and network plans. Additionally, the supplier benefits from a large purchase upfront because it means a quicker return on their investment and mitigation of risk (e.g., making them less susceptible to price fluctuations over time). Given this, it would be expected that the initial purchases will be made up of a significant proportion of wavelengths on an IRU or ownership basis.

It is to be expected that some potential customers may still purchase, initially, on a lease basis. This strategy would be justified in the case of limited capital or the preference for a more "operating-cost" approach to capacity procurement. Also, customers may be unsure or unwilling to incur a large upfront risk on a new system. In doing so, they would be paying a premium initially.

The mix of the size of capacity, i.e., 100 Gbps versus 10 Gbps blocks would depend significantly on the type of customer purchasing, their underlying network building blocks and their specific requirements. As the initial customer base will be the large players, it is also expected that 100 Gbps wavelength would be the main capacity level purchased.

In particular, based on our interviews with potential customers and discussions conducted with sales representatives of new systems, it is anticipated that IRU sales will represent 95-98% of initial sales. IRU sales will last only 12 years (to 2034) after which their terms will no longer be consistent with the commercial lifetime of the cable. Therefore, TMG/WFNS has set the initial IRU sales as proportion of total sales at 96%, with 25% by RFS year and included a reduction for the share of IRU capacity demand by 7.5% a year until zeroed out in 2034.

For a sensitivity, an initial share of IRU sales at 100% and at 75% have been tested and the Net Present Value (NPV) of revenue under these alternatives are given in the table below. These figures show that the NPV of sales is not very sensitive to the share of IRU sales. Far more important is getting sales upfront.

Dark fiber demand is handled in a different manner than wavelengths. By selling dark fiber, we have effectively given the customer the option to scale up its carrying capacity, within technological constraints, without further charges. As overall demand is fixed on the route, a dark fiber customer may take

increasing amounts of the overall demand. We therefore make an assumption about the fill rate for the fiber pair, calculated the associated residual demand and allow the consortium to sell the residual on a wavelength basis along the lines described above.

Sales of dark fiber are assumed to take place within the pre-sales period of the business. Dark fiber sales are assumed to be limited and only offered on the DGASA system. No sales of dark fiber are assumed for the Asian Onward Connectivity as the Chilean SPV is itself purchasing dark fibers on the routes and potential customers for dark fiber are likely to make their own arrangements rather than use the Chilean SPV as an intermediary. Selling fiber pairs is not a common practice as by doing so one effectively creates competition for oneself ; however in the interest of capturing high value revenue upfront a limited number of fiber sales are often made in the early stages of sales. It is therefore assumed that only two of the 16 Fiber pairs and four quarter fiber pairs are sold in the year prior to and following the RFS date. These values were chosen based on a preliminary discussions with potential buyers.

This feature of submarine cable revenue illustrates the widely accepted industry principle that, in sales, fast capital recovery is more important that the pursuit of margin. This is because, as one industry expert put it, “submarine capacity sales look like downhill skiing”: you are never better off from a price perspective than on day one of sales.

It is also important to note that most IRUs are purchased upfront as they are valid for the lifetime of the cable.

Also, leases tend not to be purchased strictly on-demand. Rather, they are purchased on a rolling multi-year period to reflect network planning forecasts. The modeling of revenues assumes a typical 3-year network planning horizon, so that 100G leases are purchased on a rolling 3-year basis. These assumptions reflect the fact that capacity purchasers tend to make “lumpy” purchases of capacity in a way that ensures that they do not run out of capacity over their planning horizon.

9.3.4 Pricing

The current level of prices for DGASA (and Asian Onward Connectivity) products and forecasts of their evolution over the 25-year period are presented in this section. Current price levels are identified through two approaches: (1) a component market price benchmarking; and (2) a comparison of Chile to Asia pricing using existing systems. Both approaches produce largely consistent results.

Forecasting is based on price declines experienced across a range of relevant submarine cable capacity markets. These projections are used to determine the likely price levels over the course of the cable’s commercially useful lifetime.

9.3.4.1 Market Price Benchmarking of Current Price Levels

In order to be competitive in the market, the price for DGASA will have to be at or below the existing level of pricing for capacity between South America to Asia plus some uplift for the benefit of the direct routing. The current level of pricing for South America to Asia is based on an indirect route running via North America. Thus, in end-to-end terms, the following elements should be considered in a benchmarking (Figure 71):

7. The pricing of the existing South America-Asia routing, i.e., combination of a) Segment A between any relevant South American capital to the U.S. landing, b) U.S. transit, Segment B and C) the transit point between U.S. West Coast hub and any relevant Asia capital, Segment C; and
8. The pricing for the DGASA route of Segment 1 between any relevant South American capital to the DGASA access plus the price for Segment 2 from DGASA access to any relevant Asian capital.

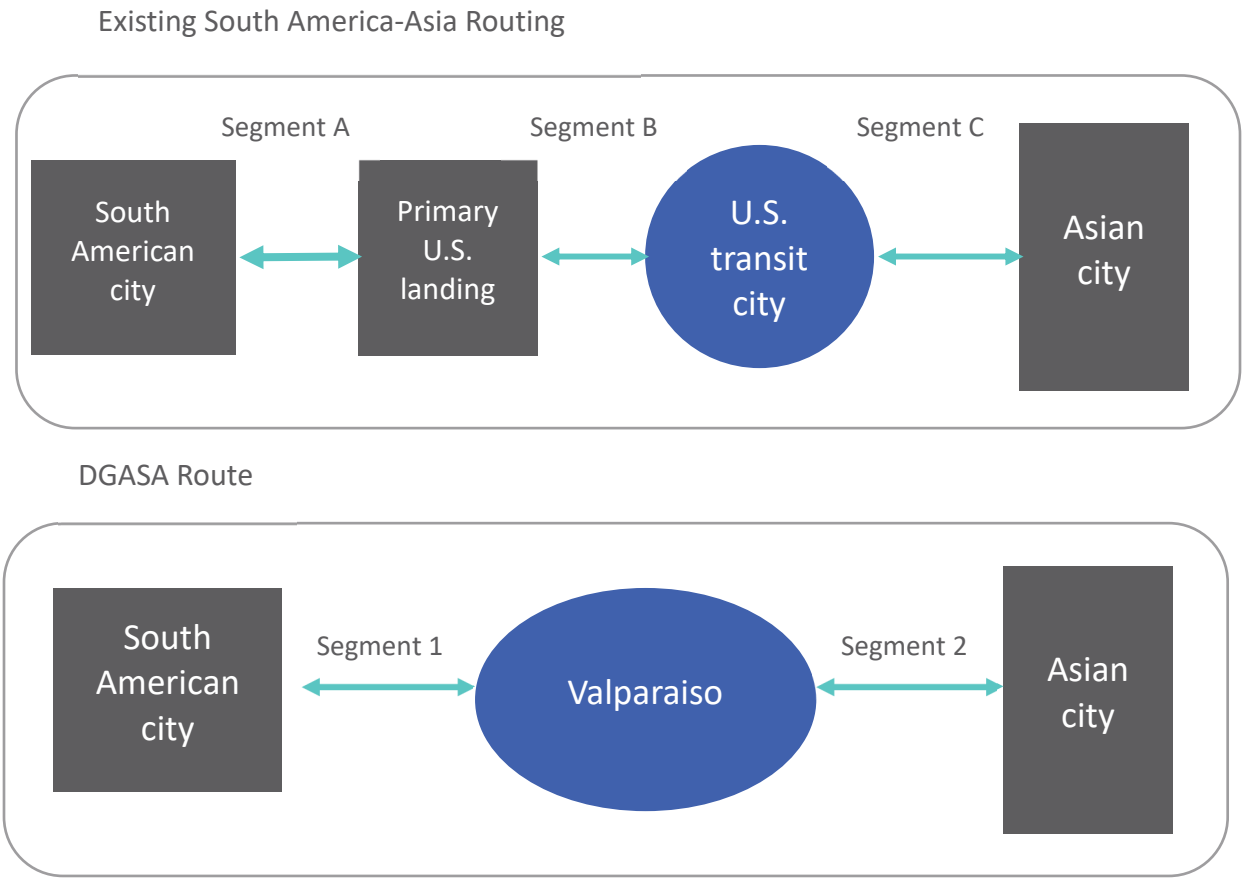


Figure 71: DGASA Versus Current Routing

Source: TMG/WFNS

9.3.4.1.1 Pricing on Existing South America-Asia Routing (Segments A, B and C)

In the tables below, the price benchmarks for major South American cities to Asian hubs as well as Sydney are given as an aggregate of the component segments A, B and C.

Table 41: Price Benchmarks Based on Price of 10 Gbps Monthly Lease, Q4 2019 (USD)

Santiago

City in Asia	Santiago to Miami (A)	Miami to Los Angeles (B)	Los Angeles to Asia City (C)	Santiago to Asian City 10 G Lease (D)=(A+B+C)	Estimated 100G IRU (E)=(D)*60*3.5
Tokyo	$15,000	$3,470	$5,298	$23,768	$4,991,233
Singapore	$15,000	$3,470	$8,819	$27,289	$5,730,643
Hong Kong	$15,000	$3,470	$9,254	$27,724	$5,821,993
Sydney	$15,000	$3,470	$18,000	$36,470	$7,658,653

Source: TMG/WFNS analysis, TeleGeography

Buenos Aires

City in Asia	Buenos Aires to Miami (A)	Miami to Los Angeles (B)	Los Angeles to Asia City (C)	Buenos Aires to Asian City 10 G Lease (D)=(A+B+C)	Estimated 100G IRU (E)=(D)*60*3.5
Tokyo	$11,922	$3,470	$5,298	$20,690	$4,344,853
Singapore	$11,922	$3,470	$8,819	$24,211	$5,084,263
Hong Kong	$11,922	$3,470	$9,254	$24,646	$5,175,613
Sydney	$11,922	$3,470	$18,000	$33,392	$7,012,273

Source: TMG/WFNS analysis, TeleGeography

Rio de Janeiro

City in Asia	Rio to Miami (A)	Miami to Los Angeles (B)	Los Angeles to Asia City (C)	Rio to Asian City 10G lease (D)=(A+B+C)	Estimated 100G IRU (E)=(D)*60*3.5
Tokyo	$13,617	$3,470	$5,298	$22,385	$4,700,803
Singapore	$13,617	$3,470	$8,819	$25,906	$5,440,213
Hong Kong	$13,617	$3,470	$9,254	$26,341	$5,531,563
Sydney	$13,617	$3,470	$18,000	$35,087	$7,368,223

Source: TMG/WFNS analysis, TeleGeography

Sao Paulo

City in Asia	Sao Paulo to Miami (A)	Miami to Los Angeles (B)	Los Angeles to Asia City (C)	Sao Paulo to Asian City 10G lease (D)=(A+B+C)	Estimated 100G IRU (E)=(D)*60*3.5
Tokyo	$7,540	$3,470	$5,298	$16,308	$3,424,633
Singapore	$7,540	$3,470	$8,819	$19,829	$4,164,043
Hong Kong	$7,540	$3,470	$9,254	$20,264	$4,255,393
Sydney	$7,450	$3,470	$18,000	$28,920	$6,073,153

Source: TMG/WFNS analysis, TeleGeography

Bogota or Lima

City in Asia	Bogota/Lima to Miami (A)	Miami to Los Angeles (B)	Los Angeles to Asia City (C)	Bogota/Lima to Asian City 10G lease (D)=(A+B+C)	Estimated 100G IRU (E)=(D)*60*3.5
Tokyo	$18,790	$3,470	$5,298	$27,558	$5,787,133
Singapore	$18,790	$3,470	$8,819	$31,079	$6,526,543

Hong Kong	$18,790	$3,470	$9,254	$31,514	$6,617,893
Sydney	$18,790	$3,470	$18,000	$40,260	$8,454,553

Source: TMG/WFNS analysis, TeleGeography

9.3.4.1.2 Transit Between Santiago and Major South American Cities (Segment 1)

Intra-regional price data has been discussed in section 3.1.3.6 of Report 2 In that section, it was concluded that the current transit price for most of the South American traffic to Chile is close to $15,000 per month for 10G lease. Given the conversion rates, this would imply $75,000 per month for a 100G lease and $2,250,000 for a 100G IRU.

However, it is important to recognize that the $15,000 10G lease benchmark is based on a market situation that would likely change in the presence of a direct submarine cable to Asia. Based on research undertaken, the amount of available capacity and provisioned capacity between Santiago and either Buenos Aires or Sao Paulo is 70 Tbps and 16-18 Tbps (for two providers interviewed). Used capacity is likely to be far less than provisioned capacity. Based on information from the demand model, actual utilization is far lower than this, perhaps as low as 1 Tbps (considering total Chile to Brazil and Argentina bilateral traffic). Still, to be conservative, utilization of this capacity is assumed to be at 4 Tbps, based on growth rates from the demand model, this would be at 6.5 Tbps by 2022.

Given that Argentina and Brazil are associated with 60-80% of the demand expected for the DGASA system (either as termination or origination points), terrestrial carriers could expect demand for terrestrial capacity for 3 Tbps in 2022 from DGASA traffic alone. Double this if the copy-cat cable were similarly reliant on transit traffic.

A simple model comparing the NPV of net revenue to the terrestrial transit providers at today's price of $15,000 for 10G leases with and without DGASA traffic illustrates that it is in the interest of the terrestrial transit providers to drop their prices up to 45% in order to make the DGASA business case happen.[17]

Beyond demonstrating that such a decrease is in the self-interest of the terrestrial transit providers, it is also clear historically that year-on-year decreases of that order of magnitude is quite typical in markets experiencing high increases in traffic. For example, the 10 Gbps price on the New York – Los Angeles route fell by as much (see below) over the 2005-2006 period.

[17] This calculation is presented in the "Transit" tab of the Revenue Assumptions Input file of the Business Case Financial Model accompanying this report.

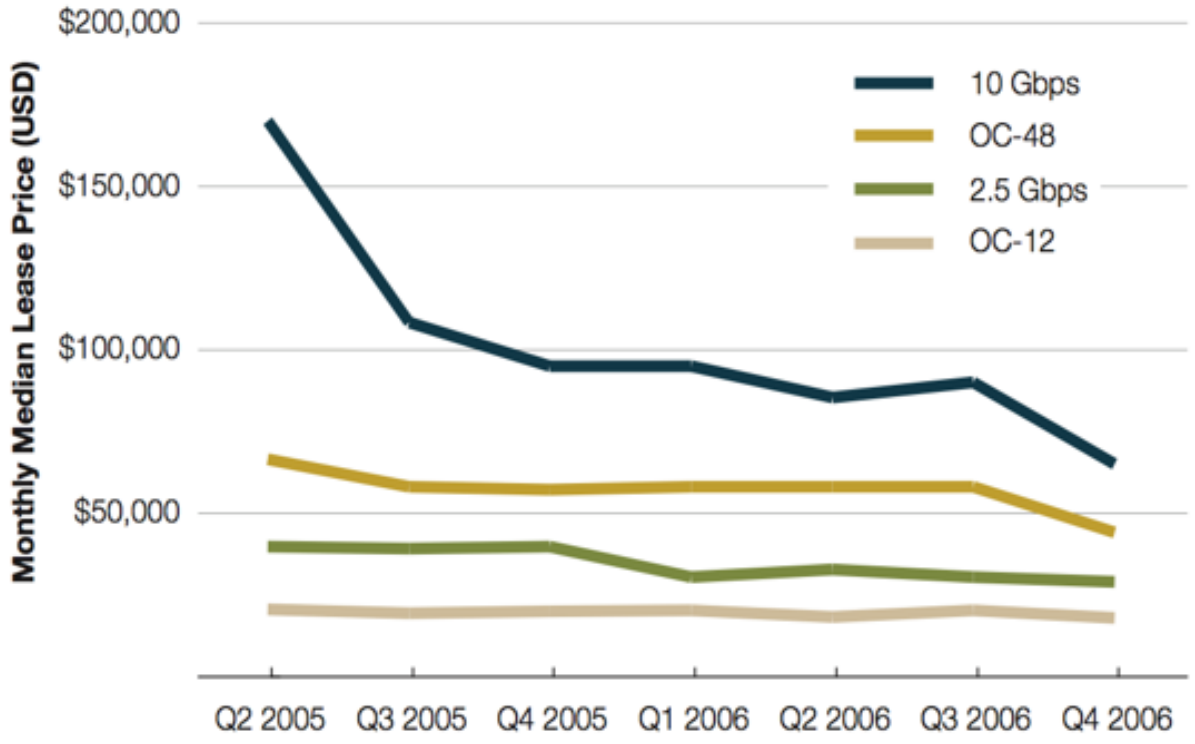


Figure 72: Los Angeles-New York Circuit Prices, 2005-2006

Note: Series represents median monthly lease prices for each circuit during 2005-2006
Source: TeleGeography

Similarly, from the end of 2016 to the end of 2019, the price on the Buenos Aires-Sao-Paulo route fell 29%. The CAGR for the Rio de Janeiro-Sao Paulo was -34% over the end 2016 to end 2019 period (Figure 73).

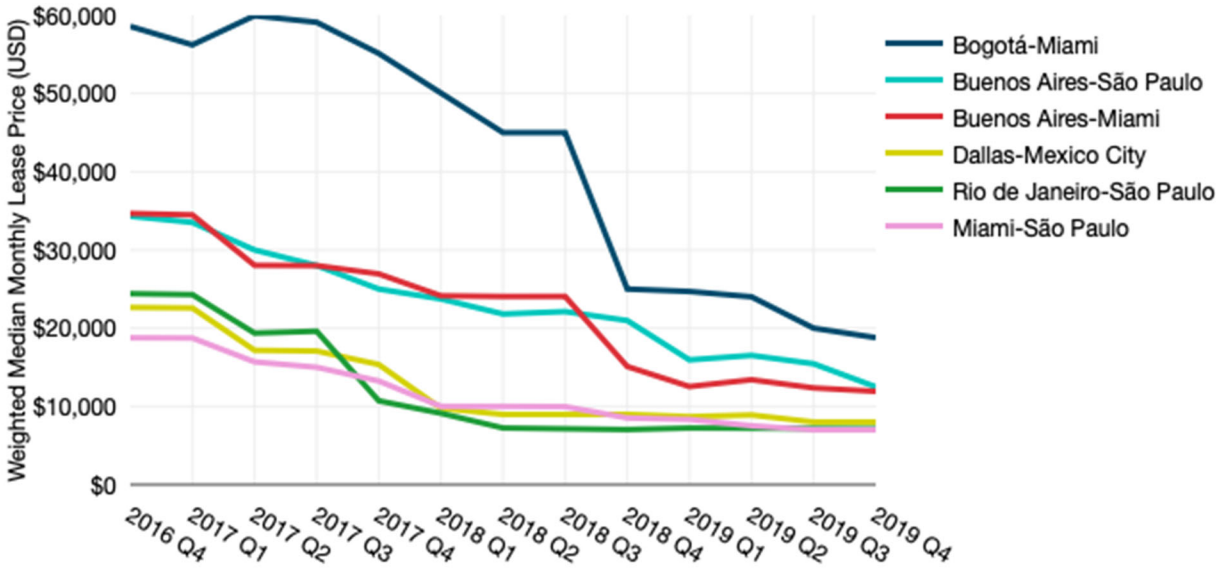


Figure 73: Weighted Median Latin American 10 Gbps Wavelength Process, Q4 2016-Q4 2019

Note: Each line represents the weighted median monthly lease price for an unprotected 10 Gbps wavelength on the listed route, Prices are in USD and exclude local access and installation fees
Source: TeleGeography

Based on the foregoing analysis, the projected competitive reference price for the terrestrial transit route is around $9,000 for the 10G lease, which implies $45,000 for the 100G lease and USD 1,890,000 for 100G IRU lease. The analysis suggests that a price of $8,000 for a 10G lease would likely imply too much of a reduction for the providers of terrestrial capacity to offer. Conversely, a price of $10,000 for a 10G lease would threaten the DGASA business case and therefore take the offer off the table.[18]

9.3.4.1.3 Base Prices for Santiago to Asian Markets (Segment 2)

Under the assumption of the equivalence in pricing between Segment A and Segment 1, the price for DGASA capacity (Segment 2) must be comparable with Segment B+C or stated another way Segments A+B+C-Segment 1.

In considering the 100G IRU price, subtracting $1,890,000 from the estimated 100G IRU price from the city pairs above yields the following prices:

Table 42: Benchmark Prices for Segment 2

City in Asia	Chile	Argentina	Brazil	Other
Tokyo	$4,991,233	$2,454,853	$1,534,633	$3,897,133
Singapore	$5,730,643	$3,194,263	$2,274,043	$4,636,543
Hong Kong	$5,821,993	$3,285,613	$2,365,393	$4,727,893
Sydney	$7,658,653	$5,122,273	$4,183,153	$6,564,553

Source: TMG/WFNS

Segment 2 is divided into two parts. The DGASA System and the Asian Onward Connectivity provided from Sydney to the other Asian city hubs. Based on our market research, we believe that there is currently availability for at least one fiber pair at the following prices of $50 million with 90 pairs of 200 Gbps cards (18 Tbps) this is equivalent to $277,778 for 100 Gbps units--significantly less than current wavelength rates. See table below.

Note that the wavelength prices to Japan from Australia are still lower than to Hong Kong and Singapore despite the significantly longer distance involved. This is because wavelength pricing reflects a large number of non-cost based considerations, e.g., the number of wholesale competitors, circuitousness of routing requirements, capacity constraints on more direct routes. Some of these factors will influence fiber prices as well. Confidential evidence from suppliers, which is confirmed by Telegeography intra-regional price data on bandwidth, shows that fiber pair pricing from Sydney to the major Asia hubs are converging, for modelling purposes therefore, the fiber pair prices to all three hubs are assumed to be the same.

[18] In order to confirm the reasonableness of this value of USD 9,000, we complemented the incentive based model in the "Transit tab" with a simple cost model to confirm that this price level was consistent with a normal fill rate (utilization) for a terrestrial system carrying the required traffic. That analysis confirms that a USD 9,000 price level would recover costs at a fill rate of 50-60%, which would be a reasonable expectation given demand on this route.

We note that the business case for the Chilean SPV is highly dependent on its ability to acquire a dark fiber at the outset of the project. If it is not able to scale from half a fiber pair at the outset to a full pair within the first few years, the viability of the project is in serious question.

Table 43: Sydney to Asia Hub (Asian Onward Connectivity) Costs, Q4 2019

Asian hub	Fiber Pair Cost	100G Wavelength Cost
Tokyo	$277,778	$3,992,730
Singapore	$277,778	$4,933,740
Hong Kong	$277,778	$6,835,290

Source: TMG/WFNS; TeleGeography

Assuming that the Chilean SPV can purchase the Asian Onward Connectivity for the Fiber Pair Cost and that other consortium members can make similar or better arrangements, the price the consortium could sell DGASA capacity itself is calculated by subtracting the Asian Onward Connectivity costs from the benchmark price for Segment 2 overall. See the table below.

Table 44: Benchmark Prices for DGASA, Q4 2019

City in Asia	Chile	Argentina	Brazil	Other
Tokyo	$4,713,456	$2,177,076	$1,256,856	$3,619,356
Singapore	$5,452,866	$2,916,486	$1,996,266*	$4,358,766
Hong Kong	$5,544,216	$3,007,836	$2,087,616	$4,450,116
Sydney	$7,658,653	$5,122,273	$4,183,153	$6,564,553

Source: TMG/WFNS

(*) Revenue maximizing

As arbitrage possibilities will likely ensure that DGASA capacity is sold at a single price, we set the price that maximizes revenue. This turns out to be the price which attracts both not only traffic between the two biggest markets, i.e., China and Brazil, but also that of the south Pacific as well, i.e., Singapore Brazil, i.e., $1,996,266.

Based on TMG/WFNS' discussions with cable operators, direct routes can earn a premium of up to 50% over indirect routes. To be conservative it is assumed that DGASA pricing could earn a premium of 20% over the current transpacific pricing.

9.3.4.2 Price Evolution

The historic rate of change of submarine cable prices is well documented on a number of routes. The trend has been rapidly declining in early years, which gives way to moderation to a level of what appears to be viability of the submarine cable systems.

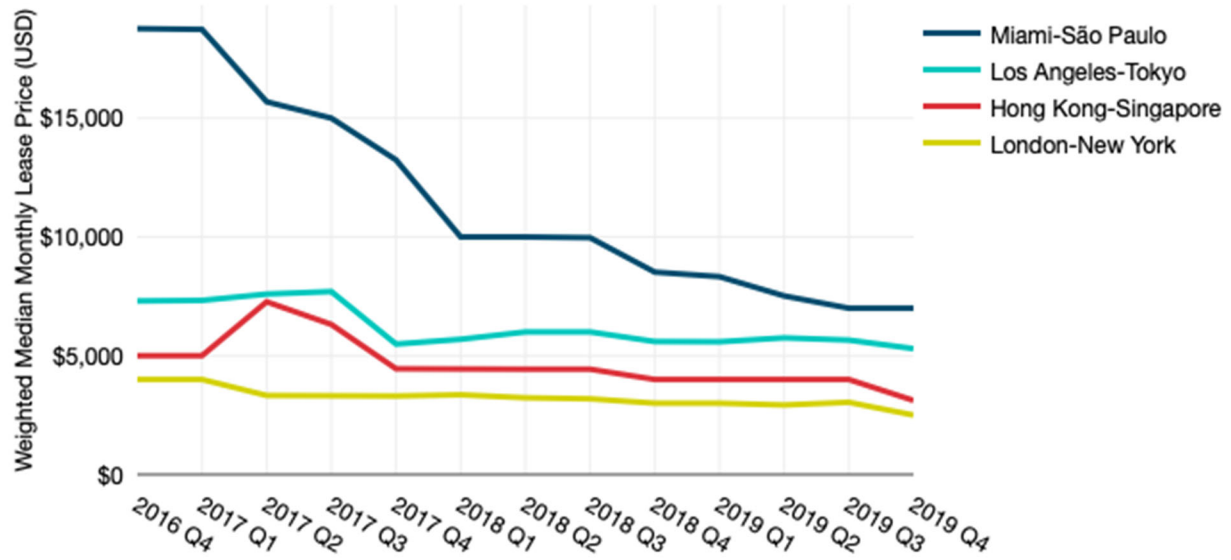


Figure 74: Weighted Median 10 Gbps Wavelength Price Trends on Major International Routes, 2016–2019

Source: TeleGeography, Global Bandwidth Research Service: Wholesale Pricing 2019

The weighted median monthly lease price for a 10 Gbps Wavelength on major routes is identified in Figure 74 above. Prices are in USD and exclude local access and installation fees.

It cannot be said, however, that there is a general trend to a specific price level or that price levels stabilize over time. The fundamental driver of price declines, liquidity or availability of lit capacity, changes over time. Thus, when new capacity appears prices tend to decrease again.

Thus, a significant price decline in the Miami – Sao Paulo route would reflect new systems coming on board, while a more stable but still consistent market rate decrease over time on all other routes.

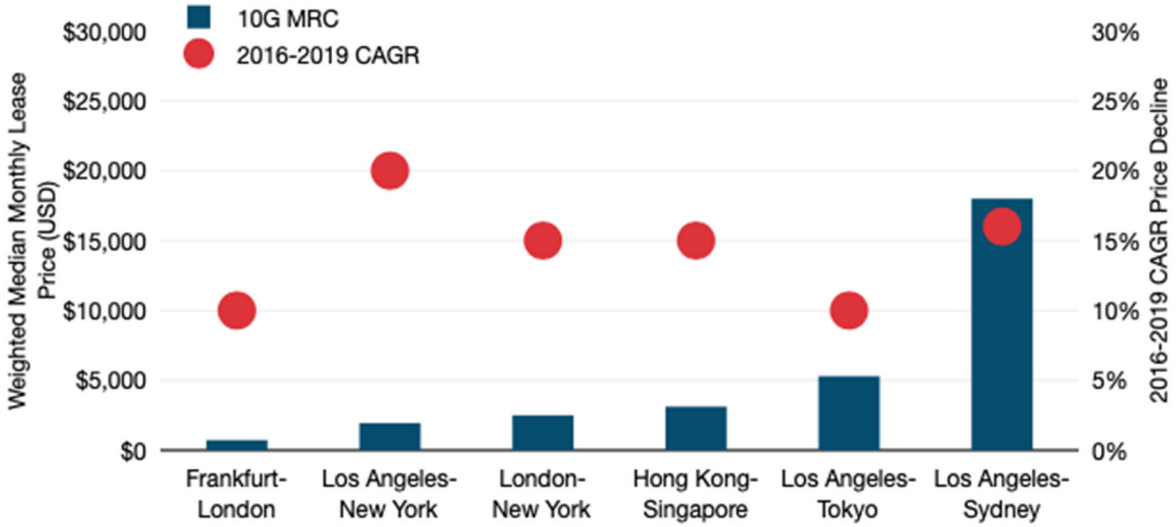


Figure 75: Weighted Median 10 Gbps Monthly Lease Prices on Select International Routes, Q4 2019

Source: TeleGeography, Global Bandwidth Research Service: Wholesale Pricing 2019

In Figure 75 above the annual price declines for weighted median monthly lease price for a 10 Gbps wavelength are indicated. The lines represent the percentage decline of the weighted median price calculated as a three-year compound annual growth rate. Again, prices are in USD and exclude local access and installation fees.

TeleGeography reports that the recent and planned network deployments are putting strong pressure on prices on the transpacific routes in general. Since quarter four of 2015, median 10 Gbps and 100 Gbps wavelength prices on the main transpacific routes fell an average of 10% and 16%, respectively, compounded annually. Established, high volume routes such as United States to Japan tend to be subject to the lower price declines as their prices are already quite low. New routes, like the United States to Hong Kong or Singapore routes have been subject to the higher end of that price decline range (Figure 76).

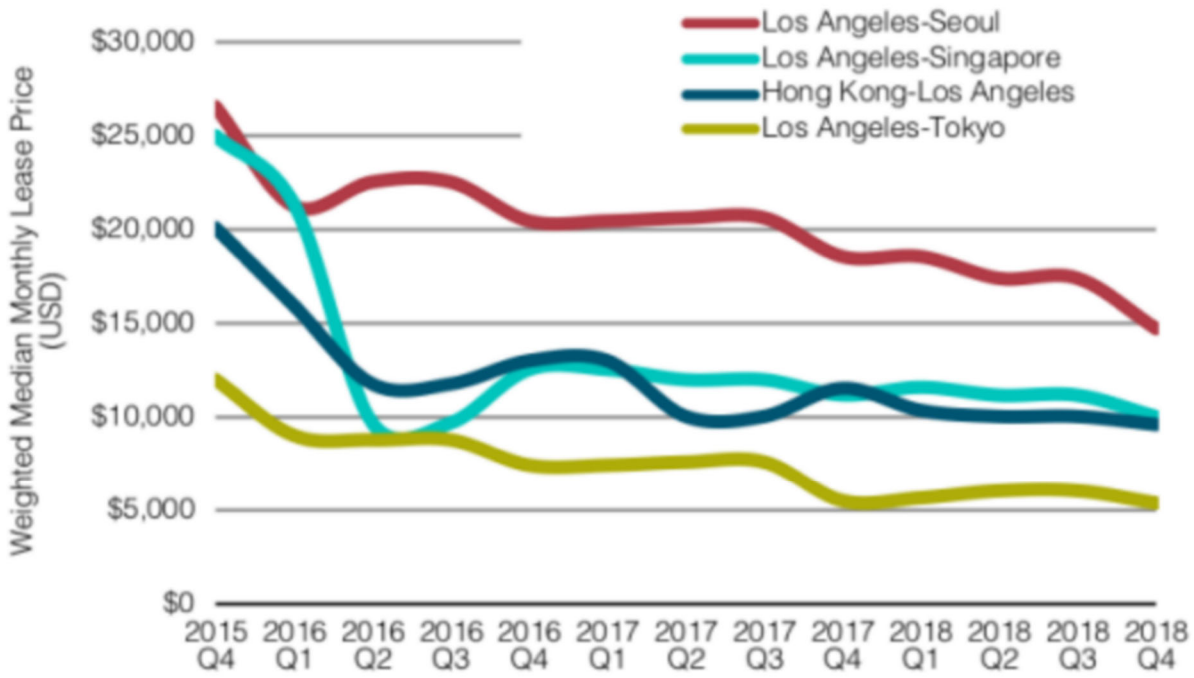


Figure 76: Weighted Median Transpacific 10 Gbps Wavelength Prices, Q4 2015–Q4 2018
Source: TeleGeography, Global Bandwidth Research Service: Wholesale Pricing 2019

A similar pricing trend is found in Latin America. Between year-end 2016 to 2019, bandwidth prices in Latin America and the Caribbean fell at an average compounded rate of 27% (Figure 77).

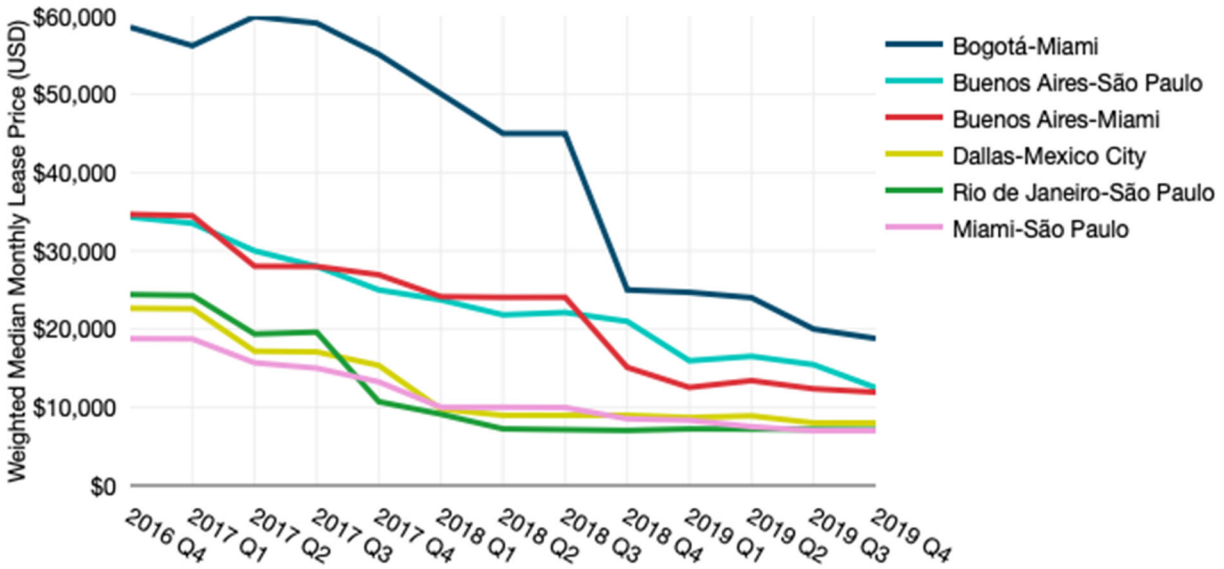


Figure 77: Weighted Median Latin American 10 Gbps Wavelength Prices, Q4 2016-Q4 2019

Source: TeleGeography, Global Bandwidth Research Service: Wholesale Pricing 2019

Based on the figures above and the fact that DGASA will be expected to be a price-taker in the market, competing with indirect transpacific routes as discussed in section 9.3.4.1, it is not unreasonable to expect a 20-30% decline per annum on lease pricing over the initial lifetime of the DGASA cable.

It is also true that lease and IRU prices tend to fall at similarly rates. Examining year-on-year price declines for leases and IRUs for two transpacific routes from the 2015 to 2018 (Figure 78), it is clear that changes are not strictly uniform. This is because in any given year, the demand for leases or IRU may be different in terms of capacity availability.

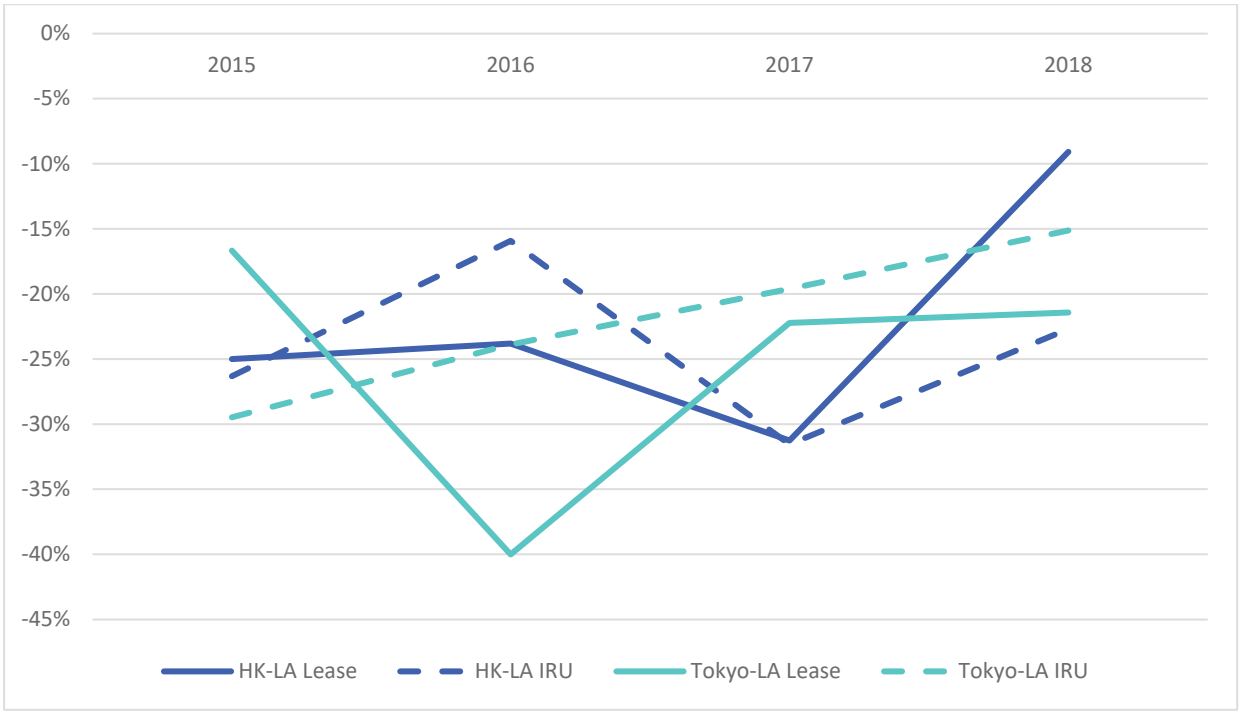


Figure 78: Transpacific Routes Lease and IRU Price Changes, 2015-2018

Sources: TMG/WFNS based on TeleGeography and APTelecom

Ultimately, however, the same capacity may be contracted in a variety of ways, so the prices changes should be similar. The same data is provided below in tabular form with the average shown in the final column of Table 45. Lease and IRU prices are very similar on average over time at around -22% to -25%.

Table 45: Transpacific Lease and IRU Price Decline Averages, 2015-2018

	2015	2016	2017	2018	YoY average
HK-LA Lease	-25%	-24%	-31%	-9%	**-22%**
HK-LA IRU	-26.3%	-15.9%	-31.6%	-22.7%	**-24%**
Tokyo-LA Lease	-17%	-40%	-22%	-21%	**-25%**
Tokyo-LA IRU	-29.5%	-23.9%	-19.6%	-15.1%	**-22%**

Sources: TMG/WFNS based on TeleGeography and APTelecom figures

Other data strengthen the assumption of consistency of lease and IRU price declines (Table 46).

Table 46: Various IRU and Lease Price Declines for the 2012-2018 Period

#	Route/Product	Time Period	YoY average Price Decline	Source
1	Sing-LA IRU	2015-2018	**-24.4%**	APTelecom
2	London-New York IRU	2015-2018	**-24.6%**	APTelecom
3	Transpacific Lease	2012-2018	**-22.7%**	TeleGeography
4	US-South America Lease	2012-2018	**-27%**	TeleGeography
5	InterAsia Lease	2012-2018	**-20%**	TeleGeography

Sources: TMG/WFNS based on TeleGeography and APTelecom figures

The specific price decline assumed for modelling is taken from the largest sample of year-on-year price declines on various transpacific routes from TeleGeography, which generates an average of -23%. In the financial modelling the price decline for both lease and IRUs is assumed to be -23%.

The commercial implication of such high price reductions is that every effort should be made to sell what the market will bear upfront. Failure to secure early sales would expose the venture to more risk of underlying market trends and the impact. A successful early sales strategy could, among other things, stymie the short-to-medium term entry of competing systems.

There are several means to encourage early sales, which should ultimately be incorporated into the sales and pricing strategy:

- Initial owners receive preferential pricing related to their early investment and associated risk and or level of capital put up;
- Secondary investors receive “early-bird” preferential discounted pricing;
- Volume related discount pricing;
- Demand based pricing based on traffic/capacity demands between end-to-end destinations; and

- Early capture of reciprocal capacity exchanges or swaps to equivalent value or for mutual restoration purposes.

9.3.4.3 IRU Recognition

In the model IRU revenue are recognized at the time of the sale. They are not distributed over the lifetime of the IRU.

9.4 Cost Analysis

9.4.1 Cost of Sales

Cost of sales are calculated in terms of commissions on sales, bad debt and sales tax. The assumptions on these parameters are found in the Input Parameters sheet.

9.4.2 OpEx

The table below presents the estimates of Opex for the DGASA system and non-cable related expenses. Marine Maintenance & Storage are typically Annual Standing Charge + Running Costs and Depot Charges. Annual Standing Charge is calculated on Length of cable in the Maintenance Agreement multiplied by a unit fee, typical US$250-300. Running Costs are calculated on a daily charge of US$30,000 times the duration of typical repair, 10-15 days and applied to the estimated fault rate e.g. one fault every 5 years. Depot charges are calculated by volume of stored items and an allowance for handling and annual testing. There is also room in the estimate for third party liaison.

With respect to the non-cable OpEx, the sources and assumptions are provided in the Sources sheet of the financial model. In addition to the associated annual initial total, the different categories are described in terms of whether they are associated with the cable itself or some other part of the enterprise as well as the per cent of total annual expected in the first year of enterprise organization, 2022.

The OpEx sheet of the financial model contains relevant assumptions of the real change in OpEx over the lifetime of the cable.

The annual O&M cost for a submarine system is dominated by the cost of having the system in one or more marine maintenance agreements and the cost of re-routing traffic should the system go down. This should be considered and planned for as soon as the marine survey is complete, and the final route length is known. Since the DGASA system is not a ring system, it is assumed that any significant system failure will occur once every five years. It is assumed that DGASA customers will provision their own redundant capacity, i.e., they are purchasing DGASA capacity on an unprotected basis.

Table 47: OpEx Table

#	Cost Category	Cable/Non-cable	Total Annual, USD 000s	% of Annual in First Year, 2022
1	Marine Maintenance & Storage	Cable	$4,459	0%
2	Marine Restoration	Cable	$350	0%
3	Land Route Maintenance	Cable	$500	0%
4	Leased CLS O&M	Cable	$6,500	0%
5	NOC	Cable	$120	0%
6	Office Lease	Non-Cable	$24	100%

7	Office Other	Non-Cable	$12	100%
8	Technical Staff	Non-Cable	$400	25%
9	Sales Staff	Non-Cable	$180	100%
10	G&A Staff	Non-Cable	$400	50%
11	Interconnect OpEx - Sydney	Non-Cable	$3	0%
12	Interconnect OpEx - Other Asia	Non-Cable	$3	0%
13	Contingency	Non-Cable	$1,304	0%
14	O&M – Asian Onward Connectivity	Non-Cable	Function of FPs purchased and price	0%
15	License Fees	Non-Cable	Function of revenues	0%

9.4.3 CapEx

The table below presents estimates for the DGASA system and Chilean specific non-cable CapEx. Please note this table differs from the Table 21 in Section 8.1.14 in that, here, an assumed discount of 15%, which would be typical between the RFI and RFP stages of procurement, is applied to cable CapEx,

Table 48: CapEx Table

#	Cost Category	Cable/Non-cable	Total Annual, USD 000s
1	Permitting	Cable	$2,231
2	Marine Route Survey	Cable	$6,926
3	Submerged Plant	Cable	$287,770
4	Spare Submerged Plant	Cable	$7,122
5	Marine Operations	Cable	$42,509
6	Civil Works	Cable	$922
6	Land Cable Installation	Cable	$1,702
7	Cable Landing Station	Cable	2,066
8	Submarine Line Terminal Eq (Exc. Cards)	Cable	$12,565
9	Spare SLTE	Cable	$883
10	Engineering & Project Management	Cable	$15,335
11	System Test & Commissioning	Cable	$408
12	Training	Cable	$367
13	Documentation	Cable	$209
14	Test Equipment	Cable	$344
15	Other Related Costs	Cable	-
16	Contingency	Cable	$38,044
17	Sydney Cross-connect equipment	Non-cable	$400

18	Consultancy Support	Non-cable	-
19	DGASA Cards	Non-cable	Variable
20	Asian Onward Connectivity Cards	Non-cable	Variable
21	Asian Onward Connectivity FP	Non-cable	Variable

A key system feature is that it will be an "Open Cable Interface" system. Open Cable means that the cable will be terminated with the common equipment needed for line monitoring and management of the undersea network elements. The system supplier will guarantee the cable parameters so that the purchaser can have other suppliers provide the terminal equipment and/or system upgrades. When it comes time to upgrade the system, the purchaser will have the option to purchase terminal equipment from other suppliers.

Capacity upgrades are identified by a joint effort between the operator's network engineering, network operations and sales organization. As a general rule, when a telecommunications facility approaches 85% utilization, it is time to reinforce the facility. For modelling purposes, it is assumed that upgrades will be implemented three years before an increase in capacity is needed. These upgrades are represented in terms of a "card provisioning" schedule.

The model allows for the user to weight the driver for capacity upgrades between actual demand and purchased capacity. See Table 33 for a discussion of these considerations. As a default 50-50% is chosen as it represents an intermediate scenario that strikes a balance between the risk of under-provisioning capacity and benefiting from lower CapEx.

Note that upgrade capabilities will depend on available technology, it is assumed that 400 Gbps will be available in the market over the course of the lifetime of the cable. The model chooses whether DGASA will continue to provision 200 Gbps cards or switch to 400 Gbps cards depending on 1) whether capacity is adequate to accommodate demand with 200 Gbps cards and 2) the relative cost of the two approaches. If 200 Gbps cards are not adequate to support the demand required over the lifetime of the cable, then a mixed technology approach (transition to 400 Gbps) will be adopted. If 200 Gbps cards are adequate for the lifetime of the cards, the model chooses which of the two approaches is least expensive to implement. Note that it is assumed that to introduce 400 Gbps cards the SLTE had to be replaced, so all cards are replaced.

The Chilean SPV has the additional CapEx associated with the purchase of full or partial fiber pairs on existing systems for a Sydney to Singapore or other Asian cities to achieve connectivity to the Asia hub market. Thus, there are additional fiber and card provisioning schedules associated with this Asian Onward Connectivity. It is assumed that DGASA will provision cards for the fiber pairs and quarter fiber pairs that it sells to customers.

For the purchase of fiber pairs, a quote from a service provider was obtained. Additional analyses were conducted to estimate the likely price in two years' time and a contingency of 30% was added to arrive at a projection of $50 million of the fiber pair. Additional calculations were conducted to confirm that purchasing fiber pairs was a more financially prudent method than to purchase quarter fiber pairs or 100G IRUs.

9.5 Taxes

9.5.1 Corporate Tax by Jurisdiction

The modeling includes a high-level Earnings Before Interest and Taxes (EBIT) tax rate for four jurisdictions: Chile, 27%; Australia, 30%; New Zealand, 28% and "Other Asia" of 20%. EBIT is segregated into these jurisdictions on the basis the proportion of sales to customers (revenues) grouped by these jurisdictions. All sales to South American customer sales are assumed to have taken place in Chile. All sales to Australian and New Zealand customers are assumed to have taken place in Australia and New Zealand, respectively. The "Other Asia" corporate tax rate is a blended rate applied to EBIT associated with other Asian countries outside of Australia and New Zealand.

9.5.2 Other Types of Taxes by Jurisdiction

Sales taxes are accounted for as Cost of Sales, for the purposes of modelling they are assumed to be passed through to the customer.

Import duties are only applied to the Chilean SPV. The import duties on equipment originating in the US, Europe and China are not subject to duty, so a 0% duty is applied to CapEx associated with the Chilean SPV.

The other fees that are considered are license fees applicable to the jurisdiction in which sales occur. License Fees are considered OpEx.

9.6 Financing

9.6.1 Equity

For the Chilean SPV, 30% of the initial funding (cable CapEx and first year's OpEx) is assumed to be financed from equity. All of the financing for the other consortium partners is assumed to be equity.

Cost of equity is based on analysis by KPMG.

9.6.2 Debt

For the Chilean SPV, 70% of the initial funding is assumed to be debt financed. A loan term of 10 years is assumed under the following summary conditions:

- Initial processing fee – 2%
- Availability fee over 2-year grace period – 1%
- Real cost of debt is based on analysis by KPMG.

9.7 Profitability Analysis

The following sections discuss the results of financial modeling for each of the stakeholders: the Chilean SPV; the consortium overall; the other consortium partners as a whole, the Chilean SPV investors; and the OpCo.

The profitability measures of NPV, Internal Rate of Return (IRR) and payback presented in tables.

9.7.1 Chilean SPV

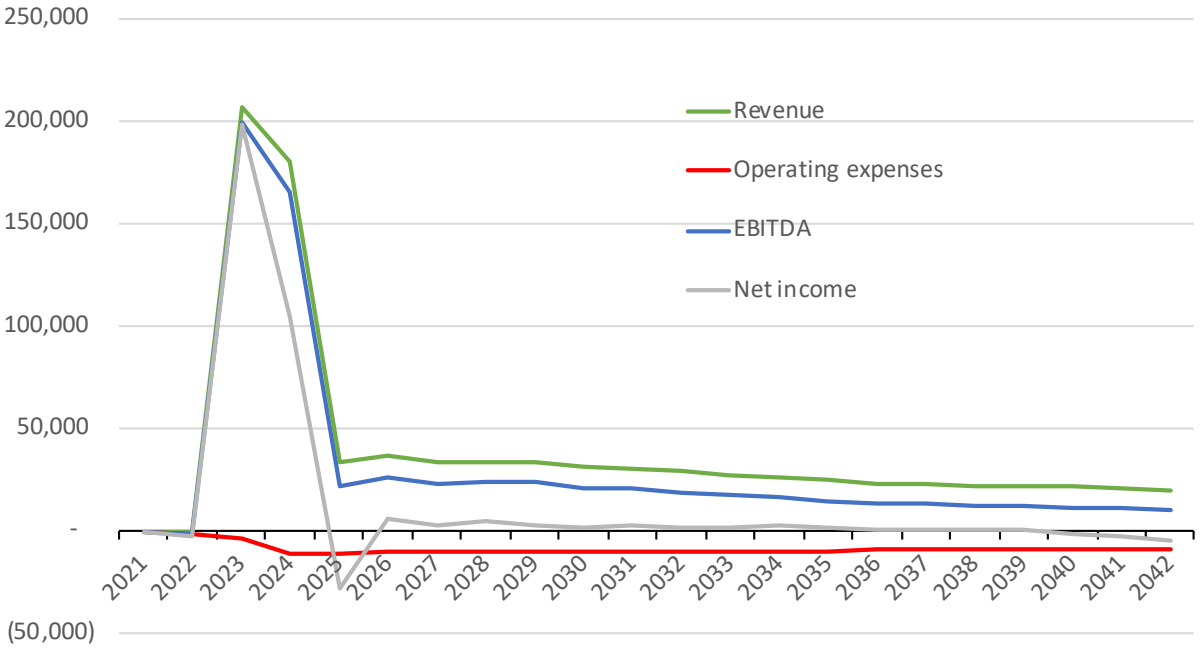


Figure 79: Chilean SPV Summary P&L, USD 000s

Source: TMG/WFNS

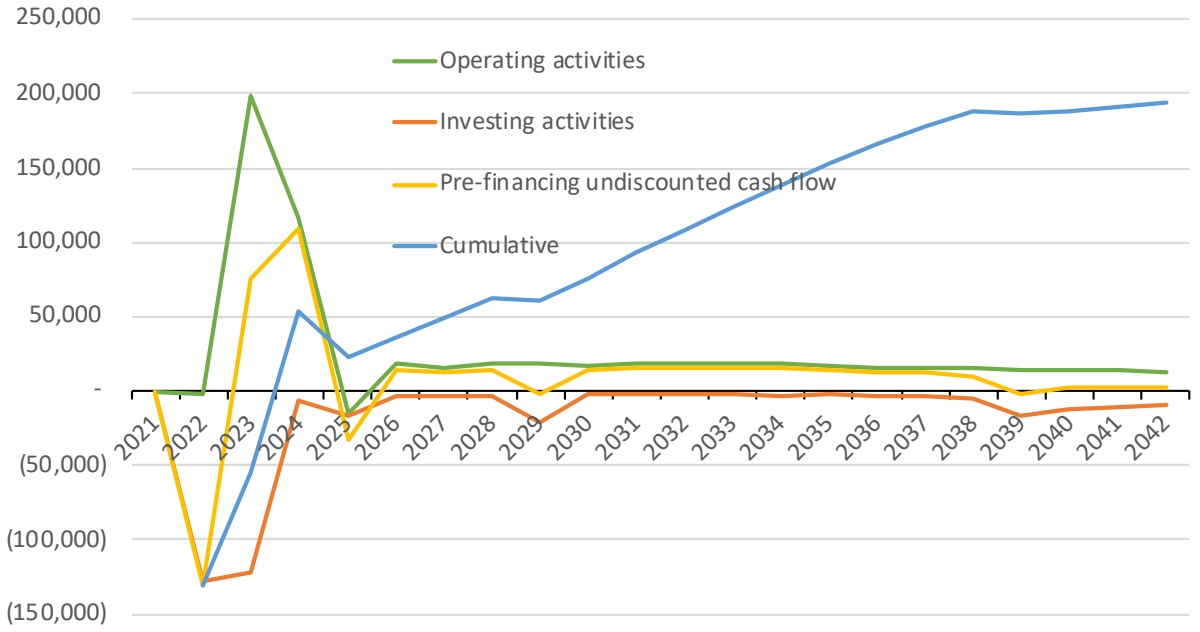


Figure 80: Chilean SPV Summary Cash Flow, USD 000s

Source: TMG/WFNS

9.7.2 Consortium overall

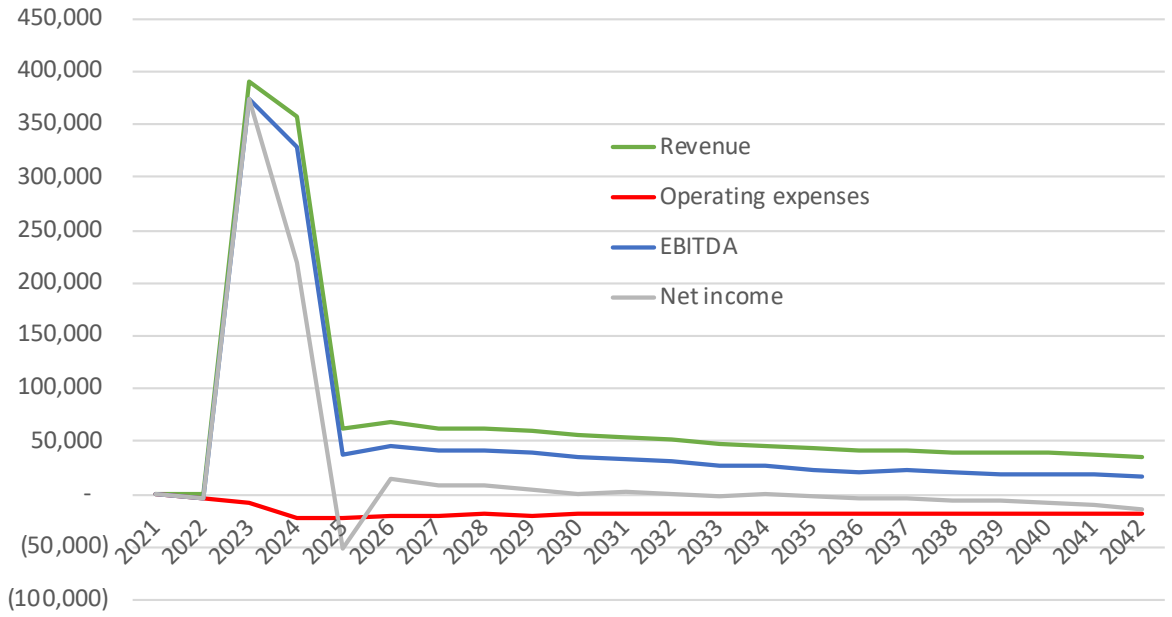


Figure 81: Consortium Summary P&L, USD 000s

Source: TMG/WFNS

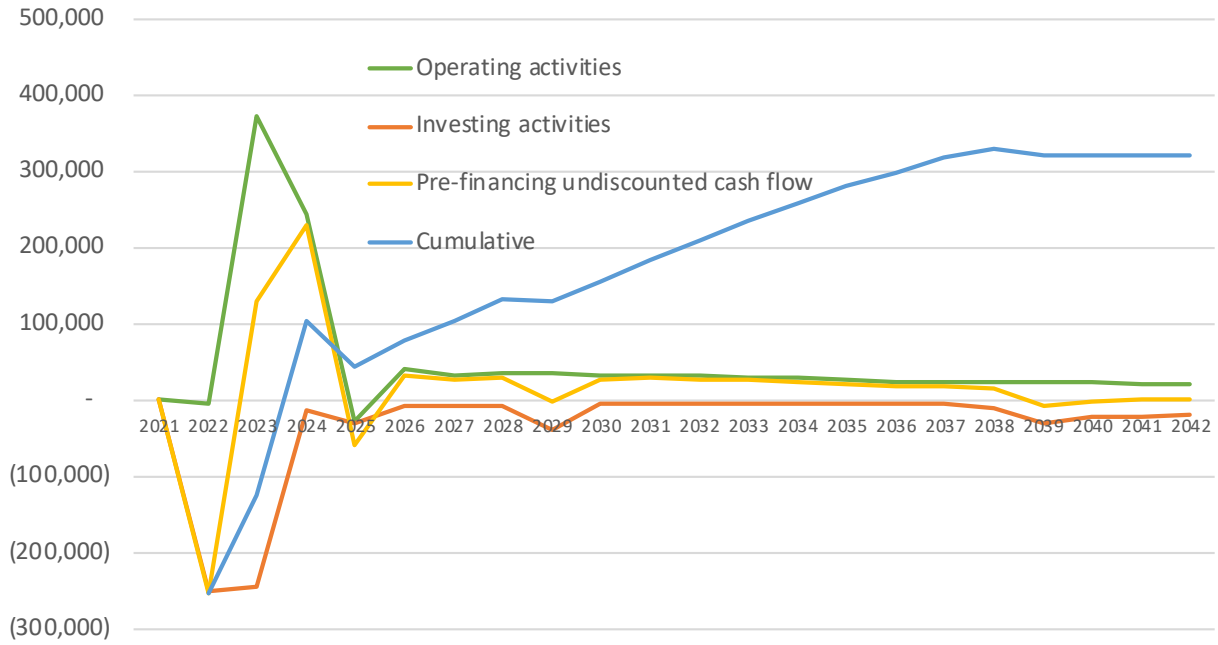


Figure 82: Consortium Summary Cash Flow, USD 000s

Source: TMG/WFNS

9.7.3 Other Consortium Partners

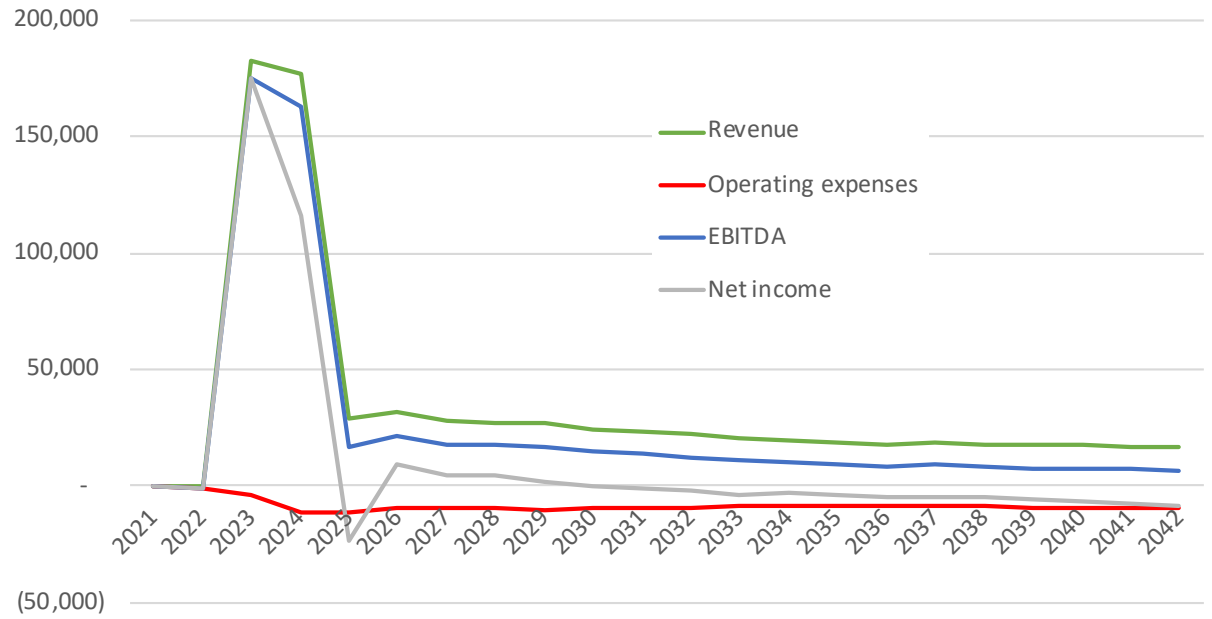


Figure 83: Other Consortium Partners' Summary P&L, USD 000s

Source: TMG/WFNS

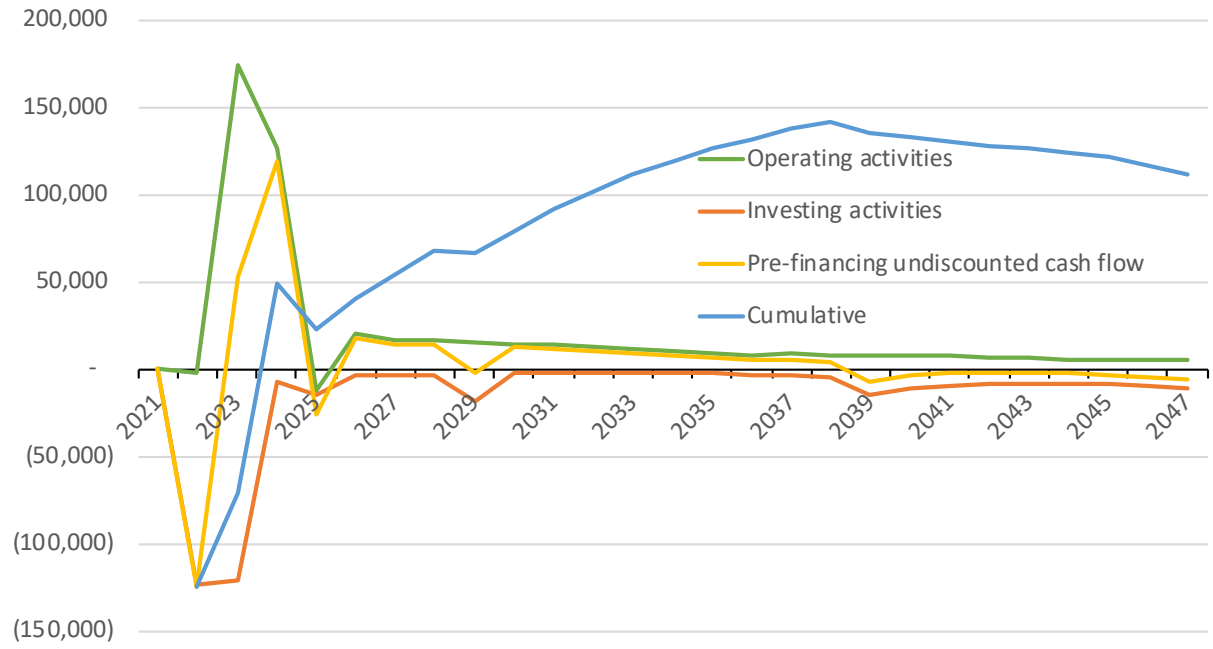


Figure 84: Other Consortium Partners' Summary Cash Flow, USD 000s

Source: TMG/WFNS

In order to understand the relative performance of the consortium overall, Chilean SPV and other consortium partners, some assumptions are made for both sets of consortium partners. For example, they each sell an equivalent number of fiber and quarter fiber pairs, their organizational OpEx is equivalent and they purchase Asian Onward Connectivity in the same manner (as the weighted average of actual demand and purchased capacity increases).

9.7.4 Internal Chilean SPV Distributions

As discussed in the institutional model section, the Chilean SPV will select an OpCo to run its cable assets, including CLSs, share of the international segments of the cable and undertake sales and other management functions. The OpCo's revenue will come from the capacity sales it makes. Out of these revenues, it will have to cover all the Cost of Sales and OpEx associated with the Chilean SPV share of the cable and Asian Onward Connectivity. In return, it will pay the Chilean SPV a concession fee made up of:

- An upfront payment of 10% of the cable CapEx; and
- An annual recurring fee amounting the larger of:
  - 50% of the Chilean SPV's debt payment due in the given year; or
  - 58% of the revenue.

The resulting financial results for the Chilean SPV investors and the OpCo, respectively are as follows:

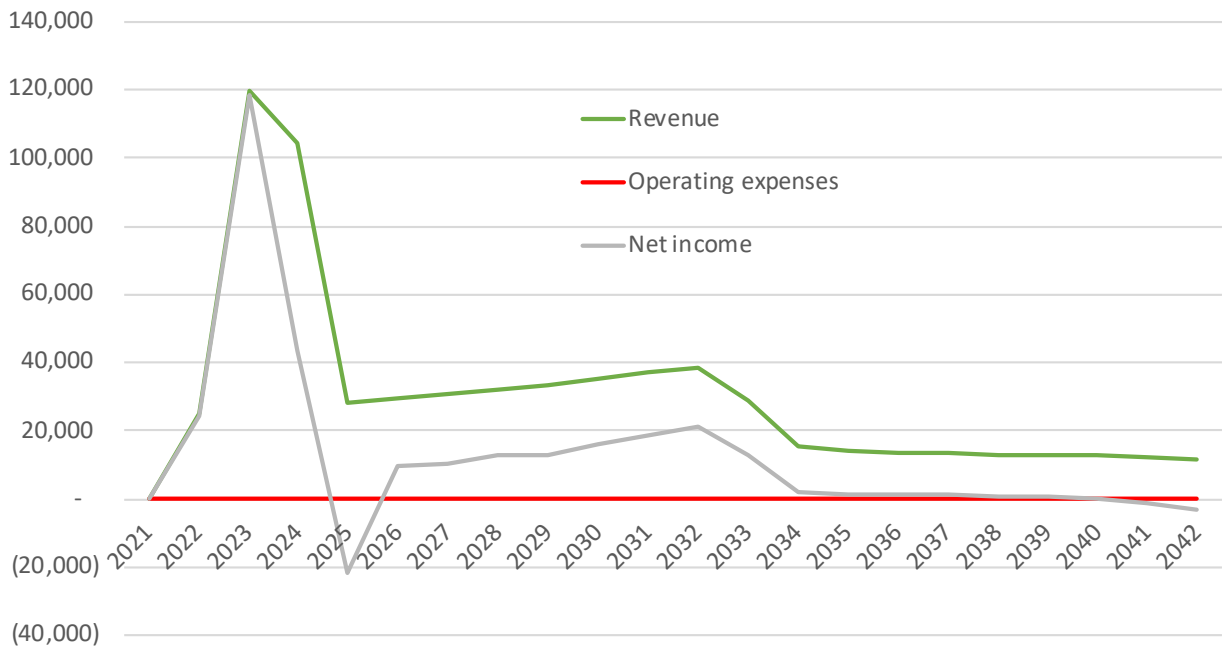


Figure 85: Chilean SPV Investors Summary P&L, USD 000s

Source: TMG/WFNS; Note for the Chilean SPV Investors Revenue = EBITDA, as the OpCo bears all the costs of sales and OpEx.

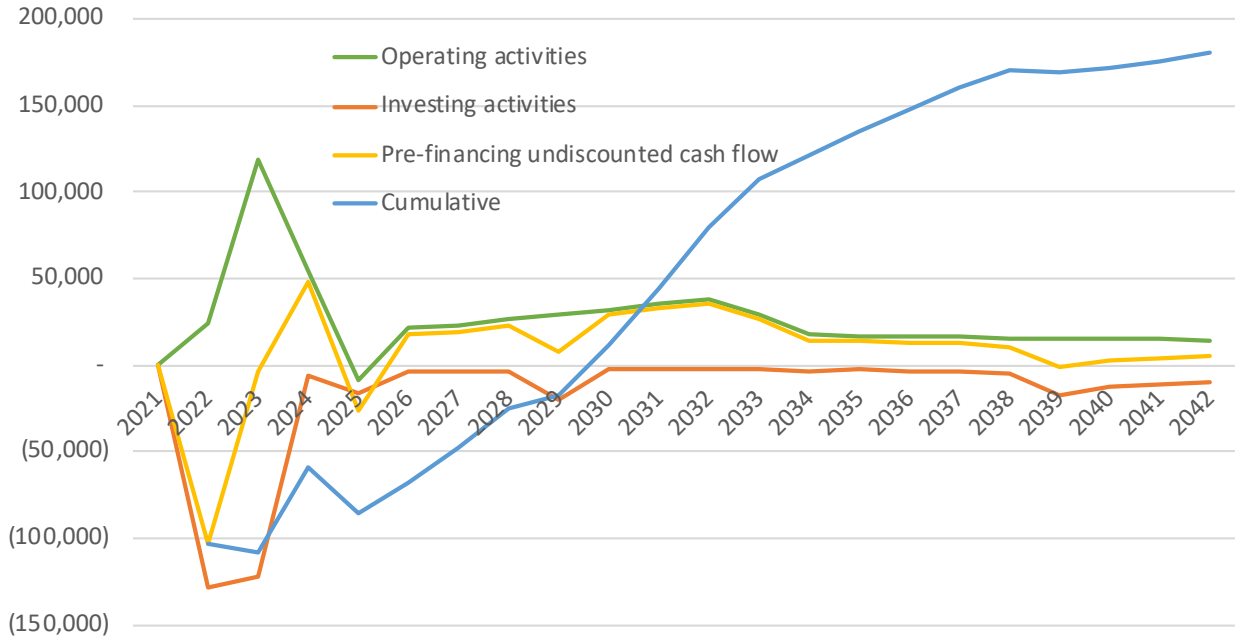


Figure 86; Chilean SPV Investors' Summary Cash Flow, USD 000s

Source: TMG/WFNS

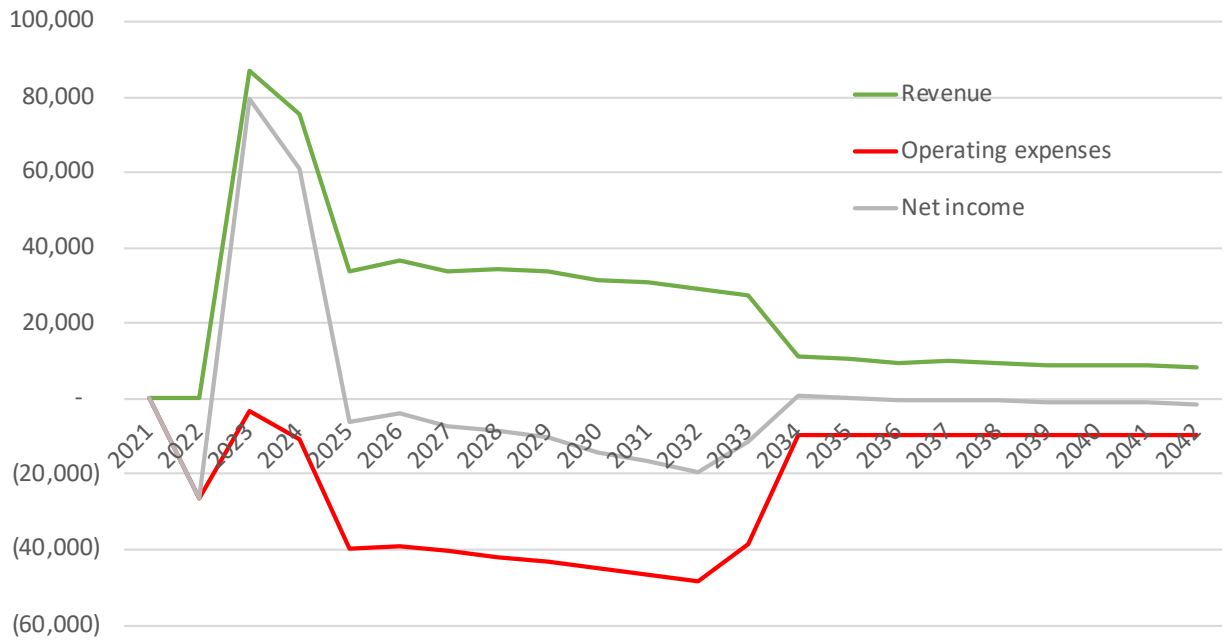


Figure 87: OpCo Summary P&L, USD 000s

Source: TMG/WFNS; Note for the OpCo EBITDA = Net income, as the Chilean SPV Investors bears all the net interest expenses and depreciation expense.

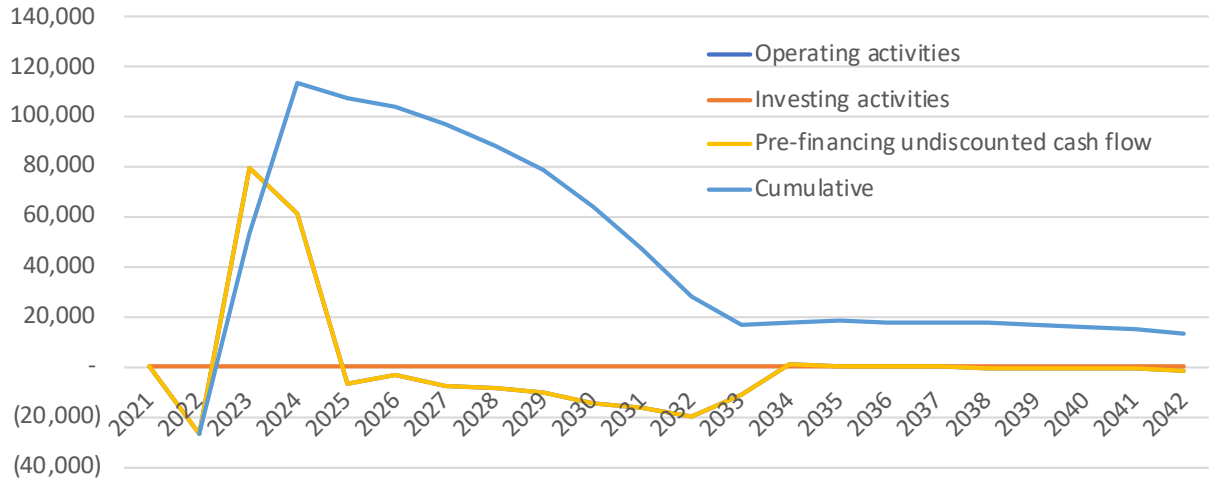


Figure 88: OpCo Summary Cash Flow, USD 000s

Source: TMG/WFNS

9.7.5 Measures of Return by Stakeholder Group

Table 49: Return Table

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Partners
Project NPV (pre-financing), USD, 000s	$131,730	$76,901	$39,712	$37,190	$54,829
Project IRR (pre-financing)	28%	28%	13%	N.A.	27%
Project Payback Year	2.55	2.50	8.59	1.33	2.59
EBIT Ratio (EBIT/Revenue)	32%	35%	47%	0.4%	28%
Average ROCE	5%	6%	6%	N.A.	4%

Sources: TMG/WFNS

9.8 Sensitivity Analysis

In the section, the results of sensitivity analysis are presented. Plus and minus 10% changes to key assumptions are made and impact on the five stakeholder NPV are given.

The section concludes with the results of the demand scenarios. The “high” and “low” scenarios are demand at 120% and 50% of the base scenario respectively.

9.8.1 Demand Sensitivities

9.8.1.1 SPV Aggregate Volume

In this sensitivity, it is assumed that the Chilean SPV wins plus or minus 10% from the base assumption of sales for Asia of 50%.

For 10% more Asian sales to the Chilean SPV the results are as follows:

Table 50: Results with +10% in SPV Share of Asia Sales

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	$132,402	$108,346	$47,267	$61,079	$24,056
Project IRR	37%	37%	14%	N.A.	17%
Project Payback year	2.61	2.37	8.40	1.31	4.06
EBIT Ratio	31%	38%	48%	7%	22%
Average ROCE	5%	8%	7%	N.A.	3%

Table 51: Compared to Base Case Value, %

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	1%	41%	19%	64%	-56%
Project IRR	32%	32%	8%	N.A.	-37%
Project Payback year	2%	-5%	-2%	-2%	57%
EBIT Ratio	-1%	10%	2%	1597%	-22%
Average ROCE	1%	23%	7%	N.A.	-34%

For 10% fewer Asian sales to the Chilean SPV the results are as follows:

Table 52: Results with -10% in Chilean SPV Share of Asia Sales

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	$120,706	$39,557	$28,216	$11,341	$81,149
Project IRR	18%	18%	12%	N.A.	34%
Project Payback year	2.57	4.39	8.89	17.36	2.45
EBIT Ratio	31%	29%	45%	-9%	33%
Average ROCE	5%	4%	6%	N.A.	5%

Table 53: Compared to Base Case Value, %

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	-8%	-49%	-29%	-70%	48%
Project IRR	-36%	-36%	-12%	N.A.	30%
Project Payback year	1%	75%	4%	1202%	-5%
EBIT Ratio	-2%	-15%	-4%	-2089%	16%
Average ROCE	-7%	-30%	-10%	N.A.	27%

9.8.1.2 Product Mix

In this sensitivity, it is assumed that the share of 100G IRU sold is plus or minus 10% from the base assumption of share of the total.

For 10% more 100G IRU sales of the total, the results are as follows:

Table 54: Results with +10% in 100G IRU Share Total

	Consortium	SPV	SPV Investors	OpCo	Other Partners
Project NPV	$122,855	$72,727	$41,676	$31,051	$50,128
Project IRR	28%	28%	14%	N.A.	26%
Project Payback year	2.54	2.48	8.49	6.33	2.59
EBIT Ratio	31%	34%	47%	-2%	27%
Average ROCE	5%	6%	6%	N.A.	4%

Table 55: Compared to Base Case Value, %

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	-7%	-5%	5%	-17%	-9%
Project IRR	-1%	-1%	2%	N.A.	-4%
Project Payback year	0%	-1%	-1%	374%	0%
EBIT Ratio	-2%	-2%	0%	-482%	-3%
Average ROCE	-4%	-3%	1%	N.A.	-5%

For 10% fewer 100G IRU sales of the total, the results are as follows:

Table 56: Results with -10% in 100G IRU Share Total

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners

Project NPV	$147,617	$86,123	$40,752	$45,370	$61,495
Project IRR	30%	30%	13%	N.A.	29%
Project Payback year	2.52	2.47	8.58	1.33	2.57
EBIT Ratio	33%	36%	47%	3%	29%
Average ROCE	6%	7%	6%	N.A.	5%

Table 57: Compared to Base Case Value, %

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	12%	12%	3%	22%	12%
Project IRR	8%	8%	1%	N.A.	7%
Project Payback year	-1%	-1%	0%	0%	-1%
EBIT Ratio	4%	3%	1%	584%	4%
Average ROCE	7%	7%	1%	N.A.	7%

9.8.2 Pricing Sensitivity

9.8.2.1 Level

In this sensitivity, it is assumed that the base price is plus or minus 10% from the base assumption.

For a 10% higher base price, the results are as follows:

Table 58: Results with +10% in Base Price

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	$171,526	$100,068	$46,521	$53,547	$71,458
Project IRR	34%	34%	14%	N.A.	32%
Project Payback year	2.45	2.38	8.43	1.31	2.50
EBIT Ratio	35%	38%	48%	6%	31%
Average ROCE	6%	7%	7%	N.A.	5%

Table 59: Compared to Base Case Value, %

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	30%	30%	17%	44%	30%
Project IRR	22%	22%	7%	N.A.	20%

Project Payback year	-4%	-5%	-2%	-2%	-3%
EBIT Ratio	10%	9%	3%	1204%	11%
Average ROCE	20%	20%	7%	N.A.	19%

For a 10% lower base price, the results are as follows:

Table 60: Results with -10% in Base Price

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	$91,178	$53,527	$32,695	$20,832	$37,651
Project IRR	22%	22%	12%	N.A.	21%
Project Payback year	2.65	2.62	8.74	16.36	2.68
EBIT Ratio	28%	31%	45%	-5%	25%
Average ROCE	4%	5%	6%	N.A.	3%

Table 61: Compared to Base Case Value, %

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	-31%	-30%	-18%	-44%	-31%
Project IRR	-21%	-21%	-7%	N.A.	-20%
Project Payback year	4%	5%	2%	1126%	3%
EBIT Ratio	-11%	-10%	-3%	-1352%	-12%
Average ROCE	-20%	-20%	-7%	N.A.	-20%

9.8.2.2 Rate of Decline

In this sensitivity, it is assumed that the rate of price decline is plus or minus 10% from the base assumption.

For a 10% higher rate of price decline, the results are as follows:

Table 62: Results with +10% in Rate of Price Decline

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	$62,224	$36,007	$29,221	$6,786	$26,217
Project IRR	20%	20%	12%	N.A.	20%
Project Payback year	2.65	2.62	8.64	17.36	2.68

EBIT Ratio	24%	27%	44%	-13%	22%
Average ROCE	3%	4%	5%	N.A.	3%

Table 63: Compared to Base Case Value, %

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	-53%	-53%	-26%	-82%	-52%
Project IRR	-29%	-30%	-8%	N.A.	-27%
Project Payback year	4%	5%	1%	1201%	3%
EBIT Ratio	-23%	-22%	-6%	-3039%	-24%
Average ROCE	-41%	-42%	-15%	N.A.	-40%

For a 10% lower rate of price decline, the results are as follows:

Table 64: Results with -10% in Rate of Price Decline

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	$215,919	$127,889	$51,388	$76,501	$88,029
Project IRR	36%	36%	14%	N.A.	33%
Project Payback year	2.43	2.37	8.55	1.31	2.49
EBIT Ratio	39%	43%	50%	14%	36%
Average ROCE	8%	10%	7%	N.A.	6%

Table 65: Compared to Base Case Value, %

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	64%	66%	29%	106%	61%
Project IRR	30%	30%	8%	N.A.	26%
Project Payback year	-5%	-5%	0%	-2%	-4%
EBIT Ratio	25%	24%	8%	3067%	26%
Average ROCE	51%	54%	18%	N.A.	48%

9.8.3 Discount Rate Sensitivity

In this sensitivity, it is assumed that the discount rate is plus or minus 10% from the base assumption.

For a discount rate 10% higher, the results are as follows:

Table 66: Results with 10% Increase in the Discount Rate

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	$120,583	$70,014	$31,711	$38,304	$50,569
Project IRR	28%	28%	13%	N.A.	27%
Project Payback year	2.55	2.50	8.59	1.33	2.59
EBIT Ratio	32%	35%	47%	0%	28%
Average ROCE	5%	6%	6%	N.A.	4%

Table 67: Compared to Base Case Value, %

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	-8%	-9%	-20%	3%	-8%
Project IRR	0%	0%	0%	N.A.	0%
Project Payback year	0%	0%	0%	0%	0%
EBIT Ratio	0%	0%	0%	0%	0%
Average ROCE	0%	0%	0%	N.A.	0%

For a discount rate 10% lower, the results are as follows:

Table 68: Results with 10% Decrease in the Discount Rate

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	$143,807	$84,460	$48,643	$35,816	$59,348
Project IRR	28%	28%	13%	N.A.	27%
Project Payback year	2.55	2.50	8.59	1.33	2.59
EBIT Ratio	32%	35%	47%	0%	28%
Average ROCE	5%	6%	6%	N.A.	4%

Table 69: Compared to Base Case Value, %

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	9%	10%	22%	-4%	8%
Project IRR	0%	0%	0%	N.A.	0%
Project Payback year	0%	0%	0%	0%	0%

EBIT Ratio	0%	0%	0%	0%	0%
Average ROCE	0%	0%	0%	N.A.	0%

9.8.4 Cost Sensitivities

9.8.4.1 OpEx Sensitivities

In this sensitivity, it is assumed that the OpEx is plus or minus 10% from the base assumption.

For OpEx 10% higher, the results are as follows:

Table 70: Results with 10% Increase in OpEx

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	$116,840	$69,113	$40,357	$28,756	$47,727
Project IRR	27%	27%	13%	N.A.	25%
Project Payback year	2.56	2.51	8.55	9.34	2.60
EBIT Ratio	29%	32%	47%	-4%	26%
Average ROCE	5%	6%	6%	N.A.	4%

Table 71: Compared to Base Case Value, %

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	-11%	-10%	2%	-23%	-13%
Project IRR	-4%	-4%	1%	N.A.	-5%
Project Payback year	0%	0%	0%	600%	0%
EBIT Ratio	-8%	-7%	0%	-925%	-9%
Average ROCE	-10%	-9%	0%	N.A.	-12%

For OpEx 10% lower, the results are as follows:

Table 72: Results with 10% decrease in OpEx

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	$146,380	$84,632	$39,009	$45,623	$61,748
Project IRR	29%	29%	13%	N.A.	28%
Project Payback year	2.54	2.49	8.63	1.33	2.58
EBIT Ratio	34%	37%	47%	4%	31%

Average ROCE	6%	7%	6%	N.A.	5%

Table 73: Compared to Base Case Value, %

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	11%	10%	-2%	23%	13%
Project IRR	4%	4%	-1%	N.A.	4%
Project Payback year	0%	0%	0%	0%	0%
EBIT Ratio	8%	7%	0%	925%	9%
Average ROCE	10%	9%	0%	N.A.	12%

9.8.4.2 CapEx Sensitivities

In this sensitivity, it is assumed that the CapEx is plus or minus 10% from the base assumption.

For CapEx 10% higher, the results are as follows:

Table 74: Results with 10% increase in CapEx

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	$77,193	$46,629	$26,137	$20,492	$30,564
Project IRR	18%	18%	11%	N.A.	17%
Project Payback year	4.12	4.28	9.05	17.37	3.99
EBIT Ratio	28%	31%	44%	-5%	24%
Average ROCE	4%	5%	5%	N.A.	3%

Table 75: Compared to Base Case Value, %

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	-41%	-39%	-34%	-45%	-44%
Project IRR	-35%	-35%	-16%	N.A.	-35%
Project Payback year	61%	71%	5%	1202%	54%
EBIT Ratio	-13%	-11%	-6%	-1255%	-15%
Average ROCE	-26%	-26%	-15%	N.A.	-27%

For CapEx 10% lower, the results are as follows:

Table 76: Results with 10% Decrease in OpEx

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	$185,465	$106,989	$53,102	$53,888	$78,476
Project IRR	42%	42%	16%	N.A.	39%
Project Payback year	2.33	2.27	8.01	1.30	2.39
EBIT Ratio	36%	38%	50%	6%	32%
Average ROCE	7%	8%	7%	N.A.	6%

Table 77: Compared to Base Case Value, %

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	41%	39%	34%	45%	43%
Project IRR	49%	49%	21%	N.A.	46%
Project Payback year	-9%	-9%	-7%	-2%	-8%
EBIT Ratio	13%	11%	7%	1255%	15%
Average ROCE	31%	31%	18%	N.A.	32%

9.8.5 Demand Scenario Results

In demand scenario, it is assumed that demand across all route pairings are 120% of the forecasted amount for the “high” scenario, and 50% of the forecasted amount for the “low” scenario.

For the “high” demand scenario, the results are as follows:

Table 78: Results for the "High" Demand Scenario

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	$192,193	$112,479	$44,256	$68,223	$79,714
Project IRR	38%	38%	14%	N.A.	35%
Project Payback year	2.39	2.30	8.55	1.29	2.46
EBIT Ratio	35%	38%	46%	9%	32%
Average ROCE	7%	8%	6%	N.A.	5%

Table 79: Compared to Base Case Value, %

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners

Project NPV	46%	46%	11%	83%	45%
Project IRR	37%	37%	5%	N.A.	32%
Project Payback year	-6%	-8%	0%	-3%	-5%
EBIT Ratio	11%	10%	-1%	2070%	13%
Average ROCE	24%	24%	2%	N.A.	23%

For the "low" demand scenario, the results are as follows:

Table 80: Results for the "Low" Demand Scenario

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	($33,965)	($16,989)	$25,615	($42,604)	($16,976)
Project IRR	4%	4%	11%	N.A.	N.A.
Project Payback year	11.36	12.21	8.52	20.55	10.98
EBIT Ratio	17%	20%	48%	-39%	14%
Average ROCE	1%	1%	6%	N.A.	1%

Table 81: Compared to Base Case Value, %

	Consortium	Chilean SPV	Chilean SPV Investors	OpCo	Other Cons. Partners
Project NPV	-126%	-122%	-35%	-215%	-131%
Project IRR	-87%	-87%	-15%	N.A.	N.A.
Project Payback year	346%	388%	-1%	1440%	323%
EBIT Ratio	-47%	-43%	4%	-9131%	-52%
Average ROCE	-78%	-77%	-9%	N.A.	-79%

9.9 Conclusions

The financial model demonstrates under the given assumptions and parameters that the DGASA cable is viable and exhibits expected cash-flow characteristics. It should also be stressed that the results of business modeling presented in this report are driven by demand modelling estimates undertaken in accordance with the TORs of this project. DGASA promoters should begin the process to validate the business model by gauging actual private interest in equity investment in the DGASA system or pre-sale capacity IRU purchases (i.e., sales that take place prior to CIF and pre- RFS dates) as soon as possible. This will require multiple rounds of consultations and negotiations across all potential stakeholders, investors and clients. Pre-sales are of prime significance during the deployment phase and the process can be expected to take at least two years before RFS. An accurate assessment of cash-flow will be highly dependent on this early stage of sales activity.

The business case for the various stakeholders shows how sensitive the business case is to several key input variables. 10% changes in the share of Asian sales, share of high bandwidth IRU sales, base price, price decline, OpEx, CapEx and the demand scenario have disproportionately large (i.e., significantly more than 10%) impact on NPV.

It should also be noted that the business case for the Chilean SPV is highly dependent on its ability to acquire a dark fiber at the outset of the project. If it is not able to scale from half a fiber pair at the outset to a full pair within the first few years, the viability of the project is in serious question.

10. Risk Analysis

10.1 Introduction

This section presents a risk analysis for the DGASA system which considered the following key issues:

- Assessment of key project risks, mitigation and potential financial impact
- Identification of what key project, technical and operational risks exist
- What other industry specific risks exist that the cable owner (and other potential lenders) should be made aware.

TMG/WFNS has considered cybersecurity, system design, technology, construction contract, geotechnical, operations and maintenance, financial model, capacity purchase agreements, environmental and social issues, permitting, project plan of work and schedule. TMG/WFNS has accomplished a thorough risk analysis of DGASA based on information made available.

This section does not address commercial risks associated with meeting capacity sales targets assumed in the business plan. As noted, such commercial risks are inherent to a submarine cable project and may be mitigated by promptly launching an effective strategy to gage private interest in equity investments in the DGASA system and to close pre-sale capacity IRU purchase agreements (i.e., sales that take place pre-CIF and pre-RFS dates).

10.2 System Implementation

Based on the analysis undertaken, Table 82 discusses the key project, technical and operational risks identified for the DGASA project. All risks identified in the matrix below apply to the proposed route between Chile, New Zealand and Australia. The information presented is intended to identify risks to the development of the system and includes suggested mitigation actions.

Table 82: Key Project, Technical and Operational Risks

Key Project Risks	Issue	Mitigation	Likelihood of Occurring	Potential Financial Impact
Cybersecurity	Unauthorized cybernetic access to the system	1. Managed security access protocols for the various layers of network management systems 2. Physical security management of access control for authorized personnel with multiple layers of physical restraint 3. Stringent security policy and procedures around Information Technologies and	Low	High, system breaches of all or part of the traffic could be affected causing loss of revenue (and reputation) The system could be deliberately sabotaged

Key Project Risks	Issue	Mitigation	Likelihood of Occurring	Potential Financial Impact
		standard security protocols		
	Unauthorized cybernetic access to the traffic on the system	1. Physical access control for authorized personnel 2. Traffic alarm monitoring	Low	High, if the traffic is compromised, all or part of the traffic could be affected causing loss of revenue (and reputation)
System Design	Long DLS with new C-Band equipment	Contract needs to include design reviews and system demonstration	Low	Medium, but manageable for risk identification and mitigation
	Qualification of new technology may delay program	1. Proven technologies need to be used 2. Use of qualified products/solutions is preferred. 3. For any product release under qualification, a specific internal follow-up to be conducted to avoid schedule delay	Low	Low
	Submerged Plant Design performance over design life may degrade if incorrectly designed	1. Proven technologies need to be used 2. If new technologies are used qualification programs/reports required and design reviews to occur	Low	Low
Technology	New Transmission Technology	Contract must include qualification programs/reports required and design reviews to occur	Low	Low
Construction Contract	Contract Variations and/or Permitting Delays	1. Choose System Supplier with established track record 2. Good project management and collaborative working relationship with System Supplier 3. Consider Chile's geopolitical position	Low	Medium, but manageable for risk identification and mitigation

Key Project Risks	Issue	Mitigation	Likelihood of Occurring	Potential Financial Impact
		and its implications to permitting		
Geotechnical	Review of the CRS report and newly identified permitting requirements against the current RPL could lead to changes in armor types and lengths	1. Ensure the DTS and marine survey are professionally reviewed, and their results professionally monitored, mitigating cable type and route length changes to ensure overall system safety and technical compliance 2. Include Cable Route Engineering Working Group as part of PMT.	Medium	Medium, but manageable for risk identification and mitigation
Operations and Maintenance	Zone or Private Marine Maintenance are available for the entire DGASA route	1. Detailed negotiation strategy for marine maintenance 2. Strategic location of system spares 3. Inhouse or outsourced support services at each landing location and/or the NOC	Low	Low. While some of the route falls outside established maintenance zones, maintenance providers will negotiate required coverage for the system
Financial Model	Late investment in capacity upgrades	Review of capacity upgrades	Low	Medium, but manageable for risk identification and mitigation
Capacity Purchase Agreements	Individual Contract Negotiation	1. Detailed negotiation strategy 2. Model agreements with clear SLAs	Low	Low
Environmental and Social Issues	No current issues, new legislation may possibly be a concern	Permit Working Group as part of PMT	Low	Low
Permitting	Permitting process requirements are for landing points in pre-existing cable designated zones	Continued communication with coastal stakeholders regarding project progress, attention and sensitivity to environmental “hot point” issues	Low	Low to Medium, but manageable for risk identification and mitigation
	No true issues defined pending results of marine survey	Documentation review indicates mitigation actions currently active and in place	Low	Low to Medium, but manageable for risk identification and mitigation

Key Project Risks	Issue	Mitigation	Likelihood of Occurring	Potential Financial Impact
	Timescales and Complexity	Permit Working Group as part of PMT	Low	Medium, but manageable for risk identification and mitigation
	Delays or refusals	1. Understand the permitting schedule and follow to the extent possible SUBTEL and Landing Party permitting applications 2. Include status of permitting on the CCM meeting agenda and request regular updates	Low	Medium, but manageable
	Delays in Operational Permits could impact Marine Schedule	1. Understand Operational Permitting Requirements in project jurisdictions, include these in the Operational Permit Plan/Listing 2. Communicate requirements to Marine Installer(s) and follow up their status	Low	Medium, but manageable
	Banned Equipment	Avoid utilizing banned equipment and companies that are banned by Australia and New Zealand	Medium	High, if decision is made to introduce banned equipment into the network
Project Plan of Work	Lack of Float	Good project management and collaborative working relationship with System Supplier	Low	Medium, but manageable for risk identification and mitigation
	Delays to POW due to permitting	Good project management and collaborative working relationship with System Supplier.	Low	Medium, but manageable for risk identification and mitigation
Survey	Delay in Survey Operation could delay manufacture	1. If survey data may be late launch materials procurement and early manufacture based on principle of an 'overlength' design, e.g., LW cable core 2. Establish a process	Low	Low

Key Project Risks	Issue	Mitigation	Likelihood of Occurring	Potential Financial Impact
		to progressively agree cable protection as the survey proceeds		
	Conditions and Routing through specific areas may dictate precise placement of Repeater(s) such that an additional Repeater is required	The cable owner and System Supplier to carefully consider the impact of Repeater and other housing locations, through Cable Route Engineering Working Group	Low	Low
	Route length could be longer than the design overlength	1. All to be aware of the maximum overlength permitted, under the supply contract 2. A route to be identified accordingly	Low	Low
Submerged Plant	Cable or Repeater Damage during Loading	1. A copy of Supplier's Marine Installation Guidelines to be part of supply contract SLLI 2. All Load's and Transfers to be in accordance with the latest issue of MIG's and in the supply contract SLLI	Low	Low
	Cable or Repeater Damage during Transits	1. Freighter Tank Design to be in accordance with System Supplier standards and covered by the supply contract SLLI 2. Cable coiling and repeater handling to be in accordance with the MIG	Low	Low
	Cable damage, cable suspensions, cable abrasion, lack of protection	1. Cable repair and restoration to be accordance with the Cable Engineering Guidelines and the SLLI 2. Cable slack control to be in accordance with Shipboard Procedures, Marine Installation Guidelines set out in the supply contract SLLI	Low	Low

Key Project Risks	Issue	Mitigation	Likelihood of Occurring	Potential Financial Impact
		3. All marine to be covered by supply contract commercial warranty and ongoing system design support		
Terminal Equipment Maintenance	Long term system maintainability	1. System Supplier to recommend that the most appropriate terminal equipment release to be deployed 2. A design review to occur if a new technology release is to be deployed 3. Terminal Equipment to be covered by supply contract commercial warranty and ongoing system design support	Low	Low
Manufacturing Schedule Slippage	Availability of SEQ Filters could impact SAT and Load date	1. Monitor SEQ manufacturing Program 2. Develop SAT and Loading Plan which permits Blocks to be loaded whilst others are jointed 3. Other work around plans that may be possible though changes in the overall marine installation program	Low	Low
Customs Clearance	Delays in Customs Clearance could impact Schedule	1. Propose Shipping Procedures, agree with the cable owner and the detail of the communications that are to occur 2. Establish good communications with Agent 3. Investigate pre-clearance, for critical shipments	Low	Low
Weather	Weather could delay Marine Operations	1. Plan Manufacture and Install of cable as soon as possible so maximum program contingency exists	Low	Low

Key Project Risks	Issue	Mitigation	Likelihood of Occurring	Potential Financial Impact
		2. Plan campaign to avoid inclement weather periods (e.g., Winter in the Tasman Sea)		
Marine Installation	Delay in availability of Installation Vessels from previous Projects	1. Develop a target POW with schedule 'float' 2. Monitor Availability of Vessel on an ongoing basis	Low	Low
	Damage to Underwater Plant as a result of incorrect plough operation	Use of experienced personnel and equipment with proven track record	Low	Low
	Delays if plough is not reliable	1. Ensure sufficient spares are carried and any plough maintenance has occurred prior to operations commencing 2. Use of equipment with proven track record	Low	Low
	Damage to cable during PLIB could require a repair	Use of experienced personnel & equipment with proven track record, as well as established procedures	Low	Low
Damage by Long Lines or Trawling	Damage by long line fishing could result in shunt fault and the need for a repair	Deploy grapnel from bow of cable ship during laying/ploughing in waters where long lines may be laid, or deploy guard ship with grapnel in front of cable ship	Low	Low
Availability of Terminal Stations, Duct Routes and Landing Facilities	If Terminal Stations, Duct Routes of Landing facilities are not available delays could result	1. Clearly communicate Installation Program requirements 2. Request regular updates from the cable owner and monitor 3. Agree SOW such that parties' responsibilities are clear	Low	Low

Key Project Risks	Issue	Mitigation	Likelihood of Occurring	Potential Financial Impact
		4. Ensure there are agreed handover prerequisites defining CLS/Civil Works and BMH completion		
Quality Assurance	To ensuring that the standard of all products and services are fit for purpose	All suppliers of products and services to have a fully documented Quality Assurance System accredited to internationally recognized bodies, e.g., ISO 9001, 14001, 27001 & 45001 or equivalent	Low	Low
Target Customers	The target customer base chosen does not revenue projected to be obtained	Ensure the customer base is comprehensive enough to ensure all end customers can be reached, either directly or indirectly prior to committing to invest	Low	High. DGASA revenues could fail to meet the expectations of the Business Case
Extension of Subsea Capacity to National Bottlenecks	Direct Customers are unable to provide the capability to distribute all DGASA products to full range of indirect customers due to limitations of their networks	Ensure all customers have the capability to meet the requirements of their end customers either directly or indirectly, by ensuring wherever possible carrier-neutral interconnect at the cable stations	Low. Markets in landing countries competitive, stations generally carrier-neutral	Low. DGASA revenues could fail to meet the expectations of the Business Case
Political	Certain countries still have developing regulatory regimes. A few have been potentially politically volatile recently.	Keep regulation, governmental changes and the geopolitical influences under close observation Remain flexible in approach, to the extent possible, should political issues impact the system	Low	Low. Delay in project implementation
Funding	At the moment it is unclear what entities will be interested in joining DGASA and in what capacity.	Continued, persistent effort to vet interest and design routing approach to cable that will maximize investor interest. Consider Chile's	Medium-High	High, existential issue for cable

Key Project Risks	Issue	Mitigation	Likelihood of Occurring	Potential Financial Impact
		geopolitical position and its implications to securing funding		
Predatory Pricing from existing submarine cable systems	Systems that offer indirect routing via U.S. drop prices beyond the forecasts in this report.	Include price sensitivity in business plan.	Low, traffic to Asia small compared to traffic to US/elsewhere, systems will not be incentivized to drop prices	Low, unique value proposition of direct routing means there may be greater than usual inelasticity in price.
Additional cables	Routes will be at risk if there is evidence that there is a new system development at the landing points under consideration	Keep pricing competitive. Consider Chile's geopolitical position and its implications to providing capacity and alternative routing for purchasers in the region.	Medium	Medium

Source: TMG/WFNS

10.3 Conclusion

Based on the information available at this time, TMG/WFNS has accomplished a thorough risk analysis for the DGASA system. This assessment considered cybersecurity, system design, technology, construction contract, geotechnical, operations and maintenance, financial model, capacity purchase agreements, environmental and social issues, permitting, project plan of work and schedule. The likelihood of occurrence of these risks is considered low in most cases. Similarly, the impact of most of these risks on the project is also low.

However, there are few areas associated with Financial Impact that were rated as High and includes Cybersecurity, banned equipment at landing countries and funding for the project. Cybersecurity is a constant risk for any network, which must always be considered and requires appropriate measures to reduce the risks.

Any submarine cable system planned to interface or utilize banned equipment, however, should expect significant permitting delays and even denial to operate such a system landing in Australia or New Zealand (Submarine Telecoms Forum, Inc., 2020). Furthermore, funding and efforts to sell services on such a system could also be affected, as investors and purchasers with a pro US or Australian perspective will likely choose to avoid the system. Such geo-political issues are negated by using any of the three other system suppliers (SubCom, ASN, NEC) for the DGASA implementation.

Therefore, the DGASA system as envisioned, that being connecting Chile with New Zealand and Australia, does not pose a higher risk than other comparable submarine cable systems.

11. Conclusions & Recommendations

TMG/WFNS has been tasked to conduct a complete and comprehensive analysis to determine if developing a submarine cable system connecting South America to Asia is economically feasible. The analysis included two main components, technical and financial evaluations. This analysis concludes that it is economically feasible to develop the DGASA system as explained in the following sections.

11.1 Technical Evaluation

The proposed DGASA cable system is found to be technically feasible with special considerations given to the local environment. As envisioned, DGASA will cost approximately $405 to $524 million to build, install and commission. Over the 25-year life of the system, there will be sufficient capacity at each of the landing sites and associated communities. DGASA will require a minimum of two years to implement, (i.e., RFS 2023 or 2024).

Technical requirements developed for SUBTEL as part of this report consider technologies, provisioning flexibility, system survivability/reliability and potential cost, supported by responses from the world's primary submarine system suppliers.

11.2 Financial Evaluation

11.2.1 Institutional Structure

The selection of an institutional model for the DGASA cable system will depend on various strategic considerations. Taking account of the Chilean government's role as promoter of and investor in the DGASA cable system and the legal framework governing DP, the choice of the institutional model for the project should focus on two layers: (1) institutional model for the DGASA system main cable and (2) institutional model for the Chilean member of the DGASA consortium.

Based on the information available at this time, an unincorporated consortium or shared cost center is deemed the optimal DGASA system main cable institutional model. Structuring the DGASA cable system as a shared cost center will facilitate greater private sector equity participation. The shared cost center structure is widely used in multi-oner submarine cable projects and enables corporate investors to manage risk by limiting investment to their own international connectivity needs and retaining control over how they use their capacity. As additional equity owners beyond the Chilean Government are recruited for the project, DGASA consortium members will agree on a final institutional structure for the system which may differ from that proposed here. Figure 89 below presents the proposed institutional structure for the DGASA main cable.

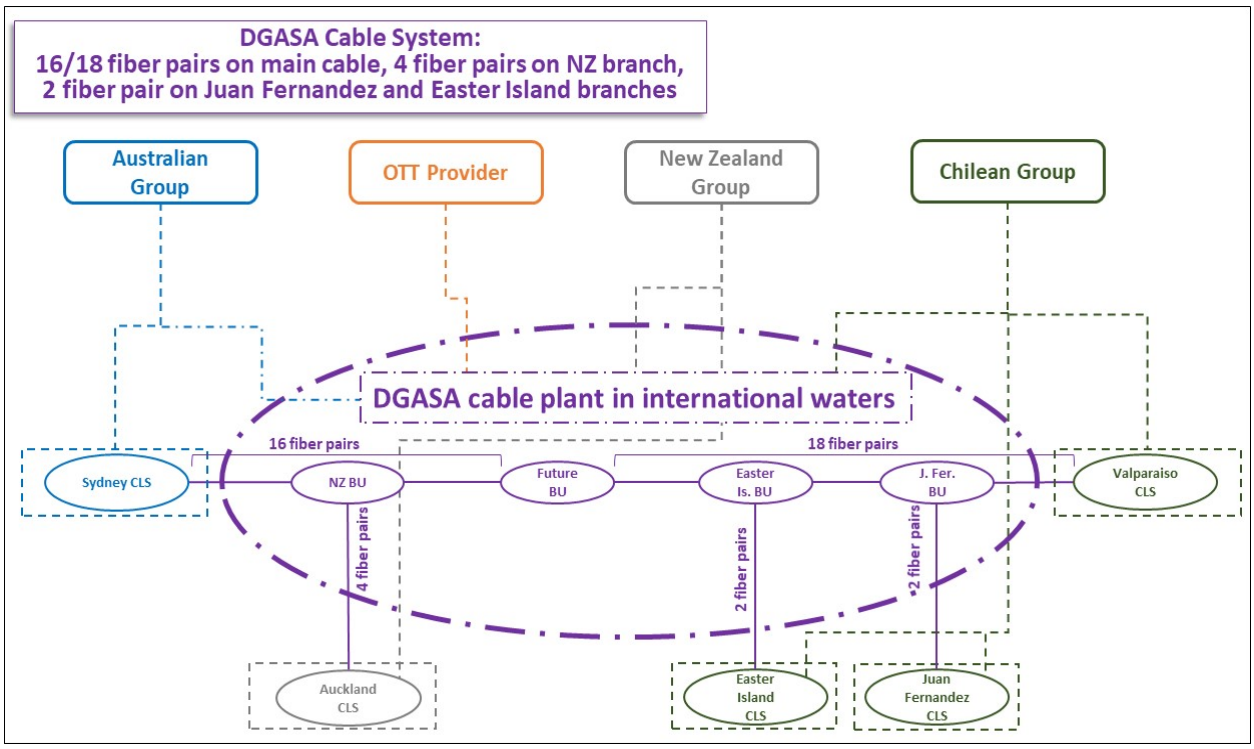


Figure 89: Proposed DGASA Main Cable Institutional Structure

Source: TMG/WFNS

Considering the legal framework applicable to DP, a Chilean SOE designated to participate as an equity owner in the DGASA project, two institutional models may be used for the Chilean member of the DGASA consortium: (1) a shared profit center PPP (Figure 90); or (2) a shared cost center PPP (Figure 91). These institutional models harness both private and public resources and will create incentives for participation in the DGASA project. As project promoters advance in the search for Chilean equity investors for the DGASA system and obtain more information on the commercial and strategic objectives of such potential partners, further review and adjustments to these options will likely be warranted to select the optimal institutional model for the Chilean member for the DGASA consortium.

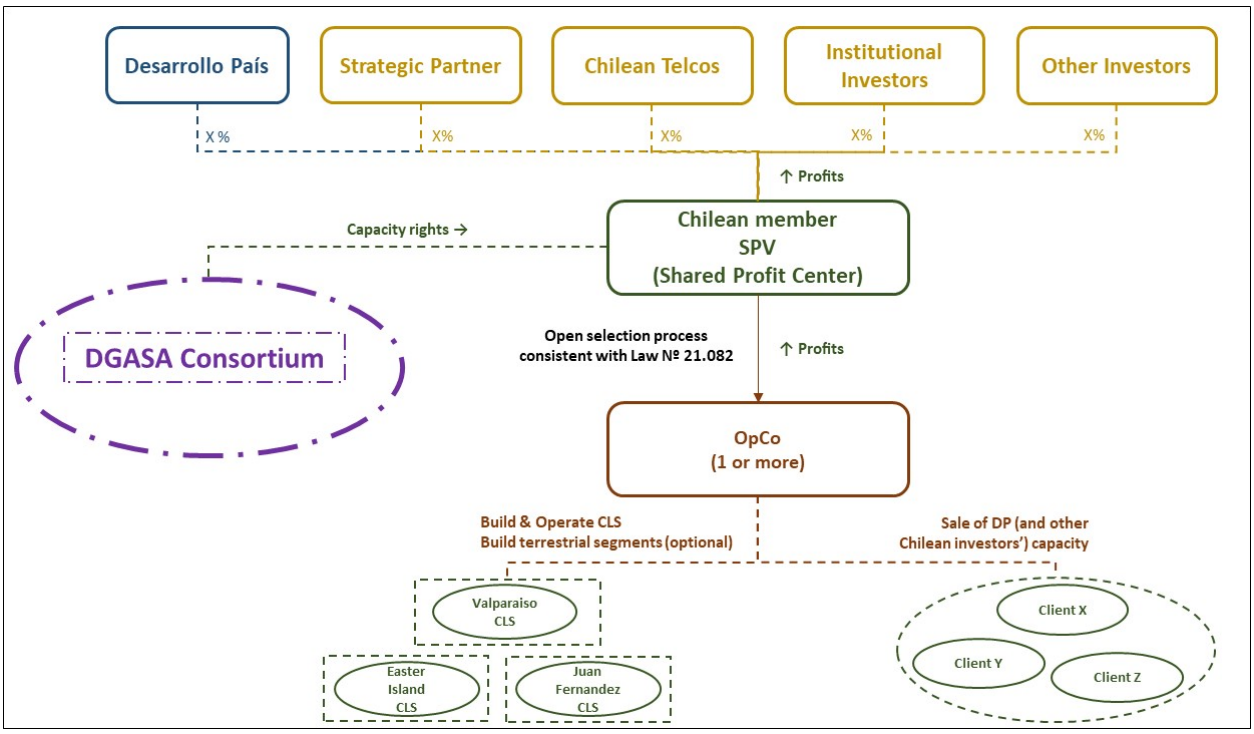


Figure 90: Chilean Member Institutional Structure as a Shared Profit Center PPP

Source: TMG/WFNS

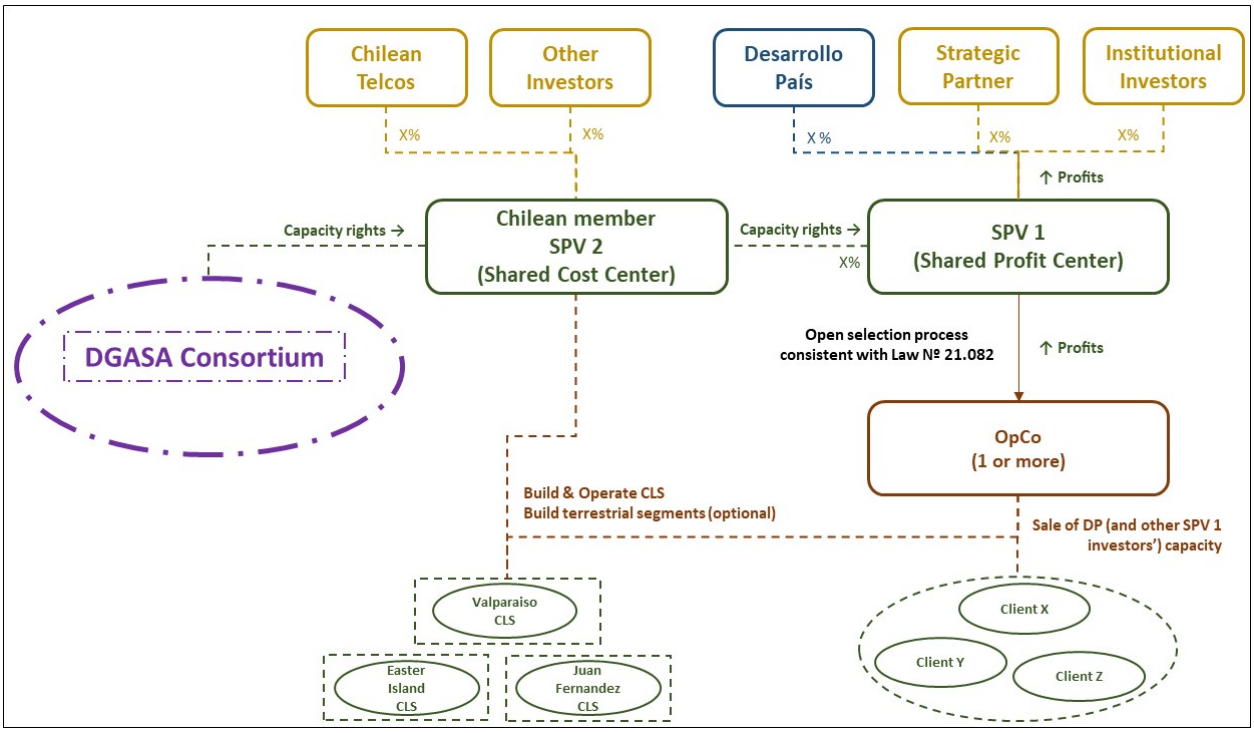


Figure 91: Chilean Member Institutional Structure as a Shared Cost Center PPP

Source: TMG/WFNS

11.2.2 Financial Analysis

The financial model demonstrates under reasonable assumptions and parameters the DGASA cable is viable and exhibits expected cash-flow characteristics. The model applies market-based prices to all used capacities. Thus, even capacity that is used by investors for internal purposes is given a market-based value for the purposes of calculating financial return.

It should be stressed that the results of business modeling presented in this report are driven by demand modeling estimates undertaken in accordance with the TORs of this project. These demand numbers should be vetted iteratively as options for potential partners, customers and pricing are progressed. DGASA promoters should begin the process to validate the business model by gauging actual private interest in equity investment in the DGASA system or pre-sale capacity IRU purchases (i.e., sales that take place pre-CIF and pre-RFS dates) as soon as possible. This will require multiple rounds of consultations and negotiations across all potential stakeholders, investors and clients. Pre-sales are of prime significance during the deployment phase and the process can be expected to take at least two years before RFS. An accurate assessment of cash-flow will be highly dependent on this early stage of sales activity.

The business case for the various stakeholders shows how sensitive the business case is to several key input variables. 10% changes in the share of Asian sales, share of high bandwidth IRU sales, base price, price decline, OpEx, CapEx, and the demand scenario have disproportionately large (i.e., significantly more than 10%) impact on NPV.

With respect to CapEx, firstly, we highlight that TMG/WFNS is confident that the system cost can be reduced beyond what is indicated in the vendor responses to the RFI. We have assumed a 15% price reduction for the base case. Secondly, we reiterate that the business case for the Chilean SPV is highly dependent on its ability to acquire a dark fiber at the outset of the project. If the SPV is not able to scale from half a fiber pair at the outset to a full fiber pair within the first few years, the viability of the project is in serious question. Finally, the cable owner should use the financial model to establish a target for the CapEx budget then work to meet this target.

11.3 Final Recommendations

It is TMG/WFNS' experience that most submarine system developments encounter some level of constraint concerning funding and timing associated for the implementation of the system. The DGASA system is complex in that there are additional activities that are required before the system can be solicited and eventually procured.

These activities include:

1. Final determination of an institutional structure
2. Establishing the selected institutional structure
3. Securing funding for the system
4. Establishing agreements with system partners
5. Defining operational governance and requirements

It is these activities and their respective timing that pose the greatest risk to this project. Developing the DGASA system in a fashion that is economically feasible will depend greatly on how effectively the Government of Chile manages these activities and their subsequent timing for completion, which should be accomplished within the next 6 to 12 months (Optimal Development Period) in order to benefit from the momentum created by this Feasibility Study.

TMG/WFNS recommends the Government of Chile solicit support for these activities and recommends the next steps for the project.

1. Seek support resources to help with these remaining activities - resources should have extensive experience and knowledge of submarine cable system development
2. Establish a plan of work that considers these activities and sets a realistic schedule for the implementation of the system
3. Execute this plan with great attention, care and resolve

TMG/WFNS' experience in managing turnkey supply contracts for submarine and terrestrial fiber optic systems is second to none, either directly or in a support role to a Purchaser, and the companies could assist the Government of Chile in the next phase of the project, if requested.

Appendices

Appendix A. Desktop Study

wfnstrategies

Desk Top Study for the Asia-South America Digital Gateway

11 February 2021

Submitted to:

Undersecretariat of Telecommunications of Chile

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Disclaimer

The information contained in this report is intended solely for the Undersecretariat of Telecommunications of Chile (SUBTEL), who is assumed to have the necessary expertise to determine whether to accept the risks inherent to the investment associated with the 'Asia-South America Digital Gateway' (DGASA) submarine cable system project.

This report contains statements regarding known and unknown risks, uncertainties and other factors which may cause the DGASA system's actual results, performance, or achievements to be materially different from any future results, performance or achievements expressed herein. Such factors include, among others, uncertainty of preliminary assessment results and of feasibility study results and the estimates on which such results are based. No prospective investor in the DGASA system should treat the contents of this report as financial investment, tax or legal advice. All prospective investors in the DGASA system must make their own investigation and evaluation of the risks of the investment and its suitability for their individual requirements.

Furthermore, the Consortium Telecommunications Management Group, Inc. and WFN Strategies, LLC (TMG/WFNS) shall, under no circumstances, be liable to SUBTEL for any consequential, special or any indirect losses or damages of whatever nature arising from actions taken on the basis of this report. TMG/WFNS accepts no duty of care to any person except solely to its client to whom it has provided services under the relevant terms of the contract of this project. For the avoidance of doubt, the fact that TMG/WFNS has authored this report does not in any way establish a duty of care from TMG/WFNS to potential investors in the DGASA system. Accordingly, regardless of the form of action, whether in contract, tort or otherwise, and to the extent permitted by applicable law, TMG/WFNS accepts no liability of any kind and disclaim all responsibility for the consequences of any person (other than its client on the above basis) acting or refraining from acting in reliance on this report.

Acronyms

AAG	Asia—America Gateway
Agr	Agriculture, forestry, and fishing
AMX-1	America Movil—1
APEC-TEL	Telecommunications and Information Working Group of Asia-Pacific Economic Cooperation
BELLA	Building the European Link to Latin America
BMH	Beach Manholes
BRUSA	Brazil—USA
BU	Branching Unit
C&MA	Construction and Maintenance Agreement
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditures
CDN	Content Delivery Networks
CLS	Cable Landing Station
Const	Construction
CoS	Cost of sales
CRE	Cable Route Engineering
DGASA	Digital Gateway Asia – South America
DLS	Digital Line Segments
DWDM	Dense Wavelength Division Multiplex
EBITDA	Earnings before interest, taxes, depreciation and amortization
Edu&H	Education, health and social work
EPFI	Equator Principles Financial Institutions
ESG	Environmental, social, and governance factors
G	Gigabits per second
Gbps	Gigabits per second
GDP	Gross Domestic Product
HDD	Horizontal Direction Drill
HSE	Local and national Health, Safety and Environment
HKA	Hong Kong-America Cable System
Hosp	Hospitality
ICT	Information and Communication Technology
IEEE	Institute for Electrical and Electronics Engineers
IFC	International Finance Corporation
IP	Internet Protocol
IP-VPN	Internet Protocol Virtual Private Networks
IRR	Internal Rate of Return
IRU	Indefeasible Rights of Use
ISP	Internet Service Provider
ITU	International Telecommunication Union
IXP	Internet Exchange Points
Km	Kilometers
Manu	Manufacturing
MARPOL	International Convention for the Prevention of Pollution from Ships
Mbps	Megabits per second
Min	Mining
MPLC	Modem Pool Line Card
MPLS	Multi-Protocol Label Switching
ms	Milliseconds
NMS	Network Management Systems
NOC	Network Operations Center
NPV	Net Present Value
O&M	Operations and Maintenance
OADM	Optical Add/Drop Multiplex

OECD	Organisation of Economic Cooperation and Development
OGB	Ocean Ground Beds
OTT	Over-the-Top
OPEX	Operational Expenditure
OSP	Outside Plant
PAC	Pan—American Crossing
PAN—AM	Pan—American
P&L	Profit and loss
PCCS	Pacific Caribbean Cable System
PFE	Power Feed Equipment
PLCN	Pacific Light Cable Network
PoP	Point of Presence
PPP	Public-Private Partnership
Prof	Professional services, financial services, insurance, and real estate
QoS	Quality of Service
RFS	Ready for Service
ROADM	Reconfigurable Optic Add/Drop Multiplex
SABR	South Africa—Brazil
SAC	South America Crossing
SACS	South Atlantic Cable System
SAEx-1	South Atlantic Express
SAm-1	South America—1
SAIL	South Atlantic Inter Link
SAPL	South America Pacific Link
SEA-US	South East Asia—United States
SLTE	Submarine Line Terminal Equipment
SOE	State-Owned Enterprise
SPC	Special Purpose Company
SUBTEL	Undersecretariat of Telecommunications
SubTel Forum	Submarine Telecoms Forum
Tbps	Terabits per second
TE	Traffic Engineering
T&C	Terms and Conditions
TMG/WFNS	Telecommunications Management Group, Inc. and WFN Strategies, LLC
TORs	Terms of Reference for this project
U.S.	United States of America
USD	Dollars of the United States of America
VAS	Value Added Service
VPN	Virtual Private Network

1. Technical Description

1.1. Introduction

The Asia-South America Digital Gateway (DGASA) submarine cable system, herein referred to as the 'System', spans over 14,000 kilometers of complex atmospheric, oceanographic, and geological ocean systems, lands at three major cities and two remote islands, and crosses three tectonic plate boundaries as it navigates some of the Earth's most impressive and recognizable ocean features.

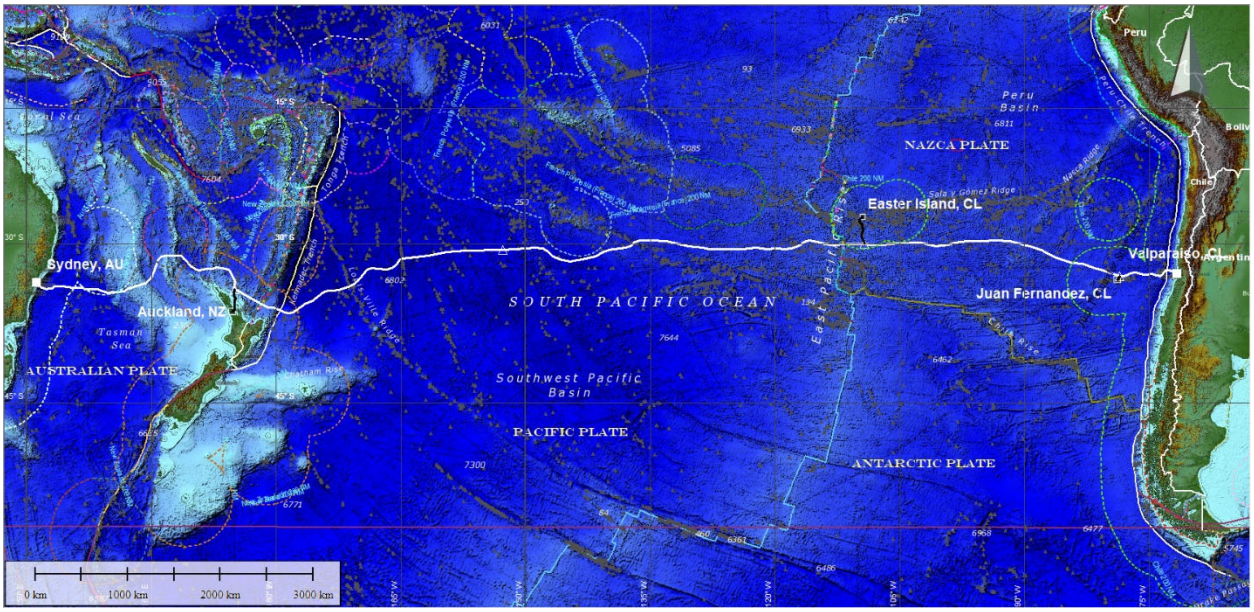


Figure 1 - DGASA System Route Overview Map

The System was planned from East to West, starting in Valparaiso, Chile and ending in Sydney, Australia with landings on Robinson Crusoe Island, a part of the Juan Fernández archipelago of Chile, Easter Island, Chile and Auckland, New Zealand. The only two landings not well known to System Suppliers are Juan Fernández and Easter Island. Valparaiso, Auckland, and Sydney all have multiple submarine cable system landings, decreasing the uncertainty around permitting, installation and maintenance risks while increasing the complexity of finding suitable seabed for crossings and landing points.

As with any submarine cable system, planning the safety and security of the cable on the seafloor is fundamentally important and accomplished using well-established route selection and cable protection guidelines published by the ICPC and the decades of experience brought to bear by the cable Supplier and the Supplier's subcontractors and Owner's consultants and representatives. This 'Team' collectively provides the intellectual and physical resources to safely plan, manufacture, install and maintain a 30-year System.

1.2. General Overview

This Desktop Study (DTS) provides historical and point-in-time information about the route over which the submarine cable will traverse, used to feed each part of the System design. Prior to finalizing the System design and execution plan, Marine Route Survey (MRS), Land Survey and Supplier-augmented DTS

activities are coupled with detailed Cable Route Engineering (CRE) to provide a least-risk, cost effective System that meets or exceeds the Owner's business objectives.

Obstacles for the DGASA System are typical as with any trans-Pacific cable system having multiple landings, but the most notable obstacle for this System is weather, closely followed by tectonic-related events such as underwater volcanoes, hydrothermal vents, and of course earthquakes and resulting tsunamis. The System maintains as high a latitude as possible to provide a best-case weather scenario for survey, installation, and future maintenance. Careful planning of marine operations should prevent excessive weather downtime, a schedule and cost risk. Historically active earthquake-prone areas are avoided as much as possible, but the System's inherent proximity to the Ring of Fire and tectonic plate boundaries mean this System will eventually 'feel' an earthquake during its lifespan. Avoidance of slopes, which can accumulate sediment, is the best singular way to keep the cable from being damaged when sediments break free from the slope face. Tsunamis pose a hazard to all the System's landings. BMH and CLS engineering and strategic placement on shore coupled with strong nearshore cable protection techniques (HDD, split pipe, Uraduct, pinning, etc.) will provide the best chance of survival against tsunami events. These and many other best-practice tactics were employed designing the DTS route.

Suppliers have planned and installed longer and just as technically complex systems around the world in recent years and the DGASA System project risks should be well known and mitigatable by the Supplier. The viability of a successful, on-time and on-budget RFS will depend on strong project management and technical skills of both the Supplier and Owner and less so on the complexities of this System's route design.

1.3. Objectives

The objective of this Desktop Study (DTS) is to provide SUBTEL with an appropriate level of detail regarding the environment, both natural and man-made, in which the proposed submarine cable system may be installed in order to assess the risks to the marine program (survey, installation, commissioning) and forecast potential maintenance issues, or survivability, of the cable system.

The primary objective of this DTS is to propose and examine a provisional cable route for a system that provides the highest level of security while minimizing total length. To meet this objective, parameters affecting the security, marine survey, cable route engineering and installation of the system were all examined. Such factors included but were not restricted to seabed physiography, seabed geology, offshore activities and hazards, oceanography, landing site selection, operational permits, and offshore oil and gas activities.

Resulting recommendations made are the opinions of WFNS based on the available information compiled during the production of the DTS and general route engineering experience. Further, this study should not be viewed as an alternative to a comprehensive and properly conducted route survey. It is recommended that detailed land surveys be conducted for the potential landing points and land routes. A detailed marine survey should then be accomplished prior to decisions being finalized for matters, such as cable lengths, armor type, burial and protection requirements and slack values.

1.4. Routing Methodology

The installation methodology proposed for this cable system will provide layered protection against geological and bathymetric risks and external aggression threats along the cable route.

Cable route planning for the cable system was accomplished with the aid of several software packages and the review and analysis of multiple databases using GIS software.

The following software was employed for the chart construction and for the development of the provisional cable route:

- Global Mapper
- Google Earth Pro

1.5. Reporting Conventions

This document follows the formatting and style guidance set forth by SUBTEL to include Letter (8 ½ x 11in) size page output, metric measurements and a language reference using the US dictionary.

Geographic coordinates referenced in the text and tables are as noted with the following spheroidal parameters:

- Datum: WGS 84
- Semi-major Axis (a): 6,378,137.000 meters
- Semi-minor Axis (b): 6,356,752.314 meters
- Reciprocal of Flattening (1/f): 298.2572235630
- Eccentricity2 (e2): 0.006694379990

Units used in this report are as follows:

- Linear units are meters.
- Angular units are degrees (°).

It should be noted that all positions and elevations cited in this document are approximate and should not be used for navigation or engineering purposes.

2. Cable System Organization and Description

The following System landings, trunk segments and branches have been organized to include consistent labelling and identification tags, for example, the landing site at Valparaiso, CL has an identifier of L1 and the branch to Easter Island, CL has an identifier of B2. Ordering of the landings, trunk segments and branches are sorted east to west.

It should be noted that the DTS route and proposed installation techniques found herein will likely change prior to cable route survey activities as more technical data and business decisions are obtained, but certainly after the cable route survey and subsequent cable route engineering activities are concluded. This is typical with any cable system and highlights the importance of the organization, identification and classification of each landing, trunk segment and branch to maintain consistency across all project activities and reports. Careful management of identifiers and any future modifications or substitutions will provide consistency between each phase of the project.

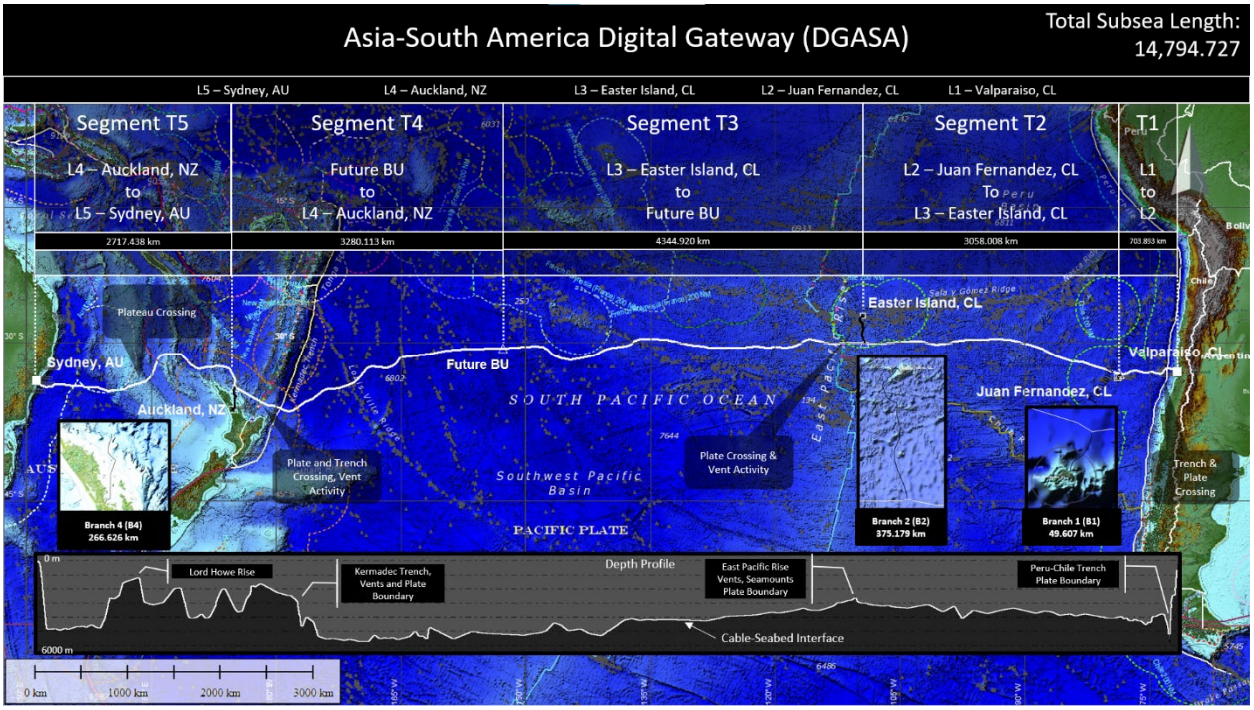


Figure 2 - DGASA System Overview

Figure 2 shows an overview of the entire System in one graphic. Salient route engineering and risk areas have been overlain on the System map. The depth profile shows above and the geographic position of all cable route points for all segments and branches can be found in Appendix A. Supplement data to this DTS is supplied in Excel, Google KMZ and PDF formats for data analysis and printing/plotting purposes.

2.1. Landings

This study focused on the five (5) landings decided in Report 2 of the DGASA project, as defined in Table 1.

Table 1 - System Landings

ID	Landing	Latitude	Longitude	Elevation (m)	Country
L1	Valparaiso	33 ° 01.351 ' S	71 ° 38.640 ' W	3	Chile
L2	Juan Fernández	33 ° 37.965 ' S	78 ° 49.760 ' W	10	Chile
L3	Easter Island	27 ° 09.446 ' S	109 ° 26.415 ' W	10	Chile
L4	Auckland	36 ° 46.469 ' S	174 ° 46.548 ' E	10	New Zealand
L5	Sydney	33 ° 55.580 ' S	151 ° 15.571 ' E	10	Australia

The cable route survey will need to identify suitable seabed placement that does not conflict with the current cable systems landing at Valparaiso, Juan Fernandez, Auckland, and Sydney.

HDD is proposed for Valparaiso. From the HDD exit the cable will likely require seabed pinning and protection to mitigate movement due storm-induced currents and tsunami events, followed up with jetted burial

2.1.1. L1 – Valparaiso, CL

"Valparaíso (; Spanish: [balparaˈiso]) is a major city, seaport, naval base and educational center in the commune of Valparaíso, Chile. "Greater Valparaíso" is the second largest metropolitan area in the country. Valparaíso is located about 120 kilometers (75 mi) northwest of Santiago by road and is one of the South Pacific's most important seaports. Valparaíso is the capital of Chile's second most populated administrative region and has been the headquarters for the Chilean National Congress since 1990. Valparaíso has two state-owned and several private universities." (Wikimedia Foundation, 2020)

Table 2 - Valparaiso, CL Statistics

Descriptor	Value
Country	Chile
Region	Valparaiso
Province	Valparaiso
Commune	Valparaiso
Founded	1536
Capital	Valparaiso
Government Type	Municipality
Elevation	10 m (30 ft)
Population (2012 Census)	284,630
Time Zone	UTC-4 (Chilean Standard) UTC-3 (Chilean Daylight)

Area Codes	56 + 32
Website	www.municipalidaddevalparaiso.cl

Figure 3 - Valparaiso Landing Looking Seaward

Figure 4 - Valparaiso Landing Looking Seaward

Figure 5 - Valparaiso Landing Looking Landward

2.1.2. L2 - Juan Fernández, CL

"San Juan Bautista is the main town in the Juan Fernández Islands. Some sources say it was founded in 1877, while others give an earlier date of 1750. It is located on Cumberland Bay on the center of the northeast coast of Robinson Crusoe Island." (Wikimedia Foundation, 2020)

Table 3 - Juan Fernández Statistics

Descriptor	Value
Country	Chile
Region	Valparaiso
Province	Valparaiso
Commune	Juan Fernández
Founded	1877
Government Type	Municipalidad
Elevation	0m (0 ft)
Population (2012 Census)	800

Descriptor	Value
Time Zone	UTC-4 (Chilean Standard) UTC-3 (Chilean Daylight)
Area Codes	+56 32
Website	www.comunajuanfernandez.cl

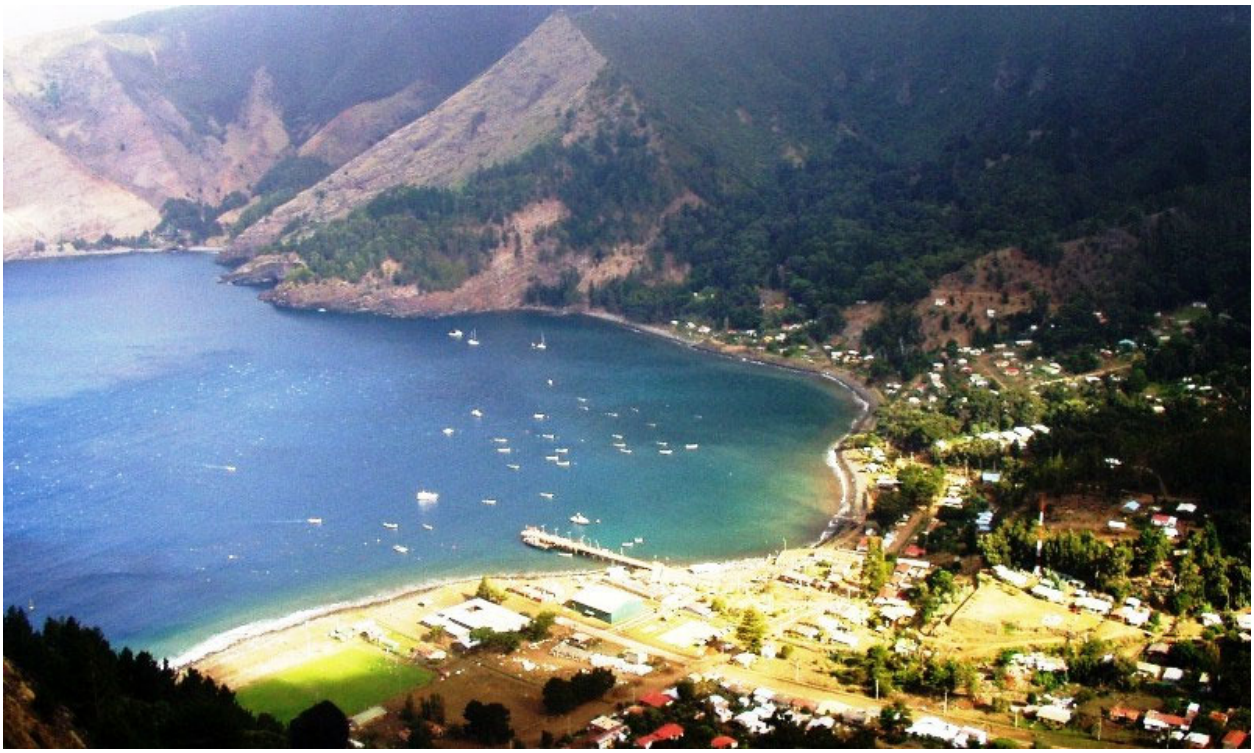


Figure 6 - Juan Fernández Landing, Seaward

Figure 7 - Juan Fernández Landing, Seaward

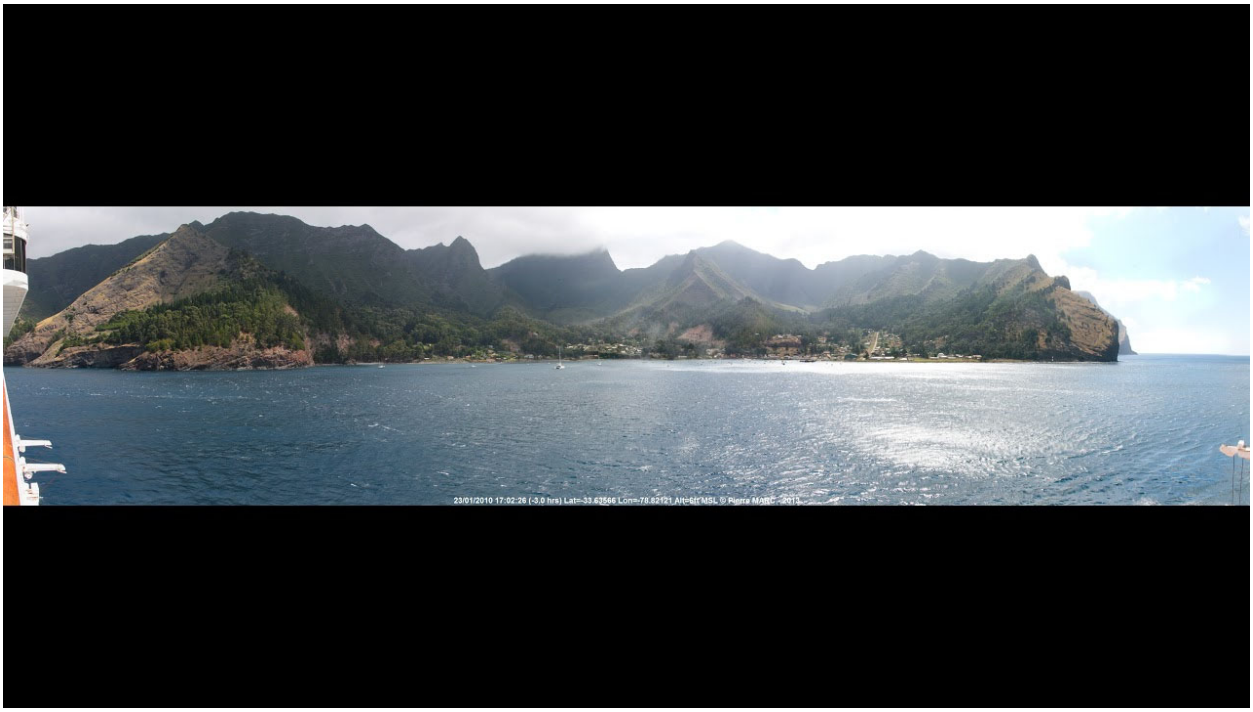


Figure 8 - Juan Fernández Landing, Landward

2.1.3. L3 – Easter Island, CL

"Easter Island (Rapa Nui: Rapa Nui, Spanish: Isla de Pascua) is an island and special territory of Chile in the southeastern Pacific Ocean, at the southeasternmost point of the Polynesian Triangle in Oceania. Easter Island is most famous for its nearly 1,000 extant monumental statues, called moai, created by the early Rapa Nui people. In 1995, UNESCO named Easter Island a World Heritage Site, with much of the island protected within Rapa Nui National Park."

Source: Easter Island - https://en.wikipedia.org

Table 4 - Easter Island Statistics

Descriptor	Value
Country	Chile
Region	Valparaiso
Province	Isla de Pascua
Commune	Isla de Pascua
Founded	1722
Government Type	Municipality
Elevation	0m (0 ft)
Population (2017 Census)	7750
Time Zone	UTC−6 (CLT) UTC−5 (CLST)

Descriptor	Value
Area Codes	+56 32
Website	www.municipalidaddeisladepascua.cl

Figure 9 - Easter Island, Aerial

Figure 10 - Easter Island Landing, Landward

Figure 11 - Easter Island Landing, Looking North Towards LP

Figure 12 - Easter Island Port, Landward

2.1.4. L4 – Auckland, NZ

"Auckland (AWK-lənd; Māori: Tāmaki Makaurau) is a metropolitan city in the North Island of New Zealand. The most populous urban area in the country, Auckland has an urban population of about 1,467,800 (June 2019). It is located in the Auckland Region—the area governed by Auckland Council—which includes outlying rural areas and the islands of the Hauraki Gulf, resulting in a total population of 1,642,800. Auckland is a diverse, multicultural and cosmopolitan city, home to the largest Polynesian population in the world. The Māori-language name for Auckland is Tāmaki Makaurau, meaning "Tāmaki desired by many", in reference to the desirability of its natural resources and geography."

Source: Auckland - https://en.wikipedia.org

Table 5 – Auckland, NZ statistics

Descriptor	Value
Country	New Zealand
Region	New Zealand
Island	North Island
Commune	
Founded	1840
Government Type	Auckland Council
Elevation	0m (0 ft)
Population (2017 Census)	1,467,800

Descriptor	Value
Time Zone	UTC+12 (NZST) UTC+13 (NZDT)
Area Codes	09
Website	www.aucklandcouncil.govt.nz

Figure 13 - Auckland Landing, Seaward

3

Figure 14 - Auckland Landing, Seaward General

Figure 15 - Auckland Landing, Seaward, Rocks Exposed

2.1.5. L5 – Sydney, AU

"Sydney ((listen) SID-nee, Dharug: Cadi) is the state capital of New South Wales and the most populous city in Australia and Oceania. Located on Australia's east coast, the metropolis surrounds Port Jackson and extends about 70 km (43.5 mi) on its periphery towards the Blue Mountains to the west, Hawkesbury to the north, the Royal National Park to the south and Macarthur to the south-west. Sydney is made up of 658 suburbs, 40 local government areas and 15 contiguous regions. Residents of the city are known as "Sydneysiders". As of June 2019, Sydney's estimated metropolitan population was 5,312,163, meaning the city is home to approximately 65% of the state's population."

Source: Sydney - https://en.wikipedia.org

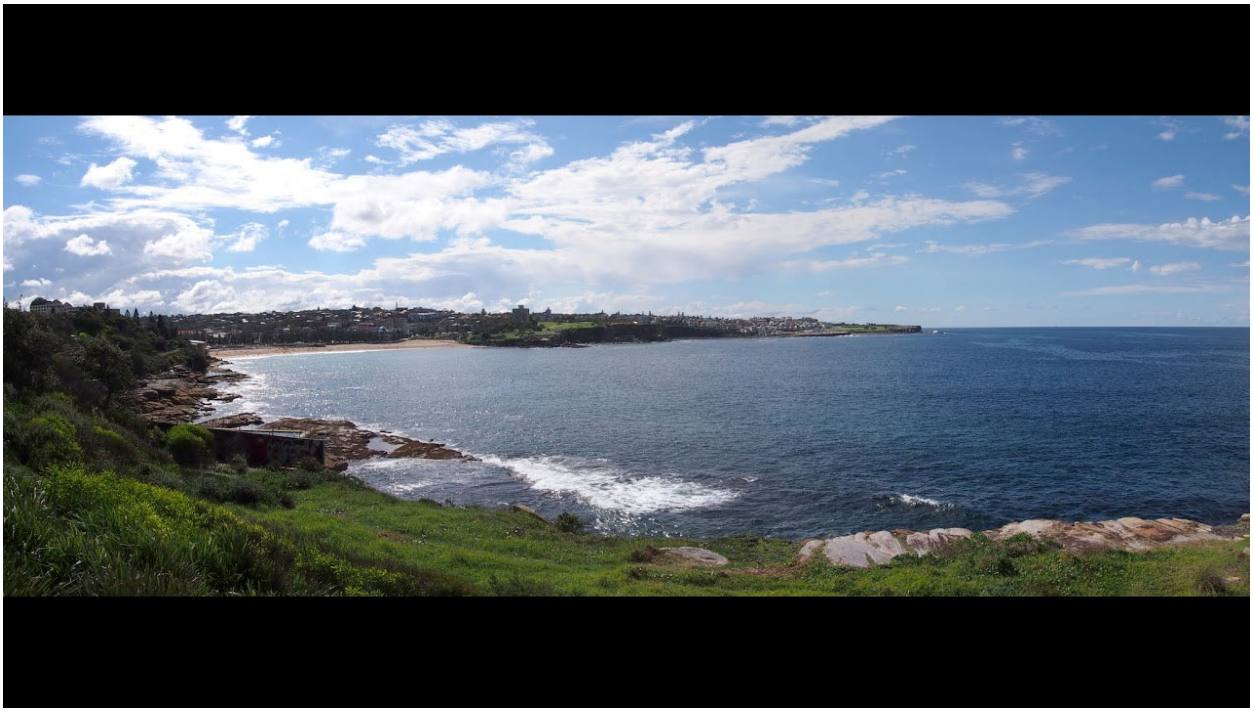


Figure 16 - Sydney Landing, Seaward

Figure 17 - Sydney Landing

Table 6 – Sydney, AU statistics

Descriptor	Value
Country	Australia
City	Sydney

Descriptor	Value
County	Cumberland
Founded	1788
Government Type	Various
Elevation	0m (0 ft)
Population (2019 Census)	5,312,163
Time Zone	AEST (UTC+10) AEDT (UTC+11)
Area Codes	+61 2
Website	https://www.cityofsydney.nsw.gov.au/

Figure 18 - Sydney Landing, Coast

2.2. Trunk Segments

The overall System starts from Santiago, CL as a terrestrial route to interface with the submarine route at the Valparaiso, CL BMH where the trunk begins its traverse due west across the South Pacific Ocean, ultimately landing at Sydney, AU. The trunk consists of four (4) Branching Units that will carry traffic to Juan Fernández, CL, Easter Island, CL and Auckland, NZ with a Future segment planned for destinations to the north of the BU.

The total trunk distance is 14,104.372 km and for reporting and future logistical and planning purposes is broken into five (5) trunk segments as outlined in Table 7.

Table 7 - System trunk Segments

ID	Start	End	Distance (km)	EEZ
T1	Valparaiso, CL	BU-JF	703.893	CL
T2	BU-JF	BU-EI	3,058.008	CL
T3	BU-EI	BU-Future	4,344.920	INTL
T4	BU-Future	BU-NZ	3,280.113	INTL-NZ
T5	BU-NZ	Sydney, AU	2,717.438	NZ-AU

Planning the execution of cable route survey and installation activities will likely require separate yet coordinated subcontracts and thus teams working different locations. The System Supplier may use these identifiers or define their own as part of their proposal.

The direction of the System route position list and the following route description of the trunk segments is from East to West, so Valparaiso, Chile to Sydney, Australia.

Note that some maps in this section are rotated to align the route horizontally on the page.

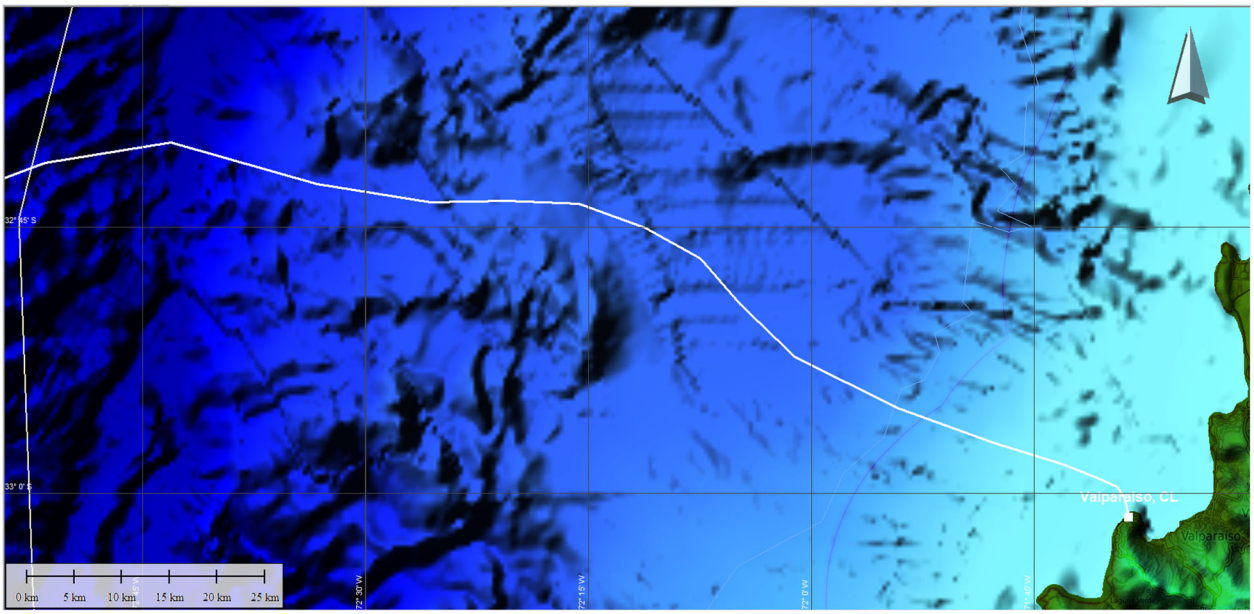


Figure 19 - Valparaiso to Peru-Chile Trench

The System trunk starts in the city of Valparaiso, a World Heritage Site and historic seaport, with a proposed BMH located at 33° 01.351' S, 71° 38.640' W near the current Google cable system Curie. The route traverses via HDD to an exit point where it will be buried until reaching the slope of the continental shelf, just before entering the Peru-Chile Trench.

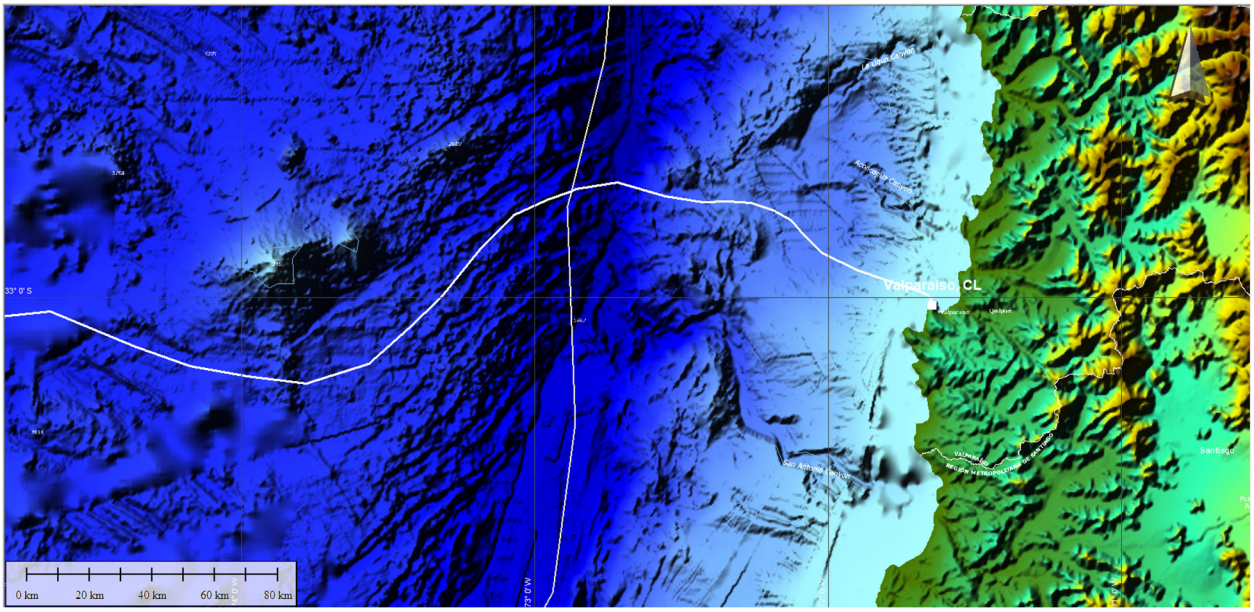


Figure 20 - Valparaiso across Peru-Chile Trench

The crossing of the Peru-Chile Trench is coincident with the plate transition from the South America Plate to the Nazca Plate at 32° 41.37724' S, 72° 51.54689' W in approximately 5700 meters water depth. The Peru-Chile Trench crossing is relatively standard until the upslope, where the route deviates to the south-west to avoid a set of seamounts before turning due West towards the Juan Fernandez BU located at 33° 16.390' S, 78° 34.278' W in approximately 4000 meters of water.

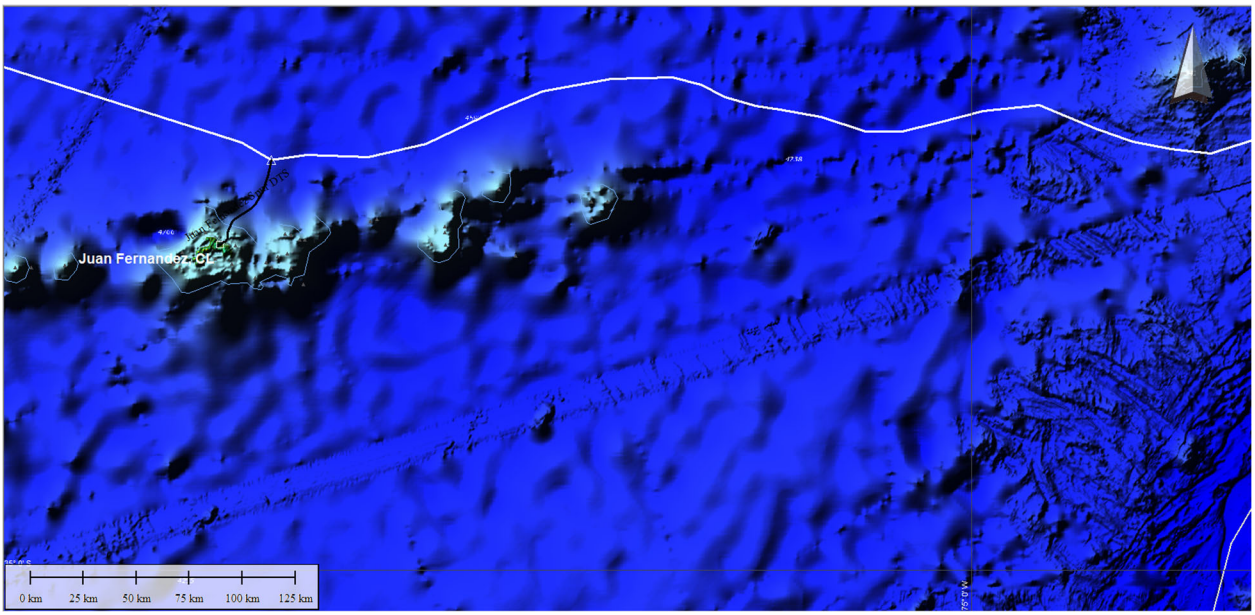


Figure 21 - Peru-Chile Trench to Juan Fernandez

The route then continues west-north-west towards the Easter Island BU, crossing the Chile EEZ at position 31° 56.68495' S, 84° 10.32648' W, continuing due west until crossing back into the Chile EEZ of Easter Island.

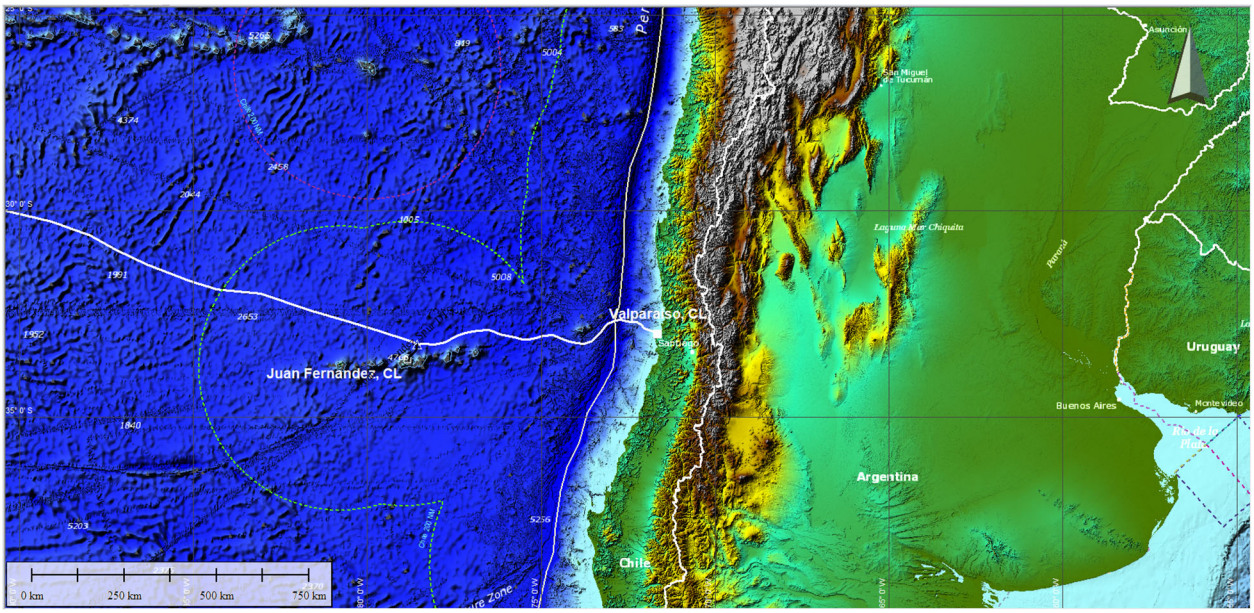


Figure 22 - Valparaiso, Juan Fernandez Overview

The Easter Island BU is located at 29° 58.184' S, 109° 17.138' W in approximately 3200 meters water depth within the Chile EEZ surrounding Easter Island. The route continues to the East Pacific Rise, located at 30° 1.13458' S, 111° 44.43583' W, where it must cross a vertical structure of seabed surrounded by hydrothermal vents due to the coincident boundary between the Nazca Plate and Pacific Plate.

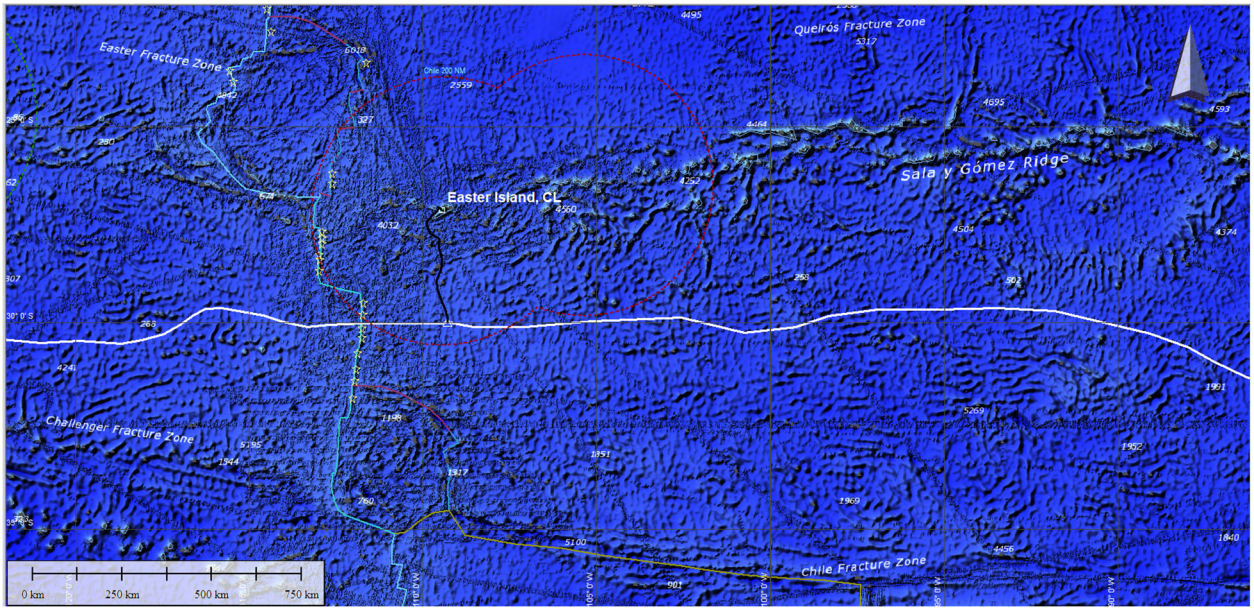


Figure 23 - Easter Island and East Pacific Rise

From the East Pacific Rise, the route continues West towards Auckland navigating around the Austral Seamounts and between the Challenger Fracture Zone and Resolution Fracture Zone while keeping out and South of the French Polynesia (France) EEZ.

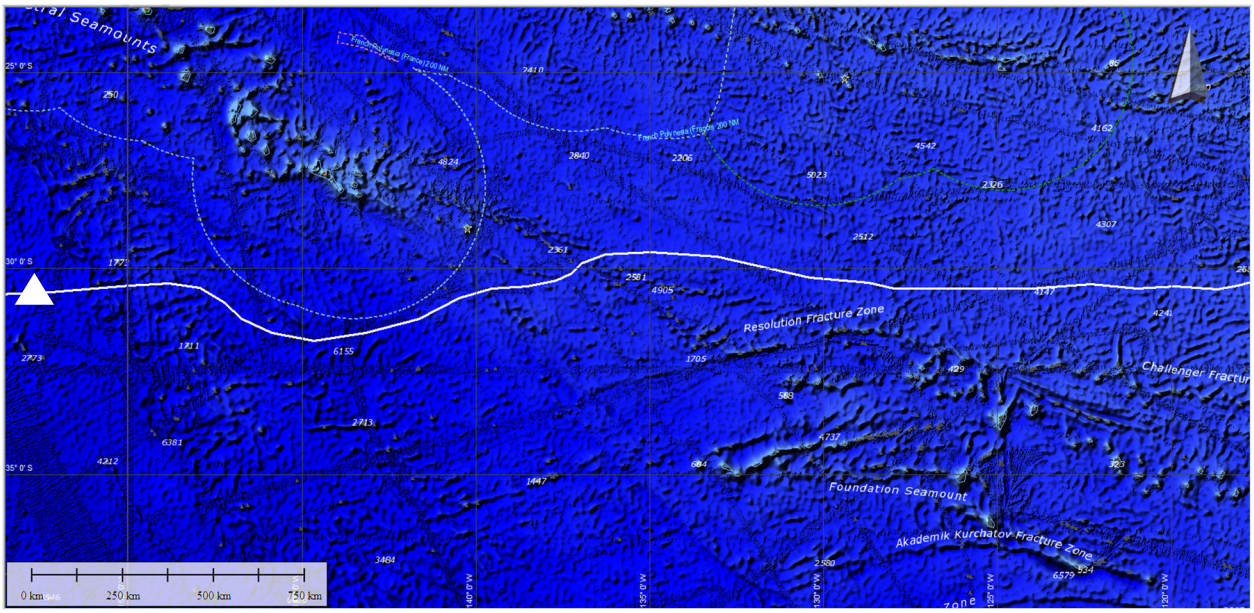


Figure 24 - Challenger and Resolution Fracture Zones

Before continuing towards Auckland, a Future BU located at 30° 37.12961' S, 152° 43.84573' W in approximately 5300 meters water depth was placed for the provision of connecting to other islands to the North of the trunk.

The route continues from the Future BU West crossing the Louisville Ridge at 34° 23.17952' S, 171° 20.99691' W and eventually the New Zealand EEZ at 36° 32.96437' S, 177° 29.77971' W.

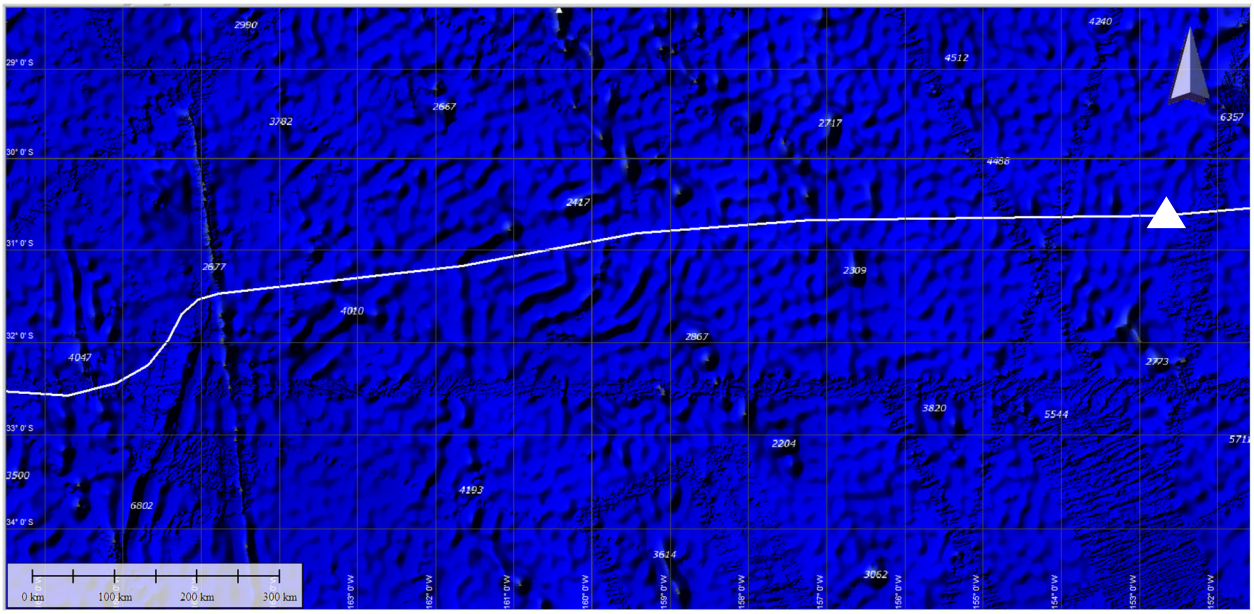


Figure 25 - Future BU

At this point, the route deviates south-west to approach and traverse the Kermadec Trench, which is the boundary for the Pacific Plate and Australian Plate, located at 36° 39.54645' S, 179° 28.81738' W in approximately 5000 meters water depth.

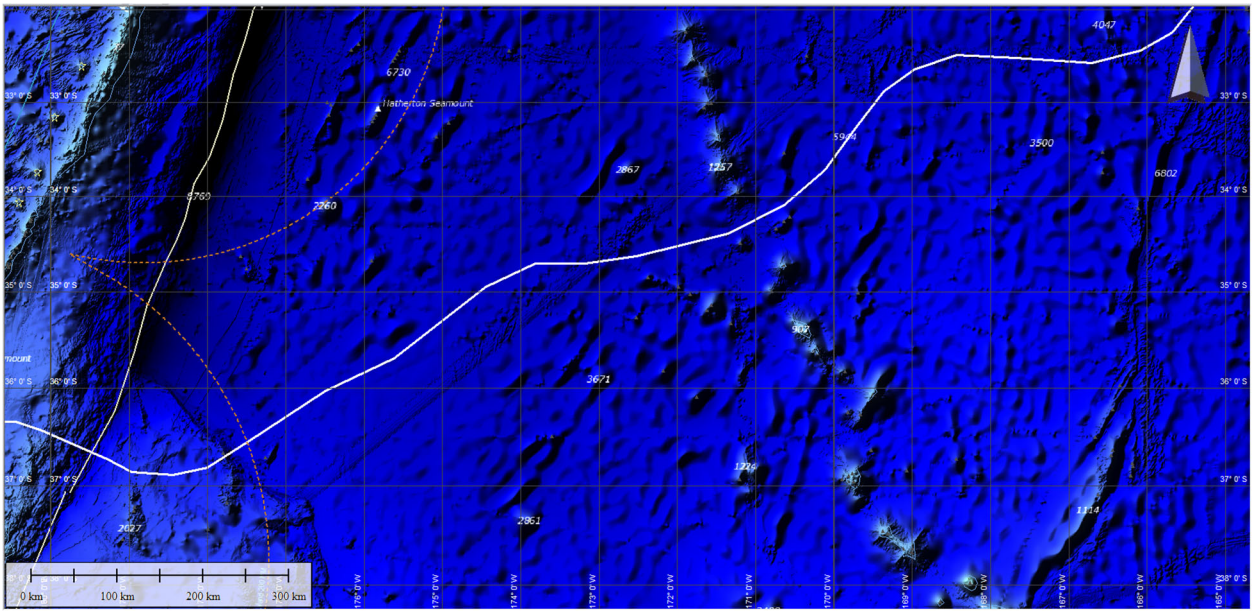


Figure 26 - Approach to Kermadec Trench and NZ

The route crosses the Kermadec Trench and continues up the continental shelf, crossing the Raukumara Plain south of the Rumble III and Lillie seamounts, and north of Rumble V seamount until reaching the Auckland BU at 34° 36.191' S, 175° 01.496' E in approximately 1850 meters water depth.

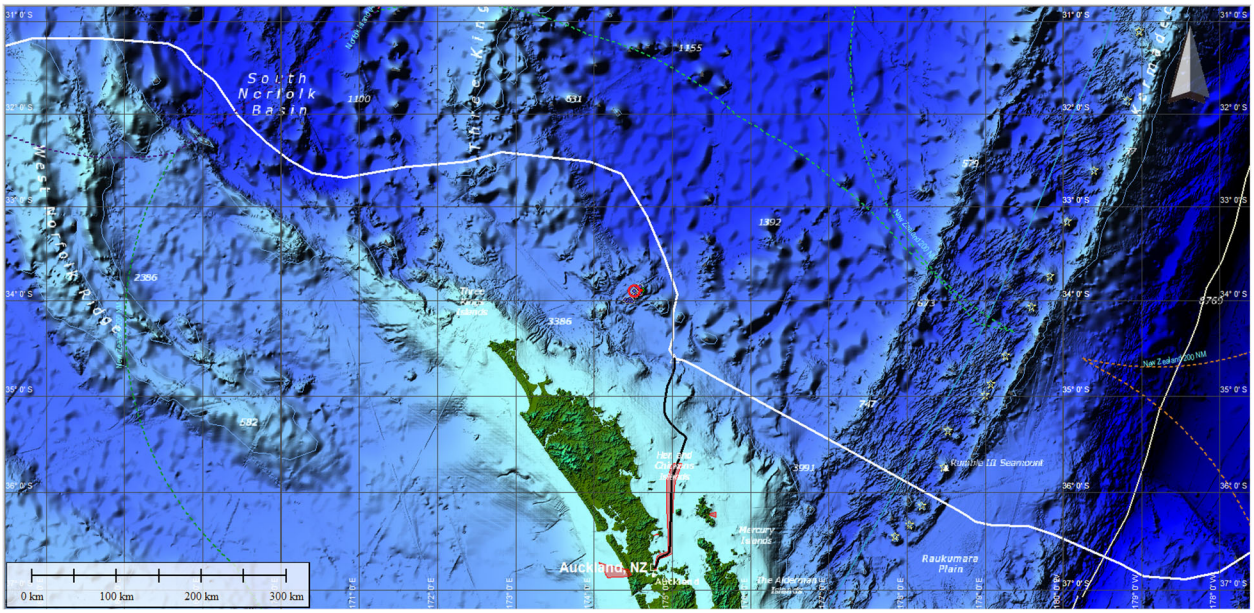


Figure 27 - Auckland Approaches Overview

The traversal of the route from the Auckland BU to Sydney is complicated by numerous basins and rises that must be crossed. The route leaves the Auckland BU due north, keeping east of the Pururua Seamount, and heads into South Fiji Basin. From there, the route turns west again into South Norfolk Basin and then swings north of Wanganella Bank, crossing into the Australian EEZ at 31° 58.80985' S, 169° 24.93457' E.

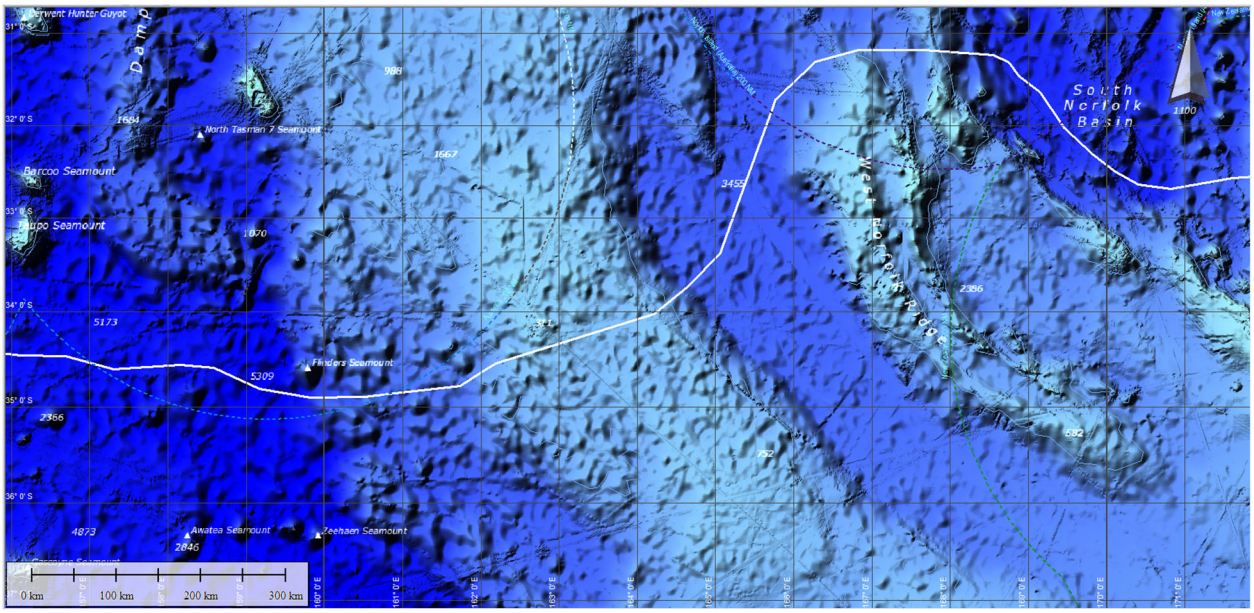


Figure 28 - Lord Howe Rise Overview

The route heads south between Wanganella Bank and Lord Howe Rise, crossing back into the New Zealand EEZ at 31° 51.16888' S, 165° 42.67808' E before turning West again to traverse Lord Howe Rise.

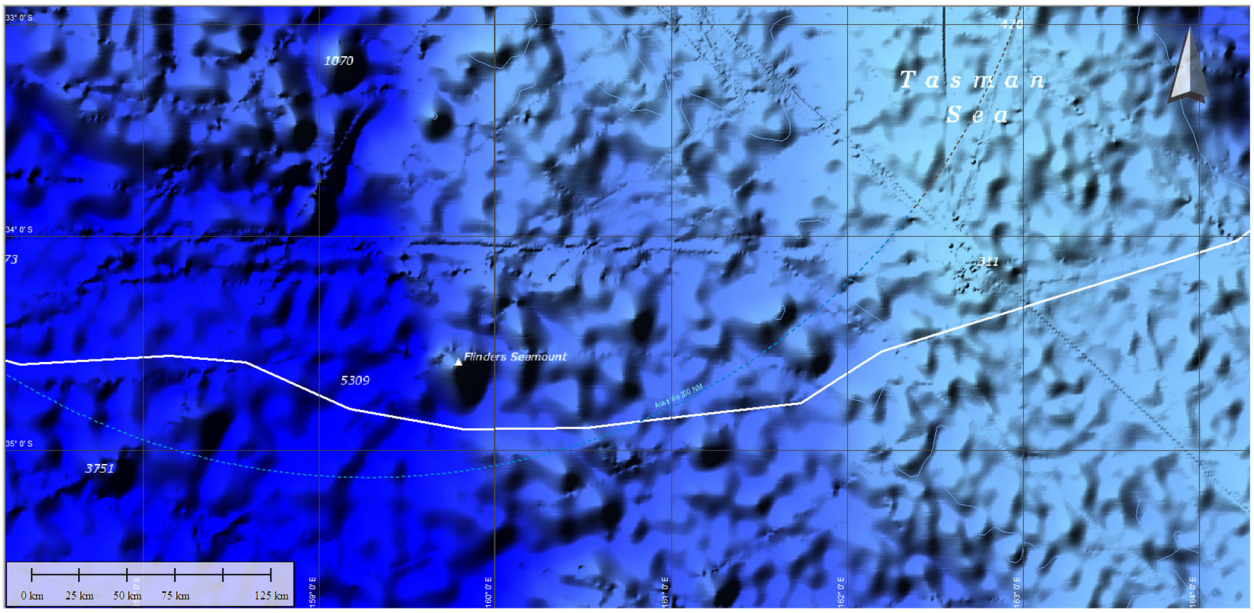


Figure 29 - Lord Howe Rise

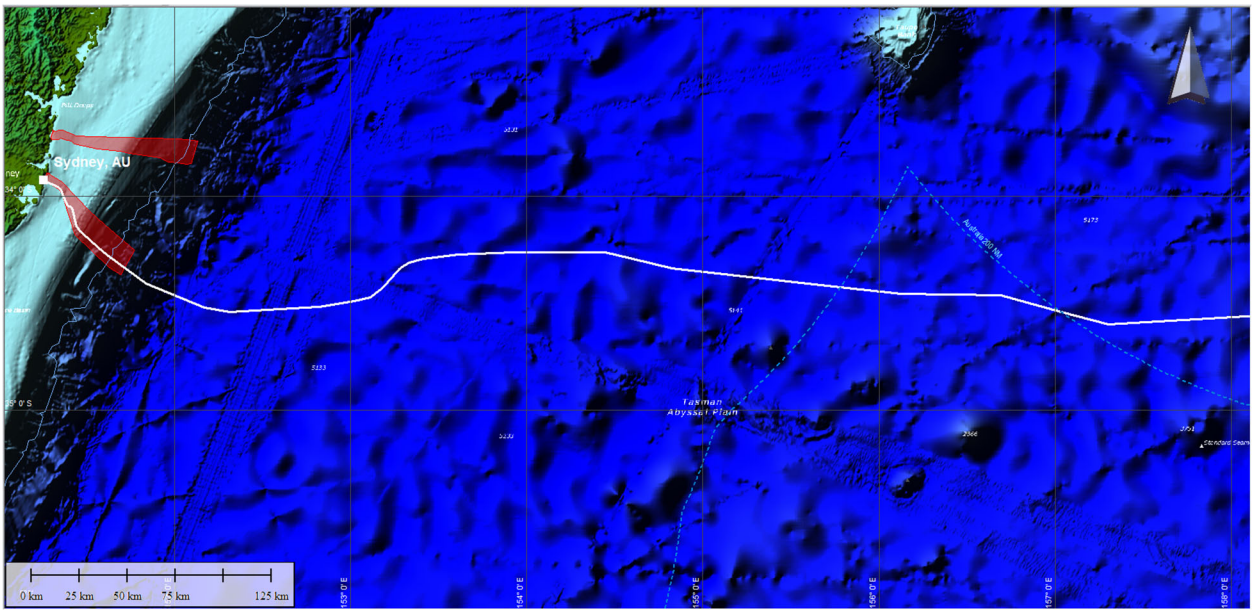


Figure 30 - Approaches to Sydney

After crossing Lord Howe Rise, the route continues due west towards Sydney, just south of Flinders Seamount, across the Tasman Abyssal Plain of the Tasman Sea.

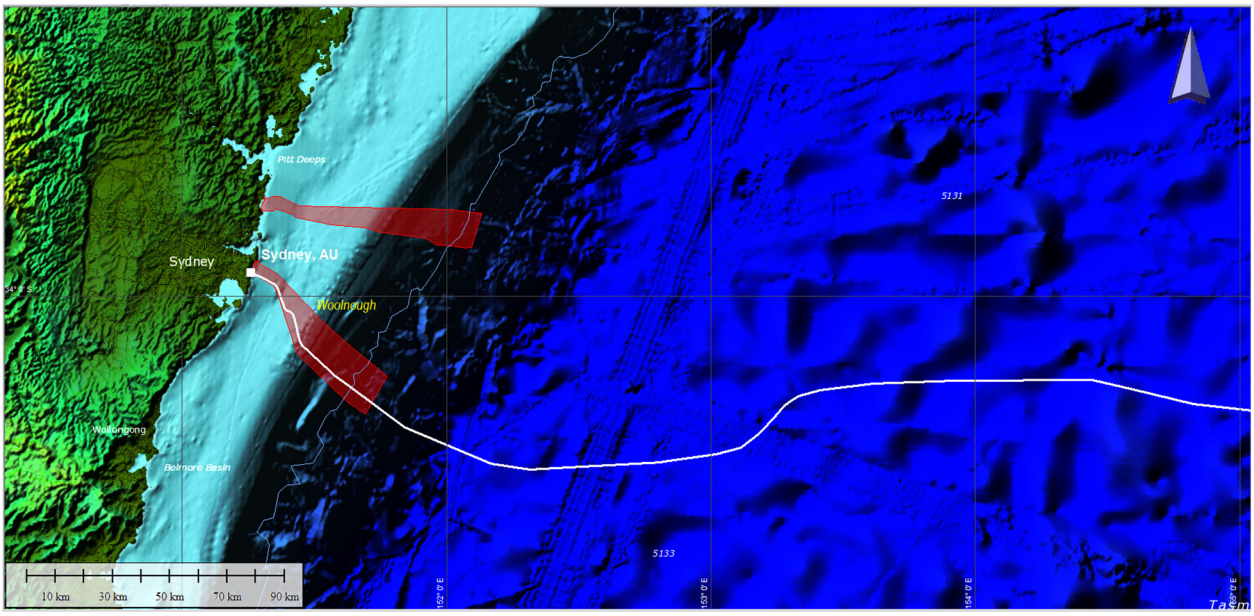


Figure 31 - Sydney Continental Shelf

The route continues up the Australian continental shelf, south of Woolnough Knoll, into the southern Sydney cable protection corridor, following the other cables into the landing at Sydney located at 33° 55.580' S, 151° 15.571' E.

2.3. Branches

There are four (4) BUs located along the trunk of the submarine cable servicing landings at L2 - Juan Fernández, CL, L3 – Easter Island, CL and L4 – Auckland, NZ and a future island landing. They are positioned in deep water and approximated low-slope bathymetry. The position along route, geographic position and water depth of each BU can be found in Table 9. Information about the branches can be found in Table 8.

Table 8 - System Branches

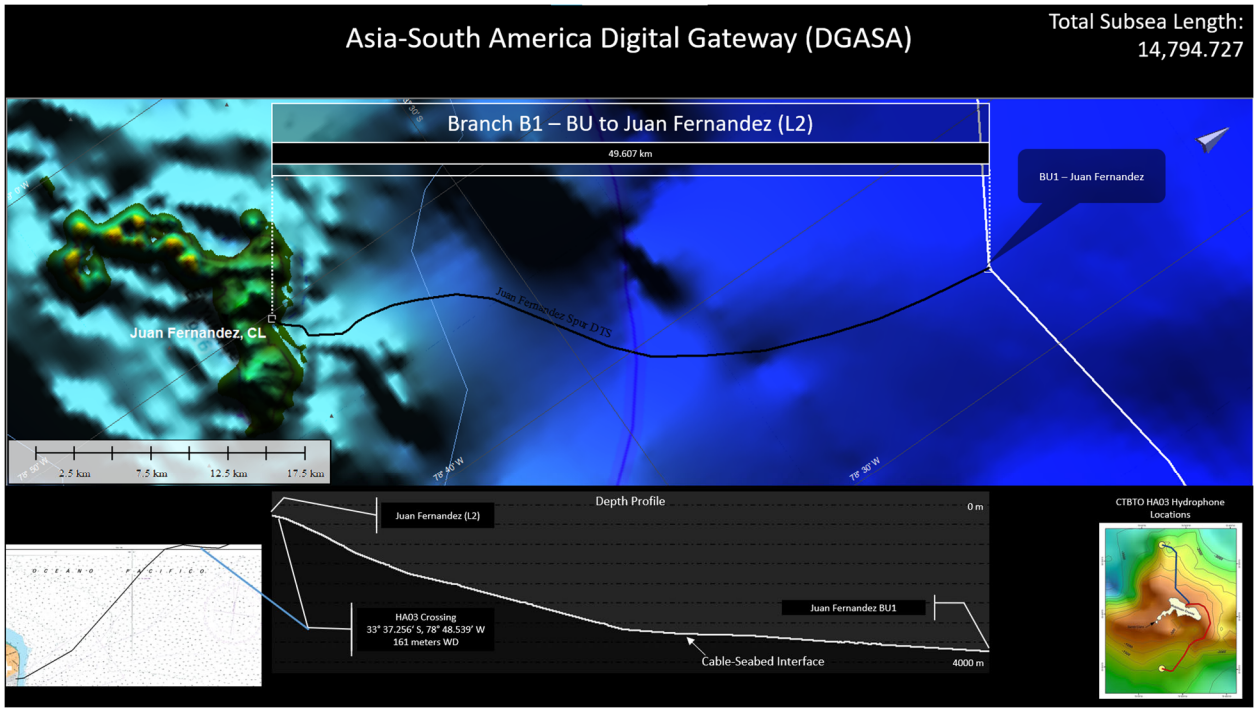
ID	Start	End	Branch Distance (km)	EEZ
B1	BU-JF	Juan Fernández	49.607	CL
B2	BU-EI	Easter Island	375.179	CL
B3	BU-Future	Tail End	18	INTL
B4	BU-NZ	Auckland	266.626	NZ

Table 9 – Branching Unit Locations

ID	Landing BU Services	Distance along Route (km)	Latitude	Longitude	Water Depth (m)	EEZ
B1	Juan Fernández	703.893	33 ° 16.390 ' S	78 ° 34.278 ' W	3961	CL
B2	Easter Island	3,761.901	29 ° 58.183 ' S	109 ° 17.138 ' W	3196	CL
B3	Tail End	8,106.821	30 ° 37.130 ' S	152 ° 43.846 ' W	5298	INTL
B4	Auckland	11,386.934	34 ° 36.191 ' S	175 ° 01.496 ' E	1850	Z

2.3.1. B1 – Juan Fernández

The Juan Fernández branch begins in 3,961 meters water depth and traverses 49.607 kilometers to the L2 landing on Robinson Crusoe Island in the town of San Juan Bautista.



This branch heads south-south-west with only minor deviations to accommodate crossing the HA03 CTBTO northern in-service cable as it approaches the shelf of the island.

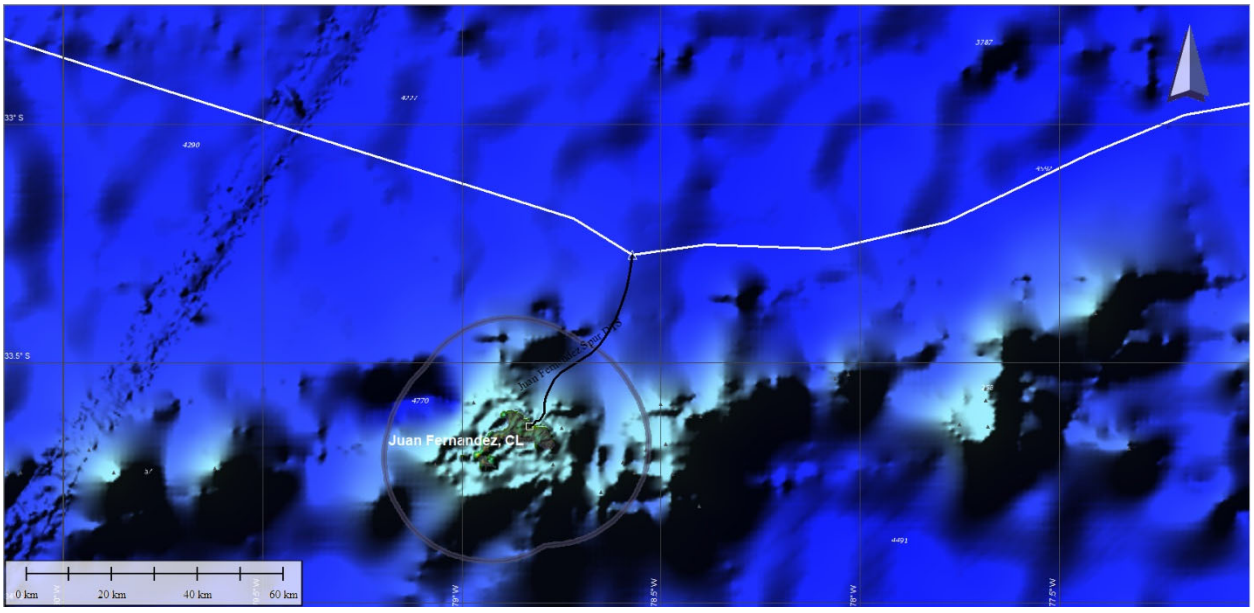


Figure 32 - Juan Fernández Branch

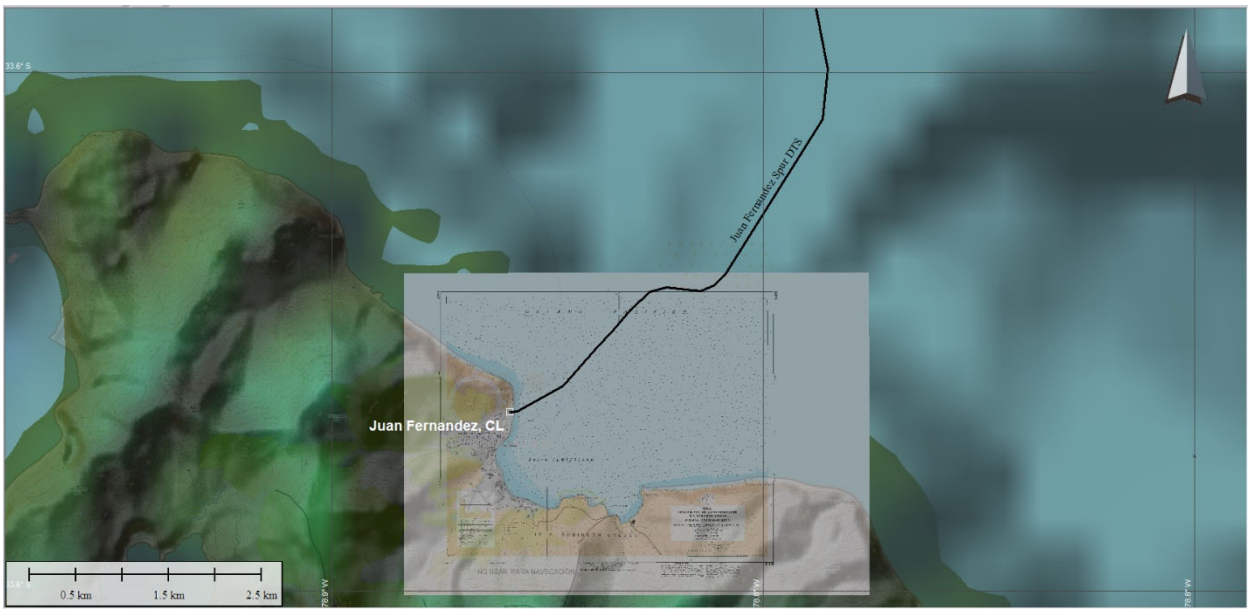


Figure 33 - Juan Fernández Branch Detail

2.3.2. B2 – Easter Island

The Easter Island branch begins in 3,195 meters water depth and traverses 375.179 kilometers to the L3 landing on Easter Island.

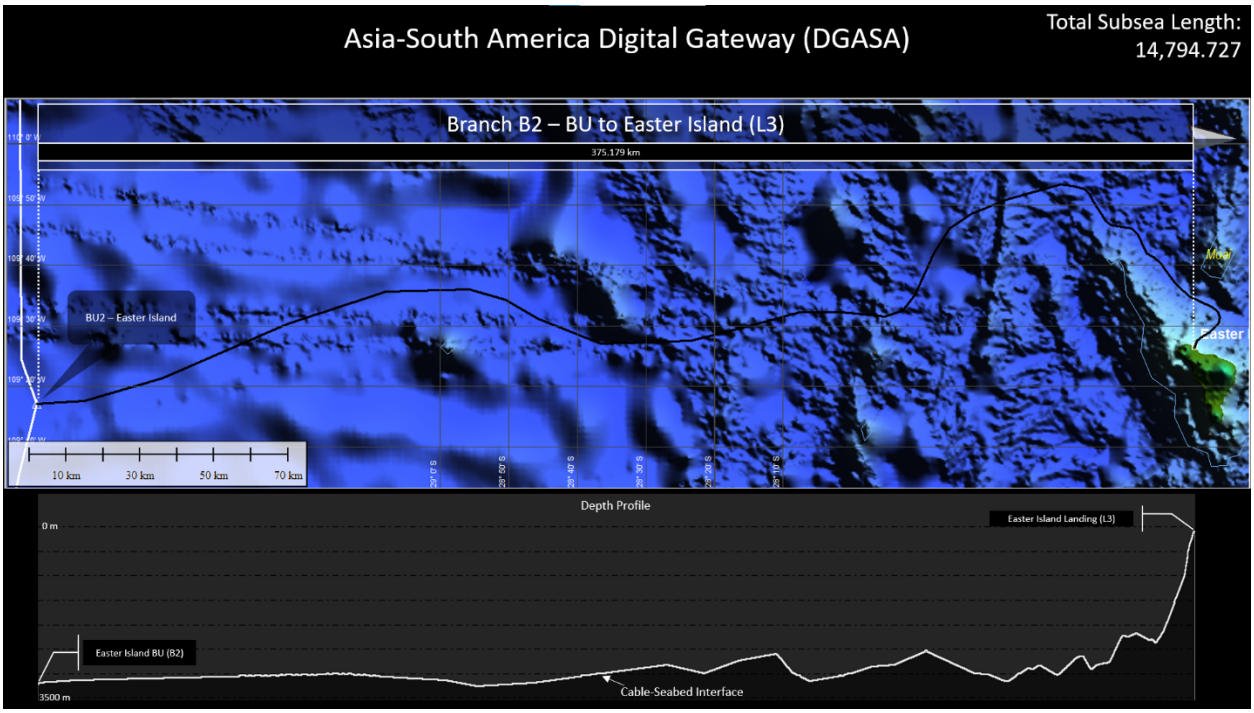


Figure 34 - Easter Island Branch Overview

The branch is the longest, heading due north with significant deviations to the route avoiding seamounts and ridges. The approach to the island's shelf is from the north-west to minimize side-slope lay down.

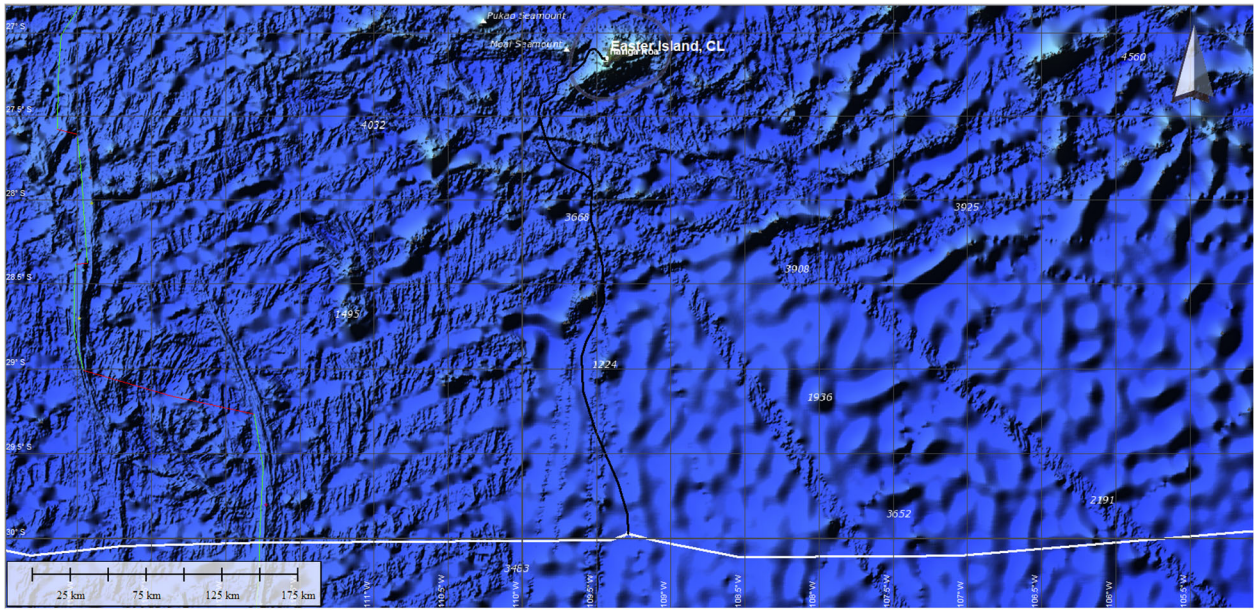


Figure 35 - Easter Island Branch

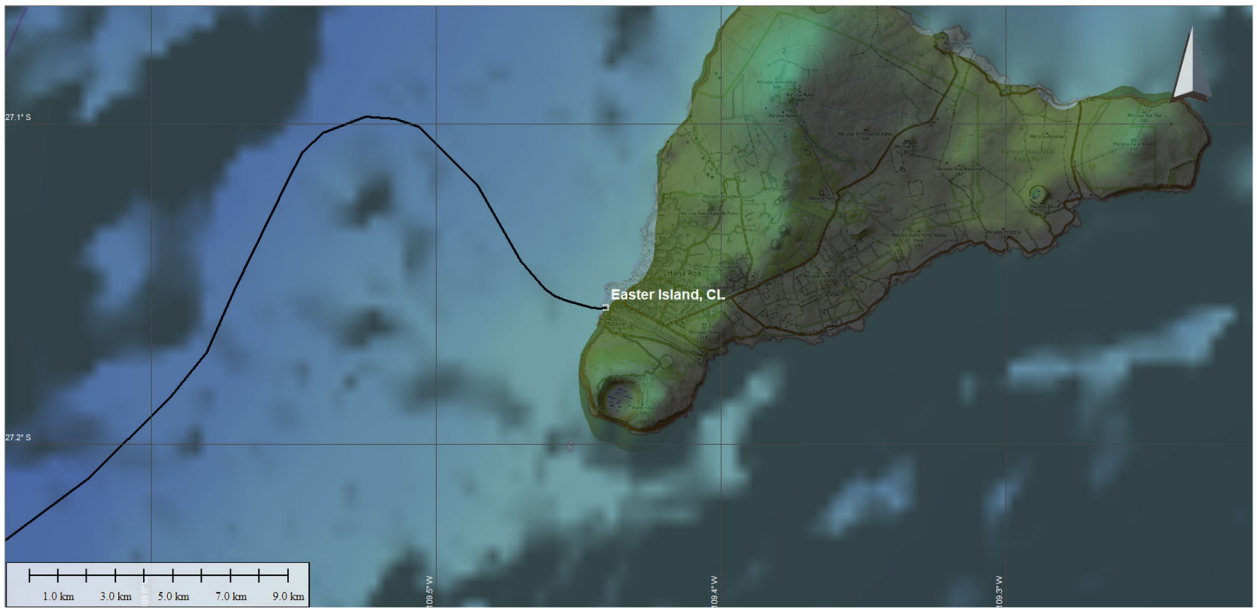


Figure 36 - Easter Island Branch Detail

2.3.3. B3 – Future

The Future BU is intended to potentially connect service to islands to the North. An 18 km BU tail has been planned to account for 3x water depth. A 5000-kilometer range ring is show in light green on Figure 37 representing a possible swath of islands that could be connected to the Future BU; however, the System design could potentially support islands further away.

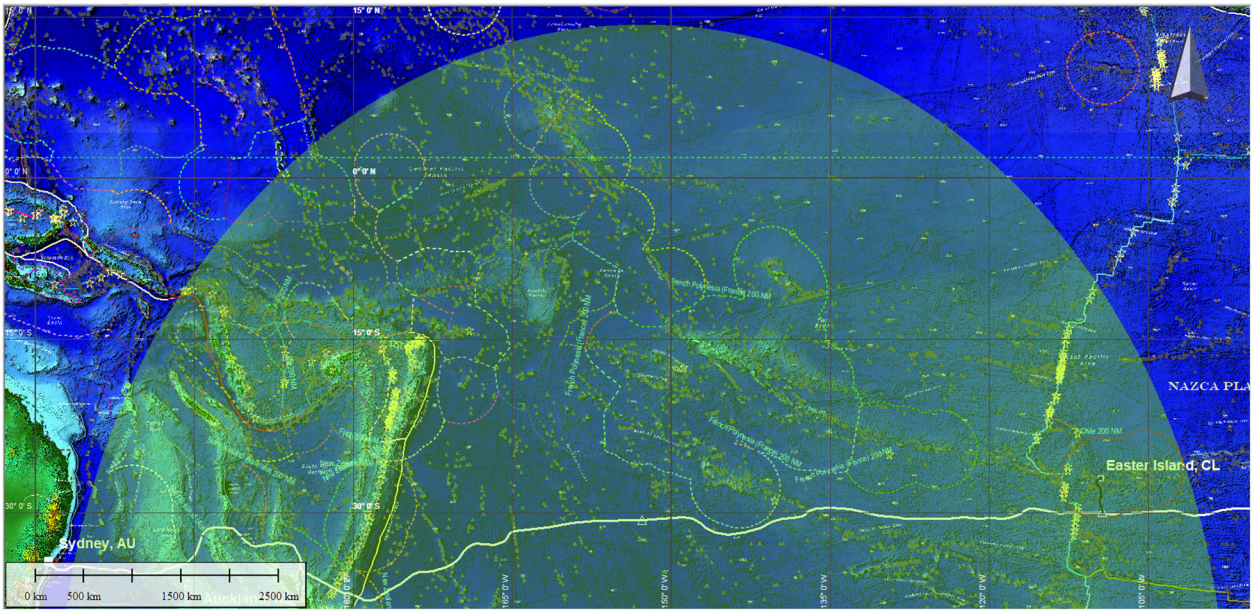
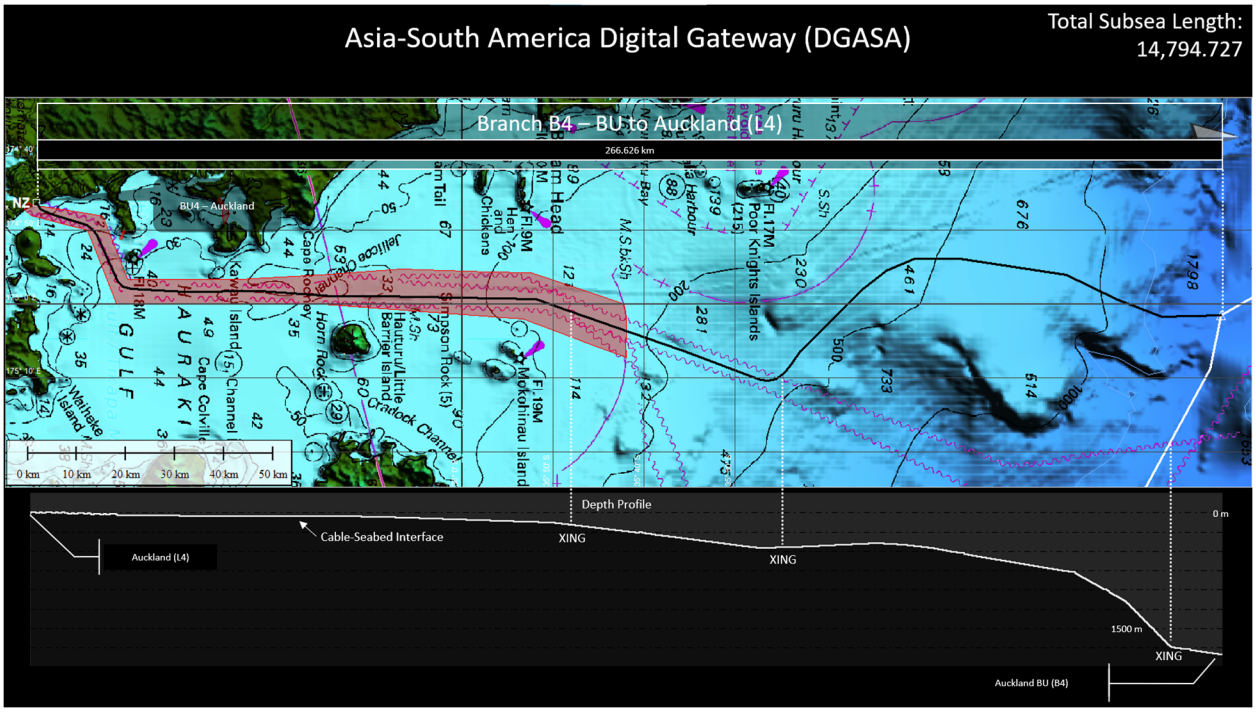


Figure 37 - Future BU 5000km Range

2.3.4. B4 – Auckland



This branch heads due south from the BU towards Auckland, picks up the submarine cable safety zone and follows current submarine cables to the landing at Auckland.

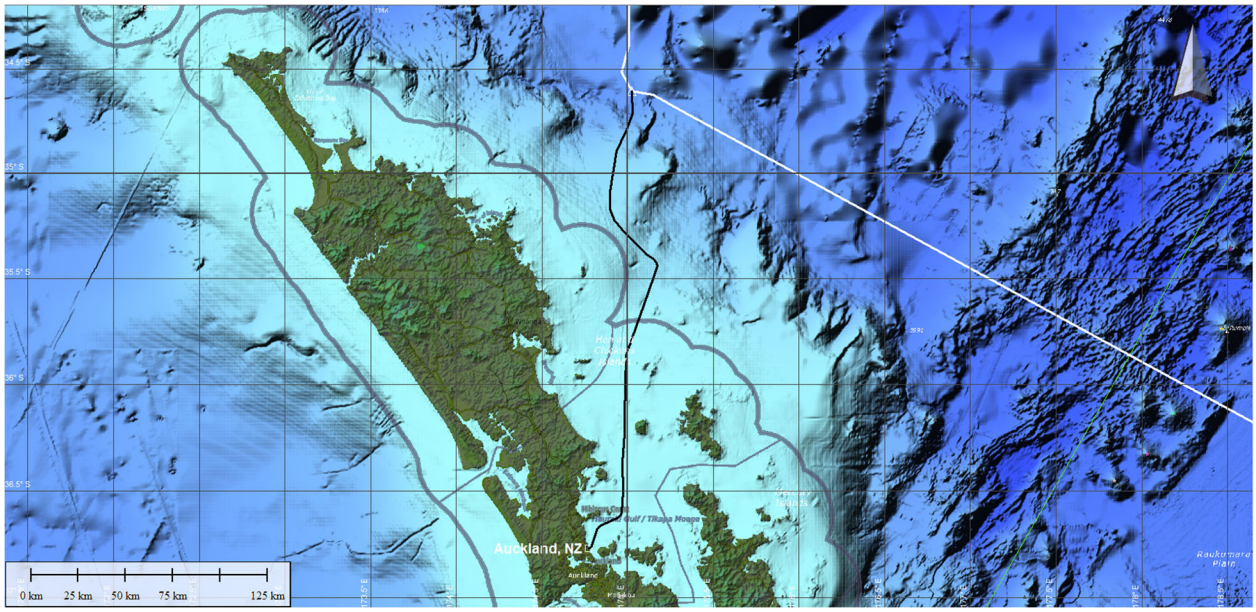


Figure 38 - Auckland Branch

3. Physiography and Geology

The overarching geological setting, along with regional and localized seafloor conditions affect cable routing, installation parameters and long-term cable system security. Regional and local seabed conditions have the potential to affect the physical safety of a submarine cable during and after installation. Understanding the geological framework will ensure the cable is in the safest possible seabed, with optimal burial potential.

3.1. Tectonic Setting & Seismicity

The Earth is comprised of a series of spherical shell layers, which can be described in two ways: compositionally and rheologically. (Rheology is the study of how materials flow under deformation.) The two ways of describing the Earth's structure give us two sets of terms for the layering: the former describes the planet in terms of the Core, Mantle and Crust; while the latter describes it as Core, Asthenosphere and Lithosphere. The latter system will be used in this report, because it is more correct when describing a tectonic setting, which discusses plate movements and deformations.

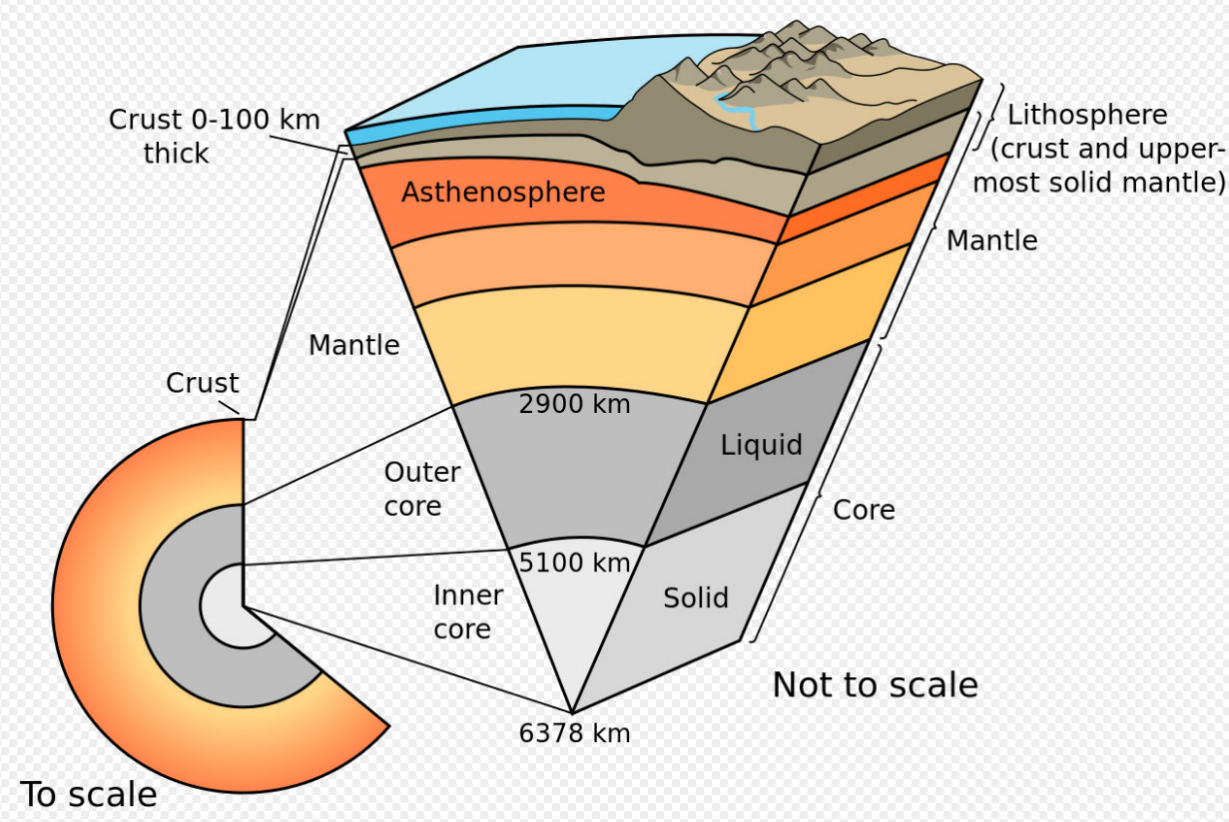


Figure 39 - Layering of the Earth (Wikipedia, 2017)

The Earth's Core is comprised of an inner mass (mainly iron and nickel), which behaves geophysically like a solid, and an outer molten layer, which can flow. The Earth's magnetic field derives mainly from the outer core. Sitting above the core is the asthenosphere. This is a highly viscous, mechanically weak layer, which behaves in a ductile manner under deformation. The upper part of the asthenosphere is believed to be the zone upon which the coherent, rigid, brittle plates of the lithosphere 'float' and move. The lithosphere behaves elastically, as opposed to in a ductile manner, and can therefore break (fault) under

strain. Plate tectonics is the study that describes the movement of these plates. See Figure 40 - Rheological Layering & Types of Tectonic Plate Boundaries (Wikipedia, 2017)

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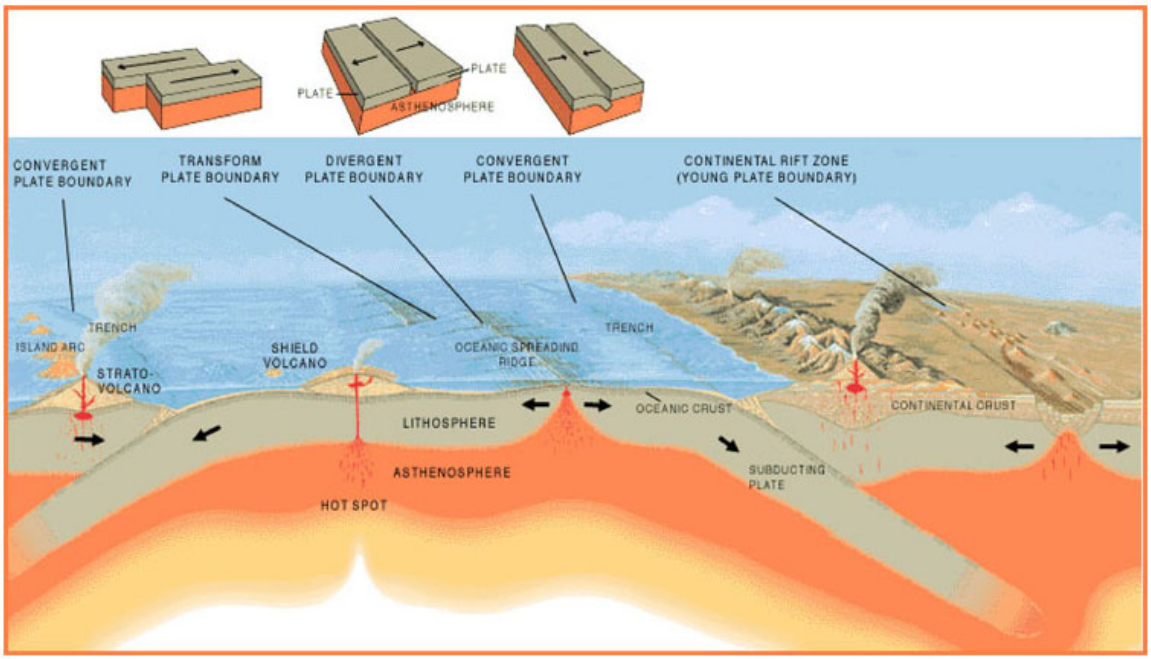


Figure 40 - Rheological Layering & Types of Tectonic Plate Boundaries (Wikipedia, 2017)

There are two types of lithosphere—oceanic and continental. New oceanic lithosphere is created at mid-ocean ridges, and it cools, gets denser and sinks as it moves away from the spreading ridge. Continental lithosphere is not as dense as oceanic lithosphere but is thicker. The way in which these two different types of lithosphere meet each other at plate boundaries dictates the type of margins seen in different parts of the world. The lithospheric plates move around and collide with each other. In very basic terms, plate motion is driven by the creation of new oceanic lithosphere at mid-ocean ridges and its destruction at subduction zones. Different types of collisions occur, oceanic/continental, oceanic/oceanic and continental/continental. The processes vary for each plate boundary scenario, due to the physical property differences between the types of lithosphere.

There are three types of plate tectonic boundary, all of which create seismic events (earthquakes):

- *Divergent* Boundaries are typified by mid-ocean ridge spreading centers in the deep ocean basins. New oceanic crust is created as two tectonic plates move apart from each other. The asthenosphere is close to the surface at the spreading center, and lava erupts along the spreading ridge. The differing rate of crust creation along the mid-ocean ridge is offset by transform (strike slip) faults, perpendicular to the ridge crest, producing a segmented pattern. Small to moderate earthquakes occur, generated at shallow depths of 10km or less.
- Convergent Boundaries are comprised of two types. Subduction Boundaries where denser oceanic lithosphere plunges down beneath lighter continental lithosphere, and Collisional Boundaries, where two continental plates meet. The former creates a deep trench on the ocean side of the boundary, while the latter creates mountain chains and volcanoes, because the

similar density of the plates resists subduction, and the crust buckles instead. Very large earthquakes occur, as deep as 700km.

- Conservative Boundaries occur where the adjoining plates are moving parallel to each other and are therefore dominated by transform (strike slip) faults. The lithosphere can be cracked or broken at these margins, but it is not destroyed or created. Large earthquakes occur, originating from depths <20km.

Earthquakes are caused by the sudden release of frictional energy, which has been built up within the lithosphere under an imposed strain regime. They typically occur when two blocks of the earth's crust slip past one another along a fault plane. The location of the fault, called the epicenter, is located beneath the ground. The epicenter depth is usually shallow at divergent and conservative boundaries, and deeper at convergent boundaries. The energy released radiates away from the epicenter in the form of seismic waves, which shake the earth as they move through it. Earthquakes are measured by instruments called seismographs, which measure the magnitude and intensity of the ground movement.

The most popular scale for measuring earthquakes is the Richter Scale, which is a logarithmic scale:

- Magnitude 2.5 or less, usually not felt by humans
- Magnitude 2.5-5.4, often felt but cause minor damage
- Magnitude 5.5-6.0, slight damage to buildings and other structures
- Magnitude 6.1-6.9, may cause significant damage in very populated areas
- Magnitude 7.0-7.9, major earthquakes, with serious damage
- Magnitude 8.0 or greater, great earthquake, can destroy communities near the epicenter

The entirety of the System lies within the Ring of Fire, "also referred to as the Circum-Pacific Belt, is a path along the Pacific Ocean characterized by active volcanoes and frequent earthquakes. Its length is approximately 40,000 kilometers (24,900 miles). It traces boundaries between several tectonic plates—including the Pacific, Juan de Fuca, Cocos, Indian-Australian, Nazca, North American, and Philippine Plates.

Seventy-five percent of Earth's volcanoes—more than 450 volcanoes—are located along the Ring of Fire. Ninety percent of Earth's earthquakes occur along its path, including the planet's most violent and dramatic seismic events.

The abundance of volcanoes and earthquakes along the Ring of Fire is caused by the amount of movement of tectonic plates in the area. Along much of the Ring of Fire, plates overlap at convergent boundaries called subduction zones. That is, the plate that is underneath is pushed down, or subducted, by the plate above. As rock is subducted, it melts and becomes magma. The abundance of magma so near to Earth's surface gives rise to conditions ripe for volcanic activity. A significant exception is the border between the Pacific and North American Plates. This stretch of the Ring of Fire is a transform boundary, where plates move sideways past one another. This type of boundary generates a large number of earthquakes as tension in Earth's crust builds up and is released." (National Geographic, 2020)

The System spans the South American, Nazca, Antarctic, Pacific and Indian-Australian plate boundaries, in that order, as it traverses from Valparaiso, CL to Sydney, AU.

3.2. Tectonic Setting & Seismicity for the System

The Peru-Chile Trench sees a high degree of movement as the Nazca Plate subducts the South American Plate, generating some of the 20th century's largest earthquakes and resulting tsunamis. There is a large

amount of sedimentation at the base of the trench with significant canyon fill up-slope, which can lead to mass sediment movement events.

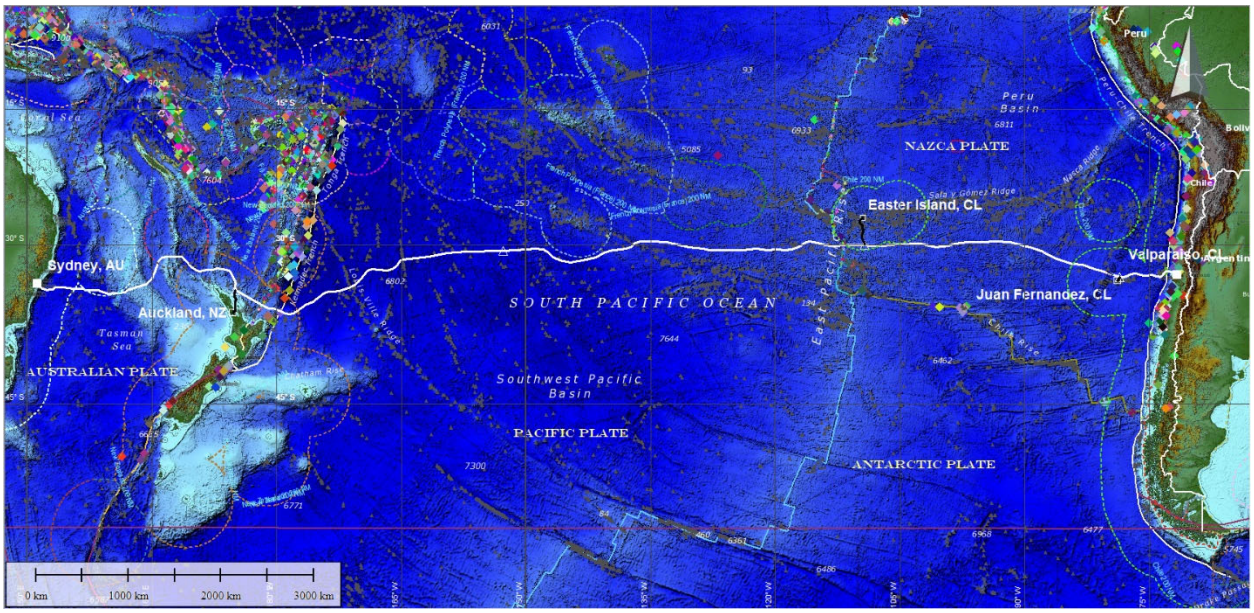


Figure 41 - Seismic Events

Figure 41 shows via colored triangles where M5.1 and greater seismic events have occurred. As to be expected, the majority are located on the South America-Nazca Plate boundary and Pacific-Australian Plate boundary. Seismic activity and magnitude are not predictable, but this System will "feel" the effects at some point and degree over the course of its lifespan.

The East Pacific Rise is a mid-ocean ridge, and the crust moves away from the center of the ridge on either side. Along the ridge are seamounts, knolls, and hydrothermal vents, all of which have newer rock formations, steeper slopes and less sediment to act as natural protection to the cable.

The Louisville Ridge or Louisville Seamount Chain consists of more than 70 seamounts, between which the DGASA System must traverse.

The transition from the South Pacific Ocean deep ocean basin to cross north of New Zealand and back to the deep waters of the Tasman Sea means crossing troughs, plateaus, rises and ridges, all of which are located in a highly active tectonic setting.

Each landing has unique tectonic and seismic attributes, which have been expanded upon in the sections below.

It is not the seismic events themselves that typically pose a hazard to the submarine cable, but rather the resulting mass movements of sediment on the seabed (sliding/slumping) and tsunamis. Tsunamis can also affect the landing through mass erosion, structural damage, and water inundation. Suitable burial, BMH hardening and building elevation are typical mitigation techniques.

4. Regional Geology & Physiography

4.1. Regional Geology

4.1.1. L1 – Valparaiso, CL

The trench is a result of a convergent boundary, where the eastern edge of the oceanic Nazca Plate is being subducted beneath the continental South American Plate. Two seamount ridges within the Nazca Plate enter the subduction zone along this trench: the Nazca Ridge and the Juan Fernández Ridge.

From the Chile Triple Junction to Juan Fernández Ridge the trench is filled with 2.0–2.5 kilometers (1.2–1.6 mi) of sediments, creating a flat bottom topography. Sediments are mainly turbidites interspersed with oceanic deposits of clay, volcanic ash, and siliceous ooze. The Peru–Chile Trench, the forearc and the western edge of the central Andean plateau (Altiplano), delineate the dramatic "Bolivian Orocline" that defines the Andean slope of southern Peru, northern Chile, and Bolivia.

4.1.2. L2 - Juan Fernández, CL

The islands are volcanic peaks rising from the Juan Fernández submarine ridge. Robinson Crusoe has a summit 3,002 feet (915 meters) above sea level, and Alejandro Selkirk rises to 5,415 feet. Bahía Cumberland (Cumberland Bay), on the northern side of Robinson Crusoe, and Bahía Padre, at the western extremity, are the only fair anchorages.

4.1.3. L3 – Easter Island, CL

The small and hilly island is not part of a sunken landmass but is a typical oceanic high island formed by volcanoes rising from the seafloor. Geologic and oceanographic evidence shows that no perceptible emergence or submergence of the island's coastline has taken place since the last fall in sea level, which occurred less than 10,000 years ago. Three extinct volcanoes chiefly composed of tuff (a porous rock formed of compacted volcanic fragments) and joined by their own lava flows give the island its characteristic triangular shape. Parasitic tuff craters and cones (i.e., craters and cones formed on the side of, or near, volcanoes after the original vent has become plugged up) are interspersed in the landscape, which is otherwise dominated by eroded lava fields in which obsidian is commonly found.

4.1.4. L4 – Auckland, NZ

"The Auckland Region of New Zealand is built on a basement of greywacke rocks that form many of the islands in the Hauraki Gulf, the Hunua Ranges, and land south of Port Waikato. The Waitākere Ranges in the west are the remains of a large andesitic volcano, and Great Barrier Island was formed by the northern end of the Coromandel Volcanic Zone. The main isthmus and North Shore are composed of Waitemata sandstone and mudstone, and portions of the Northland Allochthon extend as far south as Albany. Little Barrier Island was formed by a relatively isolated andesitic volcano, active around 1 to 3 million years ago.

The Manukau and South Kaipara Harbours are protected by the recent sand dune deposits of the Awhitu and South Kaipara Peninsulas. Recent basaltic volcanic activity has produced many volcanic cones throughout the Auckland Region, including the iconic Rangitoto Island.

Basement Rocks

As with most of New Zealand, the basement rocks of the Auckland Region are composed of greywacke (indurated sandstone, siltstone and mudstone).

Murihiku Terrane Greywacke lies beneath the Auckland Region on the western side, and outcrops south of the Waikato River. The Murihiku Terrane is considered to be an accretionary wedge of mainly volcanogenic forearc sediments. It was formed in Late Triassic to Late Jurassic times (220-145 Ma).

A line of Dun Mountain-Maitai Terrane rocks is assumed to pass north–south through the center of the Auckland Region, separating the Murihiku Terrane and Waipapa Composite Terrane. The existence of this terrane at depth is inferred from its distinctive magnetic anomaly (Junction Magnetic Anomaly or JMA) and xenoliths in the Auckland Volcanic Field. Some Murihiku rocks occur to the east of the JMA, forming the Taupiri and Hakarimata Ranges, but it is assumed that these rocks have been shifted to their present position.

Hunua Terrane Greywacke lies beneath the Auckland Region on the eastern side, as far south as the Hunua Ranges, and outcrops in the Hunua Ranges, many islands in the Hauraki Gulf (Waiheke, Motutapu, Motuihe, Tiritiri Matangi, Kawau, etc.), and Tawharanui Peninsula. It sometimes includes Chert and Argillite. The rocks are generally fine grained and highly deformed. It was formed in Late Triassic to Late Jurassic times (220-145 Ma).

The Morrinsville Terrane Greywacke lies beneath the Auckland Region on the eastern side, south of the Hunua Ranges, and further east to the Coromandel Peninsula. The rocks are generally coarser grained, with massive sandstones and conglomerate. It was formed in Late Jurassic to Early Cretaceous times (160-120 Ma).

Te Kuiti Group coal and limestone

The Te Kuiti Group Rocks overlie the basement rocks, and are present in Northland, Auckland, the Waikato, and King Country, although they have often been eroded or covered. Rocks containing coal were formed from swampland in Late Eocene times (37-34 Ma). The land sank and the sea transgressed, and calcareous sandstone, mudstone, and limestone was deposited in Oligocene times (34-24 Ma).

The coal deposits outcrop near Huntly and Maramarua, where they are mined.

Flaggy limestone bluffs are located in the area south and west of the Waikato River.

Northland Allochthon

In Early Miocene times (24-21 Ma), a series of thrust sheets were emplaced over Northland, extending as far south as the Kaipara Harbour and Albany areas. The rocks came from the northeast, and were emplaced in reverse order, but the right way up. The original rocks are of Cretaceous to Oligocene age (90-25 Ma), and include mudstones, limestone and basalt lava. These rocks outcrop around Silverdale, Warkworth, and Wellsford, reaching as far south as Albany. West Coast volcanism

A volcanic arc became active to the west of the current land in Northland in Miocene times (23 Ma), and gradually moved south down to Taranaki. It produced mainly andesitic strato-volcanoes. Volcanoes were produced in what is now sea to the west of the Auckland Region, near the Kaipara Harbour and Waitākere Ranges (22-16 Ma), and Waikato Heads (14-8 Ma).

The Waitakere volcano has mainly been eroded, but conglomerate from the volcano formed the Waitākere Ranges. The Waitākere Ranges also contain many dikes, volcanic plugs, etc., that formed part of this volcano.

Waitemata Sandstone

While the volcanic activity occurred to the west, a rapidly deepening basin developed further to the east, in the Auckland area.

These Early Miocene volcanoes, along with the Northland Allochthon, eroded and deposited most of the material that makes up the Waitemata sandstones and mudstones in the Waitemata Basin. The Waitemata sandstones and mudstones form the cliffs around the Waitematā Harbour and East Coast Bays, and land further north up to Cape Rodney, with outcrops further south down to Mercer and Miranda. Lahars produced the coarser Parnell Grit, found in many headlands around the East Coast Bays. Greywacke pebble beaches can be seen forming a layer in Waitemata sandstone cliffs on Motutapu Island.

Coromandel Volcanism

Shortly after (18 Ma), a volcanic arc developed further east to create the Coromandel Ranges and undersea Colville Ridge. The initial activity was andesitic, but later became rhyolitic (12 Ma). In the Kauaeranga Valley, impressive volcanic plugs remain, as does a lava lake that now forms the top of Table Mountain. Active geothermal systems, similar to those that now exist near Rotorua, were present around 6 Ma, and produced the gold and silver deposits that were later mined in the Coromandel gold rush. Later (5-2 Ma), volcanic activity moved further south to form the Kaimai Ranges.

The Hauraki Plains and Hauraki Gulf are believed to represent a rift valley. The Coromandel Ranges used to be much closer to Auckland, and the rift valley is assumed to have developed about 2 Ma ago, due to the clockwise rotation of the eastern North Island, that stretched the land between Auckland and East Cape. The Waikato River used to flow from Karapiro, through the Hinuera Gap, and Hauraki Plains, to come out on the east coast in the Hauraki Gulf. The sediment from Oruanui eruption of Lake Taupo caused the river to change direction and come out to the west. Rivers around Auckland, that now flow to the east, such as the rivers around Clevedon, used to flow to the west, and deposited rocks from the Coromandel Ranges in the Manukau Harbour.

Recent basaltic volcanism of the Auckland Volcanic Province

The Auckland Volcanic Province comprises the Auckland, South Auckland, Ngatutura and Okete volcanic fields. Intra-plate basaltic volcanism in the Auckland region started in the south, at Okete, near Raglan in late Pliocene times (2.7-1.8 Ma), and has moved north through the Ngatutura, South Auckland and Auckland fields since then.

Okete Volcanic Field

The Okete Volcanics erupted over short periods, between 1.8 and 3 Ma ago, from at least 27 tuff rings, or scoria mounds, surrounded by lava flows. At Maungatawhiri the initial eruption was of fine-grained volcanic tuffs, thought to be comminuted by water interacting with magma, followed by strombolian activity and lava flows. North of Papanui Point violent phreatomagmatic eruptions have formed tuff rings of airfall and pyroclastic surge deposits. The Okete Volcanics include basanites, alkali olivine basalts, hawaiites, and lavas with ultramafic xenoliths. Lava flows from the Okete Volcanic Field generated the Bridal Veil Falls.

Ngatutura Volcanic Field

Activity then moved to the Ngatutura Volcanic Field, south of Port Waikato in early Pleistocene times (1.8-1.5 Ma). Little remains of this field.

South Auckland volcanic field

Activity then moved to the South Auckland volcanic field, in the area from Pukekawa north to Waiuku and Papakura, in mid Pleistocene times (1.5-0.5 Ma), producing over 100 eruptions. This field includes the lava

flows at Hunua Falls, scoria cones that form the Bombay Hills, Pukekohe and Pukekawa, and tuff rings at Pukekohe and Onewhero. The rich soils used for market gardening in this area are the product of the Hamilton Ash tephra formation, not the weathering of the South Auckland volcanic field.

Auckland volcanic field

The Auckland volcanic field is believed to have started around 250,000 years ago, and is still active. It covers the area from Wiri in the south, through the Auckland Isthmus, to Lake Pupuke and Rangitoto Island in the north, and contains around 50 vents.

The field contains many maar craters, generated by eruptions where the magma encountered water, and a series of explosive eruptions produced a large crater, surrounded by a tuff ring. Examples include Lake Pupuke, Onepoto, Tuff Crater, Orakei Basin, Pukaki Lagoon, etc. Many of the craters have been breached by the sea and are now filled with mud. The eruption of Lake Pupuke caused the Wairau River, which used to come out around Little Shoal Bay, to change its course to north of Milford.

Dry fire-fountaining eruptions have produced scoria cones. Examples include North Head, Mount Victoria, Mount Eden, Mount Hobson, Mount St Johns, One Tree Hill, Mount Roskill, Three Kings, Mount Albert, Mount Mangere. Some produced substantial lava flows. For example, a lava flow from Mt St John flows through Sandringham, Morningside, Western Springs, and out to the Waitematā Harbour, forming Te Tokaroa Reef, which reaches within 500 m of Kauri Point, Birkenhead. Some lava flows contain caves, for example at Wiri, Three Kings, and One Tree Hill.

Rangitoto Island is the most recent volcano, erupting around 600 years ago. Apart from the summit, it is composed of Pahoehoe (smooth) and ’A’a (broken) lava flows, which are still largely bare of vegetation or soil. It also has lava caves, near the track up to the summit, that are very accessible to visitors.

While the ages of individual volcanoes in the Auckland volcanic field are somewhat uncertain, the following ages have been obtained:

- Onepoto: ~250,000 years ago.
- Pupuke: ~200,000 years ago.
- Orakei Basin: ~85,000 years ago.
- Puketutu, Taylors Hill, Mt Richmond, Wiri, Crater Hill: 32,000 years ago.
- Three Kings: 28,500 years ago.
- Mt Eden: 28,000 years ago.
- Mangere Mt: ~20,000 years ago.
- Mount Wellington: 10,000 years ago.
- Rangitoto Island: 600 years ago. Pumice deposits

Over the last few million years, rhyolitic pumice deposits from the center of the North Island have been washed down into the Auckland area, and form substantial deposits around the Hauraki Plains and Manukau Harbour, Western Waitematā Harbour, and even up into the Kaipara Harbour.

Coastal Dunes

The Awhitu Peninsula (the west coast from Waikato Heads up to Manukau Heads), and the coastal barriers north and south of the entry to the Kaipara Harbour, are essentially consolidated sand dunes, built up over the last few million years.

The black sand on the west coast beaches is known for its high iron content, and is “mined” north of Waikato Heads, being extracted by electromagnets. The iron comes from the undersea volcanoes, to the west of the coast, and from the Tongariro Volcanic Centre, and Taranaki.

Quartz sand to the north of Auckland, around Tawharanui and Pakiri, appears white, due to its purity.” (Wikimedia Foundation, 2020)

4.1.5. L5 – Sydney, AU

"The Sydney Basin is an interim Australian bioregion and is both a structural entity and a depositional area, now preserved on the east coast of New South Wales, Australia and with some of its eastern side now subsided beneath the Tasman Sea. The basin is named for the city of Sydney, on which it is centered.

Around 5,000 meters (16,000 ft) thick, the Sydney Basin consists of Permian and Triassic sedimentary rocks, which stretches from Newcastle in the north to Batemans Bay in the south, and west to the Great Dividing Range. The basin is also home to the major centers of Newcastle and Wollongong and contains economically significant reserves of coal.

Sydney's famous harbor and the sculptured cliffs of the Blue Mountains are signature formations of relatively hard upper strata of sandstone. The basin contains the UNESCO World Heritage-listed Greater Blue Mountains Area.

Geography

According to NSW Primary Industries, the basin extends through approximately 350 kilometers (220 mi) of coastline from Newcastle in the north to Durras Lake (near Batemans Bay) in the south. From Durras Lake the western boundary continues in a line through Lithgow to around Ulan (near Mudgee). To the north the boundary extends 120 kilometers (75 mi) along the Liverpool Range to a point 80 kilometers (50 mi) north of Muswellbrook, and then runs 200 kilometers (120 mi) back to the coast at Newcastle. To the east the basin continues to the edge of the continental shelf. The total area of the basin is approximately 44,000 square kilometers (17,000 sq mi) onshore plus 5,000 square kilometers (1,900 sq mi) offshore. The center of the basin is located around 30 kilometers (19 mi) west of the Sydney central business district at Fairfield, though only the youngest Triassic (middle Triassic) rocks are exposed in the Sydney area. The Australian Government Department of the Environment and Energy classifies the basin as an interim Australian bioregion consisting of 3,629,597 hectares (8,968,930 acres). Meanwhile, according to Geoscience Australia the basin covers 64,000 square kilometers (25,000 sq mi), of which 36,000 square kilometers (14,000 sq mi) is onshore and 28,000 square kilometers (11,000 sq mi) is offshore with water depths of up to 4,500 meters (14,800 ft). Another Australian Government agency classifies that the basin covers approximately 25,000 square kilometers (9,700 sq mi).

The majority of Sydney Basin is raised sandstone plateau, with the exclusion being the Hunter Valley and the low-lying Cumberland Plain.

Minor igneous activity took place in the basin during the Early Jurassic (i.e., 210 million years ago), Late Mesozoic (i.e. 100-90 million years ago) and Cenozoic eras (i.e. 65 million years ago). The Early Jurassic activity resulted in the formation of the Prospect dolerite intrusion in Prospect Hill. Although Jurassic sedimentation is not observed in the Sydney Basin, there are Jurassic volcanic breccia pipes (diatremes). The Sydney Basin is part of a major basin system that extends over 1,500 kilometers (930 mi) from the Bowen Basin in Queensland through to the Gunnedah Basin in NSW. Onshore, the basin contains 4,500 meters (14,800 ft) of Permo-Triassic clastic sediments, while the offshore basin contains 6,000 meters (20,000 ft) of sediments. The basin overlies the Lachlan Fold Belt and Late Carboniferous volcanoclastic sediments. The basin formed during extension in the Early Permian, with half-graben infilled with the

Dalwood and Talaterang Groups. Foreland loading followed with the compression of the Currarong Orogen in the Early Permian. Late Permian uplift associated with the New England foreland loading phase resulted in the formation of depocenters with the northeast Sydney Basin with best preserved marine fossils. These depocenters filled with pyroclastic and alluvial-paludual sediments of the Newcastle Coal Measures. In the Triassic, uplift of the offshore basin resulted in reworking of Permian sediments in fluvial environments. The basin underwent a final phase of deformation (thrusting) in the Middle Triassic where it was uplifted to become dry land, with an erosion occurring from this time to the present.

Extension and breakup in the Tasman Sea beginning in the Late Cretaceous resulted in the current structural boundaries of the basin's eastern margin. In the south and west the Basin finishes in cliff lines formed on sandstones and conglomerates of the primary Permian sediments, with waterfalls being widespread on all escarpments.

Timeline

The Prospect dolerite intrusion in Greater Western Sydney

Permian: 299–252 million years ago; The settling and evolution of swamp forest, which would shape tremendous coal measures. To note, Australia's coal is younger than the Carboniferous coal of the Northern Hemisphere.

Early Triassic: 252–247 million years ago; dark, high-carbon Narrabeen shales can be viewed at Long Reef and Narrabeen.

Mid Triassic: 247–235 million years ago; A monolithic river with its beginnings to the south-west of Broken Hill, in what was Antarctica at that time, had its delta in what was the Sydney Basin. It is around five times bigger than the Amazon river. There is predominance of silica sand with minor lenses of clay. Plant fossils are scarce, but some fish fossils are found in the clay lenses.

Late Triassic: 235–201 million years ago; As the river slowed with the erosion of the mountain range, finer shales were laid out. This stratum is rich in Glossopteris fern fossils.

End of Triassic: 201 million years ago; Ascension and shifting at the Lapstone fault, with the Blue Mountains rising and the western Sydney plain descending to a flat land and Sydney CBD jousting upward. Jurassic: 201–145 million years ago; Erosion, with Ashfield Shales remaining on top. Deep V-shaped valleys in the Hawkesbury sandstone. Fracturing, volcanic intrusions form Prospect Quarry, Mount Tomah, Mount Wilson and Hornsby Quarry.

Cainozoic (Tertiary and Quaternary): 66 million years to present; Development of the Botany Bay Basin, which is infilled with sand.

Hydrology

The hydrology of the basin comprises three main drainage basins as defined by the New South Wales Office of Water that lie entirely or mainly within the geography of the basin: namely the Central Coast catchment, the Hawkesbury-Nepean catchment, and the Sydney Metropolitan catchment.

In addition, some of the rivers of the Hunter-Central Rivers catchment and the Southern Rivers catchment also lie mainly in the basin. In the Hunter-Central Rivers catchment, the Hunter River sub-catchment forms the northern boundary of the basin. In the Southern Rivers catchment, the Illawarra sub-catchment and the Shoalhaven sub-catchment forms the southern boundary." (Wikimedia Foundation, 2020)

4.2. Regional Physiography

4.2.1. L1 – Valparaiso, CL

Valparaíso, region, central Chile, bordering the Pacific Ocean on the west, Argentina on the east, and Santiago metropolitan region on the southeast. It was created in 1974 and encompasses Valparaíso, San Antonio, Quillota, Petorca, San Felipe, Los Andes, Marga, and Isla de Pascua (Easter Island) provinces. Valparaíso is Chile's third most populous region. In the north the region is mountainous, interrupted by broad valleys, including the northern reaches of the Central Valley of Chile, which lies between the coastal ranges and the piedmont alluvial slopes of the Andes. Climatically, the region lies in a transitional zone between the arid northern part of Chile and the subhumid central part. Major transverse valleys include those of the Aconcagua and Ligua rivers, their tributaries, and the lower Río Maipo basin.

In the fertile northern valleys where irrigation is employed, especially around San Felipe, and in the westward-draining lowlands near Valparaíso city, the regional capital, flowers, alfalfa, grapes and other fruits, vegetables, and cereal grains are grown. Cattle and sheep are pastured in the rangeland in the coastal mountains of southwestern Valparaíso region. The region contains rich mineral resources, particularly copper, kaolin, and salt. It is among Chile's most productive industrial regions; leading products are textiles, chemicals, cement, clothing, processed foods, and tobacco. The Concón petroleum refinery and the oil storage tanks at Quintero and Viña del Mar are economically important. The port of San Antonio, south of Valparaíso city, exports copper brought by railroad from the large mine at El Teniente, near Rancagua in O'Higgins region. Highways and an electrified railway link the urban centers to Valparaíso city. The Pan-American Highway and the main north-south railroad pass through the northern portion of the region, which was heavily damaged in a 1971 earthquake. A major east-west highway connects the region with Mendoza, Argentina, via the Uspallata Pass, site of the famed statue "Christ of the Andes," on the border. Valparaíso also has several popular beach resorts, notably Viña del Mar. Portillo, near Mount Aconcagua (22,834 feet [6,960 meters]), has become South America's most popular Andean winter resort, particularly for skiing.

4.2.2. L2 - Juan Fernández, CL

Juan Fernández Islands, Spanish Islas Juan Fernández, small cluster of islands in the South Pacific Ocean, situated about 400 miles (650 km) west of and administratively part of Chile.

They consist of the 36-square-mile (93-square-km) Isla Robinson Crusoe (also called Isla Más a Tierra); the 33-square-mile Isla Alejandro Selkirk (also called Isla Más Afuera), 100 miles to the west; and an islet, Isla Santa Clara, southwest of Isla Robinson Crusoe.

The islands are volcanic peaks rising from the Juan Fernández submarine ridge. Robinson Crusoe has a summit 3,002 feet (915 meters) above sea level, and Alejandro Selkirk rises to 5,415 feet. Bahía Cumberland (Cumberland Bay), on the northern side of Robinson Crusoe, and Bahía Padre, at the western extremity, are the only fair anchorages.

The islands were discovered about 1563 by Juan Fernández, a Spanish navigator, who received a grant and lived there for some years, stocking them with goats and pigs. After his departure, the islands were visited only occasionally. In 1704, however, Alexander Selkirk, a Scottish seaman, quarreled with his captain and was put ashore at Bahía Cumberland. He remained there alone until 1709, and his adventures are commonly believed to have inspired Daniel Defoe's Robinson Crusoe. The islands passed into Chilean possession in the early 19th century. Since then, they have been used as penal settlements on many occasions, particularly for political prisoners. Isla Santa Clara is now uninhabited. Robinson Crusoe and Alejandro Selkirk are sparsely populated, most of their inhabitants being concentrated in the village of

Robinson Crusoe, on Bahía Cumberland. Their principal occupation is fishing for lobsters. In 2018 the Chilean government created Juan Fernández Islands Marine Park, a protected area that encompasses over 100,000 square miles (almost 260,000 square km) of ocean around the islands.

4.2.3. L3 – Easter Island, CL

Easter Island, Spanish Isla de Pascua, also called Rapa Nui, Chilean dependency in the eastern Pacific Ocean. It is the easternmost outpost of the Polynesian island world. It is famous for its giant stone statues. The island stands in isolation 1,200 miles (1,900 kilometers) east of Pitcairn Island and 2,200 miles west of Chile. Forming a triangle 14 miles long by seven miles wide, it has an area of 63 square miles (163 square kilometers); its highest point, Mount Terevaka, is 1,969 feet (600 meters) above sea level.

To its original inhabitants the island is known as Rapa Nui (“Great Rapa”) or Te Pito te Henua (“Navel of the World”). The first European visitors, the Dutch, named it Paaseiland (“Easter Island”) in memory of their own day of arrival. Its mixed population is predominantly of Polynesian descent; almost all live in the village of Hanga Roa on the sheltered west coast. Pop. (2002) 3,304; (2017) 7,750.

The small and hilly island is not part of a sunken landmass but is a typical oceanic high island formed by volcanoes rising from the seafloor. Geologic and oceanographic evidence shows that no perceptible emergence or submergence of the island’s coastline has taken place since the last fall in sea level, which occurred less than 10,000 years ago. Three extinct volcanoes chiefly composed of tuff (a porous rock formed of compacted volcanic fragments) and joined by their own lava flows give the island its characteristic triangular shape. Parasitic tuff craters and cones (i.e., craters and cones formed on the side of, or near, volcanoes after the original vent has become plugged up) are interspersed in the landscape, which is otherwise dominated by eroded lava fields in which obsidian is commonly found.

4.2.4. L4 – Auckland, NZ

Although New Zealand is small, its geologic history is complex. Land has existed in the vicinity of New Zealand for most of the past 500 million years. The earliest known rocks originated as sedimentary deposits some 545 million to 540 million years ago, at the close of Precambrian time (4.6 billion to 541 million years ago) and the beginning of the Cambrian Period (541 million to 485 million years ago); their source area was probably the continental forelands of Australia and Antarctica, then part of a nearby single supercontinent. Continental drift (the movement of large plates of Earth’s crust) created a distinct island arc and oceanic trench structure by the Carboniferous Period (about 359 to 299 million years ago), when deposition began in the downwarps (trenches) of the sedimentary rocks that today make up some three-fourths of New Zealand. This environment lasted about 250 million years and is typified by both downwarped oceanic sedimentary rocks and terrestrial volcanic rocks. This period was terminated in the west at the beginning of the Cretaceous Period (about 145 million years ago) by the Rangitata Orogeny (mountain-building episode), although downwarp deposition continued in the east. These mountains were slowly worn down by erosion, and the sea transgressed, eventually covering almost all of the land. At the end of the Oligocene Epoch (about 23 million years ago), the Kaikoura Orogeny began, raising land above the sea again, including the Southern Alps of the South Island. Many of the great earth movements associated with this final orogeny took place (and take place today) along faults, which divide the landscape into great blocks, chief of which is the Alpine Fault of the South Island. The erosion and continued movement of these faulted blocks, together with the continuing volcanism of the North Island, define to a large extent the landscape of the country.

New Zealand is part of the Ring of Fire—the circum-Pacific seismic belt marked by frequent earthquakes and considerable volcanic activity. The North Island and the western part of the South Island are on the Indian-Australian Plate, and the remainder of the South Island is on the Pacific Plate. Their collision creates

violent seismic activity in subduction zones and along faults. Numerous earthquakes occur annually, including hundreds that can be felt by New Zealanders. A number of these temblors have been disastrous, such as one that devastated the towns of Napier and Hastings in 1931 and a series of quakes that did likewise in Christchurch in 2010–11.

4.2.5. L5 – Sydney, AU

"The geography of Sydney is characterized by its coastal location on a basin bordered by the Pacific Ocean to the east, the Blue Mountains to the west, the Hawkesbury River to the north and the Woronora Plateau to the south. Sydney lies on a submergent coastline on the east coast of New South Wales, where the ocean level has risen to flood deep river valleys (rias) carved in the Sydney sandstone. Port Jackson, better known as Sydney Harbor, is one such ria. The Sydney area lies on Triassic shales and sandstones. The region mostly consists of low rolling hills and wide valleys in a rain shadow area. Sydney sprawls over two major regions: the Cumberland Plain, a relatively flat region lying to the west of Sydney Harbor, and the Hornsby Plateau, a plateau north of the Harbor rising to 200 meters and dissected by steep valleys. Sydney's native plant species are predominantly eucalyptus trees, and its soils are usually red and yellow in texture. The endemic flora is home to a variety of bird, insect, reptile, and mammal species, which are conspicuous in urban areas. There are more than 70 harbor and ocean beaches in the urban area. Most of Sydney's water storages are on tributaries of the Nepean River. Parramatta River drains a large area of Sydney's western suburbs. With 5,005,400 inhabitants (as of 2016) and an urban population density of 2037 people per square kilometer, Sydney's urban area covers 1,788 km2 (690 sq mi), comprising 35% of Sydney and is constantly growing." (Wikimedia Foundation, 2020)

4.3. Marine Geology & Physiography

4.3.1. L1 – Valparaiso, CL

"The Peru–Chile Trench, also known as the Atacama Trench, is an oceanic trench in the eastern Pacific Ocean, about 160 kilometers (99 mi) off the coast of Peru and Chile. It reaches a maximum depth of 8,065 m (26,460 ft) below sea level in Richards Deep (23°10′45″S 71°18′41″W / 23.17917°S 71.31139°W) and is approximately 5,900 km (3,666 mi) long; its mean width is 64 km (40 mi), and it covers an expanse of some 590,000 km2 (230,000 sq mi).

The trench delineates the boundary between the subducting Nazca Plate and the overriding South American Plate.

Geology

The trench is a result of a convergent boundary, where the eastern edge of the oceanic Nazca Plate is being subducted beneath the continental South American Plate. Two seamount ridges within the Nazca Plate enter the subduction zone along this trench: the Nazca Ridge and the Juan Fernández Ridge.

From the Chile Triple Junction to Juan Fernández Ridge the trench is filled with 2.0–2.5 kilometers (1.2–1.6 mi) of sediments, creating a flat bottom topography. Sediments are mainly turbidites interspersed with oceanic deposits of clay, volcanic ash, and siliceous ooze. The Peru–Chile Trench, the forearc and the western edge of the central Andean plateau (Altiplano), delineate the dramatic "Bolivian Orocline" that defines the Andean slope of southern Peru, northern Chile, and Bolivia.

Oceanography

Most of the time, the trade winds drive surface waters offshore near the equator, driving the Humboldt Current from the tip of southern Chile to northern Peru. This current is associated with upwelling of deep, nutrient-rich water off the coast of Peru. At times, El Niño disrupts the usual wind pattern and lessens the upwelling. The consequent loss of nutrient causes fish kills.

Associated seismicity

Significant Earthquake Faults and damaging earthquakes over the past century along the South American Subduction Zone. The subduction of the Nazca Plate below the South American Plate along the Chile-Peru Trench is associated with numerous earthquakes. Several of these earthquakes are notable for their size, associated tsunamis, and landslides. " (Wikimedia Foundation, 2020)

4.3.2. L2 - Juan Fernández, CL

The volcanic Juan Fernández Islands were created by a hotspot in the Earth's mantle penetrating the Nazca Plate. The islands were carried eastward as the plate subducted the South American continent. Radiometric dating indicates that Santa Clara is the oldest of the islands (at 5.8 million years), followed by Robinson Crusoe (3.8–4.2 million years) and Alexander Selkirk (1.0–2.4 million years). Robinson Crusoe is the largest of the islands at 93 square kilometers (36 sq mi), and its highest peak (El Yunque) is 916 meters (3,005 ft) high. Alexander Selkirk covers 50 square kilometers (19 sq mi), and its highest peak is Los Innocentes at 1,319 meters (4,327 ft). Santa Clara covers 2.2 square kilometers (540 acres), reaching an elevation of 350 meters (1,150 ft). (Wikimedia Foundation, 2020)

4.3.3. L3 – Easter Island, CL

Easter Island is a volcanic high island consisting of three extinct volcanoes: Terevaka, at an altitude of 507 meters (1,663 ft), forms the bulk of the island. Two other volcanoes (Poike and Rano Kau) form the eastern and southern headlands, giving the island its triangular shape. There are numerous lesser cones and other volcanic features: the crater Rano Raraku, the cinder cone Puna Pau and many volcanic caves (including lava tubes).

Easter Island and its surrounding islets, including Motu Nui and Motu Iti, form the comminuted apex of a large volcanic mountain rising over 2,000 meters (6,600 ft) from the seabed. It is part of the Sala y Gómez Ridge, a mostly-submarine mountain range with dozens of seamounts. Pukao and Moai are two seamounts west of Easter Island, extending 2,700 km (1,700 mi) east to the Nazca Seamount. Pukao, Moai and Easter Island were formed during the last 750,000 years, with the last eruption a little over 100,000 years ago. These are the youngest mountains of the Sala y Gómez Ridge, which was formed by the Nazca Plate floating over the Easter hotspot. Only on Easter Island is the Sala y Gómez Ridge dry land. (Wikimedia Foundation, 2020)

4.3.4. L4 – Auckland, NZ

"The harbor is an arm of the Hauraki Gulf, extending west for eighteen kilometers from the end of the Rangitoto Channel. Its entrance is between North Head and Bastion Point in the south. The westernmost ends of the harbor extend past Whenuapai in the northwest, and to Te Atatū in the west, as well as forming the estuarial arm known as the Whau River in the southwest.

The harbor is a drowned valley system that was carved through Miocene marine sediments of the Waitemata Group. Recent volcanism in the Auckland volcanic field has also shaped the coast, most obviously at Devonport and the Meola Reef (a lava flow which almost spans the harbor), but also in the explosion craters of Orakei Basin and in western Shoal Bay. In periods of low sea level, a tributary ran from

Milford into the Shoal Bay stream. This valley provided the harbor with a second entrance when sea levels rose, until the Lake Pupuke volcano plugged this gap.

The current shore is strongly influenced by tidal rivers, particularly in the west and north of the harbor. Mudflats covered by mangroves flourish in these conditions, and salt marshes are also typical." (Wikimedia Foundation, 2020)

4.3.5. L5 – Sydney, AU

The following excepts are from the Sedimentology and Geomorphology report, which contains all the details needed to plan the geophysical survey and a copy has been provided in the supplementary materials included with this DTS.

EMR Sedimentology and Geomorphology

"The shelf in the EMR is subject to relatively high wave and current energy and has had a low sediment supply since sea level reached its present position some 6,000 years ago. This has had a profound effect on the geomorphology of the sea floor and on the texture and composition of sediments found on the shelf. The shelf is shaped by the topography that was drowned as sea level rose. A wedge of sediment of varying width and thickness has accumulated during the late Cainozoic and characterizes the shape of the outer shelf and upper slope (Davies, 1979; Roy and Thom, 1991).

The inner shelf is shaped by the submarine extension of coastal headlands and rock outcrop and rock debris are common on the sea floor. Quartz sand ridges abut this outcrop in many places, and some are modified relict shorelines. Ripples and dunes in the sand and scours around rock outcrops are common on the shelf and are evidence for mobile sediment on the sea floor. This is particularly so north of Fraser Island where the quartz sands that are moving north by longshore drift form the Breaksea Spit that extends across the shelf to the shelf edge (Boyd et al., 2008).

The mid-shelf is characterized by the deposition of fine sediments that have been able to accumulate below fair-weather base, inboard from the effects of the EAC. The only significant accumulations of mud in the sand occur where the shelf is wider south of Sugarloaf Point at three locations: offshore of Newcastle, north of Sydney and Wollongong (Matthai and Birch, 2000a). North of Sugarloaf Point there is evidence that the EAC has affected sediments at all depths except in the larger embayments (Jones and Kudrass, 1982; Rule et al., 2007).

The outer shelf is generally a flat plain that is dominated by carbonate sediments, much of it relict (Marshall and Davies, 1978). Winnowing by the EAC has led to the accumulation of shelly and ferruginous gravels on the outer shelf in many places. Off Queensland significant carbonate banks have formed on the outer shelf with rhodolith gravels and carbonate hardgrounds on the sea floor.

The slope in the EMR is characterized by being relatively steep and having a relatively low rate of sediment accumulation. On the slope there are the competing processes of erosion and deposition to modify the topography inherited from plate tectonics. Canyons and scars from gravity slumping are a major feature of the NSW-Queensland slope in the EMR. They occur 50 to 100 km apart, generally off major drainage systems on land. The canyons are smaller on the Queensland section of the slope. The erosion of canyons has exposed a variety of rock types (Heggie et al., 1992; Packham et al., 2006). The canyons are also important as conduits for nutrient-rich water to reach the shelf. Nowhere are canyon heads incised into the shelf break but in 13 cases they have incised to the 150-300 m isobath. In general, the upper slope down to 1,500 m is a smooth surface of unconsolidated sediments. These sediments are the seaward face of the sediment wedge that underlies the shelf edge. Slide scars and evidence of creep are present in the

toe of this sediment wedge below 1,000 m. Most of the large canyons form from tributaries coalescing on the mid-slope where large slope failures have occurred.

From north of Brisbane to Breaksea Spit on the northern tip of Fraser Island small canyons and gullies have incised the upper slope to water depths of 150 m. Above this depth the upper slope is very steep due to outcrop of limestone platforms (Marshall et al., 1998). This is the only area where significant amounts of sediment are reaching the heads of canyons. Quartz and carbonate sand from the inner shelf are found in canyons down this slope (Boyd et al., 2008). Elsewhere the canyons are considered inactive and would have a floor draped in hemipelagic mud.

A prominent geomorphic feature of the lower slope is the major scarps, up to 2,000 m high and extending for 10s of kilometers along the base of slope where it has an abrupt contact with the abyssal plain/deep ocean floor. These scarps represent fault surfaces that were formed during breakup of the continental crust along this margin 70 to 60 million years ago. Rock and rubble are exposed on these scarps. The base of the continental slope is at 5,000 m in the south and 4,600 m in the north off Fraser Island.

At all water depths throughout the EMR the sea floor sediments are well oxygenated. This reflects the relatively low productivity in the surface waters, and hence the oxygen minimum zone in the water column between 1,000 and 2,000 m is poorly developed, and benthic communities are not affected where it impinges on the slope. Both rock and sediment form the substrate on the slope. Most rock outcrops are in water depths >1,500 m on the sides of canyons, igneous pinnacles and domes and on fault scarps. The only rocks on the upper slope are cemented hardgrounds off northern NSW, volcanic ridges off Wollongong and Port Macquarie, a seamount off Sydney and a limestone platform off Fraser Island. In general, the sediment is muddy sands and sandy muds, composed of about half carbonate and half terrigenous particles (Troedson and Davies, 2001). Scours around rock outcrops indicate that the EAC can winnow the sediment down to 1,000 m water depth. The sediment becomes more mud rich below this depth. The carbonate fraction is dominated by the calcite remains of foraminifers (sand size) and coccoliths (mud size). Minor amounts of pteropods, echinoids and sponge spicules (both silica and calcite) are also present. The terrigenous fraction is fine quartz and clay minerals. The two exceptions to this distribution of sediment texture and composition are sands on the upper slope off Queensland, where bottom sediment has been transported over the shelf edge, and off northern NSW where phosphate, glauconite and ferruginous gravels and slabs occur on the sea floor.

The abyssal sea floor of the Tasman Sea receives very little sediment today because: plankton productivity is low in the surface waters; its depth of 4,800-5,100 m leads to dissolution of carbonate particles, and little sediment is supplied from land because all except one canyon system are inactive. In the north of the basin the sea floor is shallower because there has been more sedimentation in the past, from turbidity currents generated by a greater supply of sediments to the slope. The abyssal plain extends approximately 200-250 km out from the base of slope. It was formed by deposits from turbidity currents filling the underlying volcanic topography on the oceanic crust. East of the abyssal plain are abyssal hills where the volcanic topography is draped by pelagic sediments. There are no fans or large debris aprons at the base of slope. This is unusual and probably due to bottom currents redistributing the sediments. Scours in the sediments, sediment drift deposits and moats are all evidence of strong bottom current activity along both the east and west margins of the basin and around seamounts (Jenkins, 1984). Sediments on the abyssal sea floor are slowly accumulating brown clays or calcareous muds overlying turbidite deposits. Manganese nodules occur in the abyssal hills region.

Seamounts are a major feature of the EMR. They vary in size from 2 to 50 km wide at their base and range in height from 10s of meters to ~5,000 m. They occur all over the Tasman abyssal sea floor, on the plateaus and ridges and in the Norfolk Island region. Some were formed during sea floor spreading, others were formed by the plate moving over hot spots in the mantle. The youngest discovered to date are on Lord

Howe Rise and Norfolk Island (~2 Ma). Two major seamount chains run north-south with the younger seamounts (~7 Ma) in the south and seamounts of Oligocene age (~30 Ma) in the north (McDougall and Duncan, 1988). Many reach the surface to form island and carbonate reefs, others have subsided below sea level and are capped with limestone and have a flat summit within 500 m of the sea surface. The seamounts are composed of basalt which is coated with manganese crust where it has been exposed on the sea floor for a long time. They shed carbonate and volcanic debris to the sea floor below by gravity slumping.

The Dampier Ridge and Lord Howe Rise are plateaus mostly 1,000 to 2,000 m below sea level that are blanketed in pelagic ooze consisting of foraminifers and coccoliths. They have steep sides, along some margins the scarps have over 1,000 m of relief. Slumping, gullying and small canyons occur on all slopes. Volcanic activity has formed some of the scarps on both plateaus. There is also evidence of relatively recent volcanic activity forming small seamounts on the LHR itself. Moats around seamounts on LHR suggest the presence of relatively strong bottom currents.

The Marion and Queensland Plateaus dominate the northern part of the EMR. They have a similar origin due to subsidence of continental crust attached to Australia to form marginal plateaus, followed by a period of carbonate platform construction in the Miocene (Davies and McKenzie, 1993). Reef growth on these platforms has led to carbonate platforms/atolls at the sea surface being major geomorphic features today. These atolls have very steep upper slopes where limestone is exposed. Scalloped morphology on their margins indicates mass slumping of material into the adjacent deeper water (Francis et al., in press). The platforms/atolls shed shallow water carbonate sediments to the surrounding sea floor. Many smaller platforms and pinnacles are drowned features. Limestone outcrops on the sea floor occur on both plateaus. Elsewhere, pelagic carbonate is the dominant sediment with the terrigenous mud content greater in the troughs between the plateaus and the shelf. There is strong evidence of bottom currents eroding the sediment and modifying the sea floor on the plateaus (Exon et al., 2005). Both plateaus have steep sides with small canyons and gullies leading into the adjacent basins and troughs.

East of the marginal plateaus is an area with complex geomorphology that is poorly surveyed. There is evidence for extensive volcanism in the Cato Basin area and around Mellish Reef (Exon et al., 2006a). Narrow ridges and basins characterize the area. Turbidites have formed a smooth floor in the basins whereas the ridges are rugged. Erosion and sediment movement on the ridges is confirmed by sand waves and scours. Slumping and small canyons occur on the slopes and channels have been eroded in the sediment in the troughs. Pelagic carbonate sediments drape the highs and have been redeposited into the lows. In the northeast of the EMR the presence of diatoms in the sediment from the Coral Sea Basin suggests higher surface water productivity due to the Southern Equatorial Current. In the narrow northwest section of the EMR there is a greater supply of terrigenous sediment than in other areas, as it is sourced from the rivers flowing into the Gulf of Papua.

The area around Norfolk Island in the EMR is divided in two by the N-S Norfolk Ridge. To the west the Fairway Basin floor is quite rugged compared to the smooth flat floor of the New Caledonia Basin. They are separated by a steep-sided rugged ridge with scarps of up to 1,000 m. Norfolk Ridge itself has a relatively flat top <2,000 m deep with three large areas in less than 500 m of water. Wanganella Bank at the boundary of the EMR in the south is less than 100 m water depth. East of Norfolk Ridge is a complex topography of basins, ridges and plateaus with numerous seamounts and submarine escarpments. At least four large seamounts come to within 1,000 m of the sea surface (DiCaprio et al., in press). Rock outcrop is abundant in this region. Sediments in the area are pelagic carbonates with a minor contribution from radiolarians, diatoms and volcanic ash. There is some evidence of bottom currents affecting the sediments on the tops of seamounts and ridges."

"New consistent quantitative data for the EMR have revealed regional scale patterns in sediment distribution not apparent in previous studies and forms a framework within which local scale patterns can be understood in a regional context. New data reveals some of the seabed complexity. At a regional scale our data show that the seabed sediments generally become finer with increasing water depth. Variation in sediment texture and composition generally decreases with increasing water depth, with sediments on the rise and abyssal plain/deep ocean floor being relatively homogeneous compared to those on the shelf and adjacent slope.

The shelf is predominantly composed of sand and the abyssal plain/deep ocean floor composed of mud. This trend is reported in reports by Geoscience Australia for other areas of the Australian margin (Potter et al, in press). Areas of gravel are localized and occur mainly on the inner, mid and outer shelf/slope, and are generally absent from the abyssal plain/deep ocean floor. Calcium carbonate concentrations are highest on the shelf and upper slope, and lowest on the lower slope rise and abyssal plain/deep ocean floor. Calcium carbonate content increases adjacent to the Great Barrier Reef Marine Park where calcium production is high.

At a regional scale our results agree with previous sedimentological work on the shelf, slope and abyssal plain/deep ocean floor. Our data indicate distinct variations in the sediment characteristics for the shelf, slope and abyssal plain/deep ocean floor. Our data also provides an analysis of the sediment texture of the rise within the EMR.

Our data indicate distinct variations in sediment characteristics along the inner and outer shelf, and mid to upper slope, due to high current and wave energy. These sediment characteristics were reported at local scales by (Gordon and Hoffman, 1986; Short and Trenaman, 1992; Roy et al., 1994a; Middleton et al., 1997). New data have allowed us to more accurately map the extent and recognize the regional significance of these sedimentary characteristics.

High resolution data for the seabed in the EEZ indicate that geomorphic features are characterized by a combination of several environments with zones of transition between the features. For some geomorphic features, the new data allow us to more accurately predict and distinguish between the range of environments present and, where data are adequate, estimate the relative proportions of these. Distinct sedimentary environments occurred in some geomorphic features and these include abyssal plain/deep ocean floor, basin, shallow and deep water terrace, slope, plateau, and trench/trough.

Shelf

Seabed sediments of the shelf are sand dominated, with a large carbonate component with >50% of samples containing between 50 and 100%. Bulk carbonate content increases with sand content and sand content decreases with water depth. Our data indicate that localized deposits of mud occur in the vicinity of Newcastle. This pattern corresponds to the high mud content found off the Hunter River as observed by Matthai and Birch (2000a). Our data also detected additional comparable areas of gravel (~40-80%) present locally offshore of Stradbroke Island, within Hervey Bay, north of Brisbane and offshore of Wollongong. Our results are consistent with Marshall and Davies (1978) description of the carbonate dominated outer shelf sediments. Associations between our sediment data and previous facies models for some areas of the inner shelf are difficult to resolve due to local areas of sparse data. Our data show that the regional trend for the shelf appears to be dominated by carbonate sand with localized accumulations of gravel and mud as seen by Marshall and Davies (1978).

Slope

At a regional scale, sediments of the inner slope mostly comprise sand, while seabed sediments of the outer slope are dominated by mud. Further, mud content increases with water depth on the abyssal

plain/deep ocean floor and rise. Sediment data for this province are relatively scarce, however the available data provide significantly higher coverage for this area than was previously available. Carbonate content increases with sand content with localized concentrations of bulk carbonate ranging between 40 and 100% offshore outside Hervey Bay, Stradbroke Island and to the south of Wollongong. Gravel content is generally low, however localized aggregations occur in large quantities offshore Hervey Bay, Mackay and to the south of Cairns. Smaller localized concentrations of gravel occur offshore Coffs Harbour, Byron Bay and to the north of Brisbane. Mud content on the upper slope is low, however localized clusters occur offshore Wollongong, Newcastle, Port Macquarie and north of Coffs Harbour.

Our results reveal that at a regional scale the greatest variety of sediments occur in areas containing several geomorphic features and between bioregions (i.e., features adjacent to seamounts with higher gravel amounts although there were low sample numbers taken from seamounts). This is particularly evident where features with a distinct sedimentology are interspersed with other features with a distinct sedimentology (i.e., gravel dominated pinnacles located within the homogenous, sand dominated shelf).

Addition of data in geomorphic features occurring on the shelf and inner slope have resulted in the first quantitative analysis of the sedimentology of features occurring at these water depths in the EMR, including trenches, plateaus and terraces. Sediment data show that some features in this zone are characterized by a distinct sedimentology that differentiates each feature from one another. These features include plateaus, terraces, trench/troughs, shelf and slope.

Our data provide further evidence for extensive carbonate deposits on the outer shelf with localized deposits of rhodolith gravels on the sea floor (Marshall and Davies, 1978). The outer slope contains a higher proportion of mud (20-90%) than found on the adjacent shelf.

Abyssal Plain/Deep Ocean Floor

Sediment samples procured for this task from the abyssal plain/deep ocean floor have significantly increased the sample coverage and understanding of the sediment properties. The abyssal plain/deep ocean floor is a relatively homogenous sedimentary environment dominated by calcareous mud containing foraminifers and coccoliths with small inclusions of sand and gravel. Our data concurs with the findings of Jenkins (1984) who described the sedimentology of the abyssal plain/deep ocean floor as brown clays or calcareous muds. The bulk carbonate content of sediments in deep water areas of the EMR provides further evidence that content range between 5 and 55% (Eade & van der Linden, 1970).” (Jock Keene, 2008)

5. Potential Geohazards & Recommendations to Minimize Risk

There are several geohazards along the System route that will require careful avoidance once the cable route survey results are compiled. The transition of the cable up and down the Peru-Chile Trench will require careful placement and slack management to account for slopes and sediment movement. Traversal over the plate boundaries between the Nazca, Pacific and Australian plates as well as the troughs, basins and plateaus north of New Zealand have cable armoring, slack and slope placement considerations that need to be accounted for prior to survey to find a suitable route. Identification of potential hot spots near known locations of that sort, like the East Pacific Rise, using deep-water towed or autonomous bathymetric and geophysical survey assets would help mitigate identification and placement mitigation CRE techniques.

5.1. Seismicity

The entire System lies within a highly seismic area of the world. The following figure shows magnitude 6.0 and greater recorded earthquakes. Movement of the cable due to seabed uplift, sediment mass movement or damage due to tsunami forces are the primary risks to the System. There is no clear way to estimate the probability of the frequency, magnitude, or location of seismic events across the entire System.

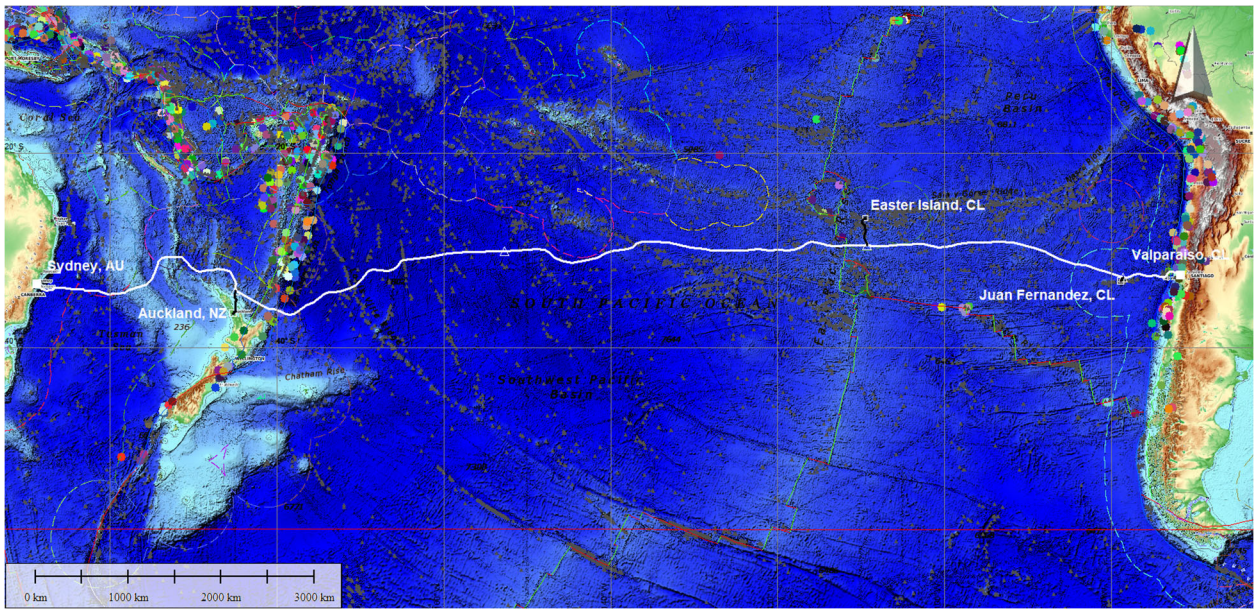


Figure 42 - Magnitude 6.0 and Greater Seismic Events

5.2. Tsunamis

Tsunamis can occur at any of the five (5) landings of this System. Valparaiso, Juan Fernandez and Easter Island are the most exposed to higher energy tsunamis, but the right conditions could pose a risk to Auckland and Sydney.

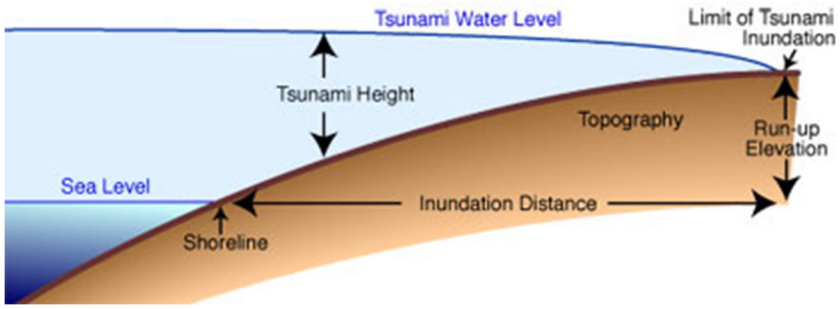


Figure 43 - Tsunami diagram

Tsunamis are long-wavelength, long-period sea waves produced by the sudden or abrupt movement of large volumes of water—including when an earthquake occurs at sea. In the open ocean the distance between wave crests can surpass 100 kilometers (62 mi), and the wave periods can vary from five minutes to one hour. Such tsunamis travel 600–800 kilometers per hour (373–497 miles per hour), depending on water depth. Large waves produced by an earthquake or a submarine landslide can overrun nearby coastal areas in a matter of minutes. Tsunamis can also travel thousands of kilometers across open ocean and wreak destruction on far shores hours after the earthquake that generated them. - *https://en.wikipedia.org*

Figure 44 - Tsunami warning buoy

The subsea risk to submarine cables is through sediment movement and/or seabed structure movement.

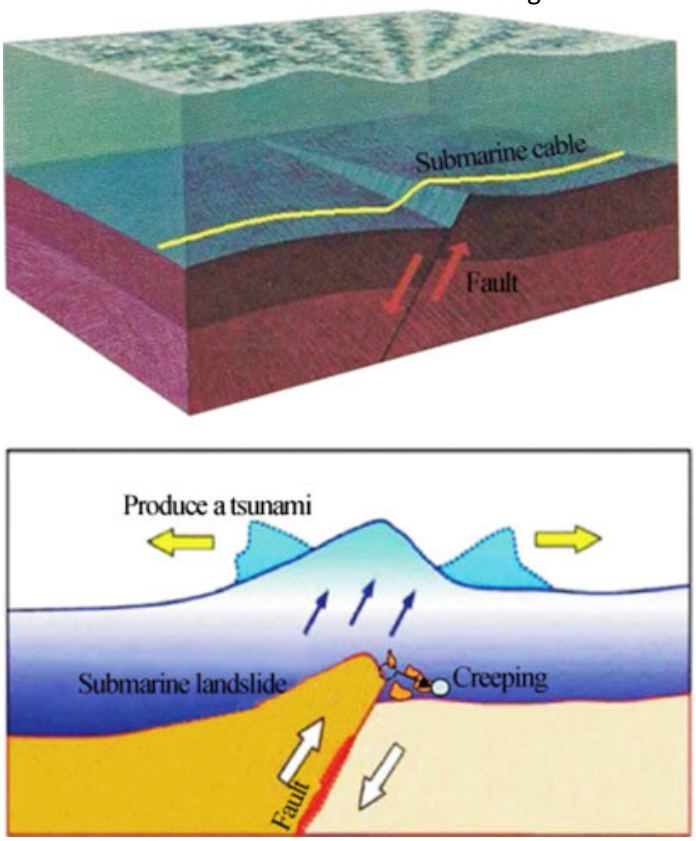


Figure 45 - Subsea Fault

In the case of a subsea fault, the seabed will change elevation, causing the tsunami but also effecting the span of cable over the fault, potentially resulting in cable spans or even breaks under tension.

5.3. Volcanic Activity

Volcanic activity is possible, but not probable, for any of the System's landings. The highest likelihood of a volcanic event would be on the seafloor near current seamount chains and plate boundaries, which are crossed by the System at the East Pacific Rise, Louisville Ridge and east of Auckland at the Pacific-Australia plate boundary. The RPL has been designed to minimize the amount of cable exposed to potential volcanic activity; however, it could occur at almost any location along this System, on the seabed or the landings of Auckland, Easter Island and Juan Fernández.

5.4. Gas Seeps & Gas Hydrates

There will likely be localized gas seeps along the route in deep water near plate boundaries and seamount chains, which will be nearly impossible to validate using conventional survey techniques for deep water cable route survey, which is multibeam-only. If located within the regimen of the side-scan sonar coverage, typically less than 1000 meters water depth, they should be visible to the sonar and look similar to Figure 46.

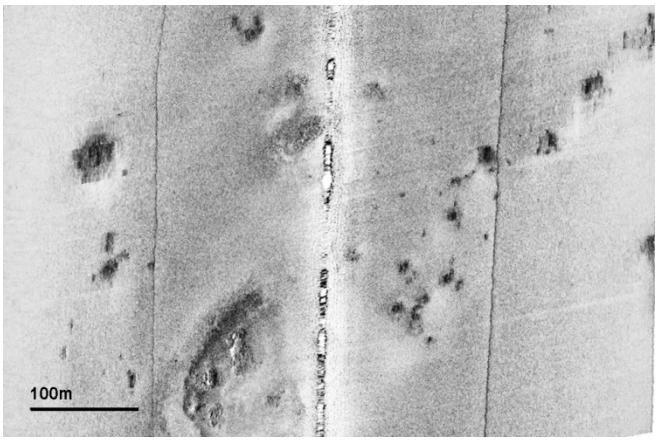


Figure 46 - Mud Volcanoes and Pock Marks (Courtesy EdgeTech)

5.5. Sediment Mobility/Sedimentary Bedforms

Seen mostly on the continental shelf, sedimentary bedforms are mobile features created by entrainment and movement of sediment grains, under a bottom current regime. Their morphology is directly related to bottom current speed and direction. Sediment grains will become entrained (suspended) if their critical bottom shear stress is exceeded. There are several types, but only sand waves and deep-water mudwaves are likely to affect a submarine cable.

Sandwaves and megaripples can occur even in relatively low current regimes, where there is a dominant current direction and adequate sediment supply to feed the sediment transport path. Sandwave/megaripple crests are always aligned at 90° to the dominant current direction. Sandwaves are >1m in height, whereas megaripples are <1m and tend to have a shorter wavelength. Typically, mobile sandwaves have an asymmetrical shape, while relict dormant ones have become smoothed over time. The steeper slope is on the lee side of the wave, which is the down-current side. Other large bedforms are relict sand banks, which are related to previous sea-level lowstands.

Sand/gravel ribbons and patches tend to form in higher current regimes, with poorer sediment supply. They form parallel to the dominant current regime and are generally only 5-10cm thick, with a transverse width of ~1-10km.

Mudwaves are deep-water features that usually form at the base of the continental slope. They are typically large features and, although they indicate a predominant bottom current regime perpendicular to their crests, their size and slope angles do not constitute a threat to a cable or burial operation. It should be noted that they can form in areas prone to turbidity currents, however, and so the overall geomorphology should be assessed. If for, example, they sit at the base of a submarine canyon, they would be an indicator of active sediment failures.

The geomorphology of sedimentary bedforms is useful to the cable engineer because it allows an interpretation of the dominant current direction. The risk to a cable is twofold. Sedimentary bedforms can cause issues for cable installation operations, due to steep slopes. In addition, sediment mobility after installation can lead to the cable becoming unburied. Only sandwaves cause installation concerns: the larger features can have steep slopes and loose, easily fluidized sediment, and plow loss has occurred on steep sandwave slopes. Plow slope limits should not be exceeded, particularly in deep water where plow control is reduced. Deep water mudwaves do not pose a threat either to burial operations or to the laid cable, but a strong bottom current may affect the former.

To minimize risks, the cable should be routed perpendicular to the sandwave crest alignment, so the plow does not experience any steep sideslopes. This also ensures that any sandwave movement is directly along the cable, so cable is not pulled sideways by sediment movement. The cable should be up armored to cross sandwaves in case there is post-installation exposure.

The marine survey will accurately delineate sedimentary bedforms, allowing an informed cable to lay and burial solution.

5.6. Sediment Mass Movements

Sediment mass movement is the process by which marine soils are moved from shallow to deep water. There are several types, forming part of a continuum. In general, they are caused by a buildup of sediment, followed by a triggering event that leads to failure and mobilization of the unconsolidated material, which subsequently flows downslope.

Slumps, slides, rock falls, gravity/debris flows, and turbidity currents are all types of catastrophic mass movements, whereas creep occurs on a slower time frame. All of them have the potential to damage a marine cable. The trigger for failure can be a shock, such as an earthquake, unequal loading under a rapid depositional environment (differential consolidation), fluid flow through the sediment matrix (or diaparism), wave-induced bottom pressure anomalies, or simply by gravitational forces acting on seabed relief-structures. Cable burial equipment can also cause slope failures in very unconsolidated sediments on steeper slopes. Basically, all events lead to a localized increase in pore pressure, which effectively liquefies the sediment grains, leading to a loss of structural integrity in the soil matrix. With no coherency, the sediment grains flow down the gravity gradient.

Slope failure typically occurs on steeper seabed slopes, but under certain conditions seafloor instability occurs in slopes as low as 1°. In comparison to terrestrial landslides, marine slides have much larger volume and distance of motion—this is because the sediment grains become entrained in water, which has lower frictional resistance. Slope instability is possible in many marine environments, including submarine canyons, deltaic fans off the mouths of large river systems, on the slopes of oceanic volcanic islands, atolls, seamounts or abyssal hills, on localized areas of steep seabed topography such as basins or trenches, or on the open continental slope.

The different types of mass movement are on a continuum related to the time or distance elapsed since the initial failure event, and the volume of sediment that fails. Figure 47 - Continuum of Mass Movements (Poulos, 1988)

summarizes the continuum and different types.

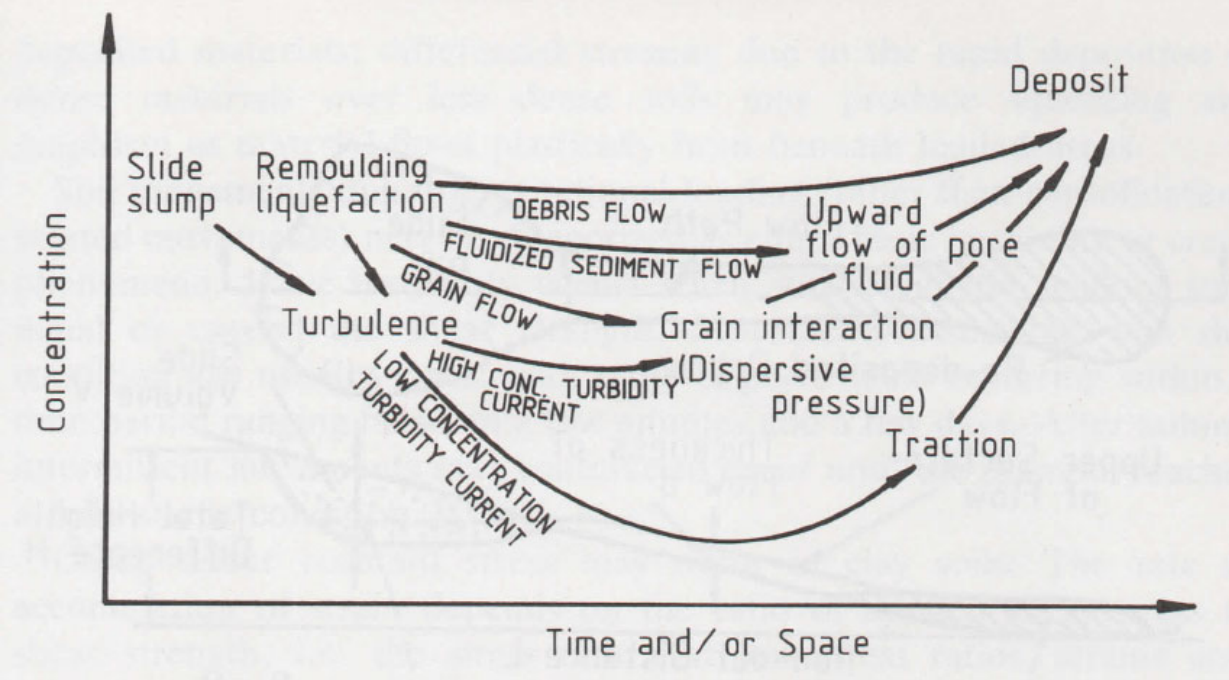


Figure 47 - Continuum of Mass Movements (Poulos, 1988)

The different types of mass movement can be summarized as follows (see also Figure 48 - Types of Mass Movement (Hydro-landslides for Students, 2017)

- *Slope Failures*—sudden failure resulting in transport of debris down slope
    - Slumps—a slide where a block of seabed rotates downward along an arced surface. It leaves a slump scar/scarp.
    - Rock or Debris Falls or Slides—pieces of distinct, coherent material become dislodged and fall/roll or slide down slope. A talus deposit results at the base of the slope.
- *Sediment Flows*—material flows down the gravity gradient, in the form of liquefied grains entrained in water
    - Granular/Debris Flows—have a low water content, but the grains are still liquefied and have little/no frictional resistance.
    - Slurry Flows—have a higher water content, sediment grains are in suspension, which grade into turbidity currents at their upper water content.
    - Turbidity Currents—high water content and fine-grained entrained sediment, flow like an underwater, turbulent cloud.
- *Creep*—a very slow, continuous movement of material down slope. Often results in notable 'steps' aligned parallel or sub-parallel to seabed contours.

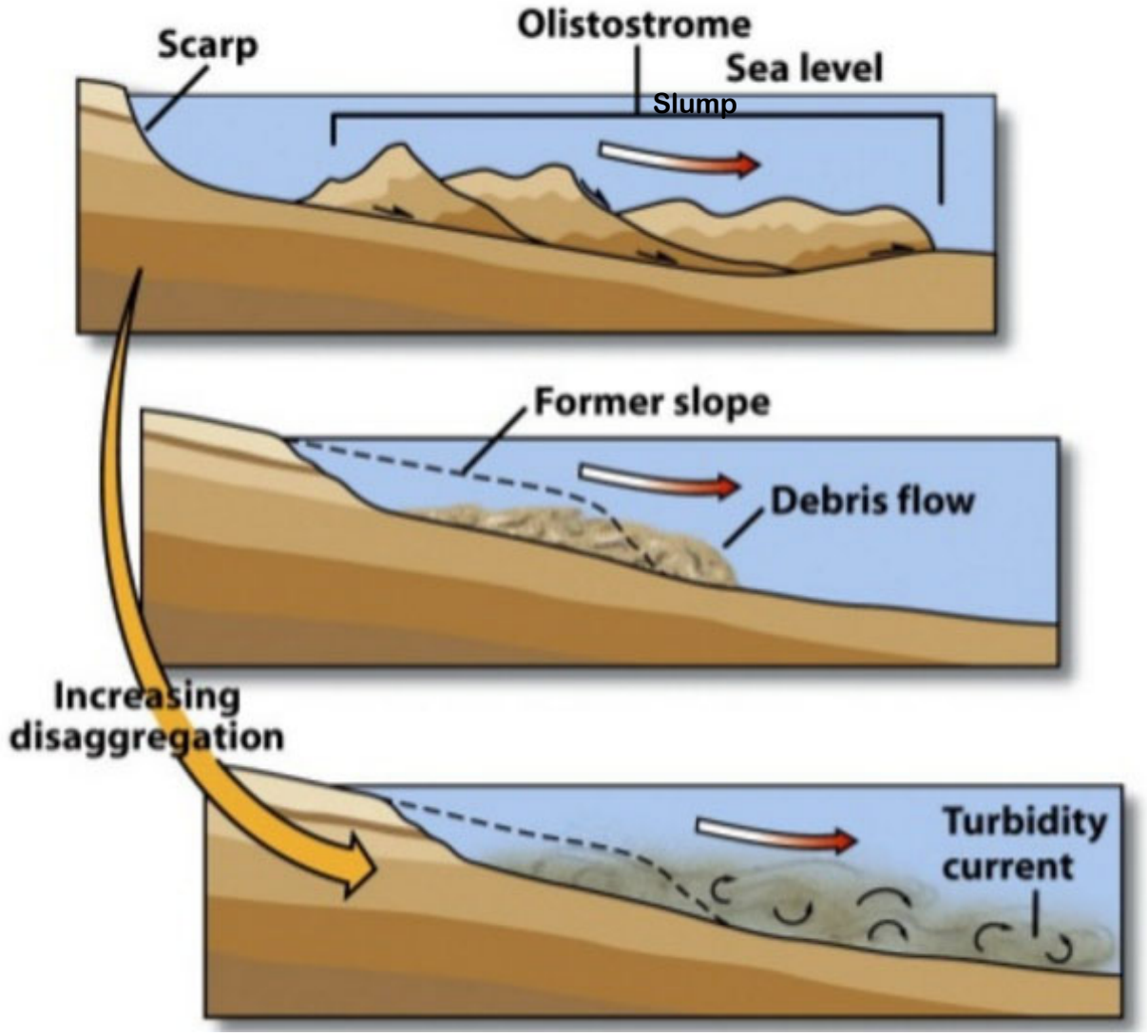


Figure 48 - Types of Mass Movement (Hydro-landslides for Students, 2017)

It is not easy to predict this risk, but side scan sonar and sub-bottom profile imagery can identify areas of sediment creep or historical slide/slump areas. Very steep slope areas with very soft clay sediments are also prone to slippage when plowed, so these should be identified during the survey. Route and cable engineering, along with a realistic burial plan should minimize the risks associate with this hazard.

Mass movements often occur in submarine canyons, with the failure typically starting as a slump/slide at the head of the feature, and ultimately ending as a turbidity current in deep water at the base. Routing cables down canyons is not advisable. If they must be crossed, it is best to cross them at 90° in deep water, at the distal end of the feature. At this point, the mass movement would be a slower speed turbidity current, in the process of depositing out. Turbidity currents in this final phase consist of very fine sediment grains (clay/silt) in suspension, moving at a slower rate on low seabed slopes.

5.7. Seabed Scours

Seabed scour is erosion that occurs when a strong bottom current entrains sediment grains and moves them out of the area. Without deposition of new sediment, the upper seabed level will be lowered over time. Sheet scour occurs on relatively flat seabed under a high current regime, where large expanses of seabed sediment can be mobilized. Locally, scours can occur around spot features, due to eddy currents, and several features can coalesce to form large, complex depressions. Most scour occurs in shallow water, for example at shore-ends in surf zones or over reefs/rock outcrop.

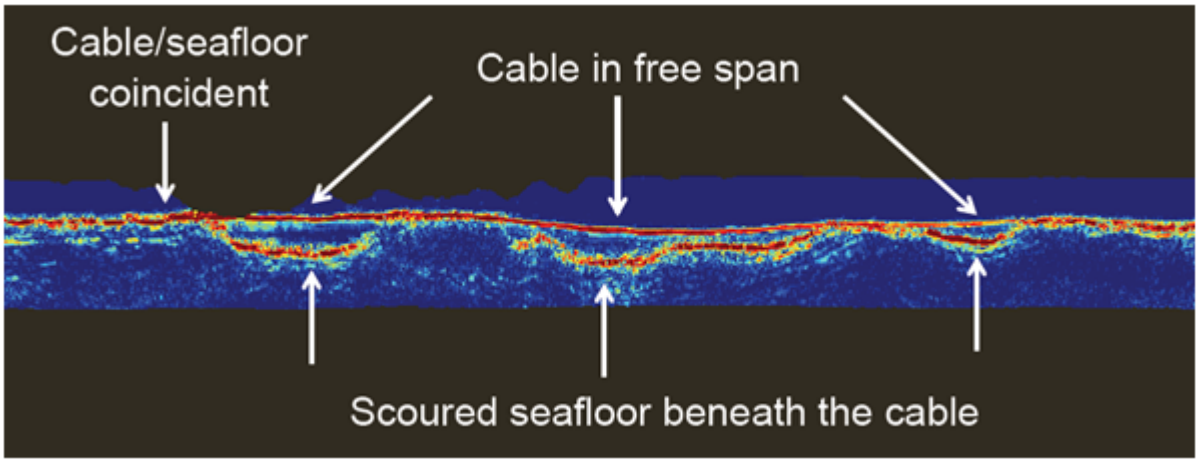


Figure 49 - Sonar Image of Scours and Cable Spans (Courtesy of Pangeo Subsea)

Where the risk of active scouring is identified, the cable will be at risk of being moved on the seabed. If the system crosses rock outcrop in this area, abrasion and chafe will occur over time, potentially leading to shunt faults. Remedial protection, such as articulated pipe and pinning should be considered.

5.8. Rock Outcrop

Rock outcrop is a problem because it precludes cable burial. Although the cable can be routed to avoid smaller, isolated rock outcrops, more extensive areas of rock will need to be crossed with surface lay. The risks associated with crossing rock outcrop depend on the rock lithology and topography, because rugged, hard rock is more likely to lead to cable suspension and chafe, especially if bottom currents exist.

Rock lithology in the study area is typically igneous, with some metamorphic and a few regions of sedimentary rock. Igneous and metamorphic rock outcrops are hard and tend to be more rugged, with a higher likelihood of chafe. They are also harder to cut, which will affect directional drilling and shore end operations.

Rock outcrop should be avoided wherever possible, with route engineering and Route Development during the marine survey. Ideally, the survey would locate a plowable route through isolated rocky areas. Where unavoidable rock exists in the offshore area, it presents an abrasion risk to the cable, especially when there is considerable topography associated with the outcrop, and where strong bottom currents occur. In this worst-case scenario, the cable will have unavoidable suspensions, and bottom currents can lead to strumming, cheese-wiring and cable abrasion/shunt faults. The cable should be up armored to cross areas of unavoidable rock outcrop. Pinning of cable across shallow water rock outcrop areas should be considered, to avoid strumming and cable abrasion (e.g., in shore ends or nearshore areas).

5.9. Rock Subcrop, Hardground & Very Dense/Very Stiff Sediment

Rock subcrop is rock that sits within the planned burial depth. Standard burial equipment will not bury into rock, so subcrop will limit the burial depth to the cover of overburden. Other substrates that limit burial depth with standard equipment are dense to very dense sand, and hardground (very stiff to hard clay or very dense to cemented sand). Denser sands pose problems for plows because they generate high tow tensions and result in share rideouts. Based on the potential for rock outcrop to occur on most System segments, rock subcrop is also expected. Areas of reduced burial are highly probable.

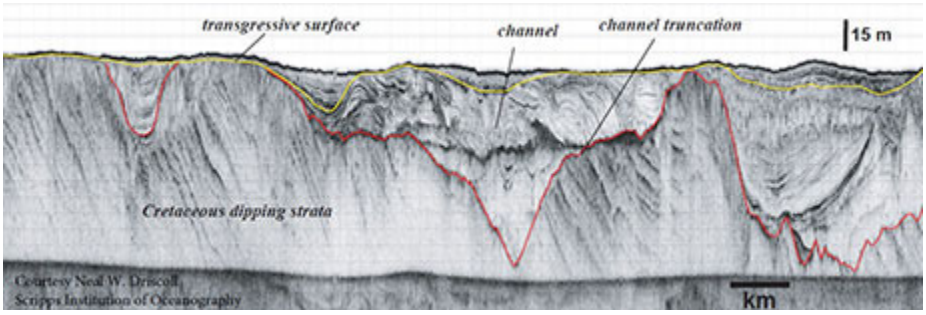


Figure 50 - Channels and Subcropping Horizons (Courtesy EdgeTech)

The marine survey will identify areas of rock subcrop and harder/denser sediment. Numerous sub-bottom profile lines are run in shallow water, sometimes allowing the cable to be routed into areas of thicker, loose sediment cover. Cone Penetrometer Tests (CPTs) are a vital component of the survey in areas of subcrop or dense/stiff sediment because they accurately delineate the density of sands and shear strength of clay units. The Burial Assessment will predict the achievable burial depth, based on this data set. If poor burial is likely, the cable should be up armored for long-term security.

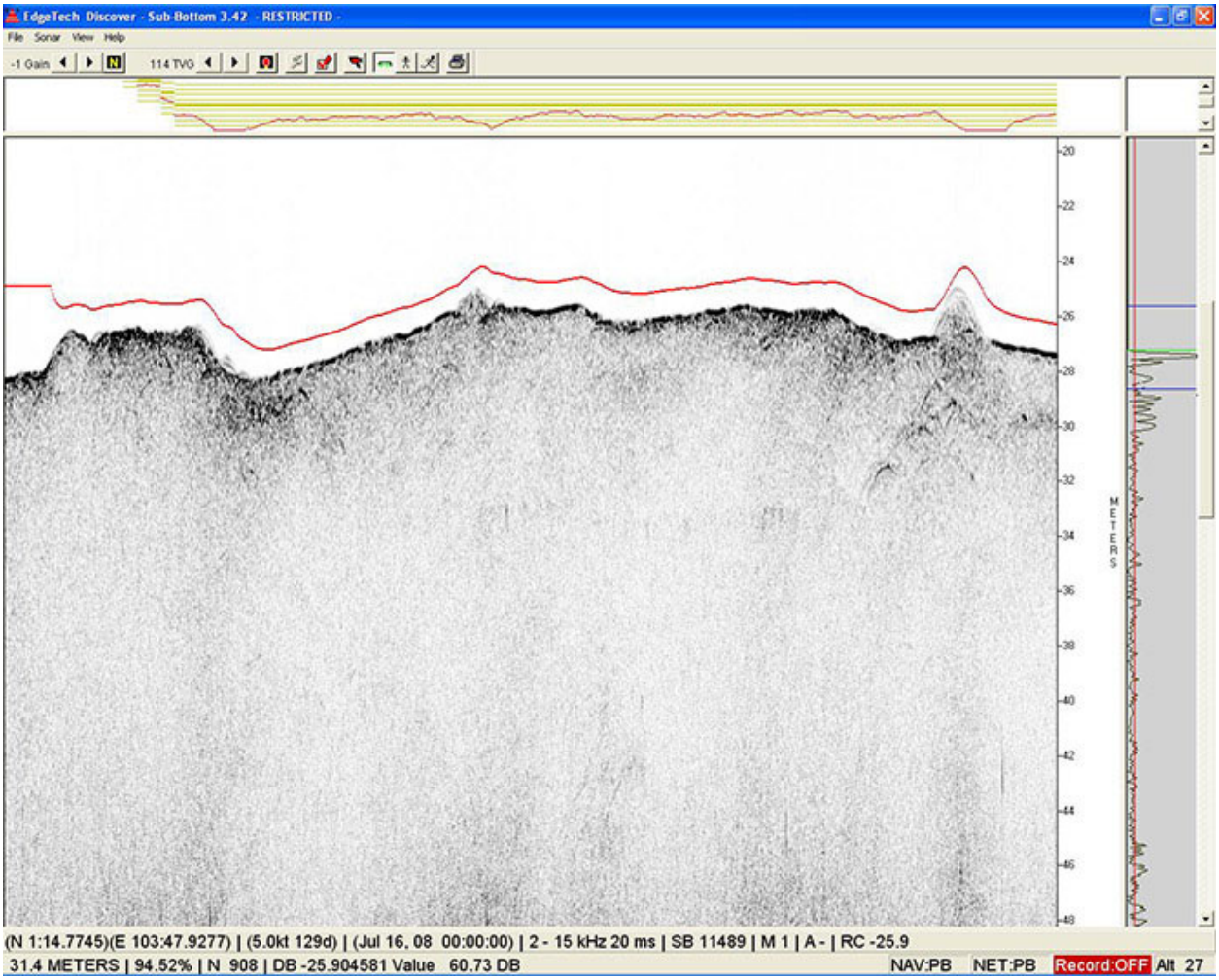


Figure 51 - Subcropping (Courtesy EdgeTech)

Given the likelihood of dense/hard seabed, consideration should be given to specification of a Heavy Duty (HD) plow for the System installation. An HD plow typically requires a cable vessel with high bollard pull.

5.10. Very Soft Clay

Very soft clay poses a risk for the cable installation, due to low seabed bearing capacity. Plow/ROV sinkage will occur in seabeds <5kPa shear strength, which can lead to uncontrolled cable overburial. Sinkage of burial equipment becomes riskier with increasing seabed slopes, and for plow operations, with increasing water depth. The combination of steep slopes, very soft seabed and deep water reduces the control of underwater burial equipment, particularly towed vehicles. Plows can roll, especially if there is a sideslope component, leading to cable and vehicle damage.

Areas of very soft clay typically occur in deeper water, usually on the continental slope. The marine survey will delineate slopes and shear strengths, and the Burial Assessment should predict any installation issue that might occur in such conditions.

If steep, soft seabed is to be plowed, an upslope installation direction would offer more control, thereby minimizing the risk of loss of control and cable/vehicle damage.

5.11. Steep Slopes

Up-, down- and side-slopes pose a risk to both surface laid and buried cable. For buried areas, there are slope limits for plow and ROV operations. These are typically 12° downslopes, 14° upslopes and 6° sideslopes. These limits should not be exceeded, especially in deeper water and soft seabed, with a down slope plow direction.

For surface laid areas, steep slopes tend to lead to cable suspensions, which increases the chance of chafe faults over time, especially in areas of rock outcrop.

Steep slopes should be avoided wherever possible, with route engineering and Route Development during the marine survey. Ideally, the survey would locate a plowable route through slopes, adhering to the plow limits, to avoid rolling the plow and causing cable damage. Where steep up- or down-slopes are unavoidable, they should be crossed with a routing angle as close to 90° as possible, to place the shortest section of cable at risk from mass sediment movements, or suspensions. Adequate slack should be planned in both buried and surface laid cable areas, and installation slack management should be carefully monitored and implemented.

As with steep up- or down slopes, steep sideslopes should be avoided by re-routing or Route Development during the survey stage. Where they are not avoidable, the length of cable crossing sideslopes should be minimized. In buried areas, plow limits for sideslopes should be adhered to, to avoid rolling the plow and causing cable damage.

5.12. Sonar Contacts

Sonar contacts are identified during the marine survey, from side scan sonar interpretation. The most common sonar contact will probably be boulders, but other features such as wrecks or debris, will also be located.

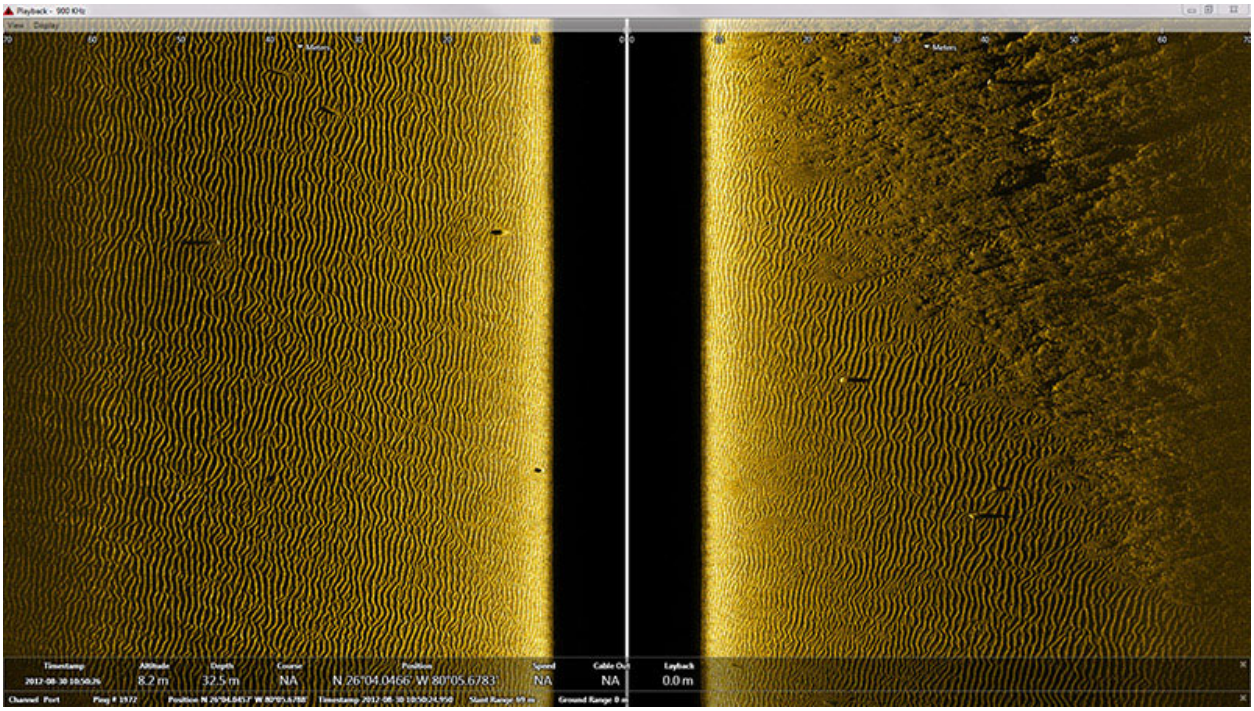


Figure 52 - Sonar Contacts (Courtesy EdgeTech)

Boulders are expected to occur in the shallower water sections of the route, which will affect burial operations. These are a relict feature from historical glacial processes. If they are very large and very dense, or occur in large boulder fields, it might not be possible to avoid them, and areas of surface lay might be required.

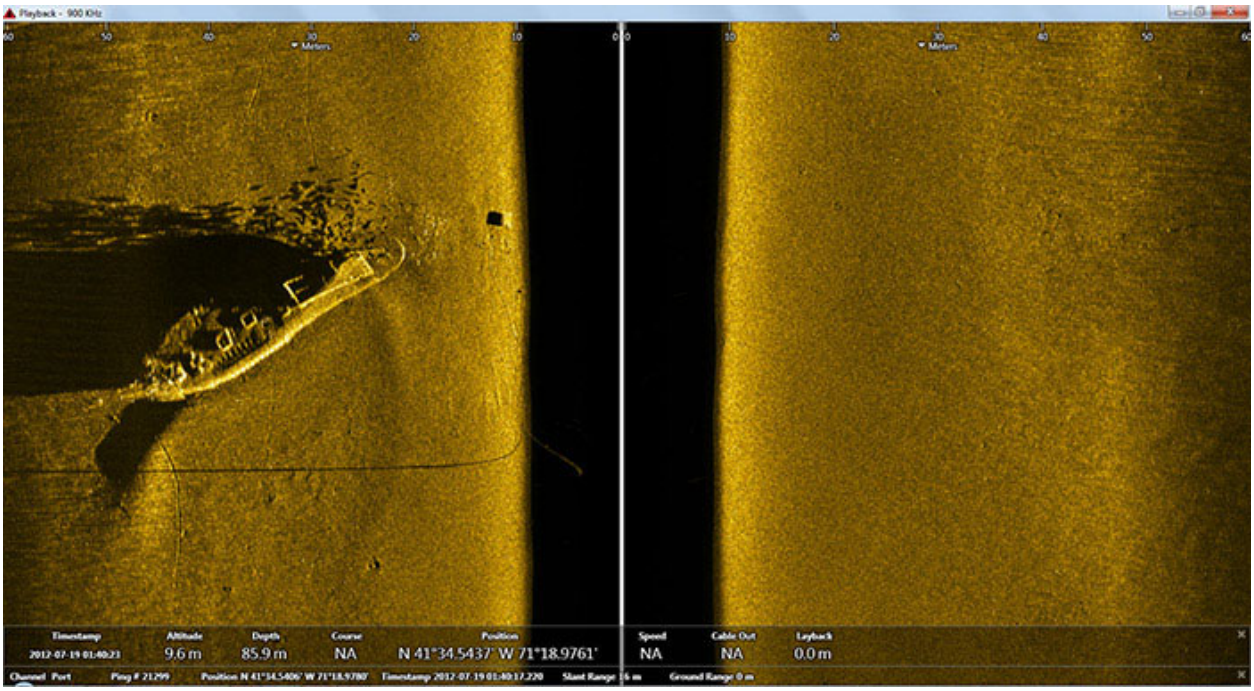


Figure 53 - Wreck (Courtesy EdgeTech)

The marine survey should be specified to identify sonar contacts >0.5m high. Most modern side scan sonar systems can resolve objects much smaller than this, but the interpretation should focus on marking individual objects on the charts. Many sonar contacts can be avoided with route engineering, allowing a plowed solution. However, boulder fields might well occur along the System route, which could preclude burial. The Installer and Client Representatives onboard the marine survey vessel should be tasked with ensuring that sufficient route development is carried out to optimize routing and burial.

6. Route Seafloor Conditions, Sediment Types & Burial Conditions

Most of the route is in deep water with hundreds of meters of sediment suitable to submarine cable. The landings at Valparaiso, Juan Fernández, Easter Island, Auckland, and Sydney will all have nearshore sediment cover challenges to some degree. Auckland and Sydney may or may not require full burial, depending on the risk profile to be assumed since those landings have their own submarine cable protection zones and well-established cable awareness initiatives. The remote nature of Juan Fernández and Easter Island and the newness of their islands, relative to geological history, means sediment cover will be limited. Offshore Valparaiso, there is enough alluvial sediment transport to both fill the Peru-Chile Trench submarine canyons and its base but nearshore coastal processes, storm events and resulting currents may produce areas of seabed with sparse or no sediment cover. Please refer to Figure 2 for the general locations of the features and hazards identified below.

6.1. Things We Know or Suspect About Route Conditions

- There are risks related to cable movement due to storm events, currents and tsunamis nearshore.
- Crossing plate boundaries, like the hotspots and hydrothermal vents along the East Pacific Rise, require high resolution mapping to avoid them.
- The trenches offshore Peru, Australia and Sydney will require proper placement.
- Lord Howe Rise contains hazardous features that will require particular route engineering post-survey.

6.2. Things We Don't Know About Route Conditions & Survey Recommendations

- Specific seabed slopes that will allow a prediction of how where burial is possible. These will be identified by the marine survey. 1m contours are recommended in all areas planned for burial.
- Specific areas of rock outcrop that will allow a prediction of where burial is not possible. This will be delineated by the marine survey, but not that some route development might be required.
- Specific areas of subcrop or hardground that will lead to reduced burial. CPTs are recommended in areas planned for burial.
- Submarine canyons should be identified, and an attempt made during the survey to ascertain whether they are actively acting as sediment conduits today (recent mass movements). The spurs and backbone cables should be route to avoid running in active canyons and cross them in deep water if they are active.
- Gas release features, such as pockmarks and chimneys might occur, particularly in and around seamounts and plate boundaries. The survey should carefully note such features, with an aim to avoiding them if possible. Cores should note hydrogen sulfide/methane odor.
- Sediment bedforms are likely to occur in places. These should be analyzed for active sediment transport. Sandwaves should be crossed at 90°.

6.3. Summary of Impacts on the Submarine Cable by Route Seafloor Conditions

While there are many risks located on the seafloor for this System, proper survey and cable route engineering practices will mitigate the impact.

7. Physical Environment

The physical environment presents the single largest challenge to the installation and maintenance of the proposed cable system. Extremely high winds and sea states present hazards across all elements of the survey, installation, and maintenance programs. While prevalent for much of the route length, industry standard risk mitigation techniques for these conditions, if applied correctly, can reduce the overall risk to the cable system.

The physical environment for the System is generally homogeneous considering it spans between South America and Australia. The reason being it is generally situated along a common latitude, 30 degrees South. That said, there are specific meteorological and oceanographic situations for each landing due to their geographic diversity. There are strong nearshore and offshore winds, waves, and currents that effect Valparaiso, Juan Fernández and Easter Island, mostly in the winter months. Auckland experiences a much less pronounced wind and wave effect due to its sheltered location and shallow water.

7.1. Meteorology

7.1.1. L1 – Valparaiso, CL

“Under the Köppen Climate Classification climate classification, "dry-summer subtropical" climates are often referred to as "Mediterranean". This climate zone has an average temperature above 10°C (50°F) in their warmest months, and an average in the coldest between 18 to -3°C (64 to 27°F). Summers tend to be dry with less than one-third that of the wettest winter month, and with less than 30mm (1.18 in) of precipitation in a summer month. Many of the regions with Mediterranean climates have relatively mild winters and very warm summers.

The Köppen Climate Classification subtype for this climate is "Csb". (Mediterranean Climate).

The average temperature for the year in Valparaiso is 58.0°F (14.4°C). The warmest month, on average, is January with an average temperature of 64.0°F (17.8°C). The coolest month on average is July, with an average temperature of 53.0°F (11.7°C).

The highest recorded temperature in Valparaiso is 94.0°F (34.4°C), which was recorded in February. The lowest recorded temperature in Valparaiso is 32.0°F (0°C), which was recorded in June.

The average amount of precipitation for the year in Valparaiso is 19.9" (505.5 mm). The month with the most precipitation on average is June with 5.9" (149.9 mm) of precipitation. The month with the least precipitation on average is January with an average of 0.1" (2.5 mm). In terms of liquid precipitation, there are an average of 38.8 days of rain, with the most rain occurring in June with 10.1 days of rain, and the least rain occurring in February with 0.7 days of rain.” (Weatherbase, 2020)

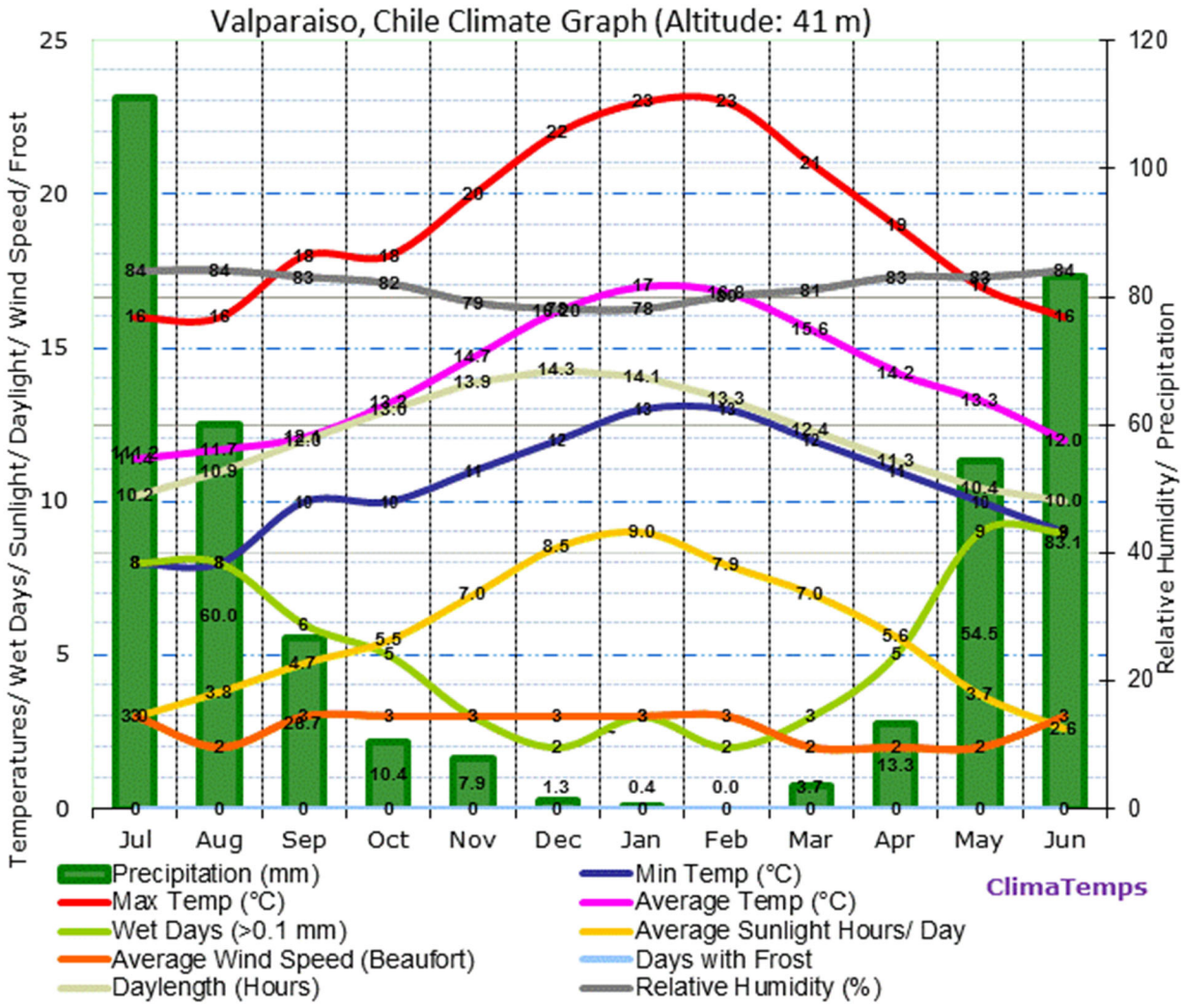


Figure 54 - Valparaiso Climate Graph

7.1.2. L2 - Juan Fernández, CL

"The islands have a subtropical Mediterranean climate, moderated by the cold Humboldt Current, which flows northward to the east of the islands, and the southeast trade winds. Temperatures range from 10 °C (50 °F) to 22 °C (72 °F), with an annual mean of 15.4 °C (60 °F). Higher elevations are generally cooler, with occasional frosts on Robinson Crusoe.

Average annual precipitation is 1,081 mm (42.6 in), varying from 318 mm (12.5 in) to 1,698 mm (66.9 in) year to year. Much of the variability in rainfall depends on the El Niño-Southern Oscillation. Rainfall is higher in the winter months and varies with elevation and exposure; elevations above 500 m (1,640 ft) experience almost daily rainfall, while the western, leeward side of Robinson Crusoe and Santa Clara are quite dry." (Wikimedia Foundation, 2020)

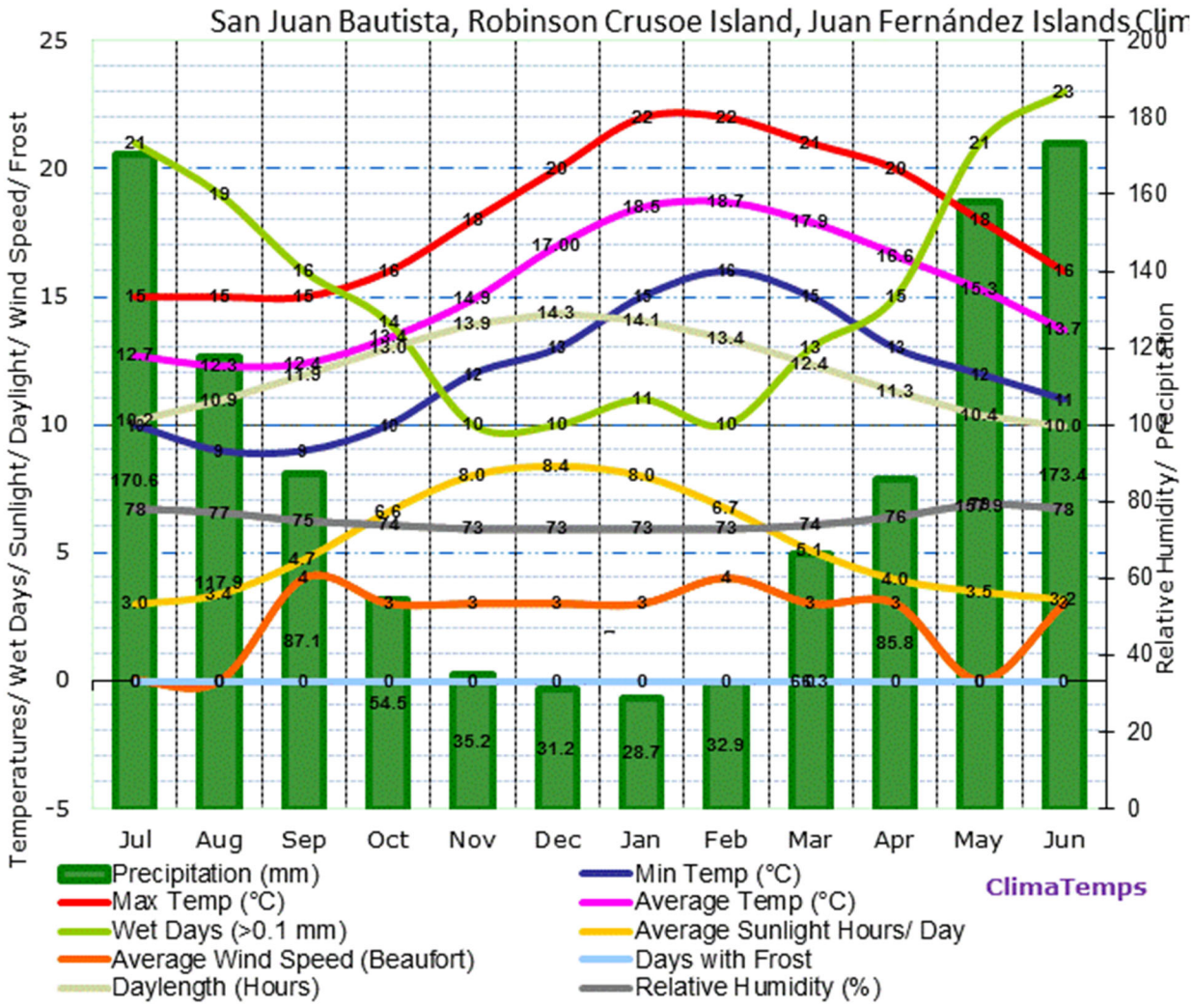


Figure 55 - Juan Fernandez Climate Graph

https://en.wikipedia.org/wiki/Juan_Fern%C3%A1ndez_Islands

7.1.3. L3 – Easter Island, CL

"The climate is subtropical: i.e., sunny and dry. The warmest months are January through March, when the average temperature is 73 °F (23 °C), and the coolest months are June through August, when the average temperature is 64 °F (18 °C). Average annual precipitation is about 49 inches (1,250 millimeters) but with considerable annual variation. September is the driest month, and the heaviest rainfall occurs in June and July in accordance with the passage of austral winter fronts. Winds in June and August are irregular; during the rest of the year trade winds from the east and southeast are dominant. From September through March the Peru (or Humboldt) Current, which has an average temperature of about 70 °F (21 °C), flows against the island." (Encyclopedia Britannica, inc., 2020)

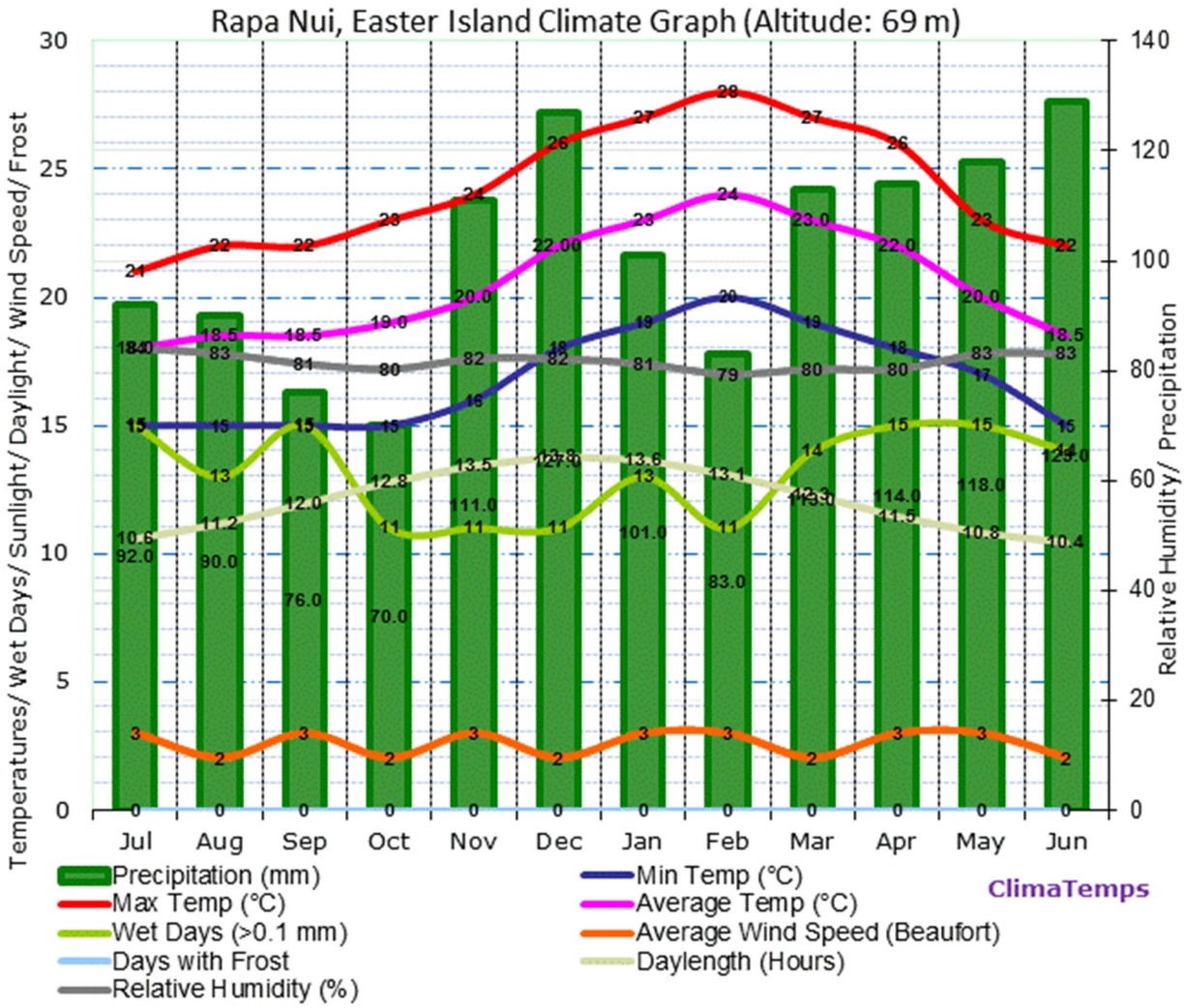


Figure 56 - Easter Island Climate Graph

7.1.4. L4 – Auckland, NZ

"This is a sub-tropical climate zone, with warm humid summers and mild winters. Typical summer daytime maximum air temperatures range from 22°C to 26°C, but seldom exceed 30°C. Winter daytime maximum air temperatures range from 12°C to 17°C. Annual sunshine hours average about 2000 in many areas. Tauranga is much sunnier with at least 2200 hours. SW winds prevail for much of the year. Sea breezes often occur on warm summer days. Winter usually has more rain and is the most unsettled time of year. In summer and autumn, storms of tropical origin may bring high winds and heavy rainfall from the east or northeast." (NIWA, 2020)

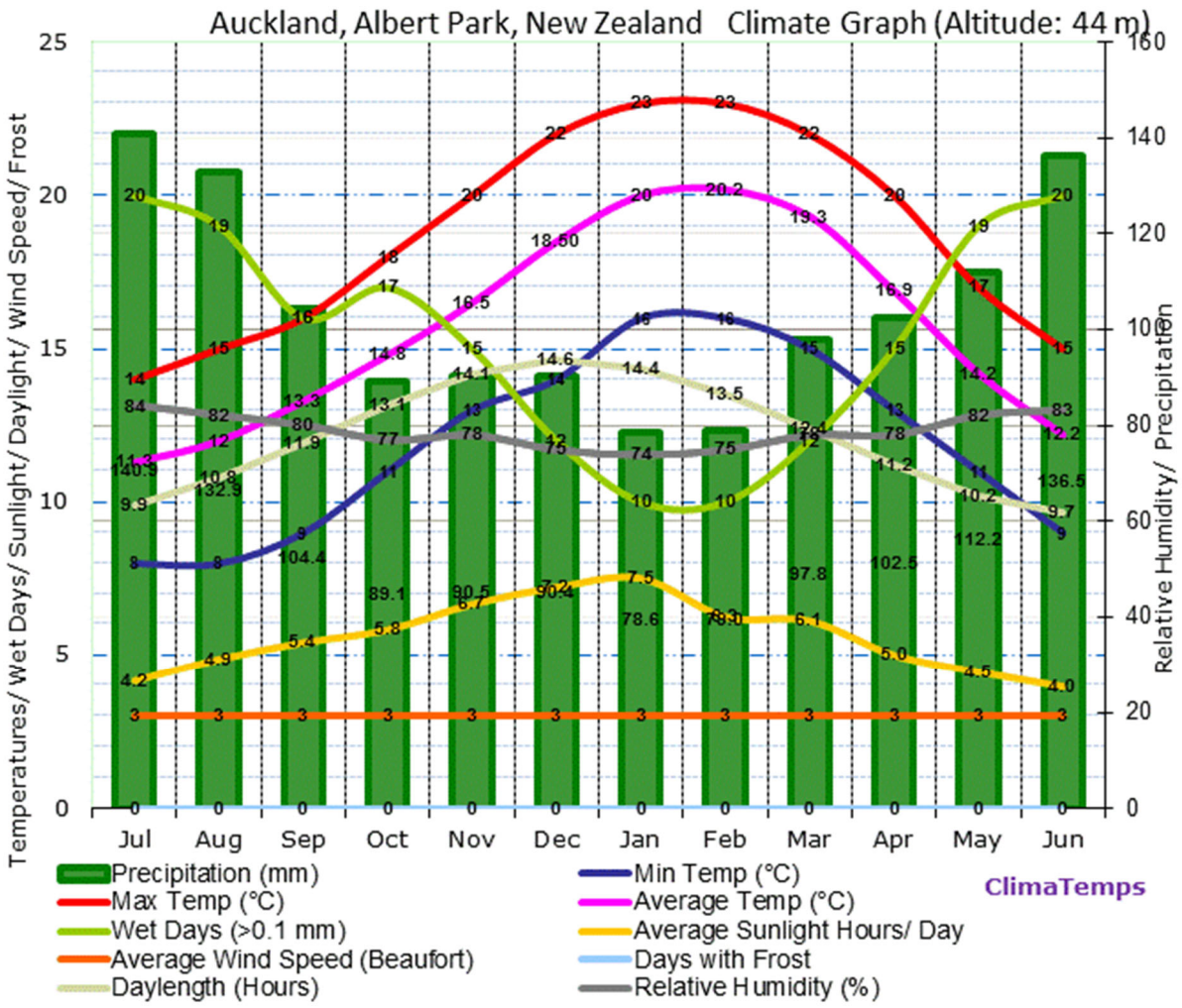


Figure 57 - Auckland Climate Graph

7.1.5. L5 – Sydney, AU

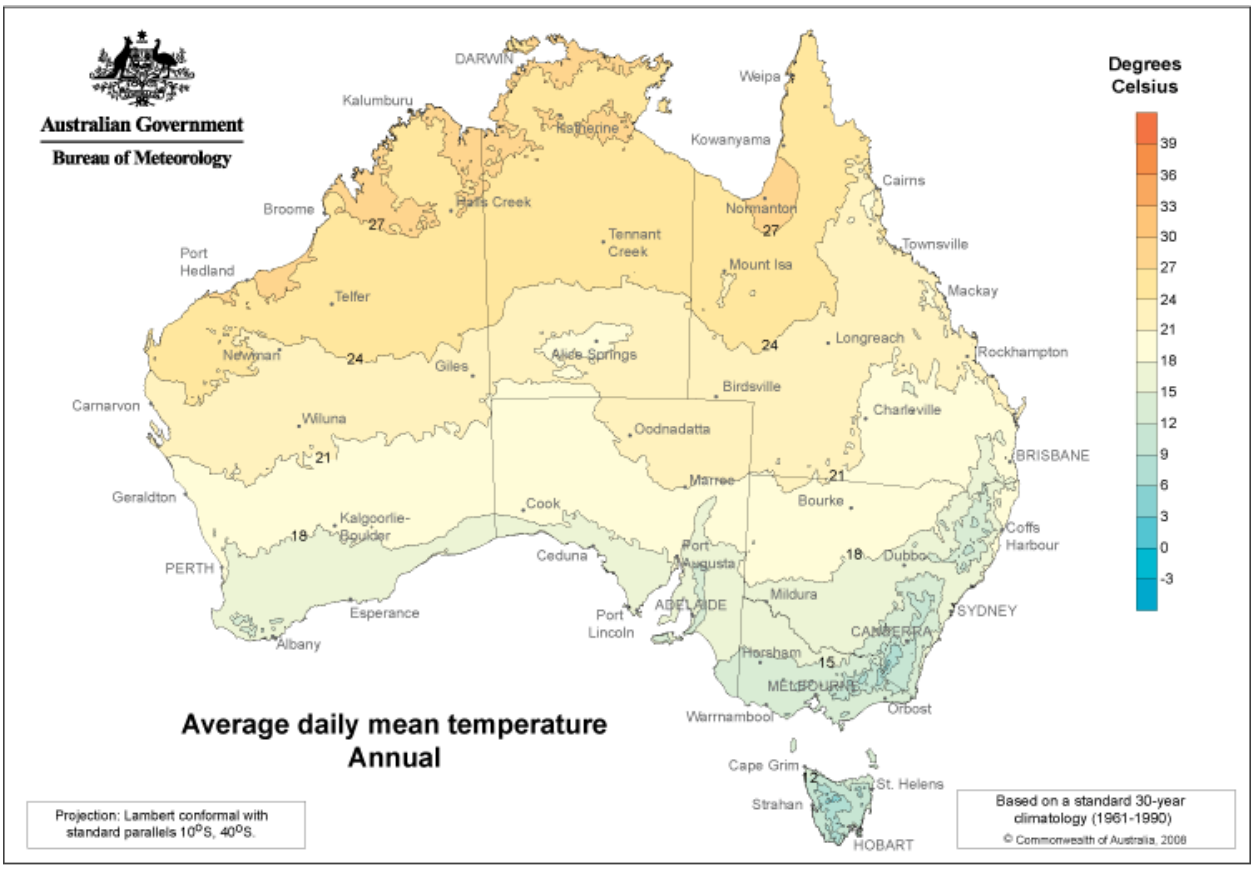


Figure 58 - Sydney, AU Mean Temperature

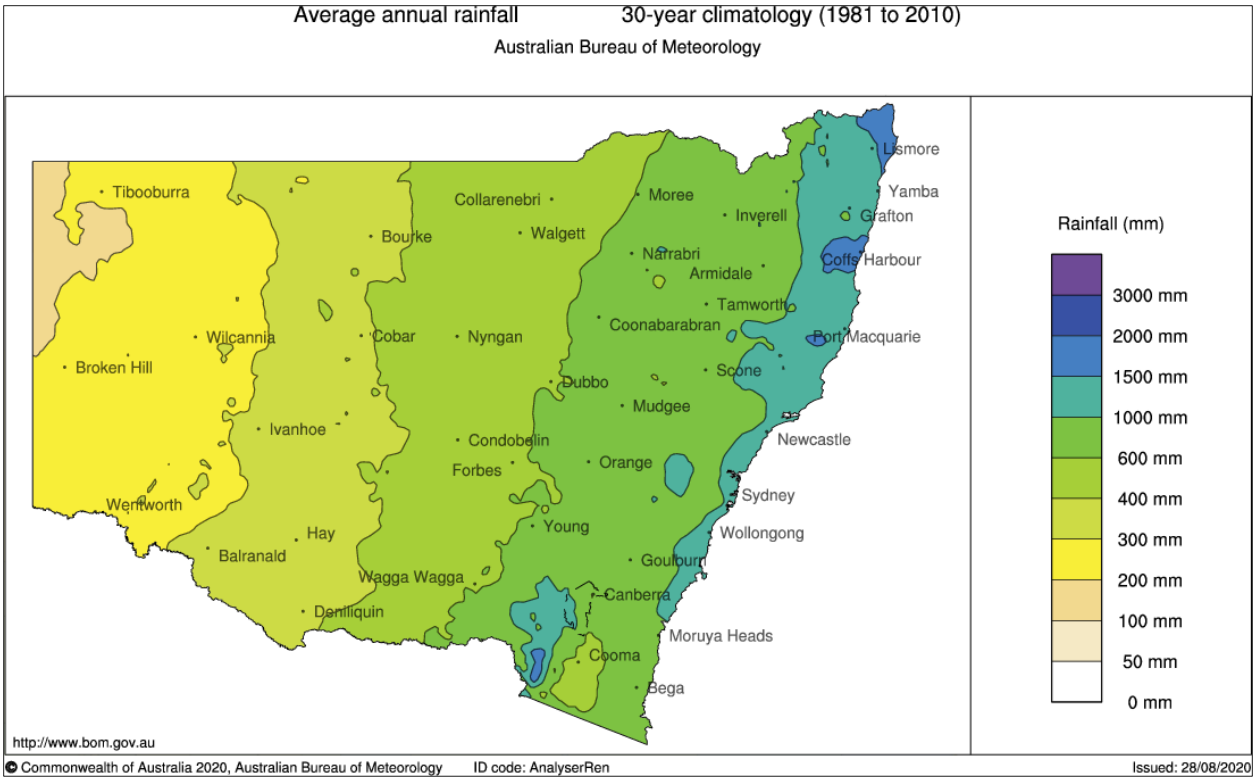


Figure 59 - Sydney, AU Rainfall

Figure 59 shows "…the average annual, seasonal, and monthly rainfall over the period 1961 to 1990. Average annual rainfall is calculated by adding rainfall totals over a specified period (1961 to 1990) and dividing by the number of years in that period (30 years in this case). Similarly, average seasonal/monthly rainfall is calculated by adding seasonal/monthly rainfall totals and dividing by the number of years in the specified period.

The annual rainfall map shows that extensive areas in central Australia are generally very dry. Rainfall in these areas is highly variable and falls on very few days. These areas are under the dominance of the subtropical high-pressure belt for most of the year and lie far from potential moisture sources.

Rainfall generally increases towards the coast as proximity to both moisture sources and reliable rain-producing weather systems improves. Elevation also has an important influence on rainfall, with the mountain areas of northeastern Queensland, southeastern Australia and western Tasmania receiving higher rainfall totals.

In the northern parts of the country, most of the rainfall is associated with the monsoon and occurs in the summer months. In southern Australia, most rain falls during the winter months and is normally associated with frontal systems." (Commonwealth of Australia, 2020)

7.2. General Weather Conditions

Rain, wind, wave, and temperature snapshots for the first day of each month have been included as graphics with wind currents shown as an overlay. It is highly recommended that survey and installation planning activities analyze the results of these models and in situ measurements closely to appropriately plan the time window for at-sea operations.

There is a pattern of less-intense wind and waves across the Study area during the December-February months. The primary schedule and cost risk associated with the project is the timing of survey and installation during months of least weather activity, which varies greatly in the project region, especially between Chile and New Zealand.

The following are 3h rain totals for the 1st day of each month. (Ventusky, 2020)

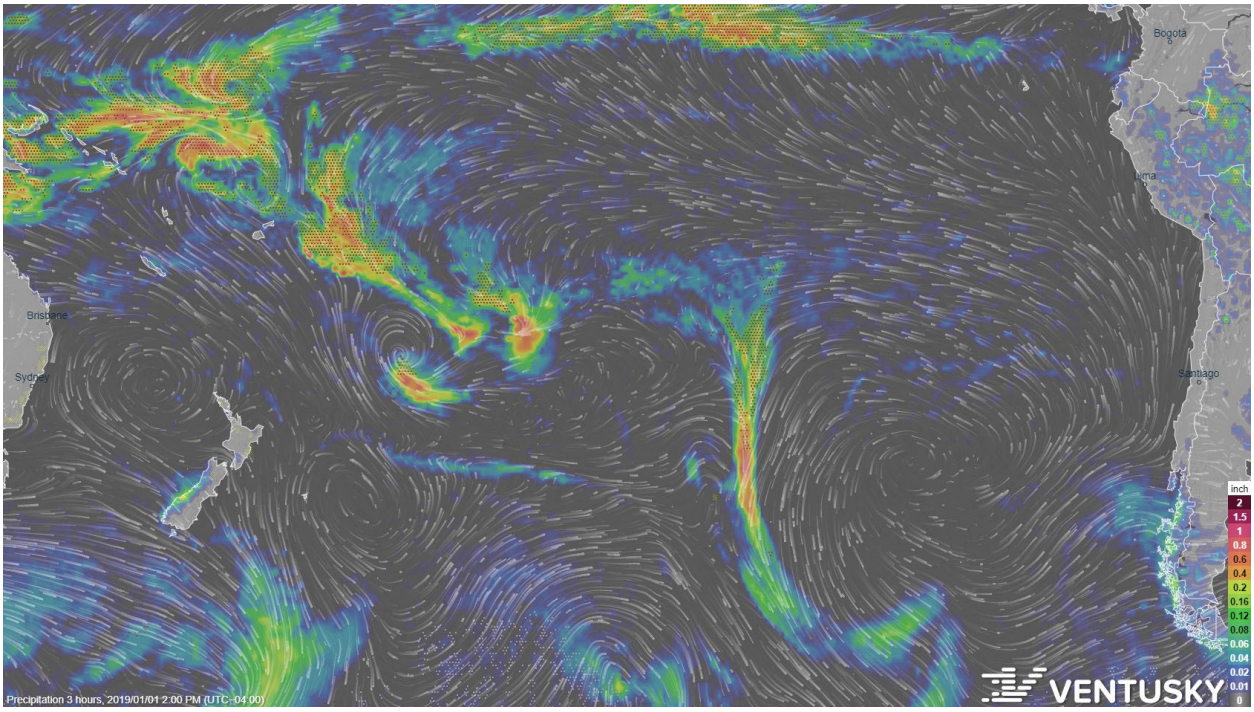


Figure 60 - Rain Totals January 1st, 2019

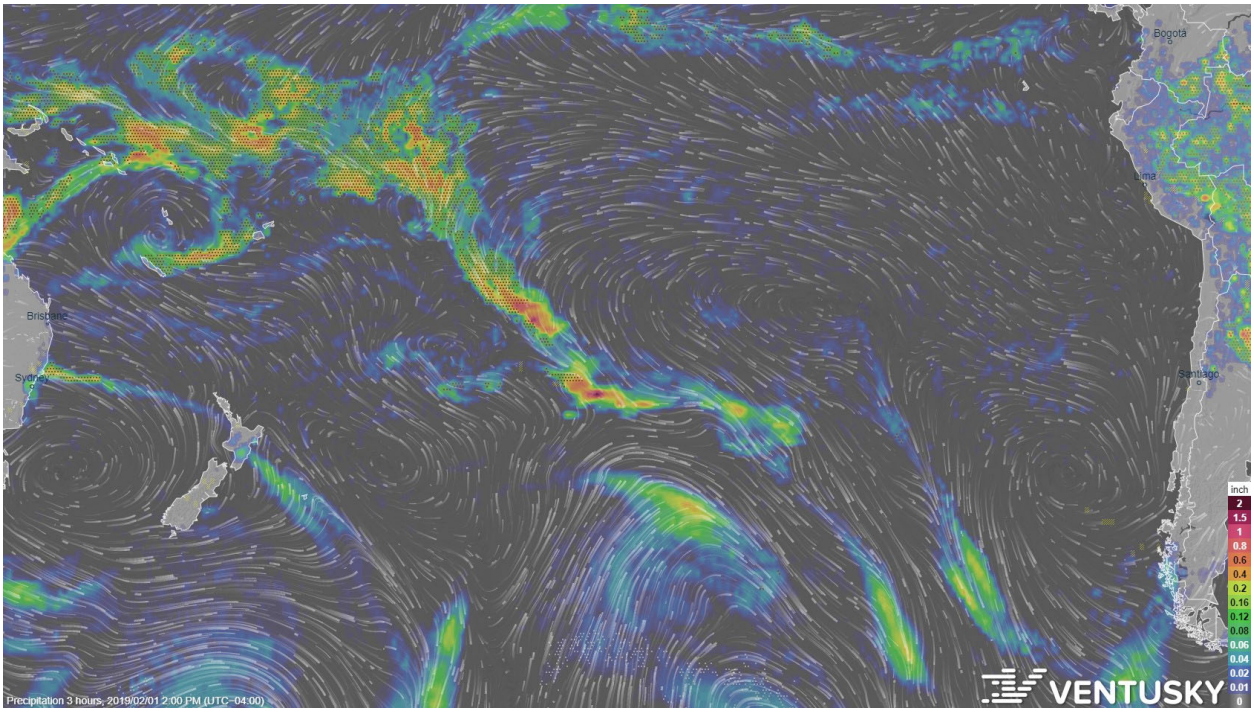


Figure 61 - Rain Totals February 1st, 2019

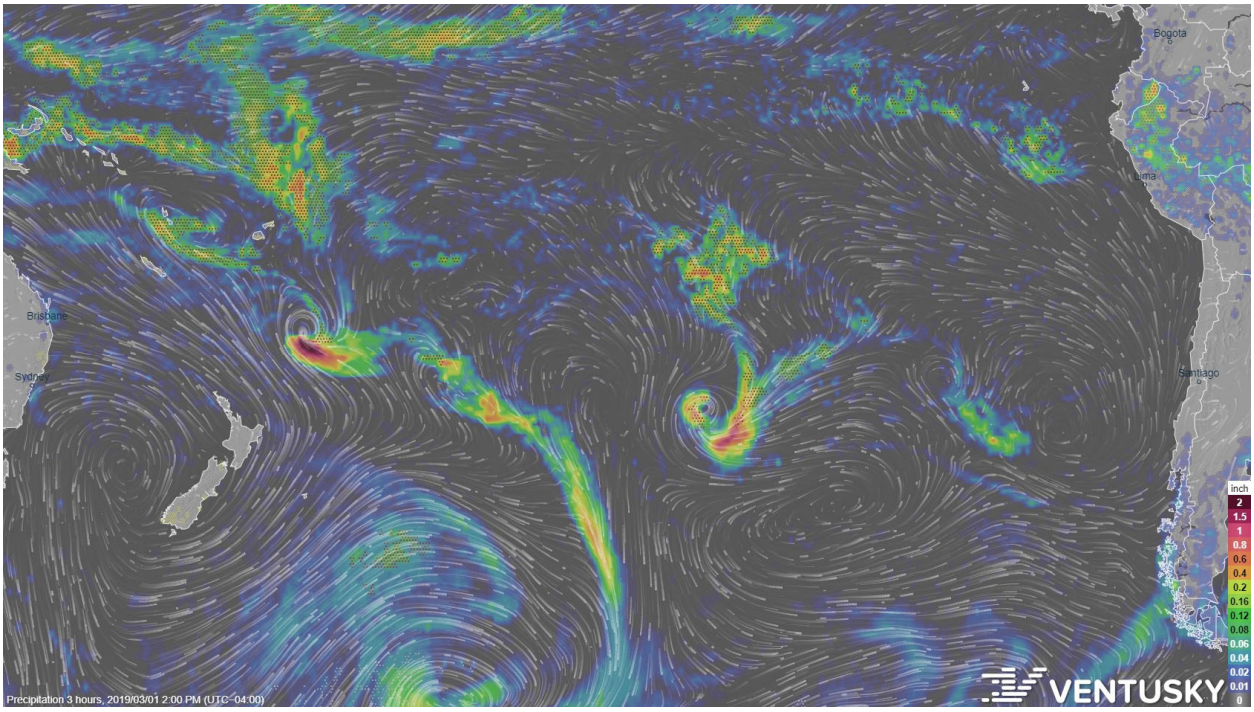


Figure 62 - Rain Totals March 1st, 2019

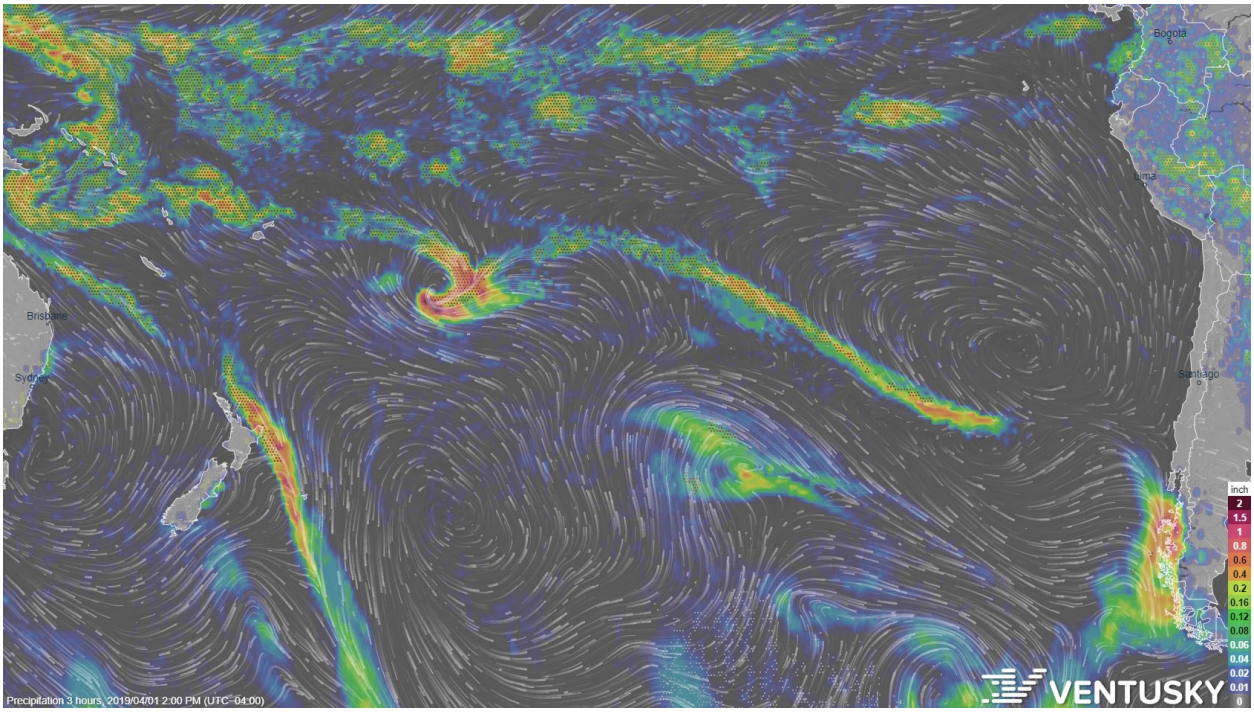


Figure 63 - Rain Totals April 1st, 2019

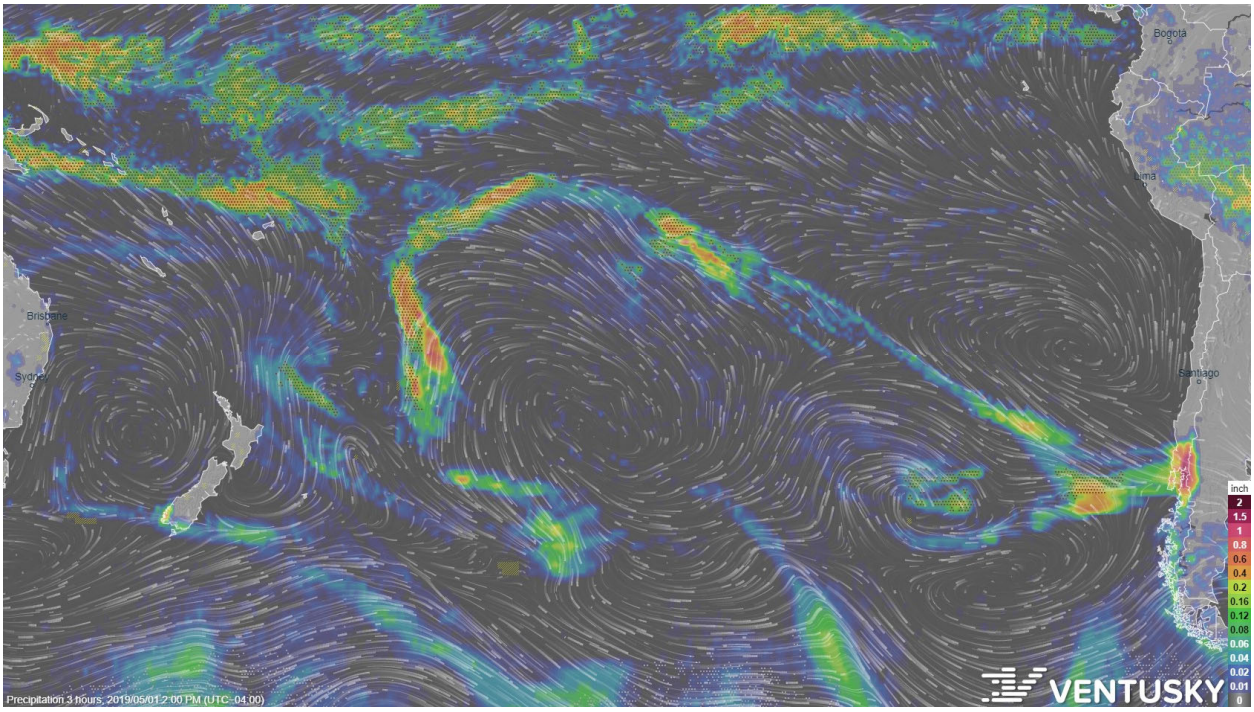


Figure 64 - Rain Totals May 1st, 2019

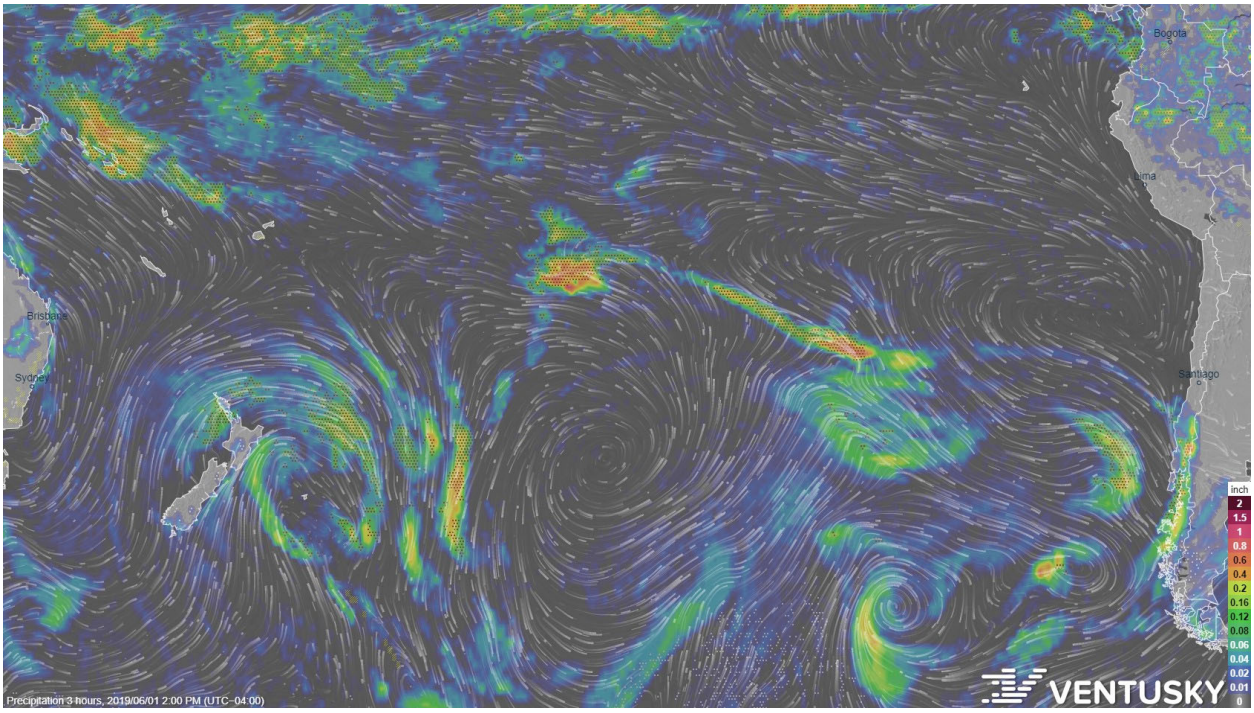


Figure 65 - Rain Totals June 1st, 2019

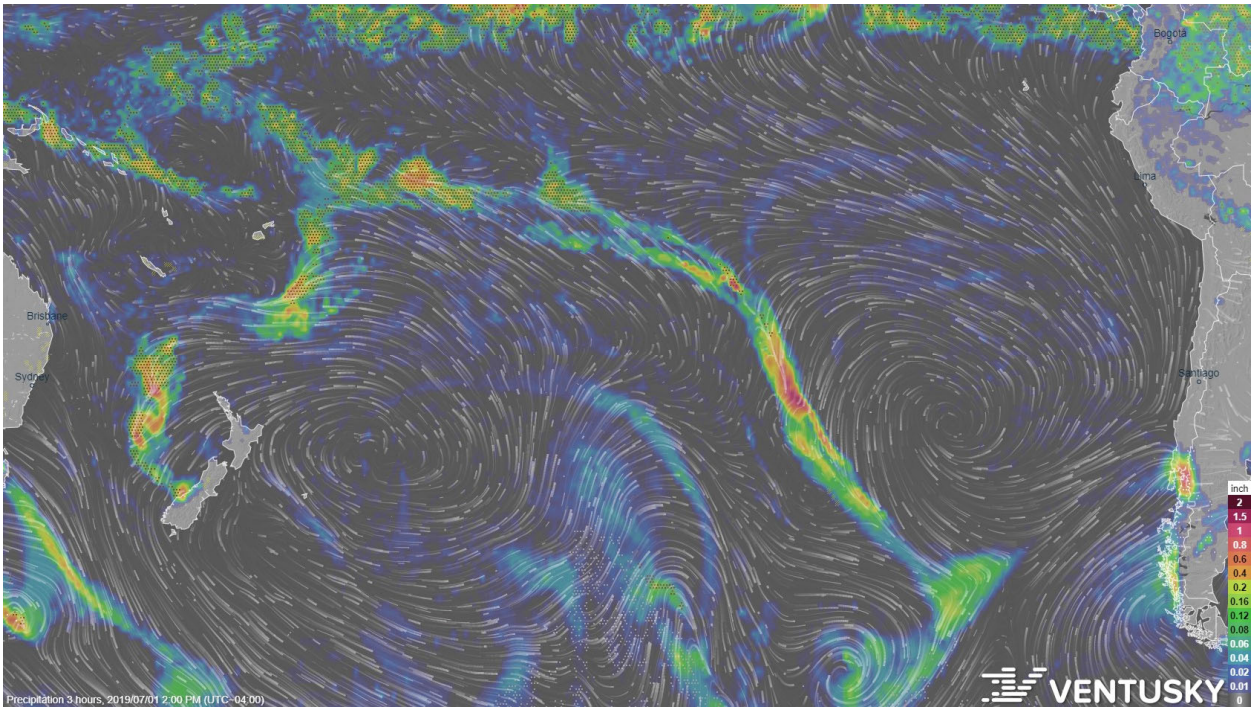


Figure 66 - Rain Totals July 1st, 2019

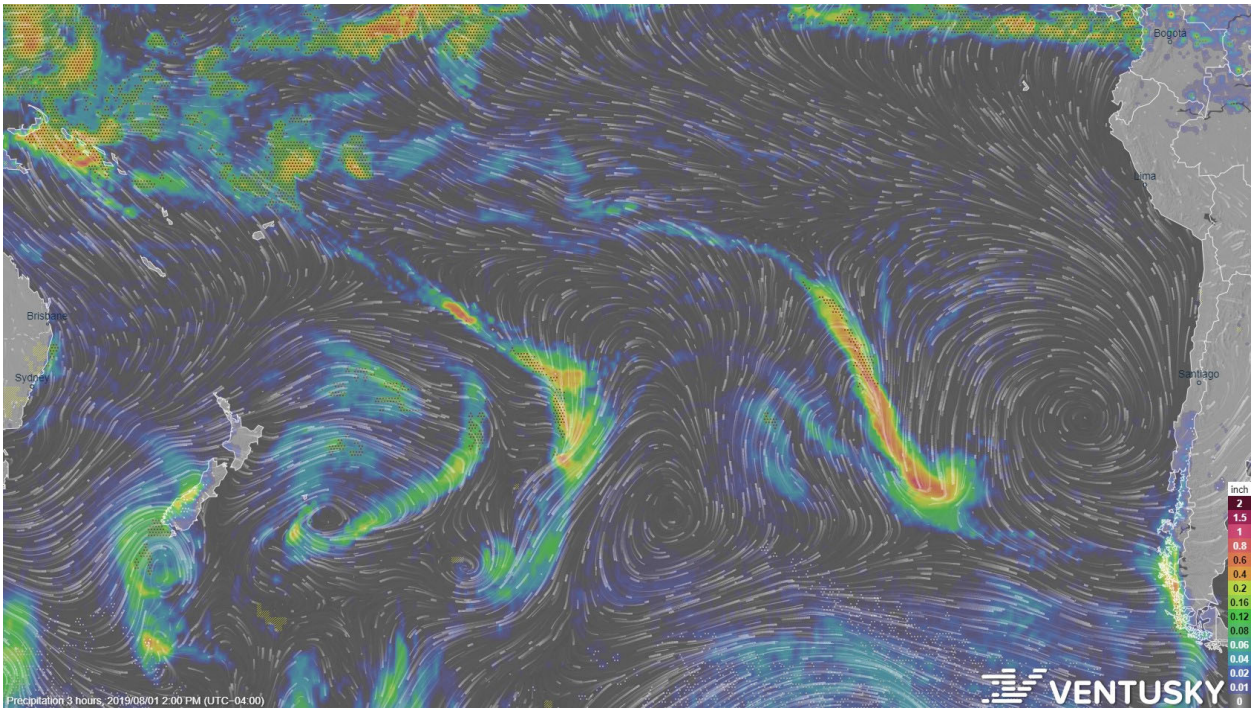


Figure 67 - Rain Totals August 1st, 2019

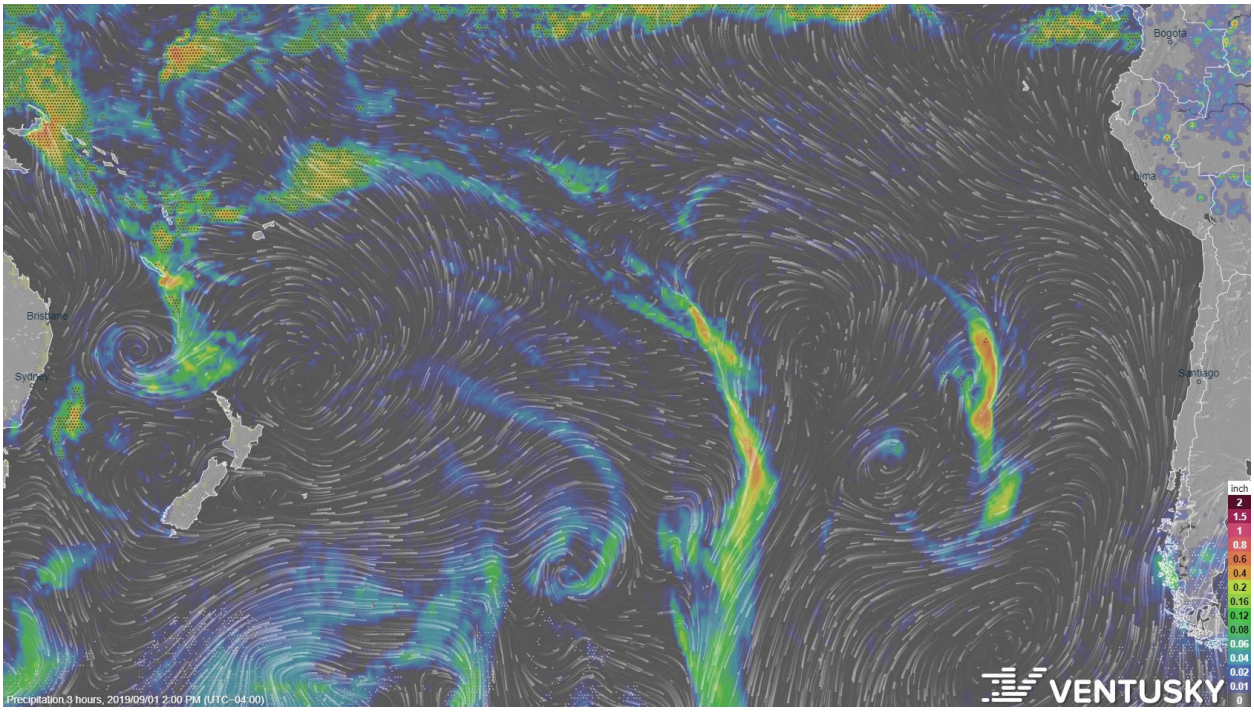


Figure 68 - Rain Totals September 1st, 2019

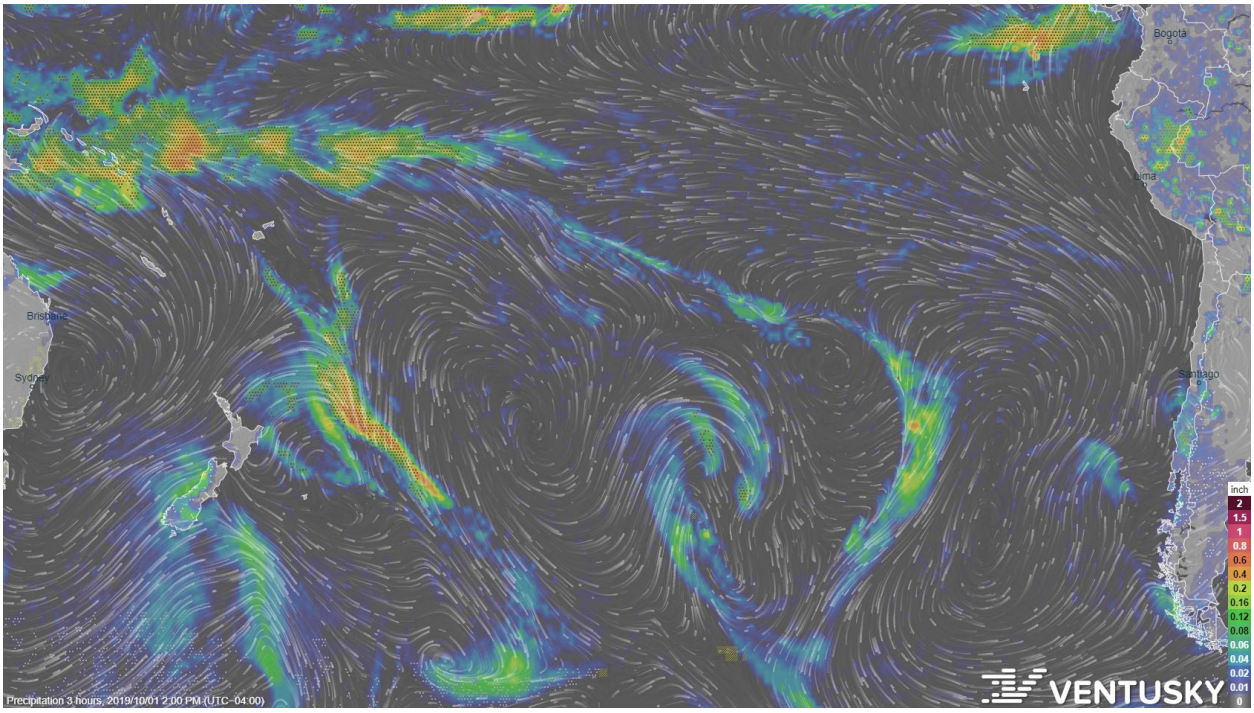


Figure 69 - Rain Totals October 1st, 2019

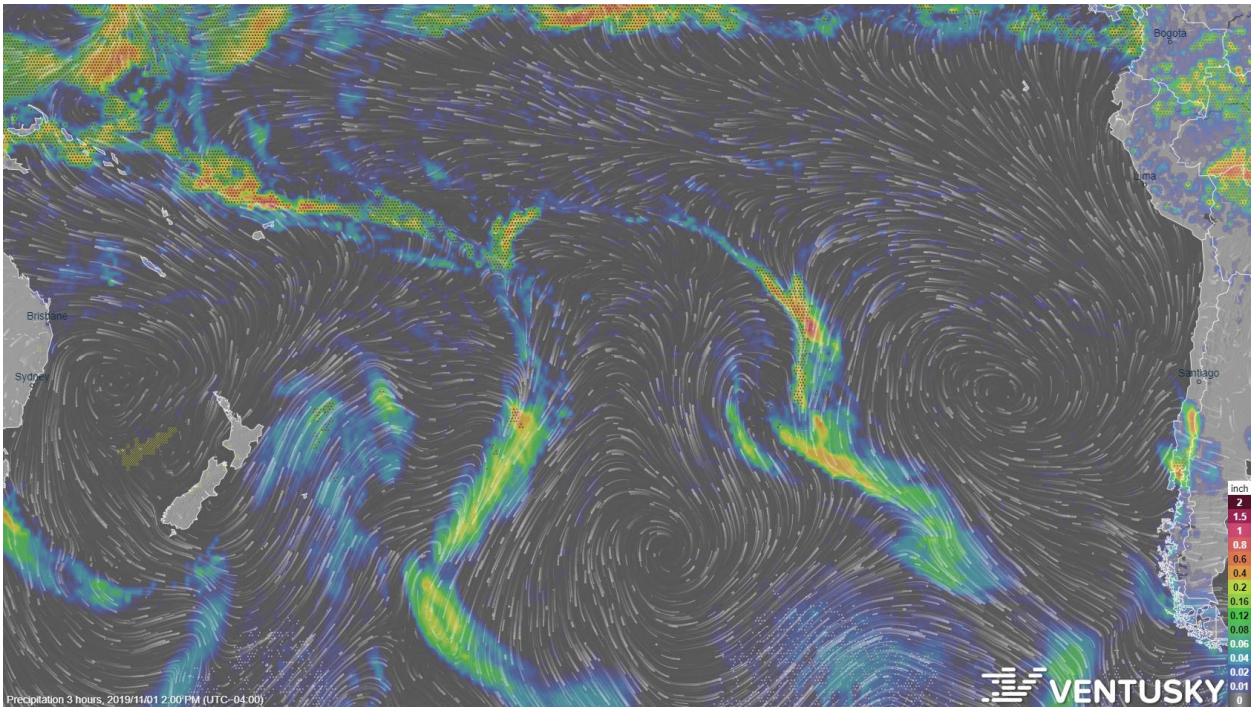


Figure 70 - Rain Totals November 1st, 2019

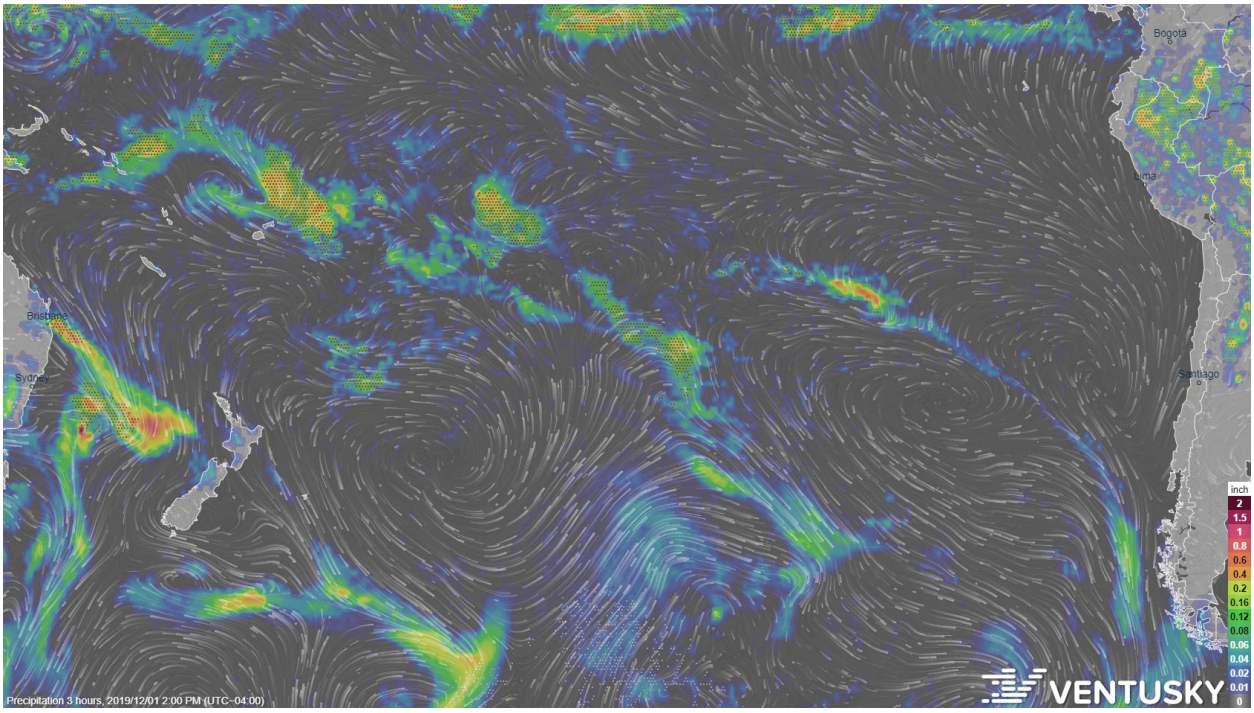


Figure 71 - Rain Totals December 1st, 2019

The following are 2m temperatures for the 1st day of each month.

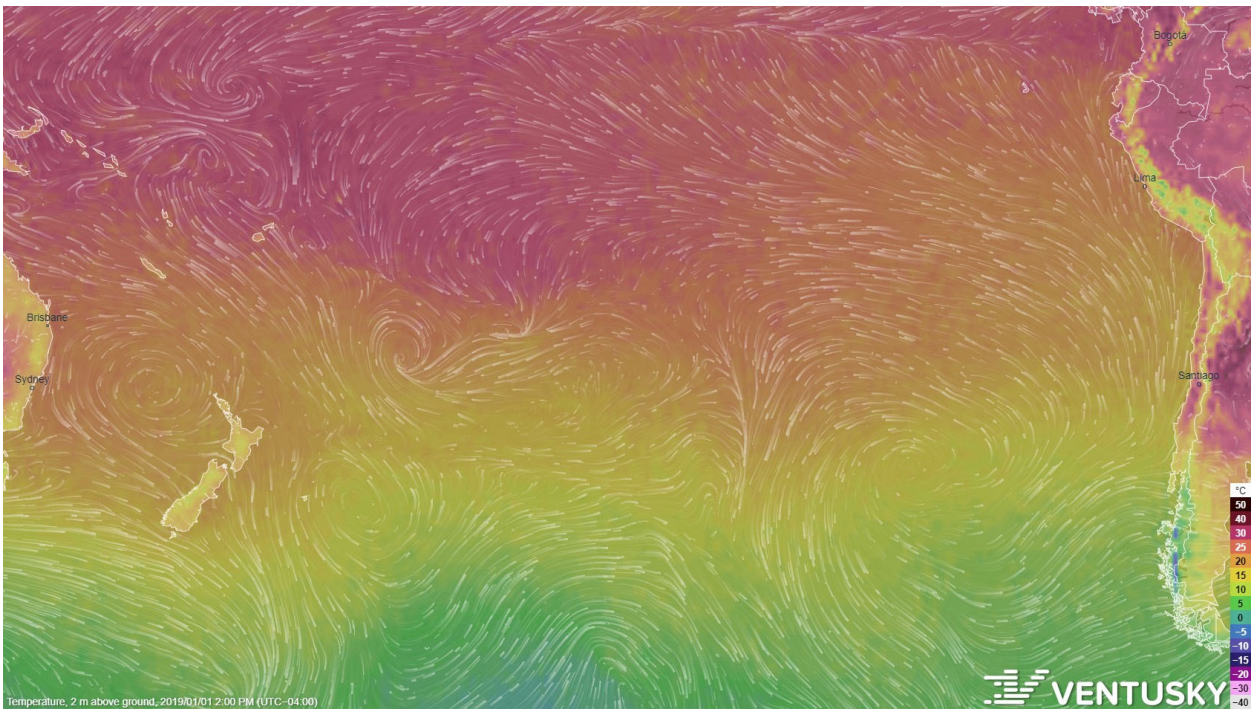


Figure 72 - Temperature January 1st, 2019

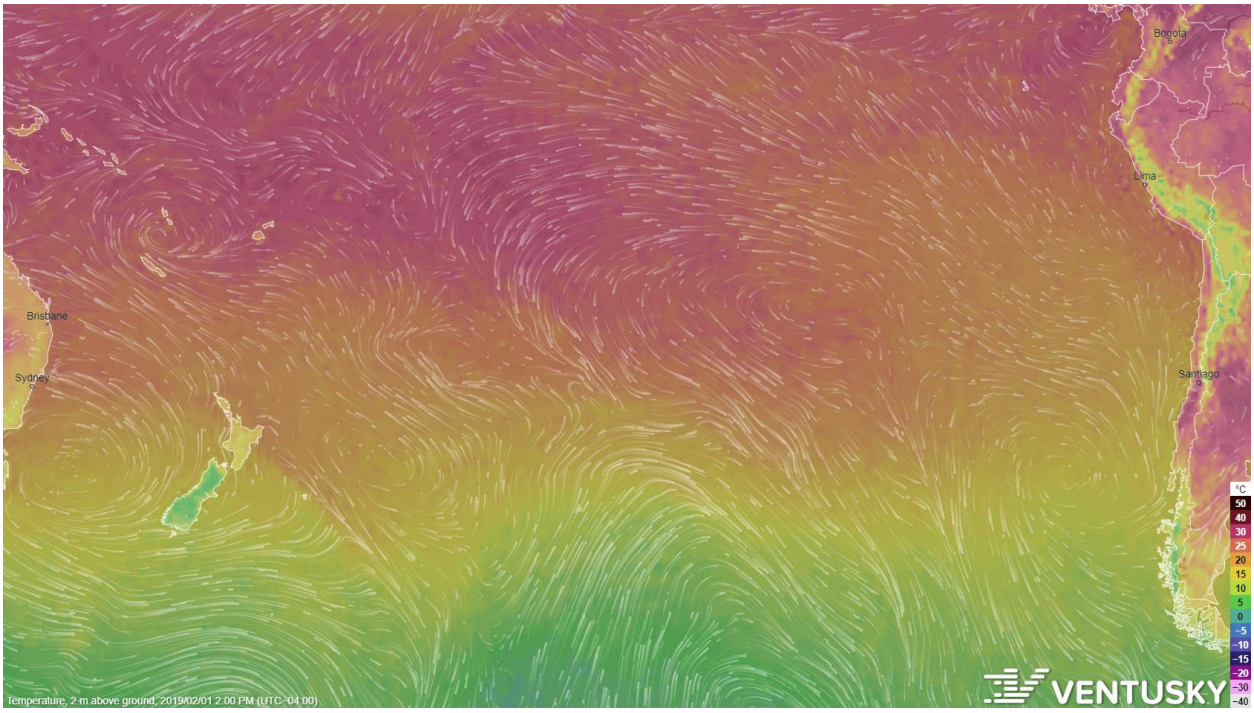


Figure 73 - Temperature February 1st, 2019

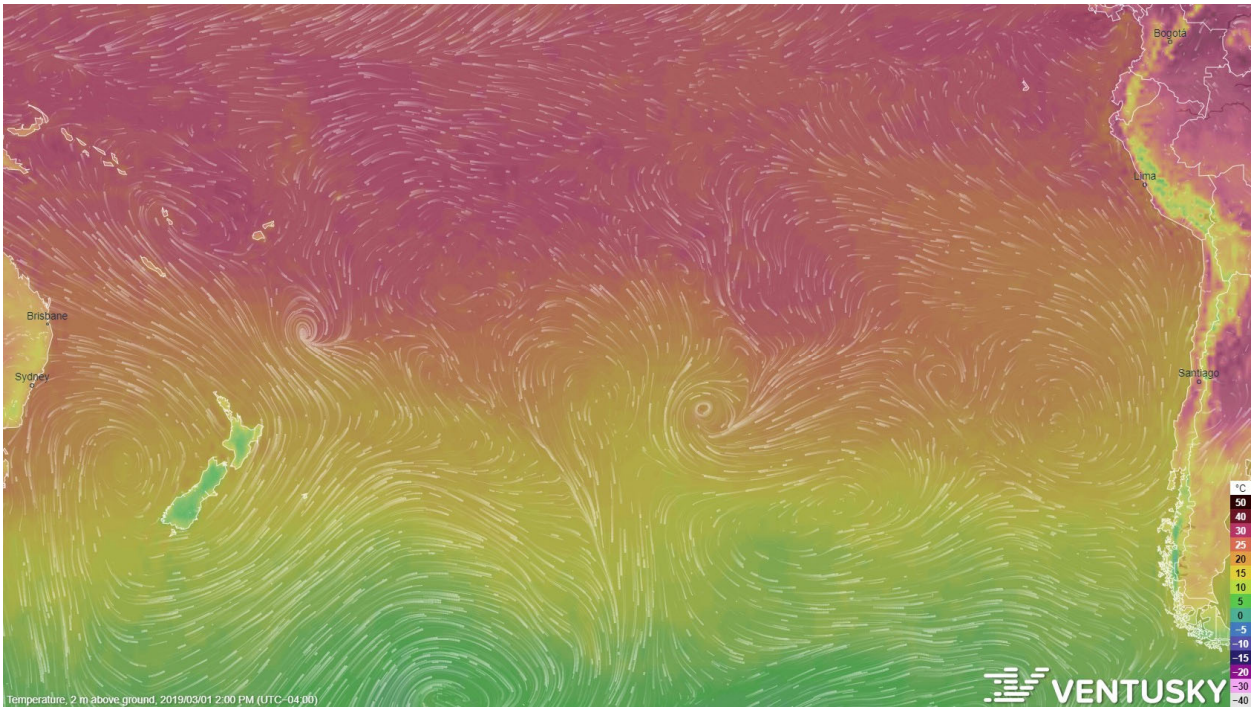


Figure 74 - Temperature March 1st, 2019

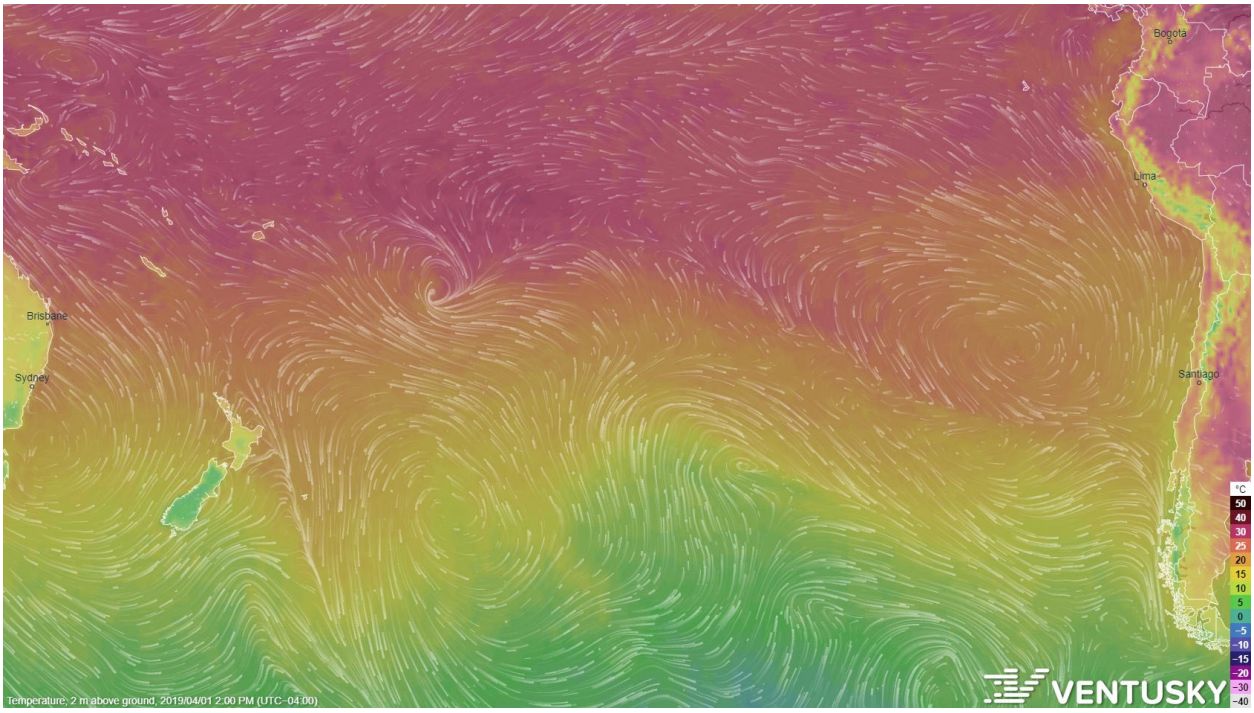


Figure 75 - Temperature April 1st, 2019

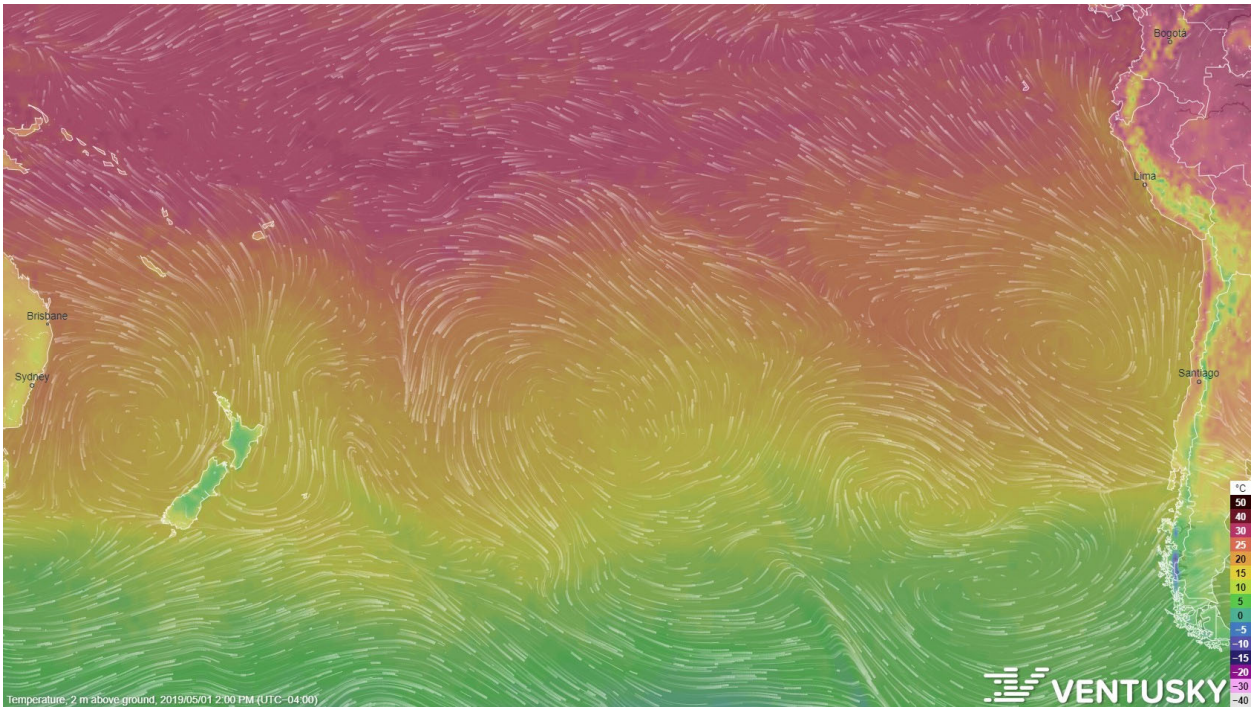


Figure 76 - Temperature May 1st, 2019

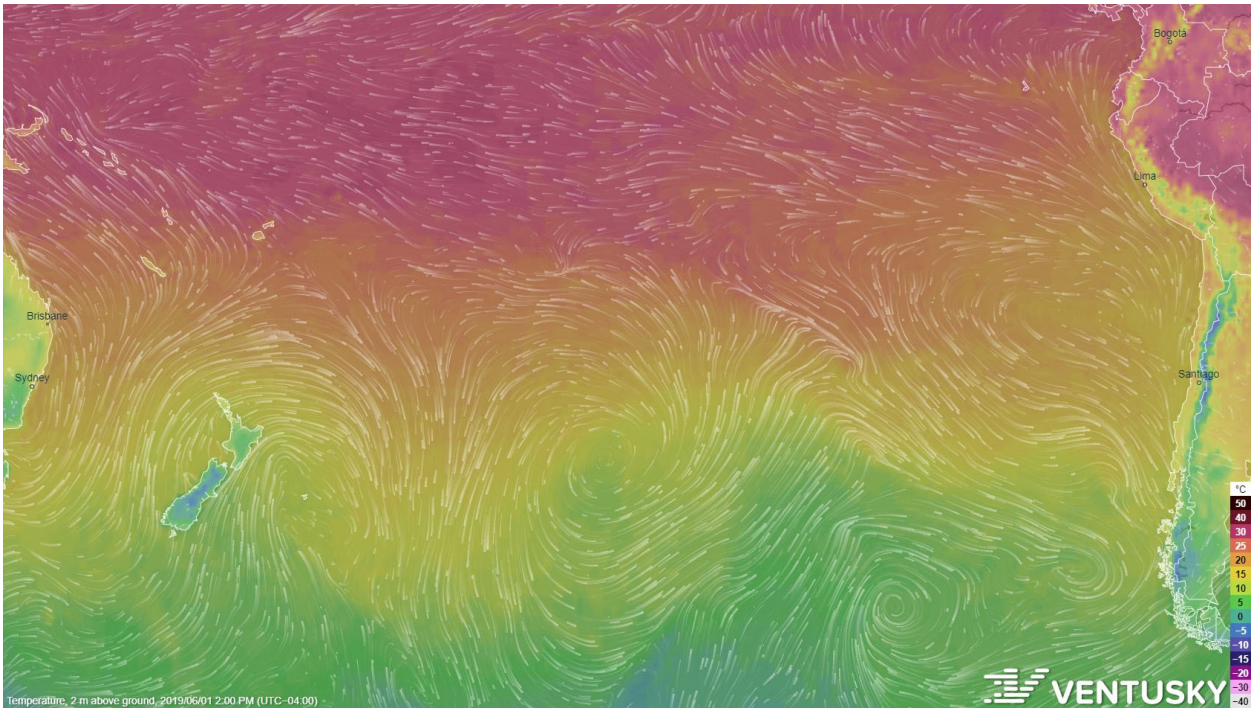


Figure 77 - Temperature June 1st, 2019

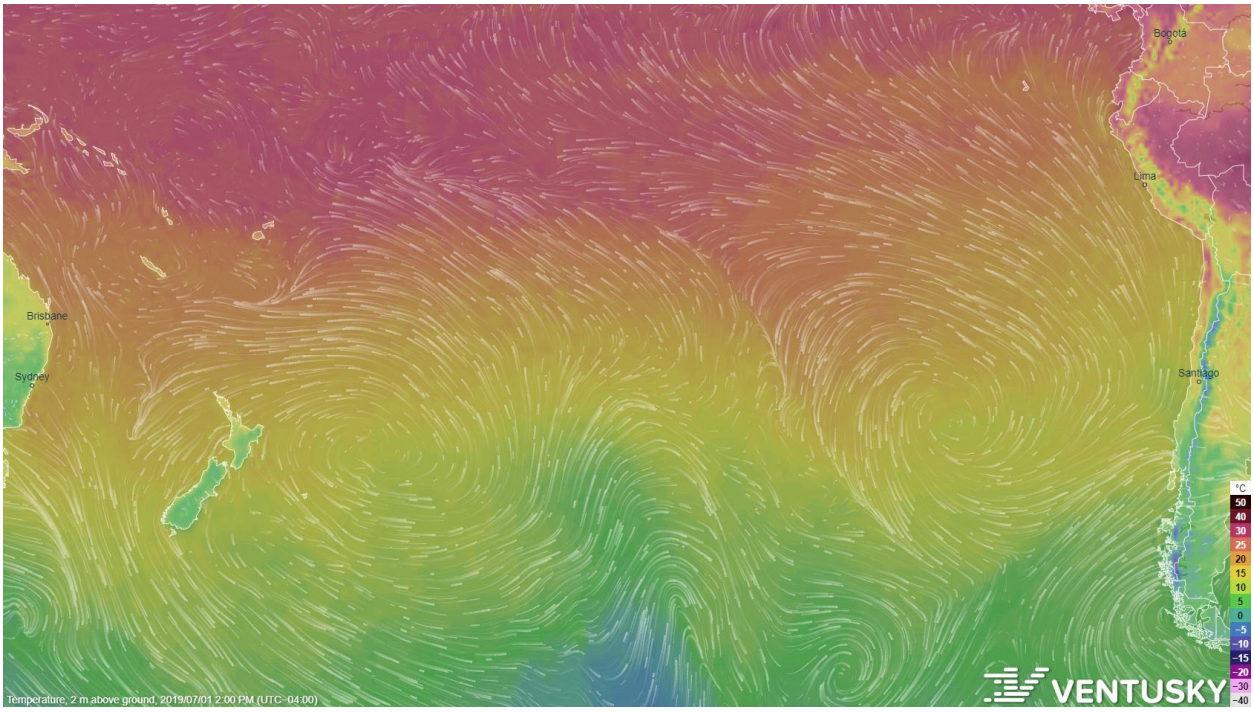


Figure 78 - Temperature July 1st, 2019

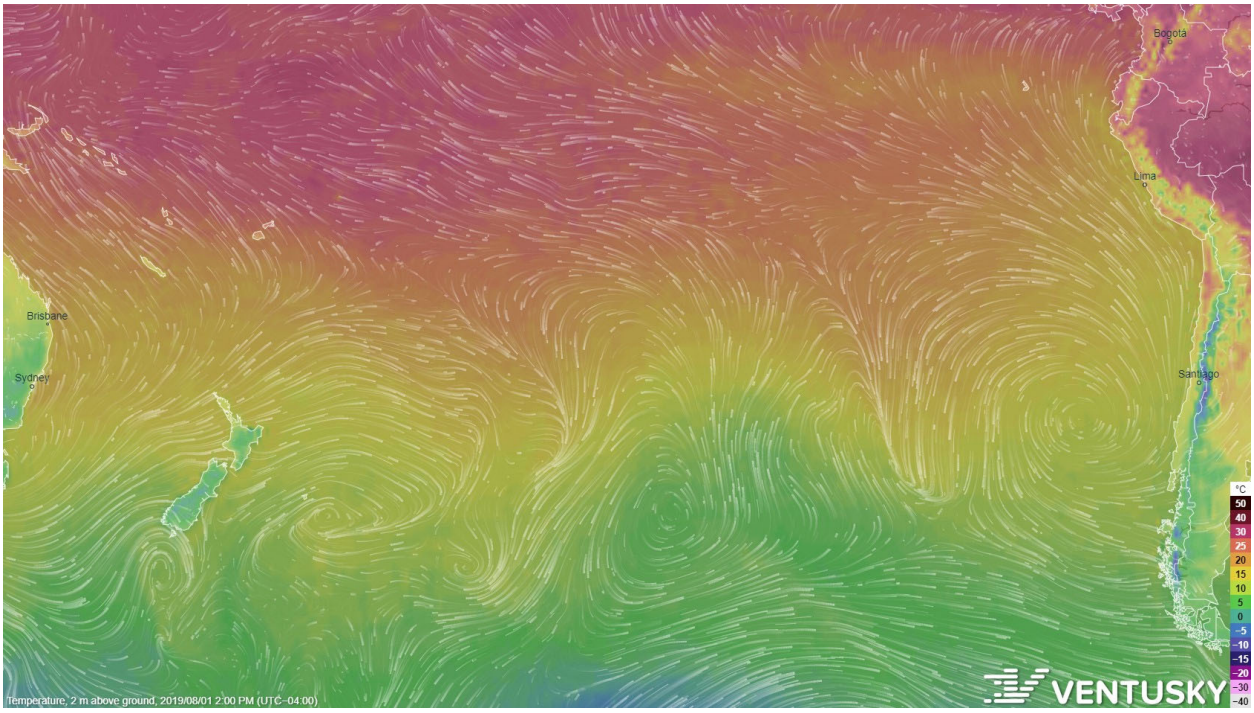


Figure 79 - Temperature August 1st, 2019

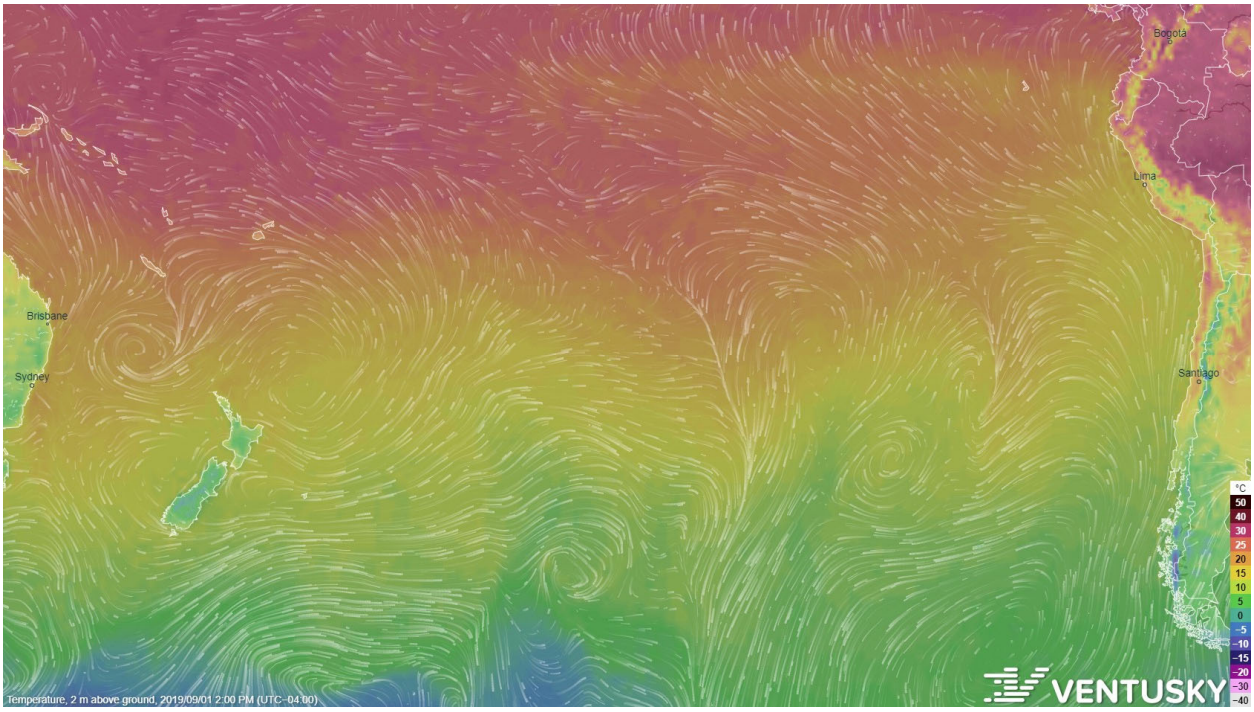


Figure 80 - Temperature September 1st, 2019

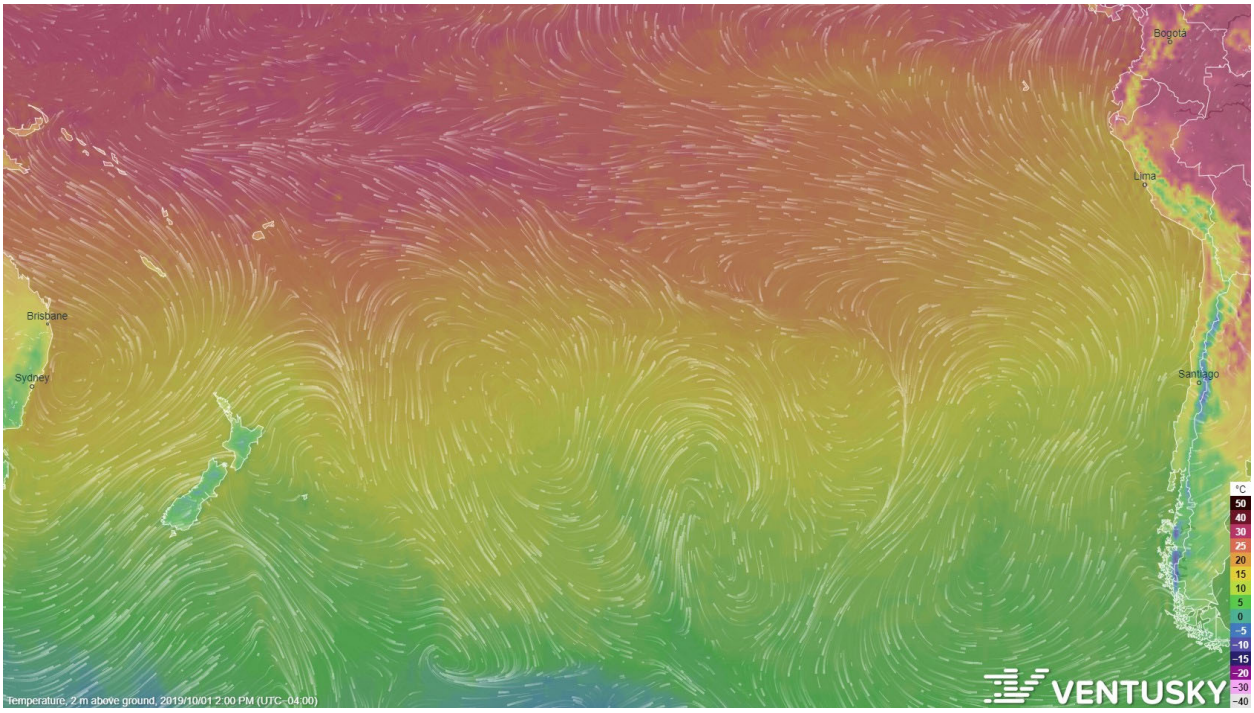


Figure 81 - Temperature October 1st, 2019

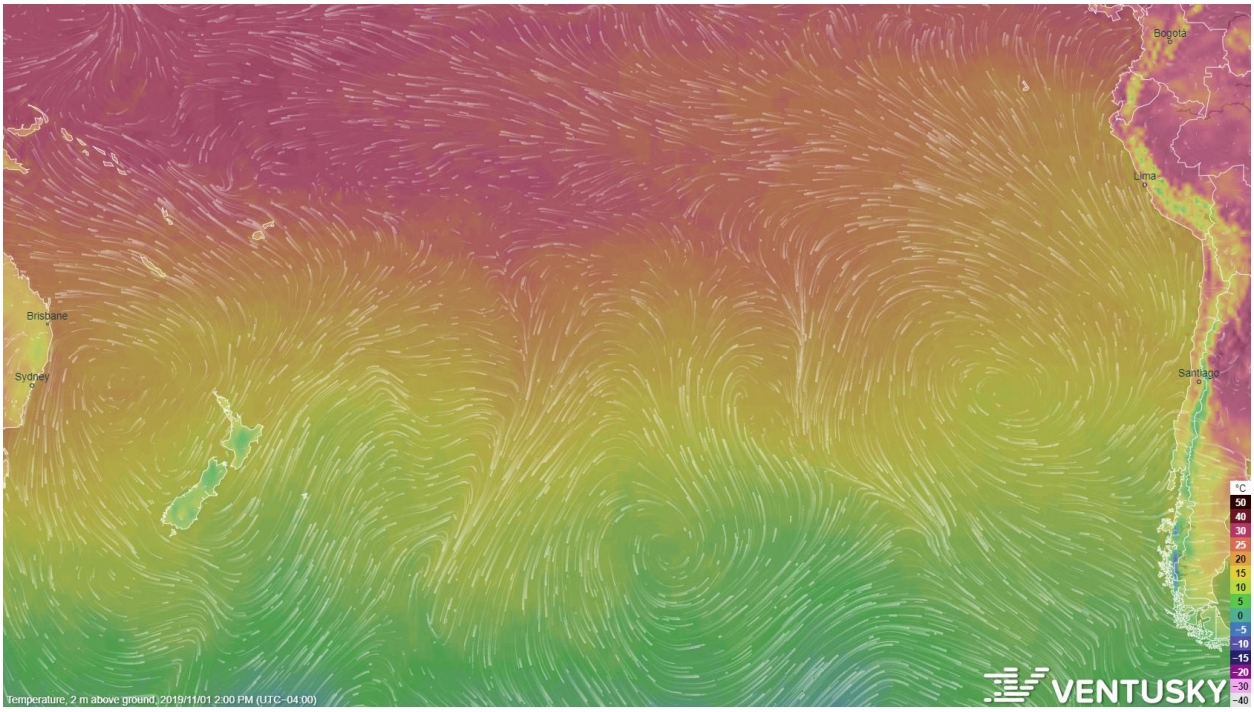


Figure 82 - Temperature November 1st, 2019

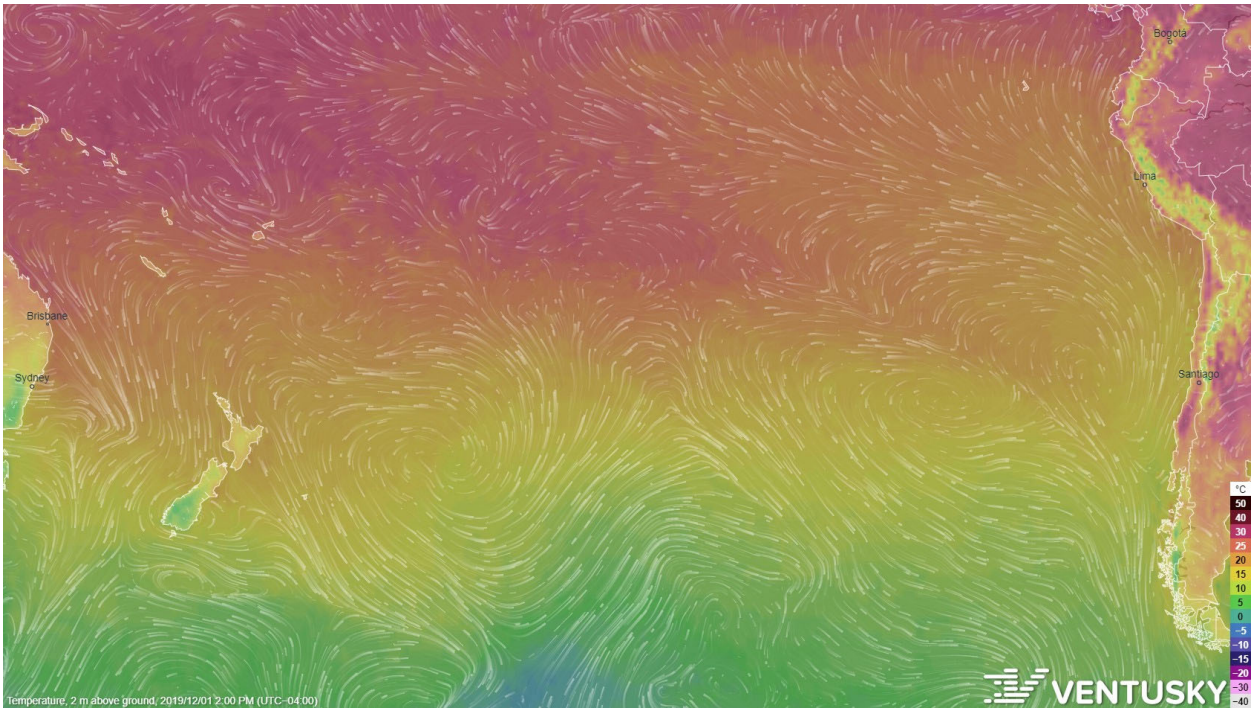


Figure 83 - Temperature December 1st, 2019

The following are wave heights from the 1st day of each month.

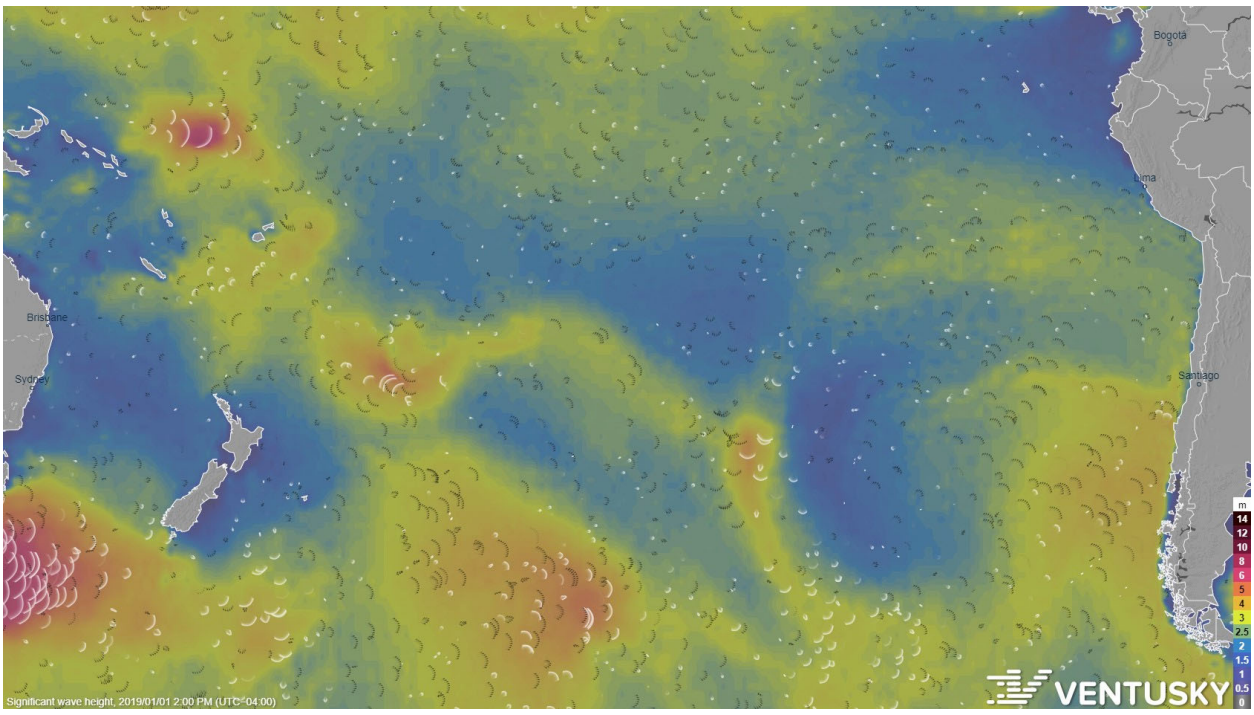


Figure 84 - Wave Heights January 1st, 2019

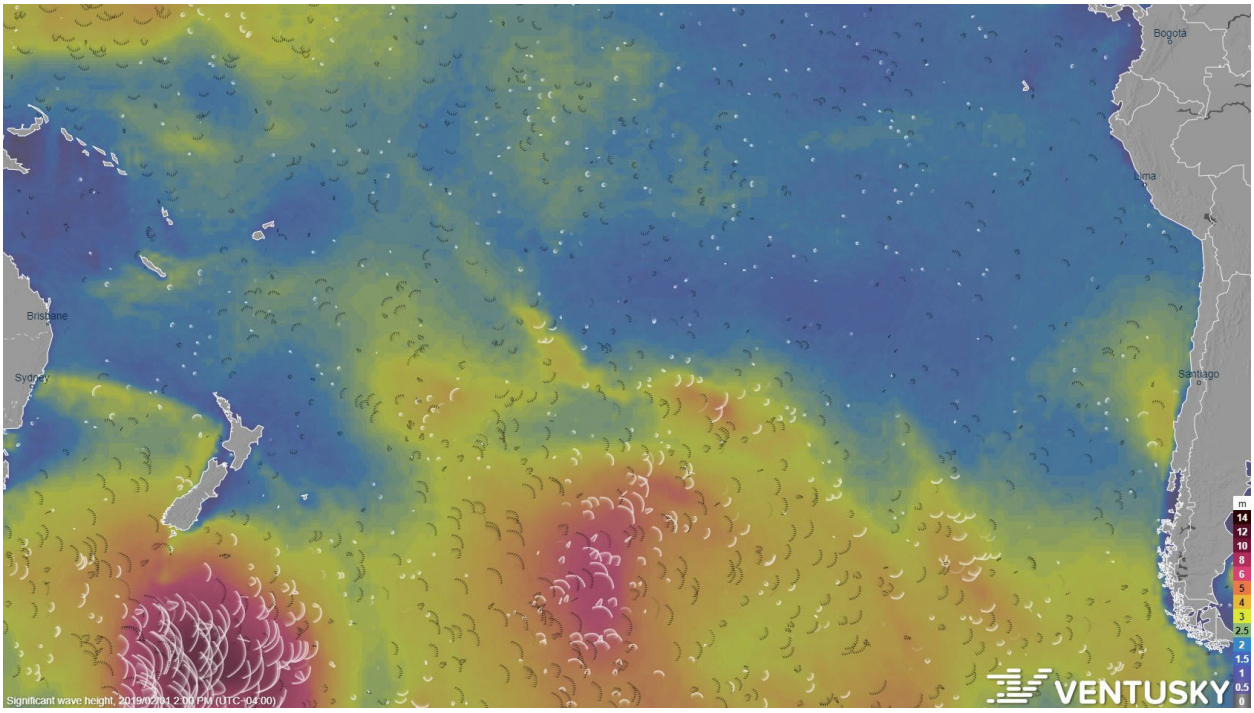


Figure 85 - Wave Heights February 1st, 2019

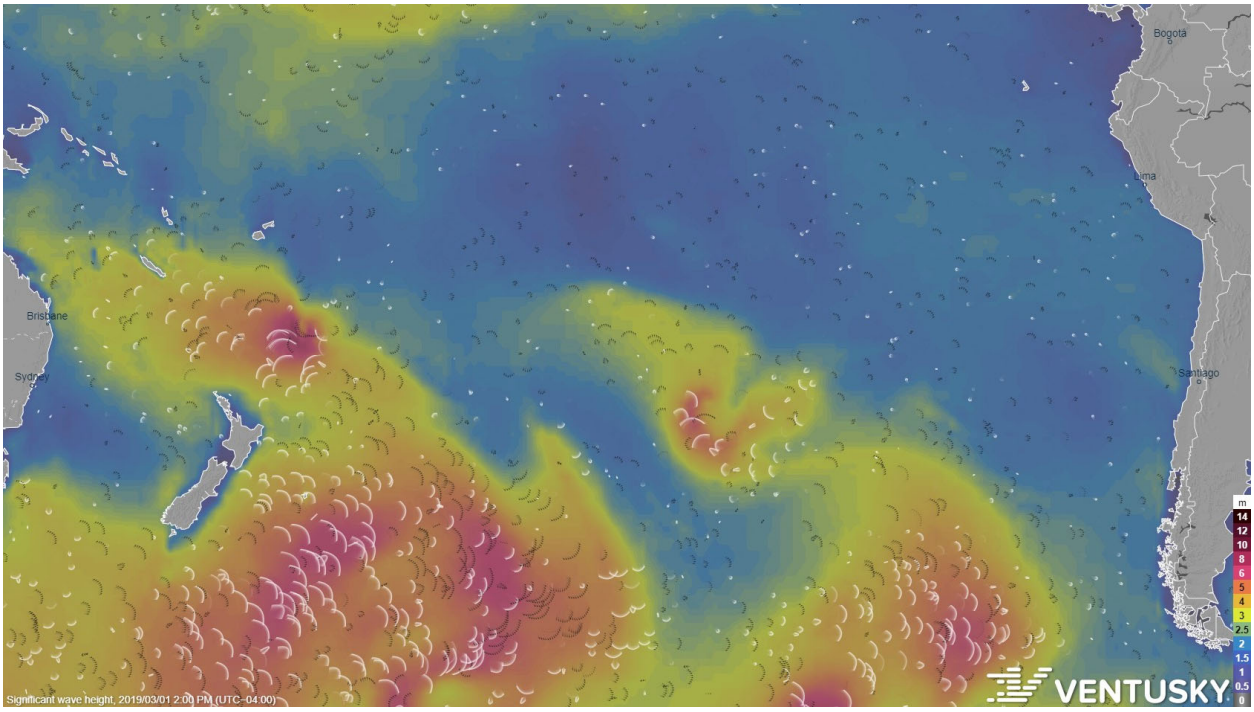


Figure 86 - Wave Heights March 1st, 2019

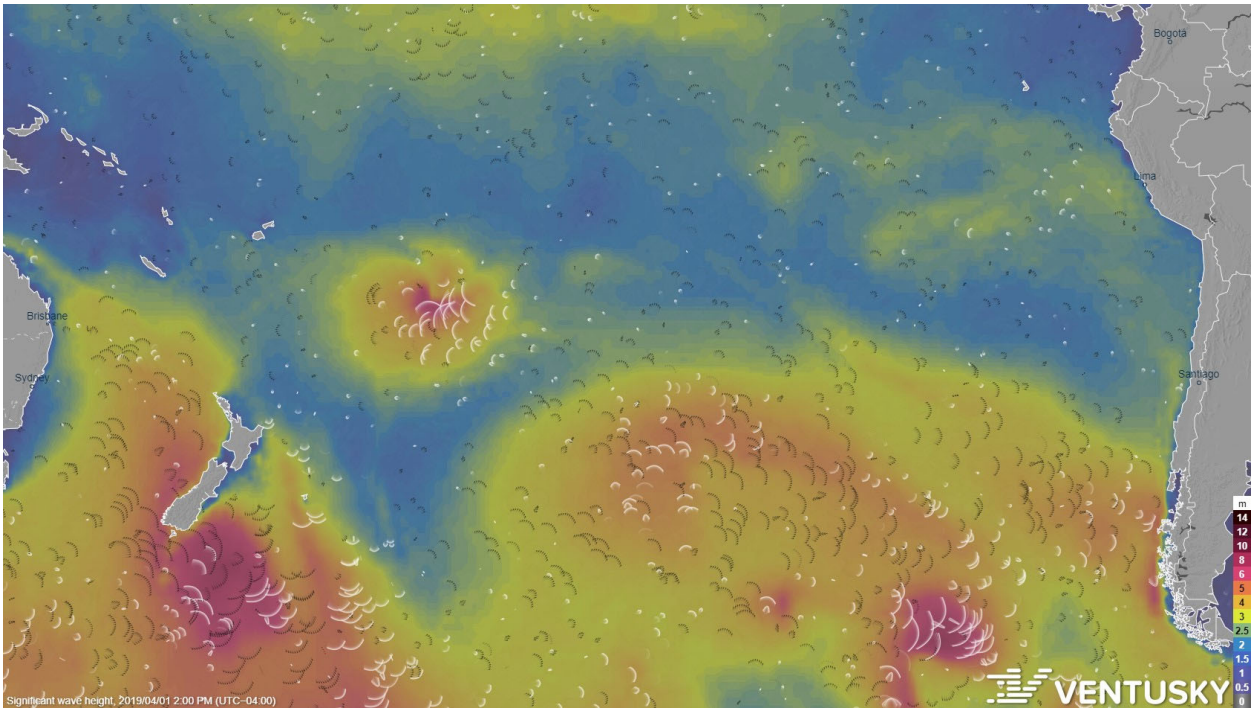


Figure 87 - Wave Heights April 1st, 2019

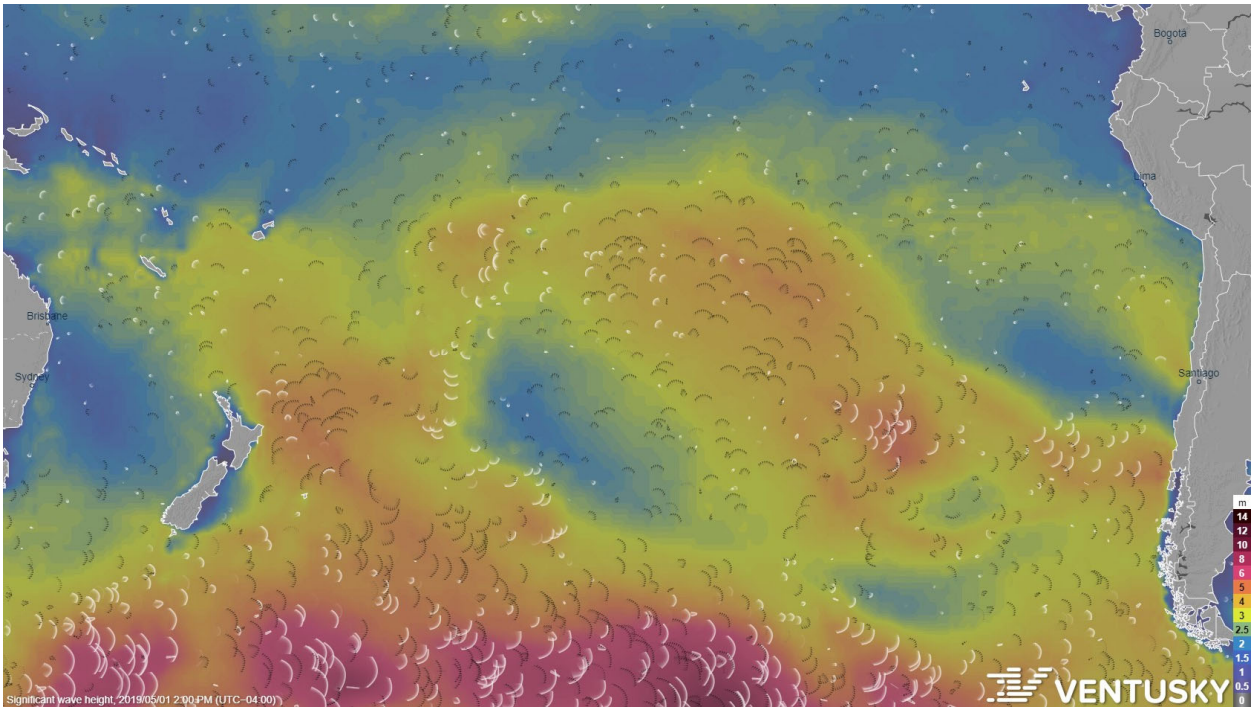


Figure 88 - Wave Heights May 1st, 2019

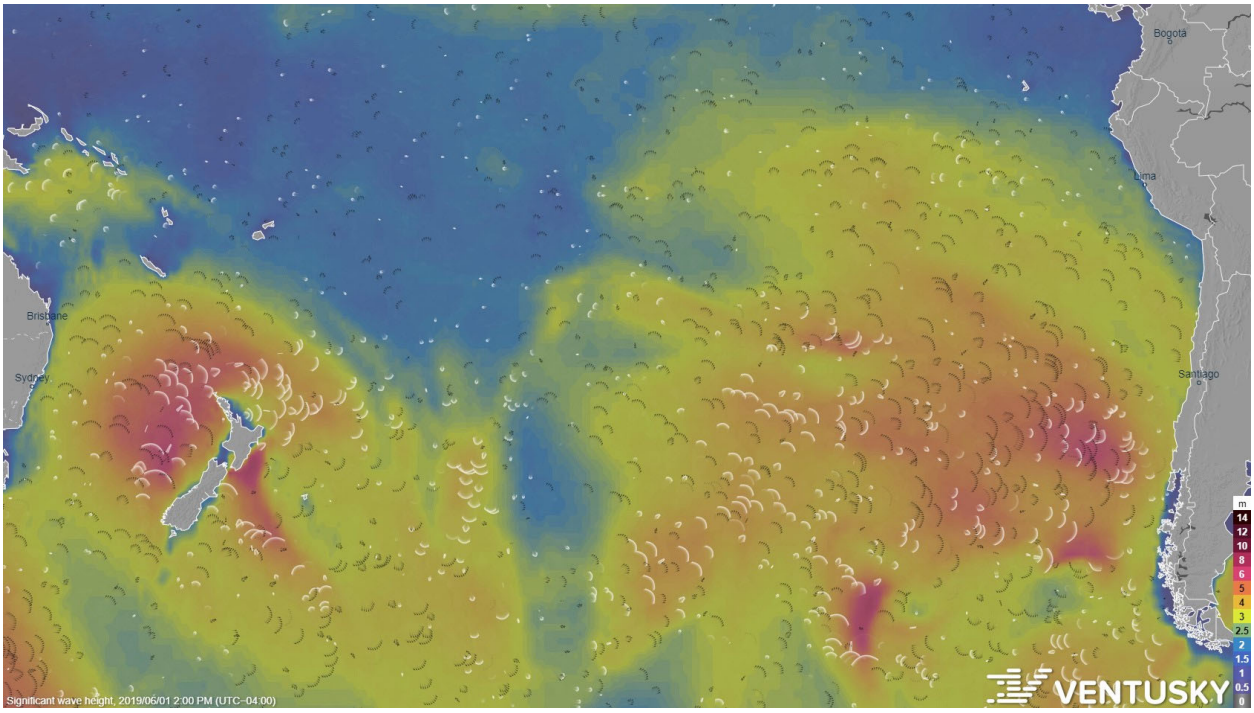


Figure 89 - Wave Heights June 1st, 2019

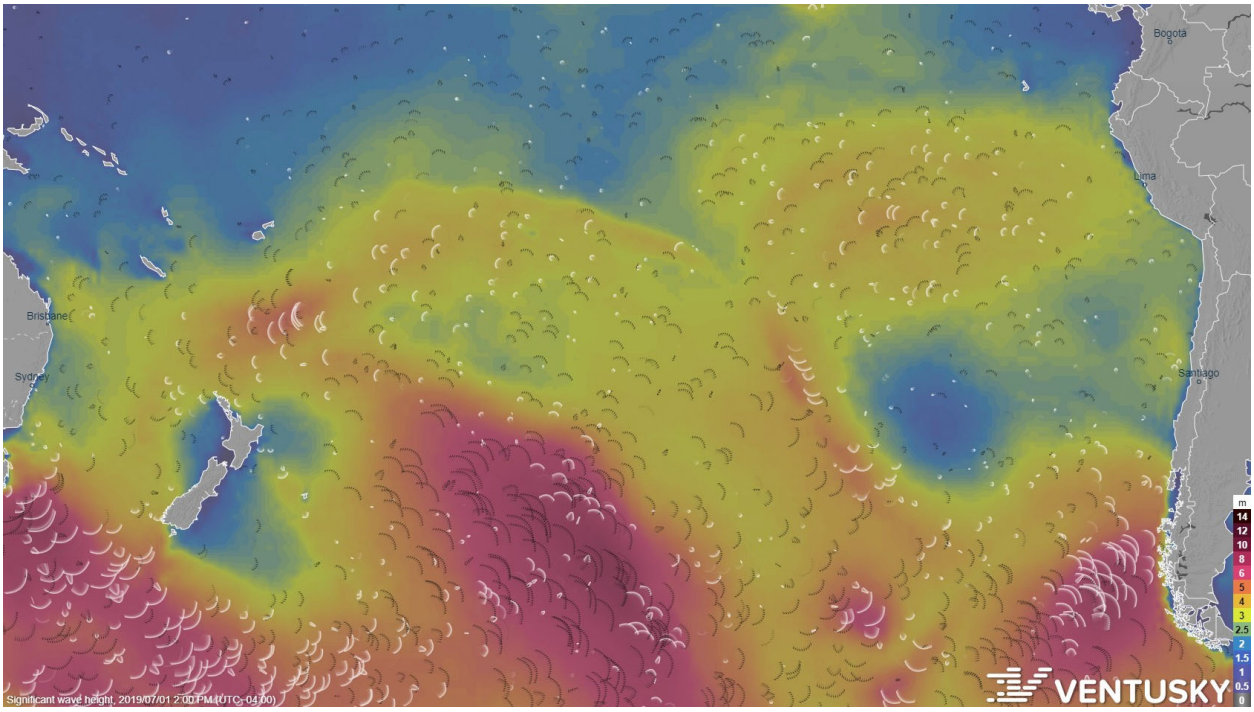


Figure 90 - Wave Heights July 1st, 2019

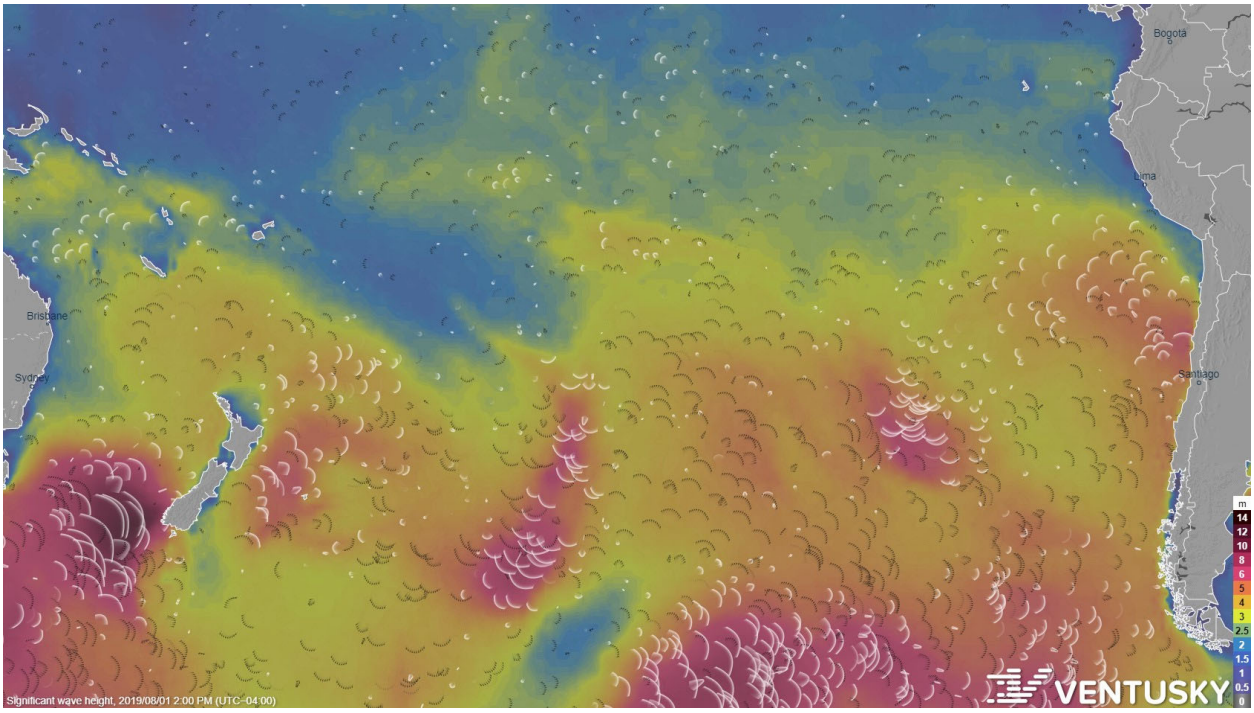


Figure 91 - Wave Heights August 1st, 2019

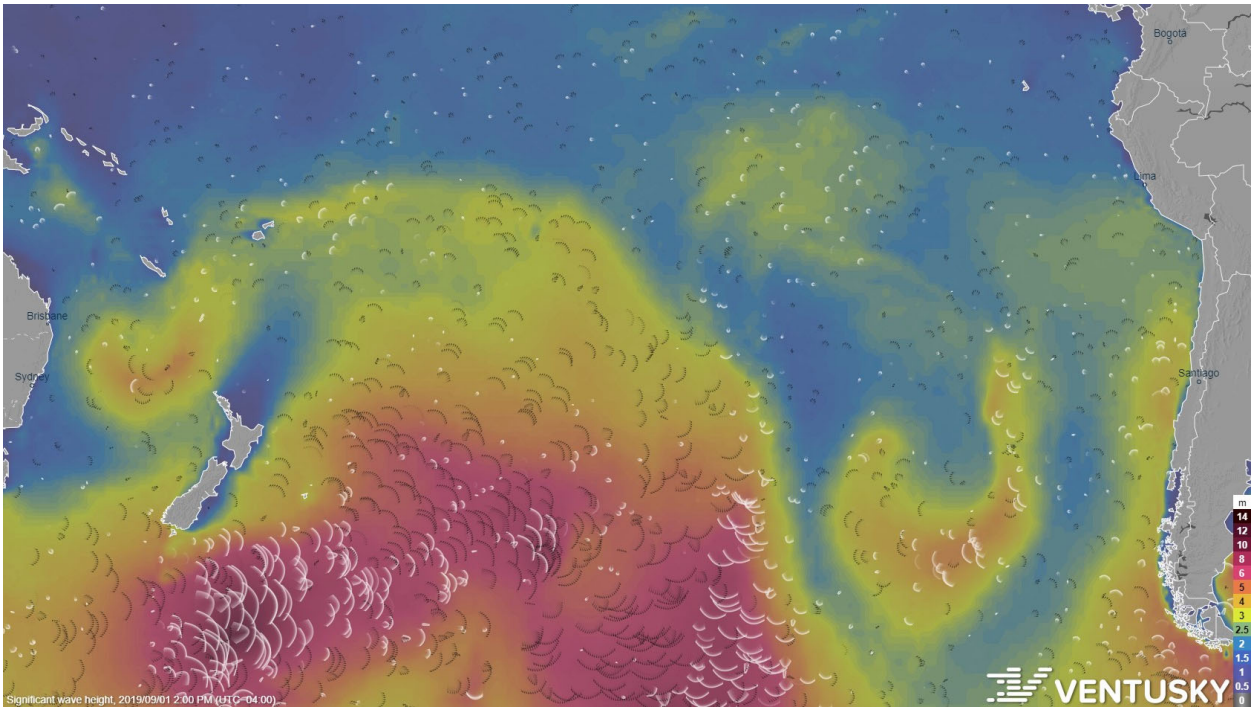


Figure 92 - Wave Heights September 1st, 2019

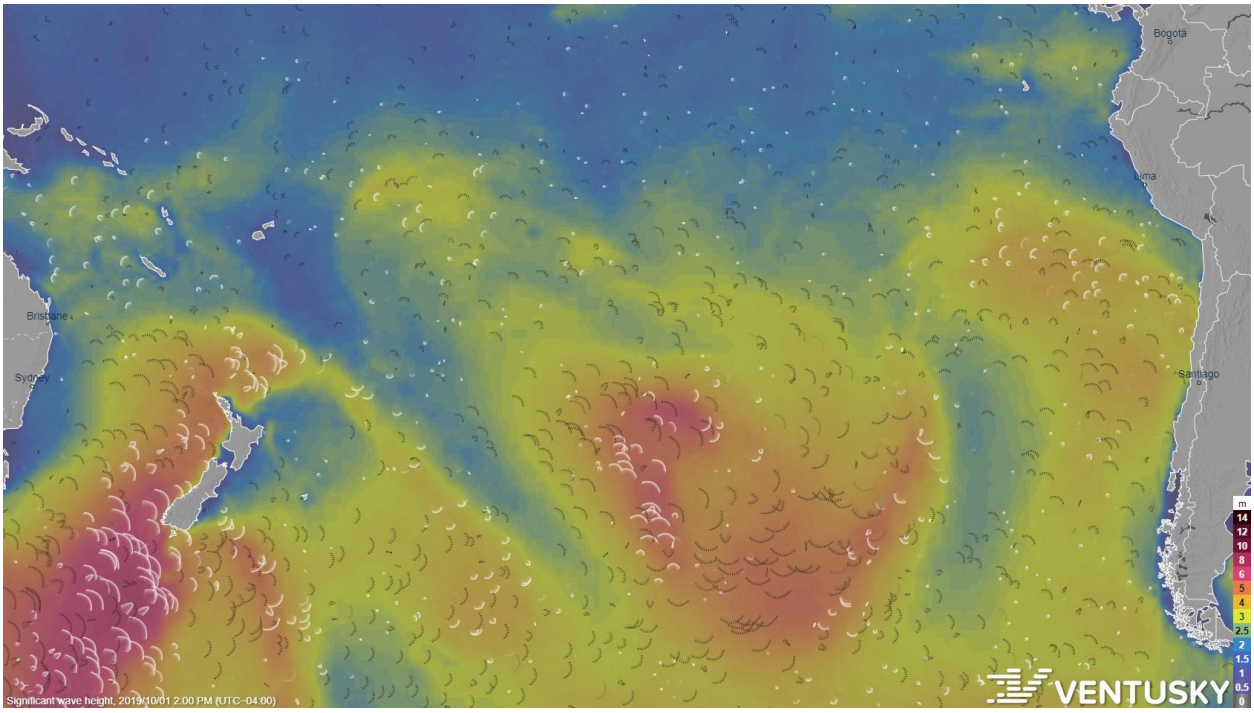


Figure 93 - Wave Heights October 1st, 2019

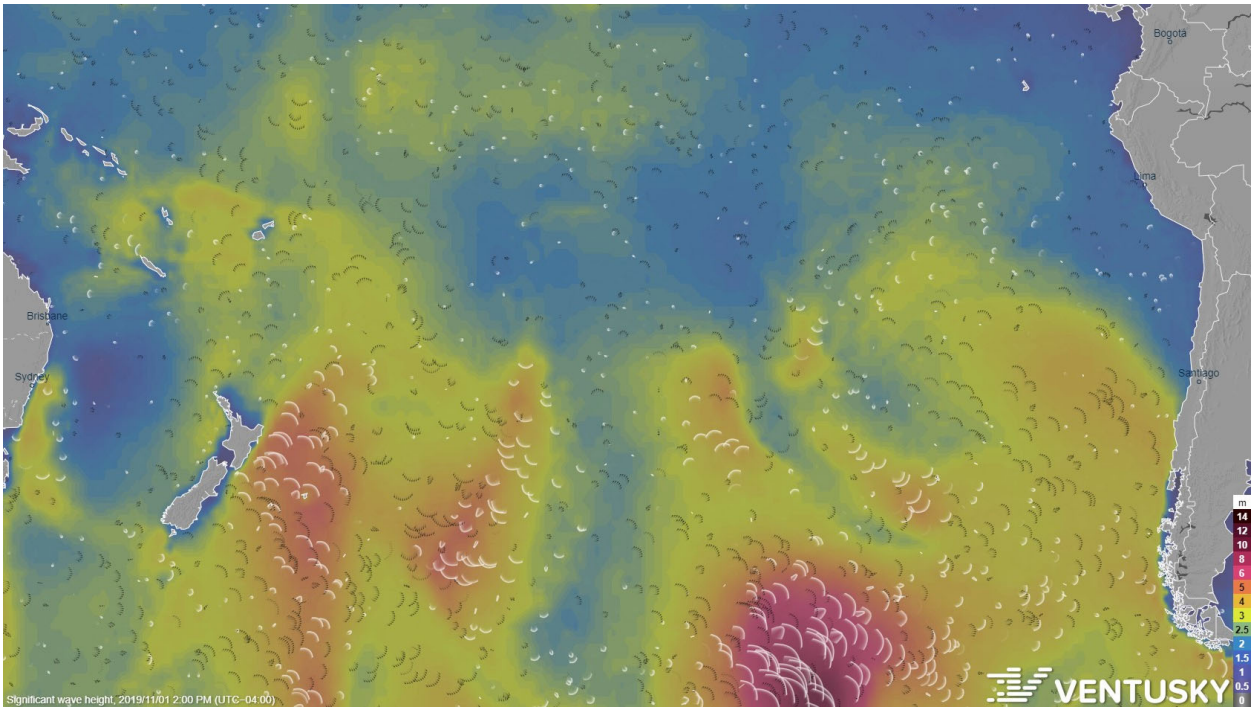


Figure 94 - Wave Heights November 1st, 2019

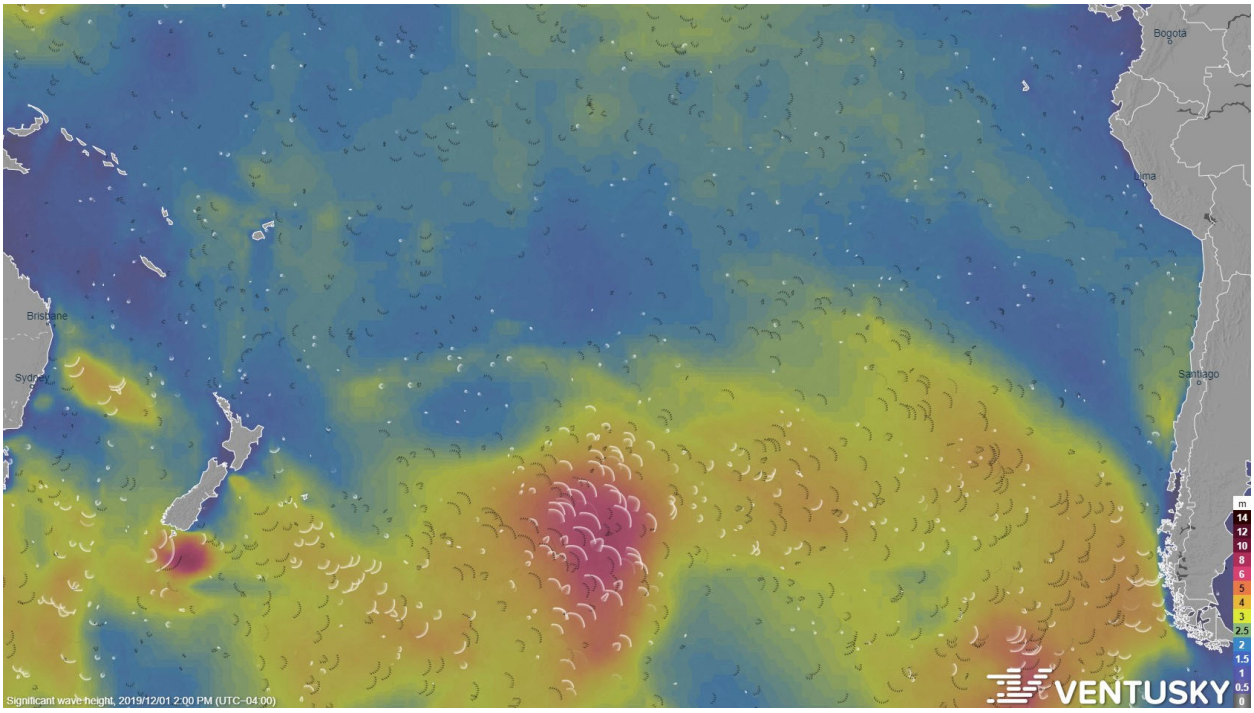


Figure 95 - Wave Heights December 1st, 2019

The following are wind speeds at 10m on the 1st day of each month.

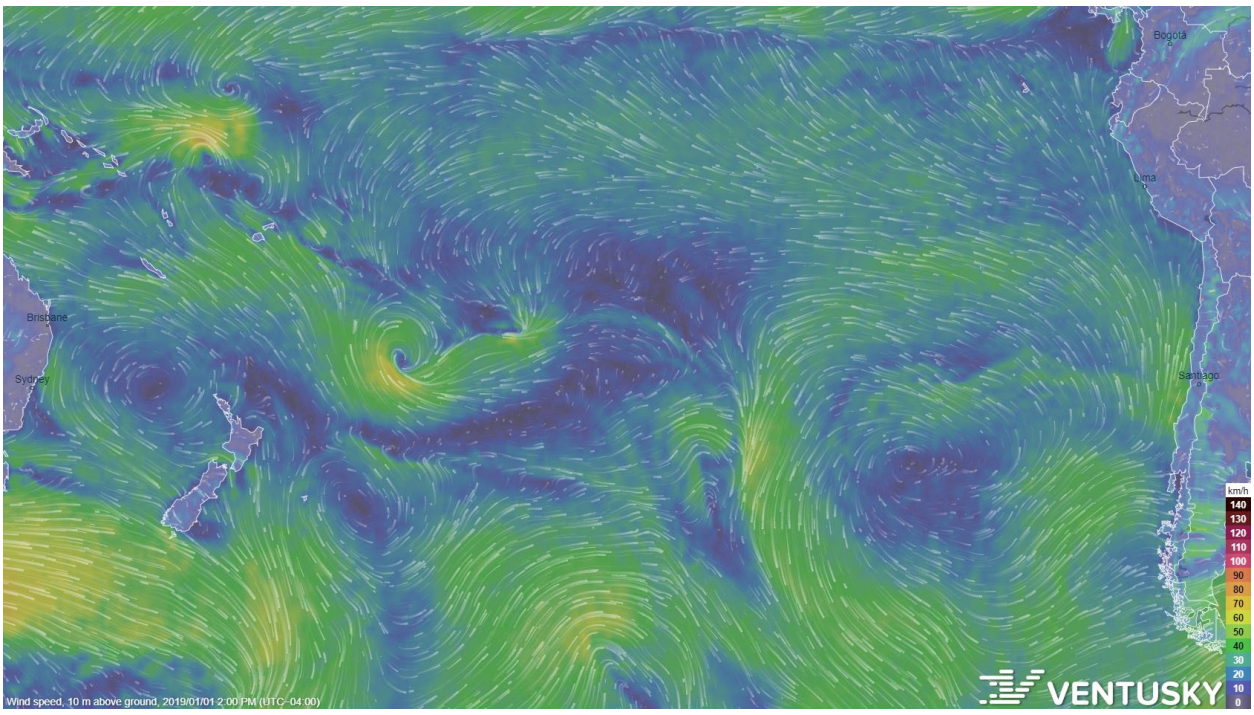


Figure 96 - Wind January 1st, 2019

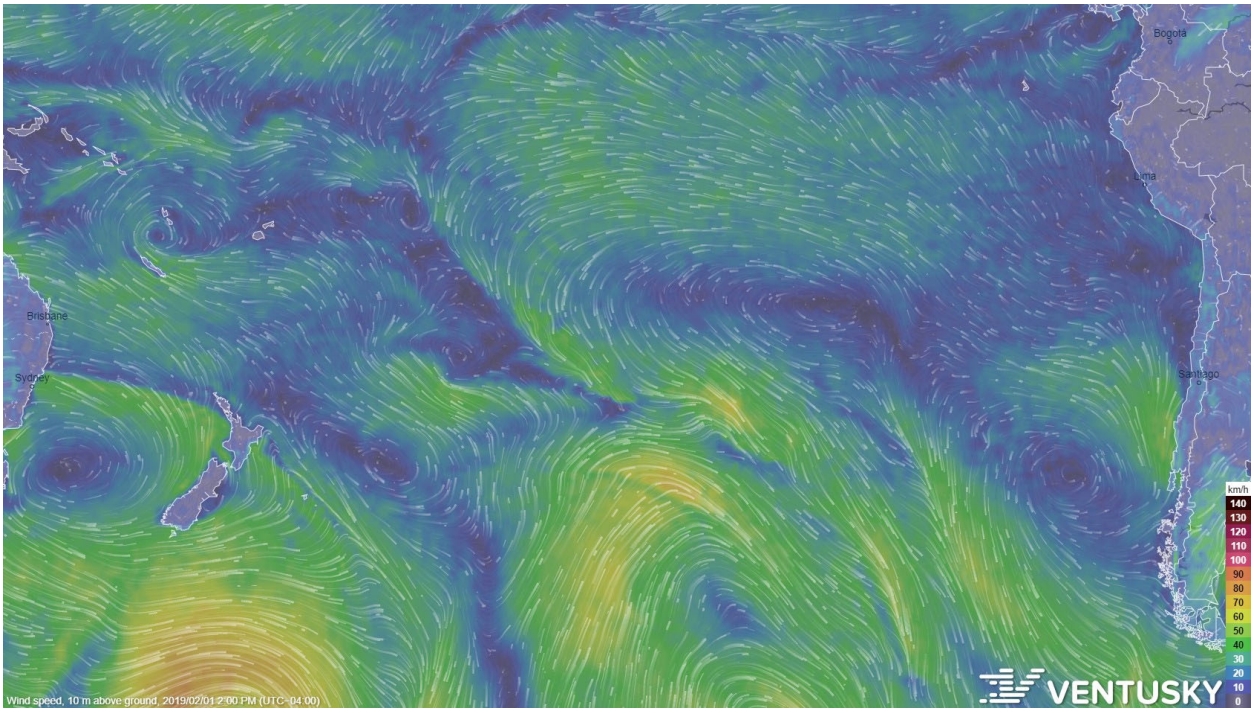


Figure 97 - Wind February 1st, 2019

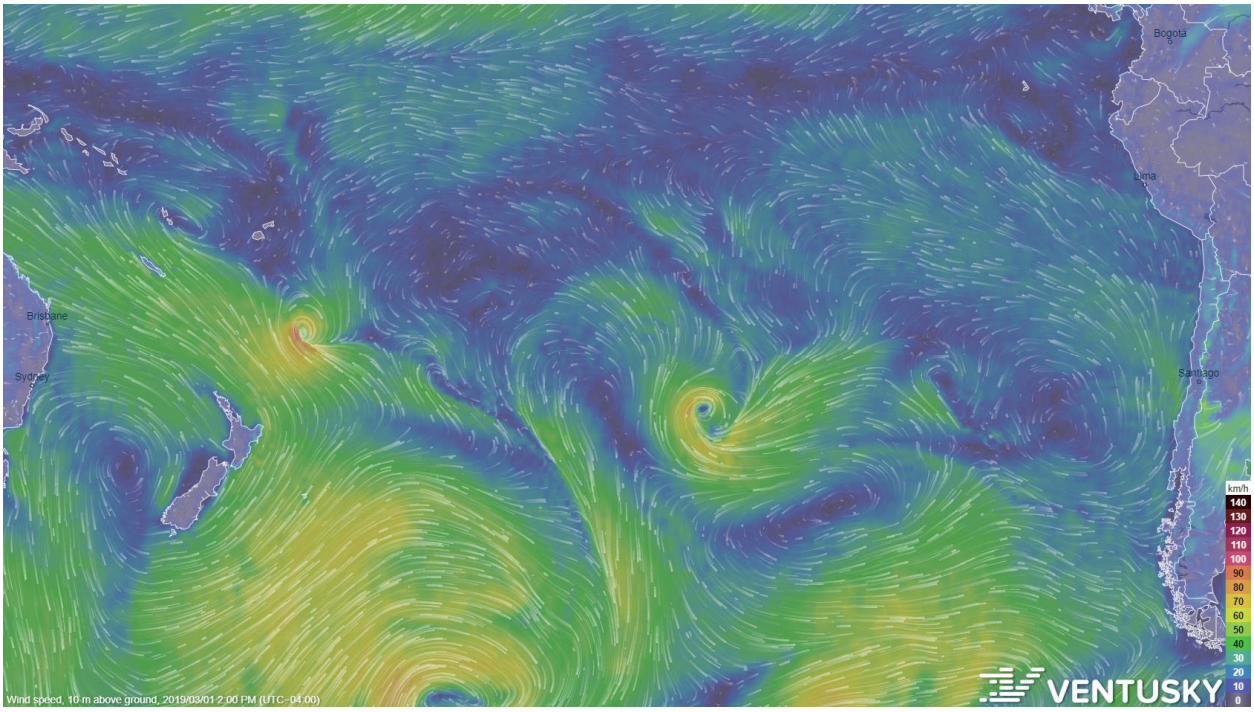


Figure 98 - Wind March 1st, 2019

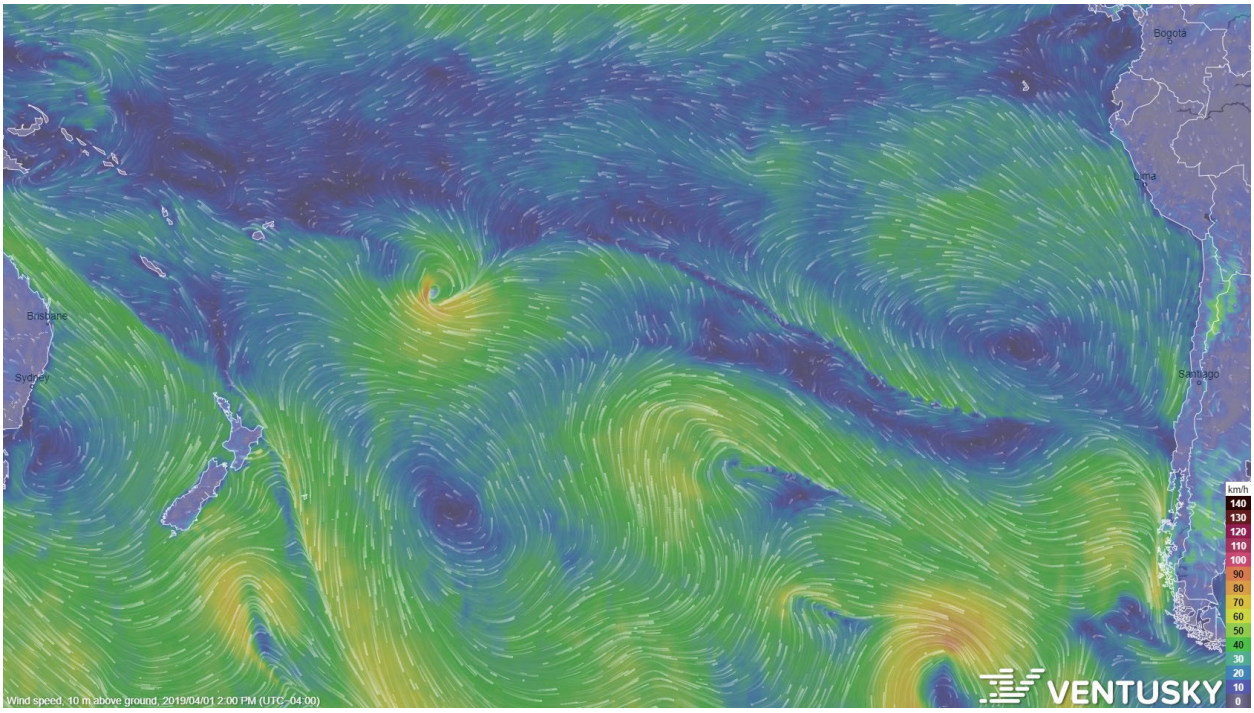


Figure 99 - Wind April 1st, 2019

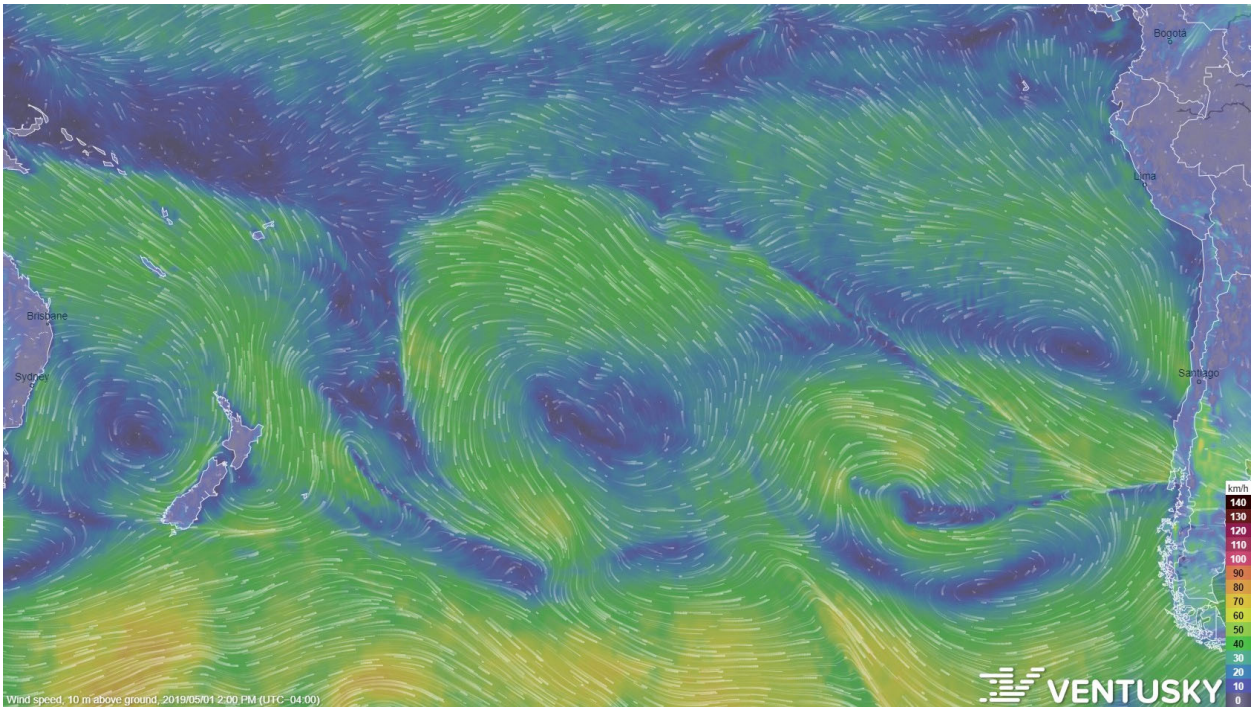


Figure 100 - Wind May 1st, 2019

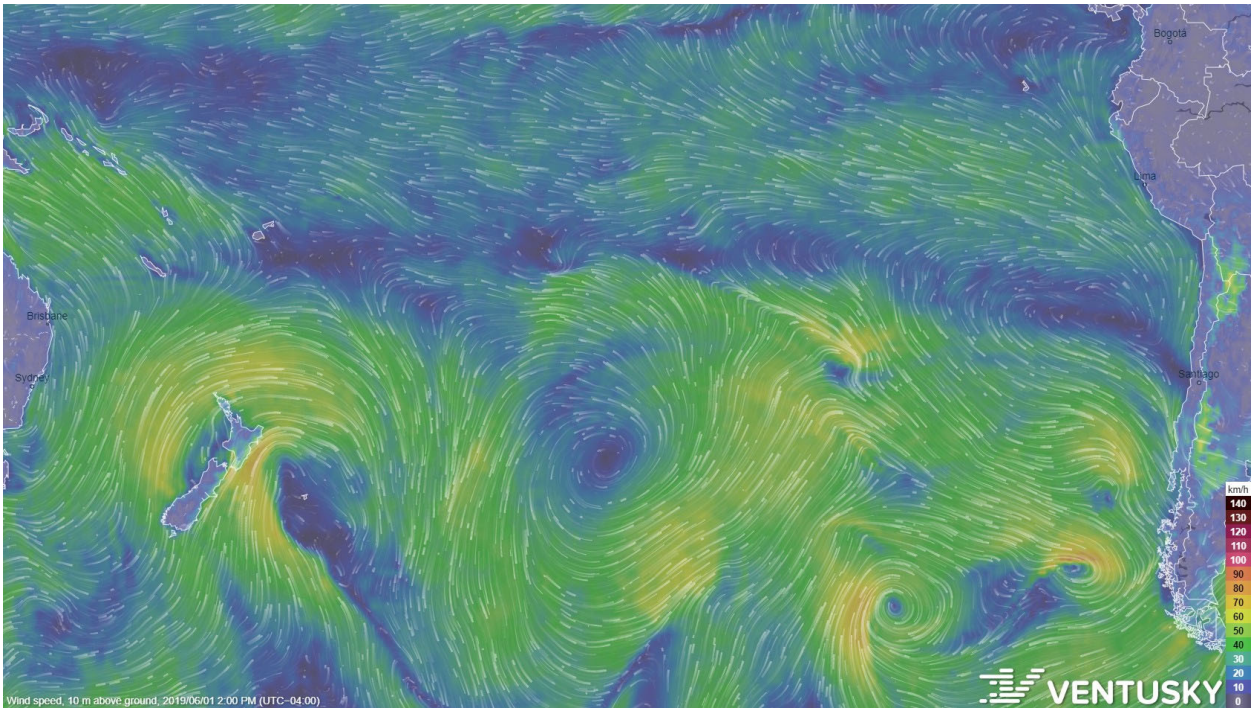


Figure 101 - Wind June 1st, 2019

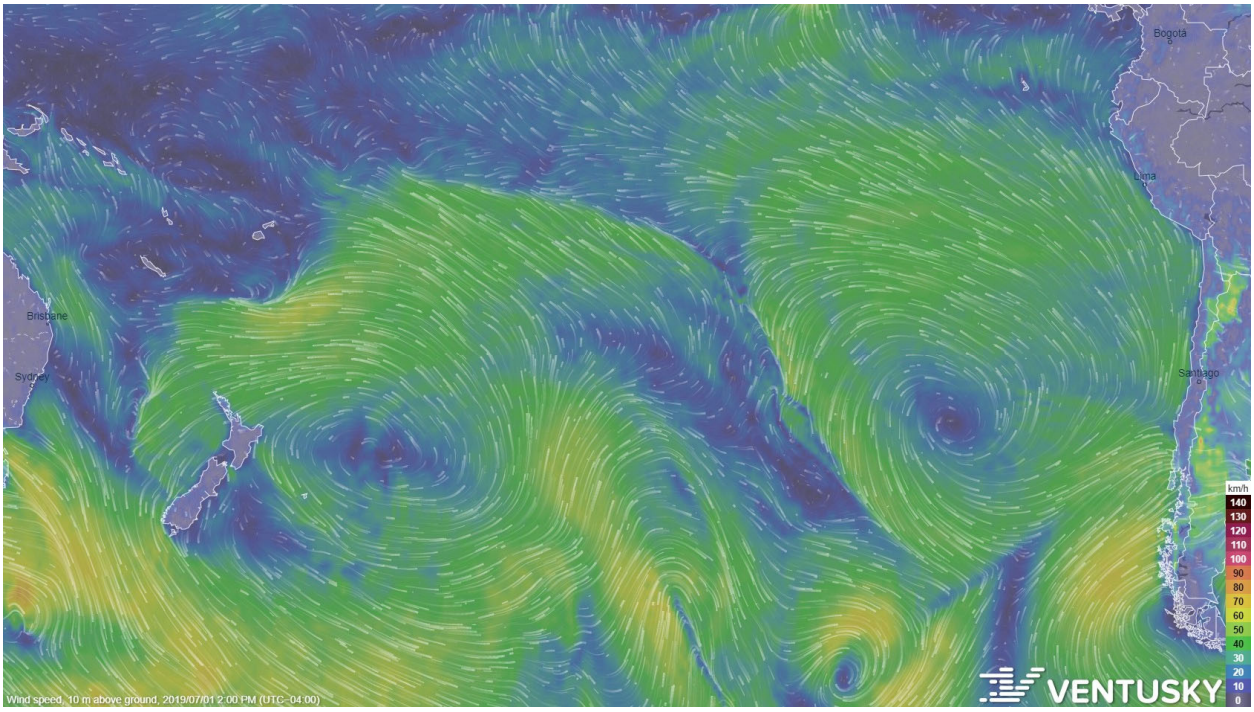


Figure 102 - Wind July 1st, 2019

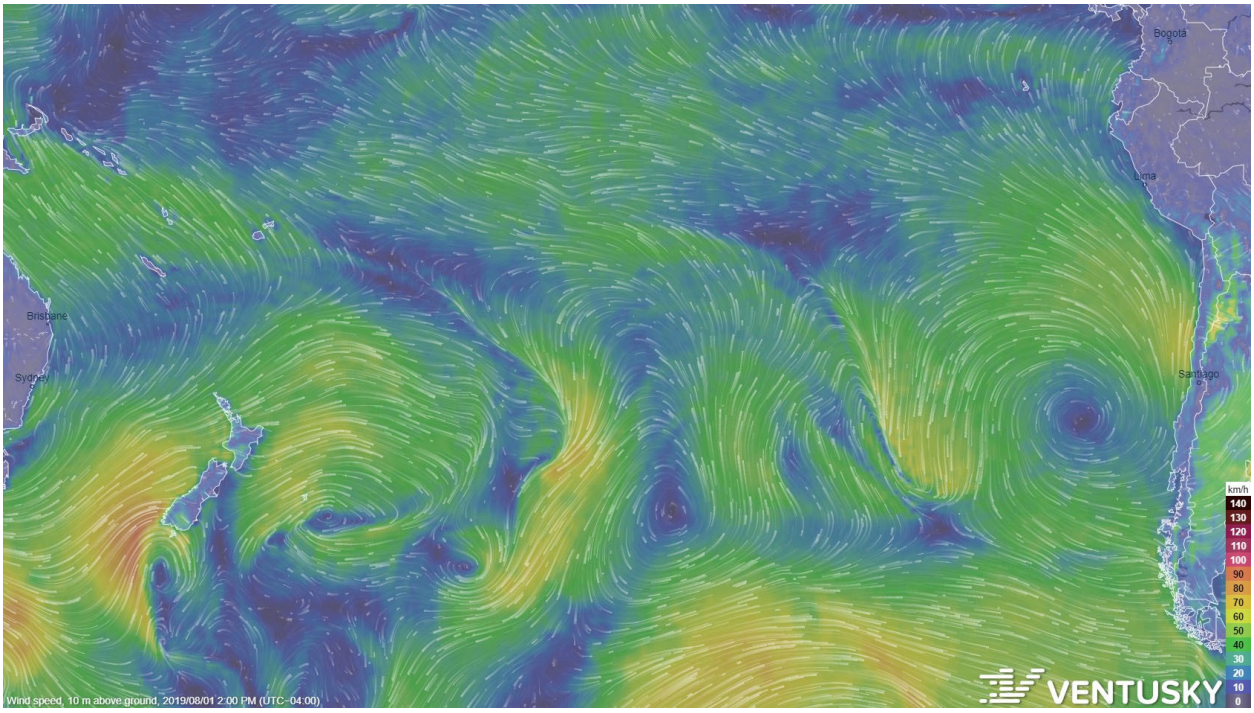


Figure 103 - Wind August 1st, 2019

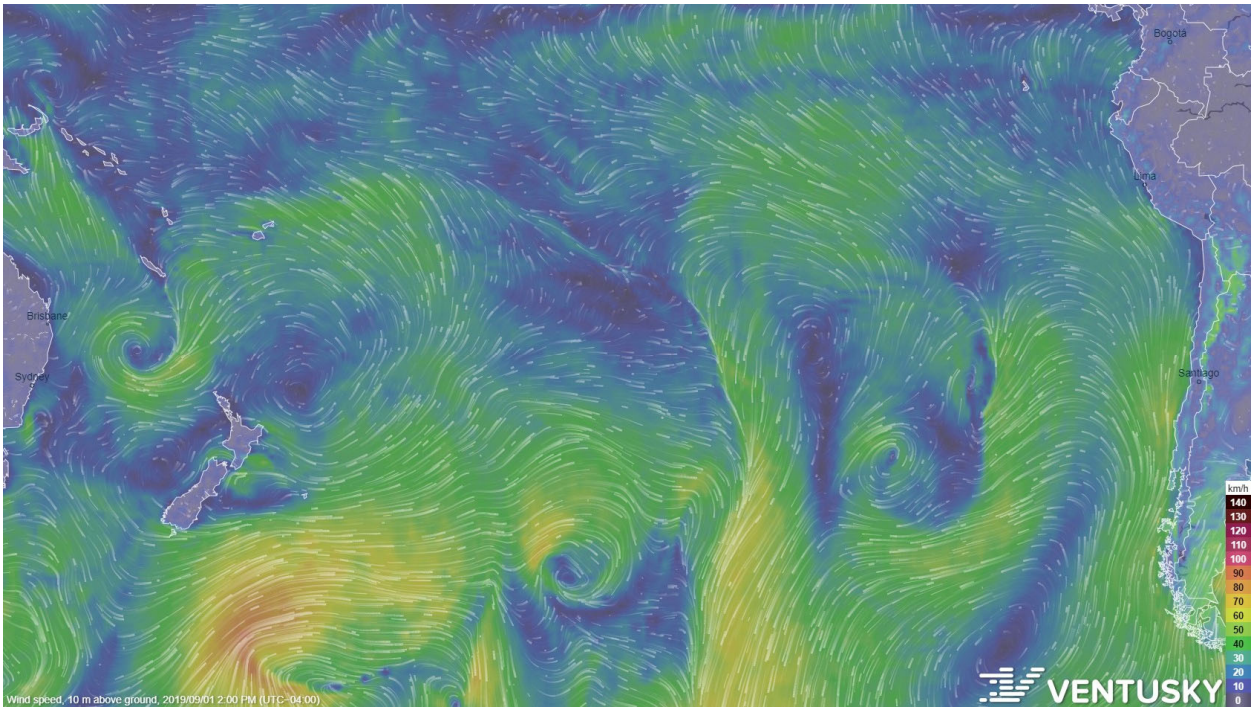


Figure 104 - Wind September 1st, 2019

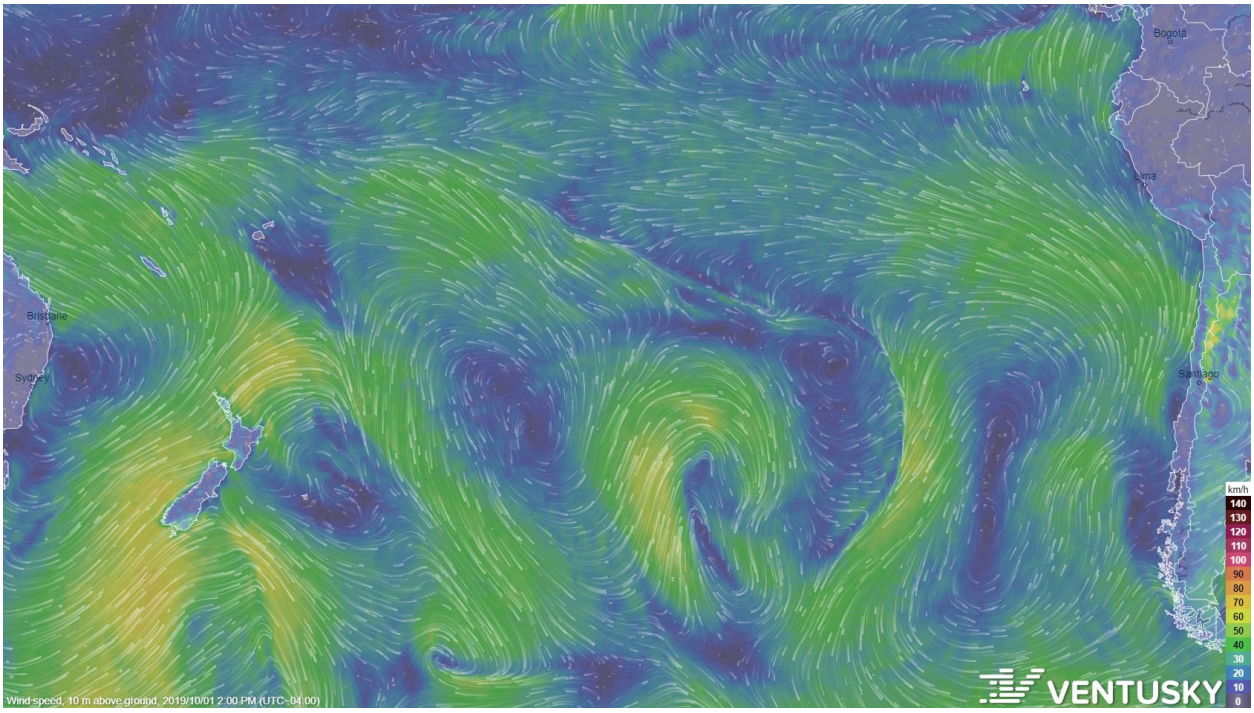


Figure 105 - Wind October 1st, 2019

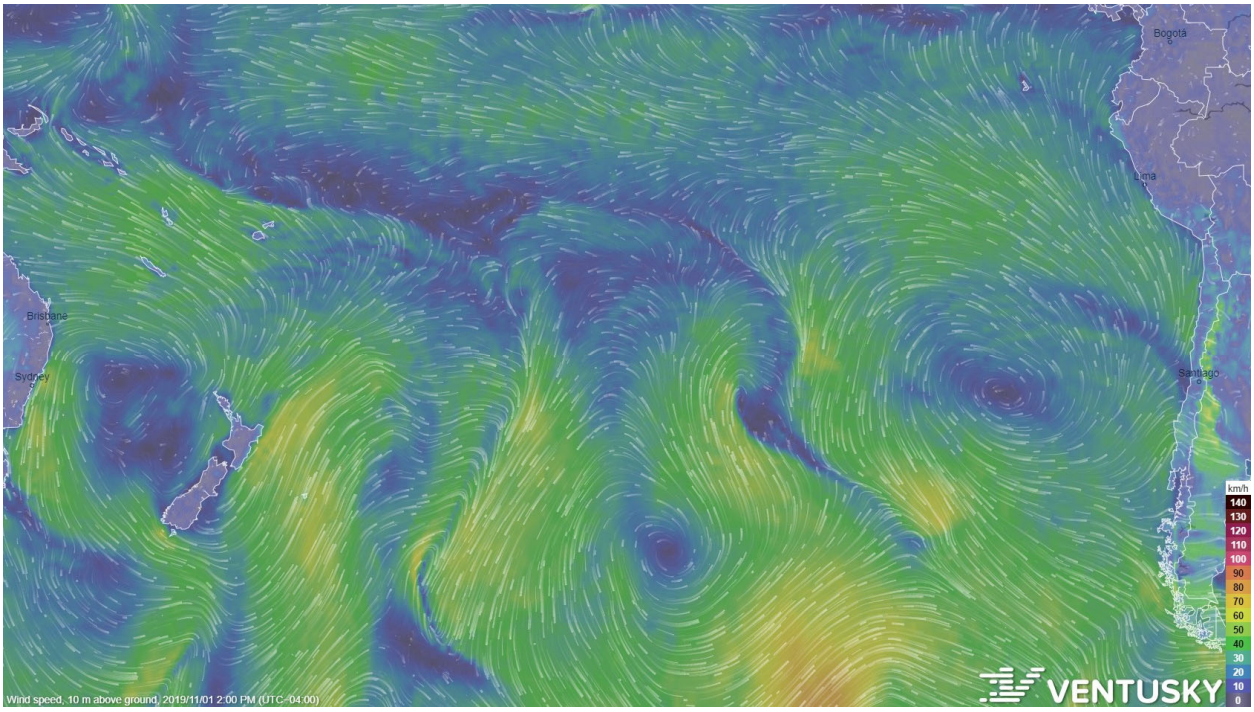


Figure 106 - Wind November 1st, 2019

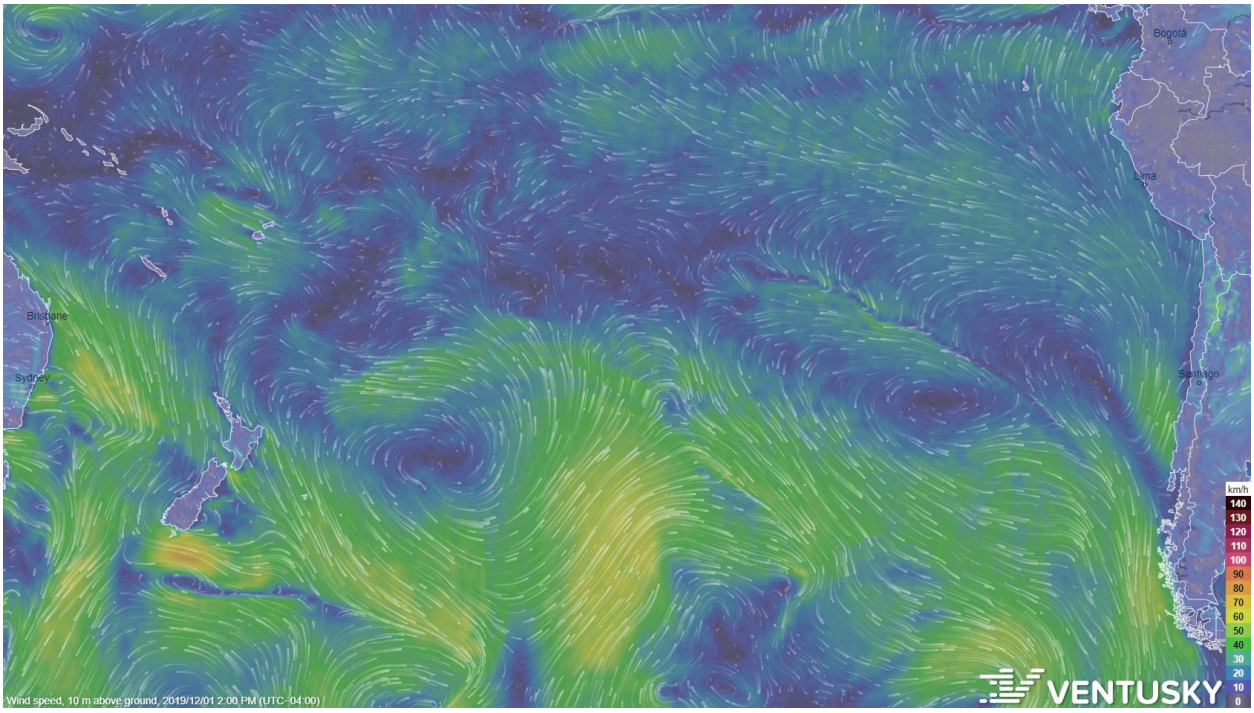


Figure 107 - Wind December 1st, 2019

As shown in the figures above, there is a trend of less-severe weather between the months of November and February. This observation is a general trend along the System's route and likely the best time to schedule survey and installation operations but does not preclude pop-up weather events from interfering with sea going operations, similar to any at-sea operational schedule. Proper allocation of weather days and port call contingency plans will be critical components of any at-sea operational plan.

Weather patterns the rest of the year may not completely rule out at-sea operations, especially landing site, nearshore, and continental shelf survey and installation activities, which could fit into localized weather windows if other externa factors preclude optimum dates of operation.

Proper cable protection schemes on the part of the Supplier, as determined using post-survey data, should prevent any potential weather-related cable damage.

7.3. Extreme Weather Conditions

Tropical cyclones are possible anywhere in the Pacific Ocean but are most likely between Auckland and Sydney. The following Neutral, El Nino and La Nina observed heat maps provide an historical representation of tropical cyclone activity between New Zealand and Australia.

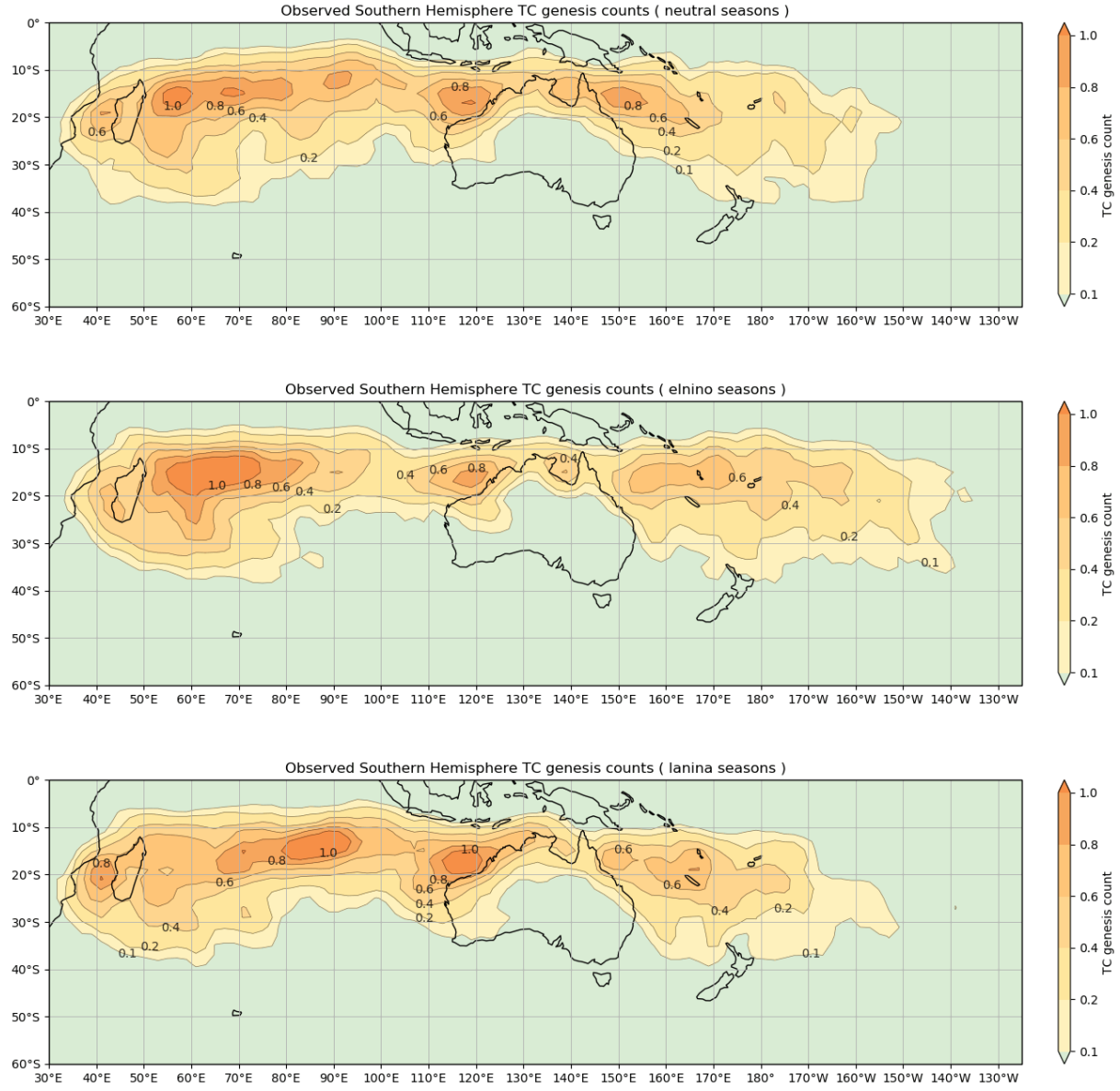


Figure 108 - Extreme Weather Conditions

The overall heat index in the Australian region have been rising in recent history and causing extreme drought and wildfires. These events could continue in future years causing possible delays to operations

7.4. Oceanography

The sea state varies greatly across the region of the cable route with open ocean swell effects on the Pacific, fetching and current-driven channel waves in the straits and shallow water chop in all bays and inlets. Wind and sea state conditions can degrade quickly with sudden storm events.

Table 10 - Beaufort Scale

Wind Force	Description	Speed km/h	Speed mph	Speed knots

0	Calm	<1	<1	<1
1	Light Air	1-5	1-3	1-3
2	Light Breeze	6-11	4-7	4-6
3	Gentle Breeze	12-19	8-12	7-10
4	Moderate Breeze	20-28	13-18	11-16
5	Fresh Breeze	29-38	19-24	17-21
6	Strong Breeze	38-49	25-31	22-27
7	Near Gale	50-61	32-38	28-33
8	Gale	62-74	39-46	34-40
9	Strong Gale	75-88	47-54	41-47
10	Storm	89-102	55-63	48-55
11	Violent Storm	103-117	64-72	56-63
12	Hurricane	118 plus	73 plus	64 plus

"The East Australian Current (EAC) is the southward western boundary current that is formed from the South Equatorial Current (SEC) crossing the Coral Sea and reaching the eastern coast of Australia. At around 15° S near the Australian coast the SEC divides forming the southward flow of the EAC. It is the largest ocean current close to the shores of Australia. The EAC reaches a maximum velocity at 30° S where its flow can reach 90 cm/s. As it flows southward it splits from the coast at around 31° to 32° S. By the time it reaches 33° S it begins to undergo a southward meander while another portion of the transport turns back northward in a tight recirculation. At this location the EAC reaches its maximum transport of nearly 35 Sv (35 billion liters per second). The majority of the EAC flow that does not recirculate will move eastward into the Tasman Front crossing the Tasman Sea just north of the cape of New Zealand. The remaining will flow south on the EAC Extension until it reaches the Antarctic Circumpolar Current. The Tasman Front transport is estimated at 13 Sv. The eastward movement of the EAC through the Tasman Front and reattaching to the coastline of New Zealand forms the East Auckland Current. The EAC also acts to transport tropical marine fauna to habitats in sub-tropical regions along the south east Australian coast." (Wikimedia Foundation, 2020)

7.4.1. Surface, Mid-Water Depth and Bottom Currents

Strong currents pose a risk to cable lay and burial operations. Depending on the direction of the current with respect to the direction of the cable route, strong surface currents can affect a cable vessel's ability to maintain dynamic positioning. This is less of an issue for surface lay operations, because the vessel can crab along the route to a larger degree. However, it is a significant problem for plow operations because plows can only be launched, towed and recovered with a vessel offset angle of less than ~20°.

Mid-water depth currents cause an issue for surface lay in deep water, because the cable catenary can act as a sail in the water column, resulting in an as-laid Route Position List offline from the planned location.

Strong bottom currents pose a risk for burial operations (plows and ROVs) because it can be difficult to tow along the planned route and maintain position.

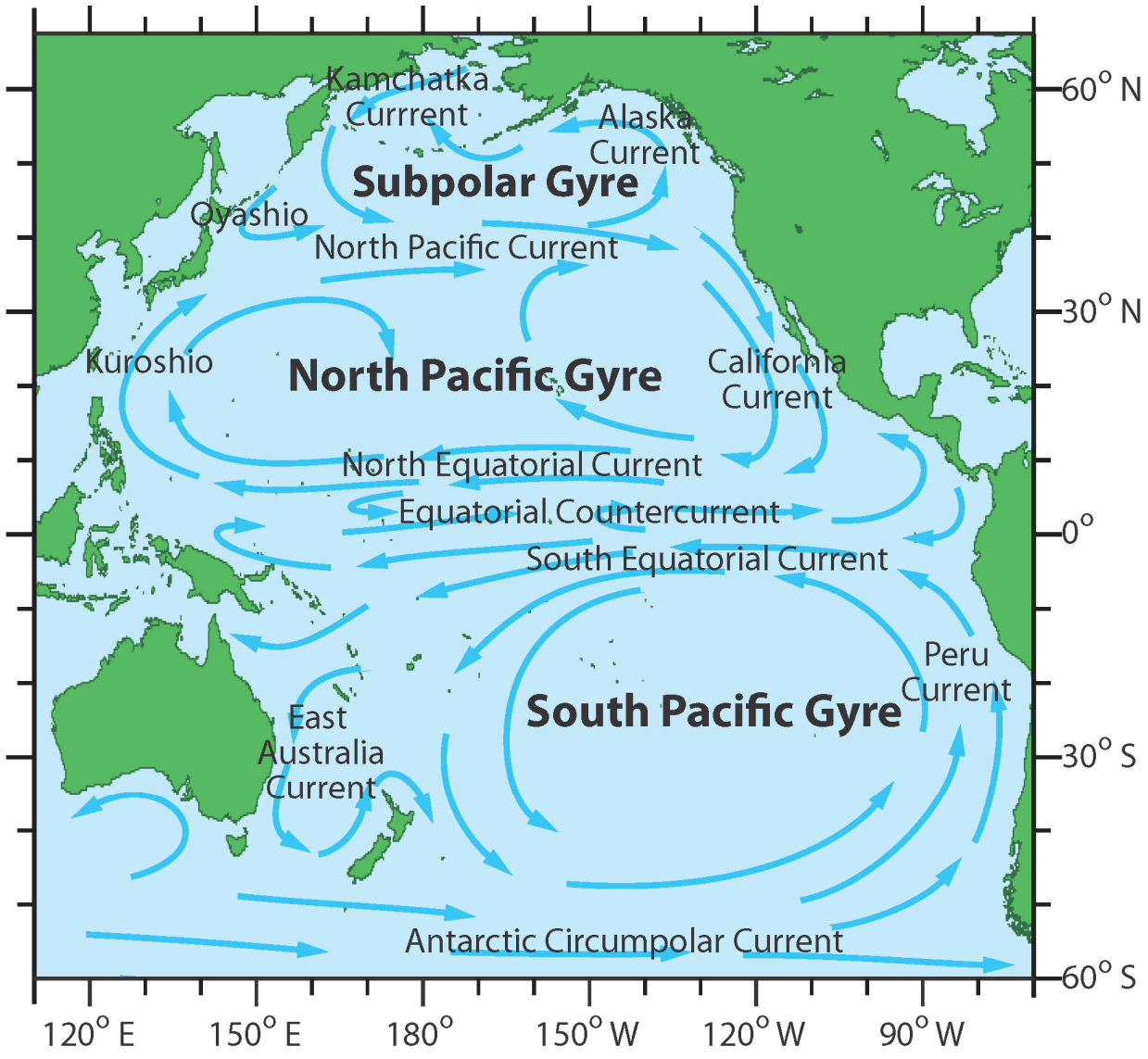


Figure 109 - Major Currents

Figure 109 shows the South Pacific Gyre and East Australia Current, both will have an effect on the installation of the System but not to an extent that precludes normal dynamic positioning operations.

7.4.2. Sea Surface Temperatures

"Sea surface temperature (SST) is the water temperature close to the ocean's surface. The exact meaning of surface varies according to the measurement method used, but it is between 1 millimeter (0.04 in) and 20 metres (70 ft) below the sea surface. Air masses in the Earth's atmosphere are highly modified by sea surface temperatures within a short distance of the shore. Localized areas of heavy snow can form in bands downwind of warm water bodies within an otherwise cold air mass. Warm sea surface temperatures are known to be a cause of tropical cyclogenesis over the Earth's oceans. Tropical cyclones can also cause a cool wake, due to turbulent mixing of the upper 30 metres (100 ft) of the ocean. SST

changes diurnally, like the air above it, but to a lesser degree. There is less SST variation on breezy days than on calm days. (Wikimedia Foundation, 2020)

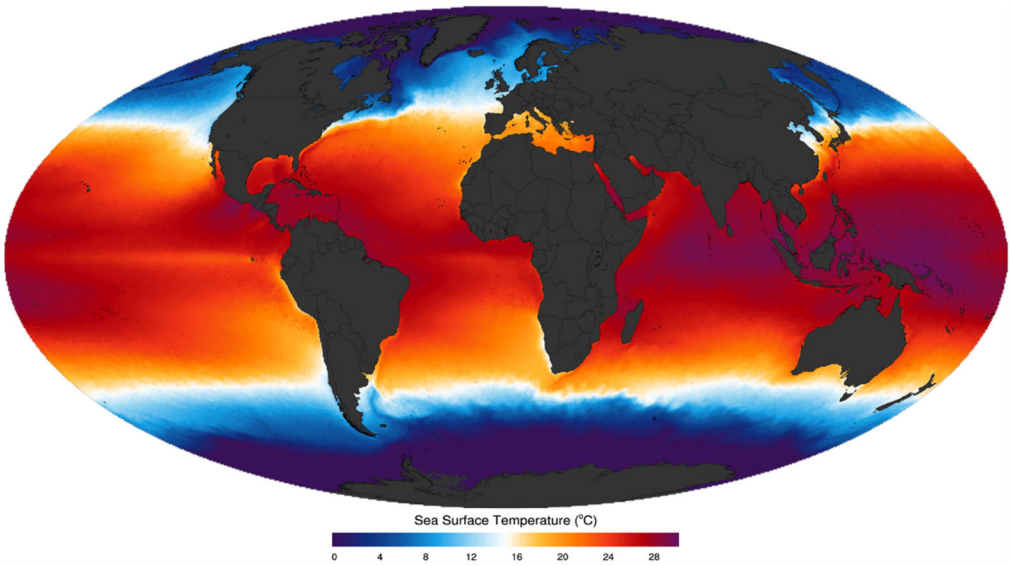


Figure 110 - MODIS Aqua sea surface temperature 2003-2011 average.

Refer to a monthly snapshot of sea surface temperatures in section 7.2 to review the variations of SST over the course of the year along the route.

7.4.3. Wave Action

"In fluid dynamics, wind waves, or wind-generated waves, are water surface waves that occur on the free surface of bodies of water. They result from the wind blowing over an area (or fetch) of fluid surface. Waves in the oceans can travel thousands of miles before reaching land. Wind waves on Earth range in size from small ripples, to waves over 100 ft (30 m) high, being limited by wind speed, duration, affected area and water depth.

When directly generated and affected by local waters, a wind wave system is called a wind sea (or wind waves). Wind waves will travel in a great circle route after being generated - curving slightly left in the southern hemisphere and slightly right in the northern hemisphere. After moving out of the area of fetch, wind waves are called swells and can travel thousands of miles. A noteworthy example of this are waves generated south of Tasmania during heavy winds that will travel to southern California producing desirable surfing conditions. More generally, a swell consists of wind-generated waves that are not significantly affected by the local wind at that time. They have been generated elsewhere or some time ago. Wind waves in the ocean are called ocean surface waves.

Wind waves have a certain amount of randomness: subsequent waves differ in height, duration, and shape with limited predictability. They can be described as a stochastic process, in combination with the physics governing their generation, growth, propagation, and decay—as well as governing the interdependence between flow quantities such as: the water surface movements, flow velocities and water pressure. The key statistics of wind waves (both seas and swells) in evolving sea states can be predicted with wind wave models." (Foundation, Wikimedia, 2020)

The System will experience wave action near shore; however, the use of plough burial and HDD should mitigate any movement. There is a risk of sediment transport due to the currents and in extreme cases the orbital motion of the waves during storm events, causing sediment movement and erosion.

7.4.4. Long Shore Currents

Longshore currents are tidal and wave-generated currents that transport sediment along the coast between the surf zone and the shoreline. They are created when a breaking wave strikes the shoreline at an angle. The momentum of the breaking wave has an along shore component in the direction of wave propagation. This creates longshore currents with flow paralleling the beach inside the breaker zone.

7.4.5. Tidal Flows

The tidal flows in and around each of the five landings for the System will have some impact to the timing of the installation around the days of installation nearshore. Prior to survey or installation activities, the standard practice is to review the tide charts, identify any predicted anomalies and adjust the operational plan, as necessary. It is not anticipated that the tidal flows will require special or extraordinary accommodations by the cable installer.

7.4.6. Tidal Currents

“The tides' influence on current flow is much more difficult to analyze, and data is much more difficult to collect. A tidal height is a simple number which applies to a wide region simultaneously. A flow has both a magnitude and a direction, both of which can vary substantially with depth and over short distances due to local bathymetry. Also, although a water channel's center is the most useful measuring site, mariners object when current-measuring equipment obstructs waterways. A flow proceeding up a curved channel is the same flow, even though its direction varies continuously along the channel. Surprisingly, flood and ebb flows are often not in opposite directions. Flow direction is determined by the upstream channel's shape, not the downstream channel's shape. Likewise, eddies may form in only one flow direction.

Nevertheless, current analysis is similar to tidal analysis: in the simple case, at a given location the flood flow is in mostly one direction, and the ebb flow in another direction. Flood velocities are given positive sign, and ebb velocities negative sign. Analysis proceeds as though these are tide heights.

In more complex situations, the main ebb and flood flows do not dominate. Instead, the flow direction and magnitude trace an ellipse over a tidal cycle (on a polar plot) instead of along the ebb and flood lines. In this case, analysis might proceed along pairs of directions, with the primary and secondary directions at right angles. An alternative is to treat the tidal flows as complex numbers, as each value has both a magnitude and a direction.

Tide flow information is most commonly seen on nautical charts, presented as a table of flow speeds and bearings at hourly intervals, with separate tables for spring and neap tides. The timing is relative to high water at some harbor where the tidal behavior is similar in pattern, though it may be far away.

As with tide height predictions, tide flow predictions based only on astronomical factors do not incorporate weather conditions, which can completely change the outcome.” (Foundation, Wikimedia, 2020)

No significant tidal currents should affect operations at any of the landings with proper planning.

7.4.7. Tsunamis

See section 5.2 for details concerning tsunamis.

7.5. Summary of Impacts on the Submarine Cable by the Physical Environment

The physical environment has the potential to cause serious damage to the submarine cable and terrestrial facilities over its lifetime of service. Currents induced by tidal flows, storms and longshore currents can move, vibrate, or even displace the cable from its secured position. The added complexity of river discharge interacting with tidal and wind/wave forces along the Auckland and Sydney landings will increase the risk to survey and installation operations.

Each landing has the potential to be affected by tsunamis, but the timing and severity is hard to predict; therefore, each landing should incorporate tsunami cable station and nearshore approach engineering principles during the design of the System.

All but the Auckland landing is directly exposed to the open ocean and high seas/surf nearshore. Proper cable engineering to ensure cable stability on the seabed will be necessary.

Marine survey and installation operations could be impacted by inclement weather and/or sea conditions. These factors need to be addressed in the installation program plan and associated contract to mitigate the logistics and associated costs with weather delays.

8. Fisheries

8.1. Fishing Statistics

Commercial and recreational fishing is highly active along the continental shelves of all System landings, except Juan Fernández and Easter Island, where most fishing is artisanal or recreational.

Table 11 - General Fishing Statistics Types of Fishing and Equipment (FAO)

Land Area	Trade flow	Commodity	2018
Australia	Exports	Crustaceans	13 479
		Fish	30 001
		Fish, crustaceans, mollusks and other aquatic invertebrates	5 024
		Mollusks, aquatic invertebrates	3 291
	Sub-total Exports		51 795
	Processed production	Crustaceans	4 451 *F*
		Fish	15 592 *F*
		Fish, crustaceans, mollusks and other aquatic invertebrates	5 000 *F*
		Mollusks, aquatic invertebrates	1 182 *F*
	Sub-total Processed production		26 225 *F*
Total Australia			78 020
Chile	Exports	Crustaceans	8 648
		Fish	830 165
		Fish, crustaceans, mollusks and other aquatic invertebrates	378 533
		Mollusks, aquatic invertebrates	168 608
	Sub-total Exports		1 385 954
	Processed production	Crustaceans	10 492
		Fish	663 610
		Fish, crustaceans, mollusks and other aquatic invertebrates	477 493
		Mollusks, aquatic invertebrates	178 830
	Sub-total Processed production		1 330 425
Total Chile			2 716 379
New Zealand	Exports	Crustaceans	3 543
		Fish	184 725
		Fish, crustaceans, mollusks and other aquatic invertebrates	25 572
		Mollusks, aquatic invertebrates	53 515
	Sub-total Exports		267 355
	Processed production	Crustaceans	674 *F*
		Fish	163 844 *F*
		Fish, crustaceans, mollusks and other aquatic invertebrates	39 140 *F*
		Mollusks, aquatic invertebrates	50 726 *F*
	Sub-total Processed production		254 384 *F*
Total New Zealand			521 739
Grand total			3 316 138

8.2. Fishing Hazards

Commercial, artisanal, and recreational fishing is active and performed year-round. The cable route is proposed to be surface laid deeper than 1500 meters offshore all landings and thus could be impacted by

commercial fishing activities. Chilean, New Zealand, Australian and foreign commercial fishing vessels tend to fish the 500 meter to 1000 meter depth regime; however, this is not always true. If, upon further research with direct contact with relevant government officials, the commercial fishing industry regulations and associated permitting do not allow for strict avoidance of cable areas or particular depth regimes, then 100% cable burial to the allowable plough limits or known-to-be-used fishing equipment might be advantageous.

Horizontal and vertical longlines can range in length from 200 to 2,000 meters but lengths of 400 to 800 meters are more common. The quantity of hooks attached varies from 100 to 500 hooks. A bottom longline fishing rig is a main line with several branch lines that remained laid on the seafloor with an anchor at each end. Individual hooks are attached to each additional line. The fishing technique is therefore static, but problems can arise during retrieval. The force generated by the hauling winch when trying to clear a long line snagged on a cable has been estimated as 4 tons. Lost lines are recovered by towing a grapnel across the seabed.

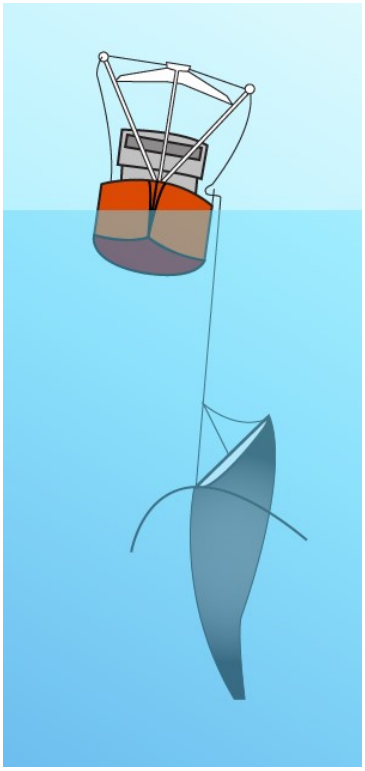


Figure 111 - Trawling Cable Snag

Suspended mid-water longline fishing and trawling can also be a risk to submarine cable during the laying operation. If the cable is laid across a suspended longline, the weight of the cable will eventually sink the buoys and the steel longline and/or hooks will damage the insulation of the submarine cable causing shunt faults. It has also been known for the cable to remain in suspension over these suspended longlines for several months and then, over time, abrasion faults occur at the cable touchdown points. When cable is being laid in areas where suspended longline fishing is prevalent, it is advisable for a grapnel be deployed over the bow of the laying cableship, or a small ship to precede the cableship with a grapnel deployed to the appropriate depth.

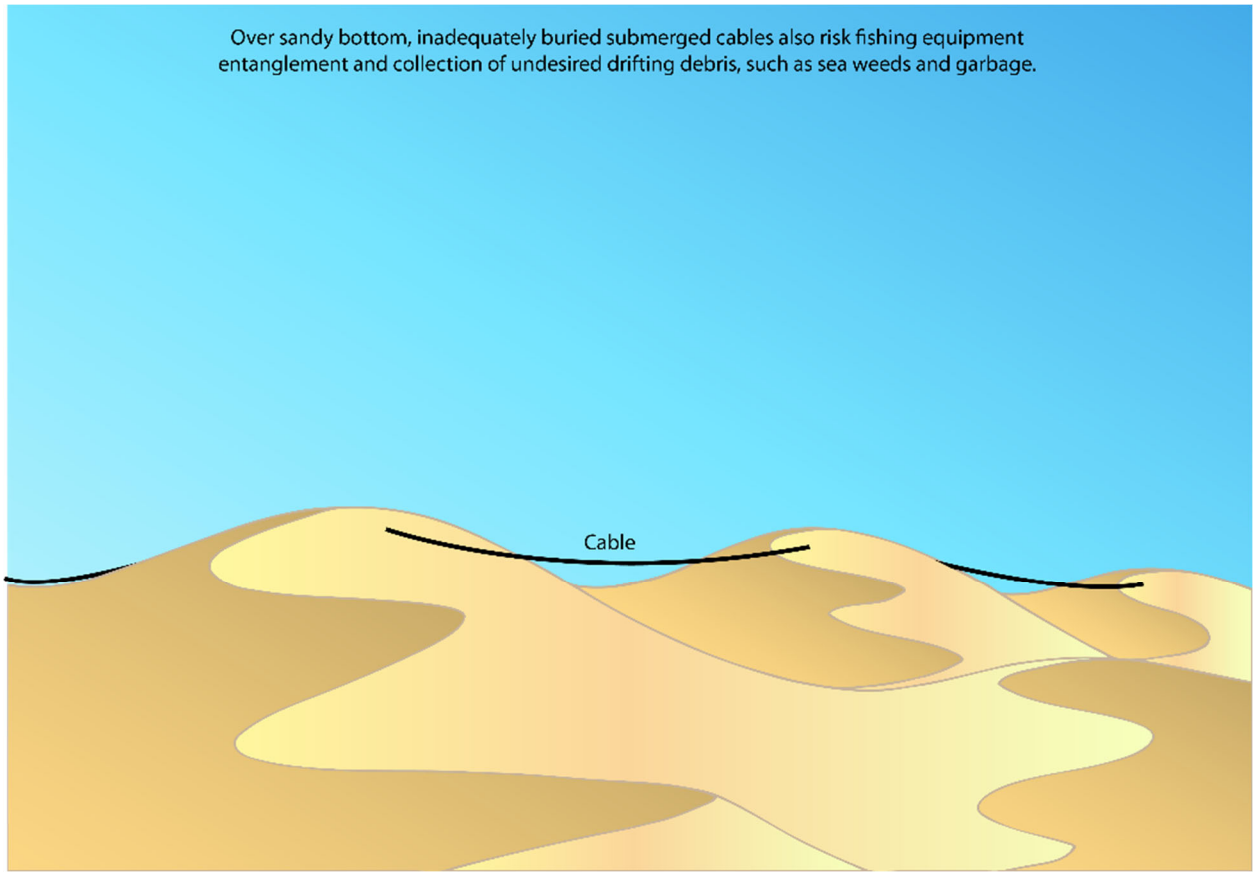


Figure 112 - Cable Suspensions

8.3. Summary of Impacts on the Submarine Cable by Fishing Activity

Most of the risk to the cable system due to fishing activity is located on the approaches to each landing from deep water. There are gill nets, long lines, otter board trawlers and crab pots known to be used between the shore and 1500+ meters water depth. A definitive maximum water depth for known impactful fishing techniques was not determined during this study. It is recommended that the AIS positioning data for all types of commercial fishing vessels be requested from each Government authority to be used by the cable supplier prior to marine survey operations to ascertain the overall risk. Interviews with the identified fishing vessel owners/companies should be performed to correlate their fishing gear usage procedures and ensure they have knowledge of submarine cable emergency "snagging" procedures and the Owner's contact escalation plan.

Offshore Sydney, Auckland and Valparaiso the trawling community has previously suggested during other submarine cable installations that cable burial is required down to 1500 meters water depth to a minimum burial depth of 1m. No documentation was supplied by the other System owners to corroborate the informal knowledge WFNS has acquired.

9. Marine Activities

9.1. Shipping and Port Activities

The presence of large vessels, such as cruise ships and commercial fishing boats, pose an inherent risk due to accidental grounding, inadvertent anchorage, or fishing activity. There are also scientific and military activities, albeit infrequent, using large vessels capable of damaging a submarine cable. A cable awareness public information campaign should be designed as part of the overall maintenance strategy and implemented prior to marine survey activities.

9.2. Shipping Fairways and Anchorages

The System does not cross charted anchorages. Shipping fairway crossings are minimized in the route design and generally only constitute a risk if a vessel sinks or has an emergency requiring anchorage, which is rare.

9.3. Maritime Boundaries

The System lies within the UNCLOS-recognized maritime boundaries of Chile, New Zealand and Australia. Figure 113 shows the entire route and EEZs. The only EEZ the System approaches close to but does not cross, besides those listed above, is that of French Polynesia (France).

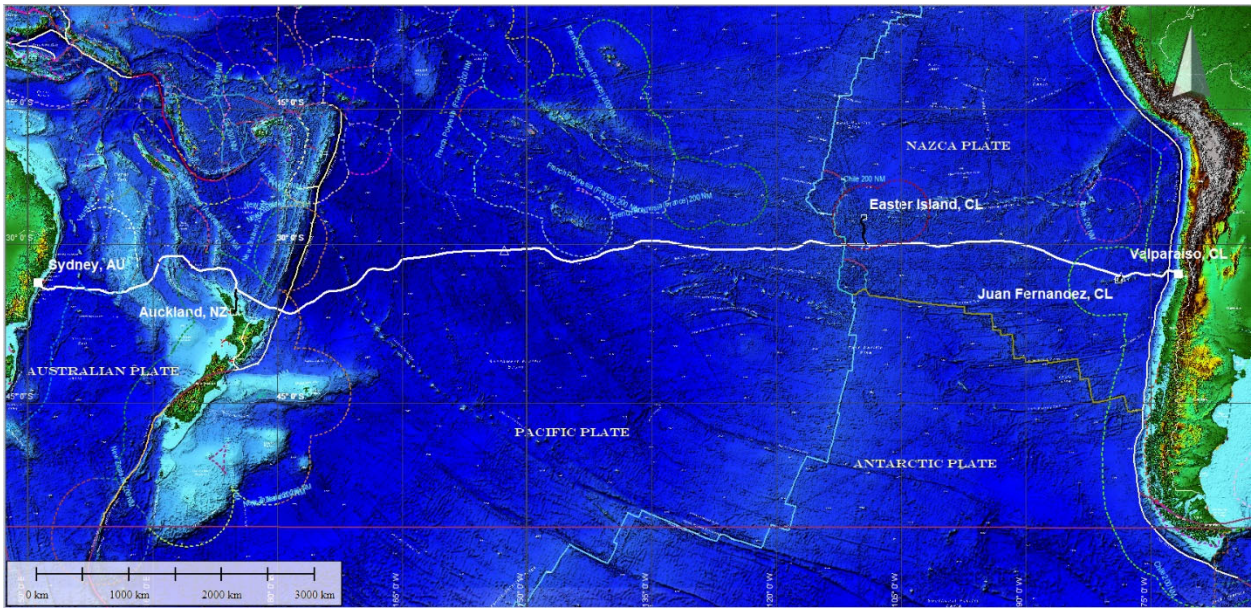


Figure 113 - EEZ Boundary Map

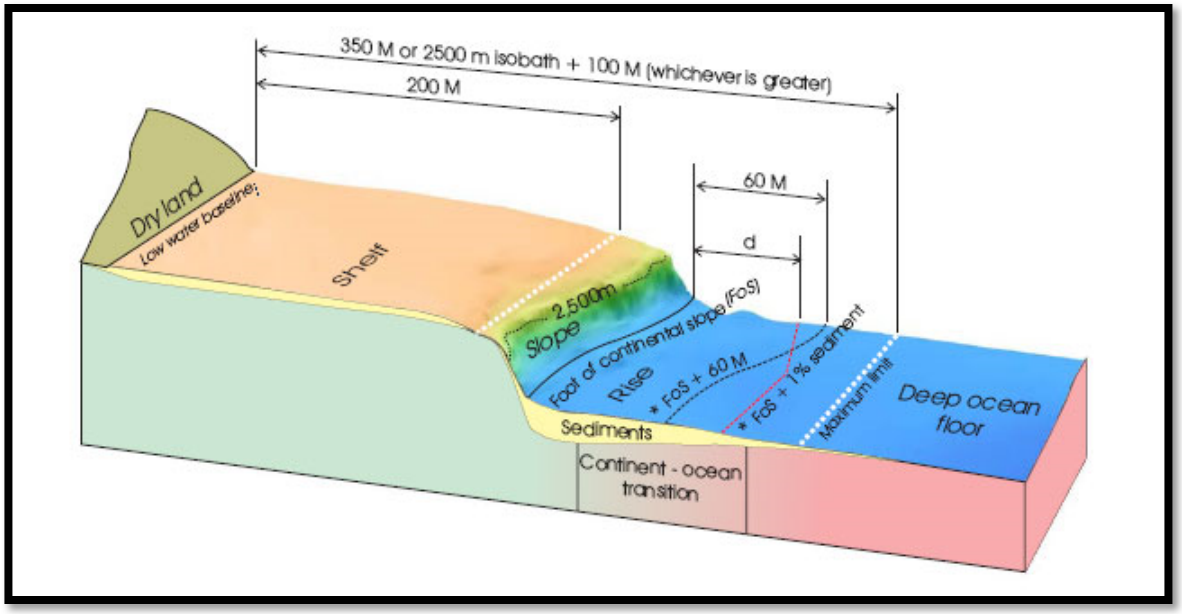


Figure 114 - UNCLOS Article 76 Continental Shelf Outer Limits Constraints

As defined by UNCLOS:

Territorial sea – "the sovereignty of a coastal state extends beyond its land territory and internal waters to an adjacent belt of sea", described as the territorial sea in the UNCLOS (Part II); "this sovereignty extends to the air space over the territorial sea as well as its underlying seabed and subsoil; every state has the right to establish the breadth of its territorial sea up to a limit not exceeding 12nm; the normal baseline for measuring the breadth of the territorial sea is the low-water line along the coast as marked on large-scale charts officially recognized by the coastal state"; the UNCLOS describes specific rules for archipelagic states.

Contiguous zone - according to the UNCLOS (Article 33), "this is a zone contiguous to a coastal state's territorial sea, over which it may exercise the control necessary to: prevent infringement of its customs, fiscal, immigration, or sanitary laws and regulations within its territory or territorial sea; punish infringement of the above laws and regulations committed within its territory or territorial sea; the contiguous zone may not extend beyond 24nm from the baselines from which the breadth of the territorial sea is measured" (e.g., the US has claimed a 12nm contiguous zone in addition to its 12nm territorial sea).

Exclusive economic zone (EEZ) - the UNCLOS (Part V) defines the EEZ "as a zone beyond and adjacent to the territorial sea in which a coastal state has: sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources, whether living or non-living, of the waters superjacent to the seabed and of the seabed and its subsoil, and with regard to other activities for the economic exploitation and exploration of the zone, such as the production of energy from the water, currents, and winds; jurisdiction with regard to the establishment and use of artificial islands, installations, and structures; marine scientific research; the protection and preservation of the marine environment; the outer limit of the exclusive economic zone shall not exceed 200nm from the baselines from which the breadth of the territorial sea is measured".

Continental shelf - the UNCLOS (Article 76) defines the continental shelf of a coastal state as “comprising the seabed and subsoil of the submarine areas that extend beyond its territorial sea throughout the natural prolongation of its land territory to the outer edge of the continental margin, or to a distance of 200nm from the baselines from which the breadth of the territorial sea is measured where the outer edge of the continental margin does not extend up to that distance; the continental margin comprises the submerged prolongation of the landmass of the coastal state, and consists of the seabed and subsoil of the shelf, the slope and the rise; wherever the continental margin extends beyond 200nm from the baseline, coastal states may extend their claim to a distance not to exceed 350nm from the baseline or 100nm from the 2,500meter isobath; it does not include the deep ocean floor with its oceanic ridges or the subsoil thereof”.

9.4. Summary of Impacts on the Submarine Cable by Marine Activities

There is schedule risk due to the high volume of recreational and commercial vessel activity. The cable route mostly avoids high traffic areas and notification to mariners (NOTAM) bulletins will be required for all landings.

10. Hazards and Obstructions

Hazards to navigation will be encountered in the cable route's vicinity and typically come in the form of geological hazards, wrecks, and other man-made debris. Current nautical charts do not generally have the resolution or are not up to date enough to determine the extent of these hazards along most of the route. Therefore, a cable route survey with seabed classification capabilities should be performed for the cable route corridor in water depths less than 1500 meters.

10.1. Cables and Pipelines

There are enough existing, planned and out-of-service submarine cables in the vicinity of the Valparaiso, Auckland, and Sydney landings to warrant inclusion of magnetometer survey as part of the cable route survey. The precise location of these crossings will be identified after considered cooperation with the other cable owners prior to and during the cable route survey. Upon request, the 3rd party cable owners should provide as-laid or planned RPLs. These will feed the CRE process of creating a pre-CRS RPL.

No known pipelines or pipeline crossings were found during this Study; however, near landings, it is always prudent to investigate for the possible occurrence of storm and waste outflow pipes.

10.1.1. Existing and Planned Cables

L1 – Valparaiso, CL

Specific cable system route position lists were not obtained for the Valparaiso landing; however, we do know that Prat and Pacific Cable are planned for a 2020 RFS and that Curie, South American Crossing, and Southern America-1 already land at Valparaiso. Given the moderate density of cables landing at Valparaiso it can be assumed that crossings will occur in both shallow and deep water.

L2 - Juan Fernández, CL

There are two (2) in-service submarine cables landing south of the football pitch that support Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) monitoring using hydrophones, as shown in Figure 115. The northern hydrophone submarine cable route will be crossed once but the location is to be determined after Subtel coordinates with the CTBTO

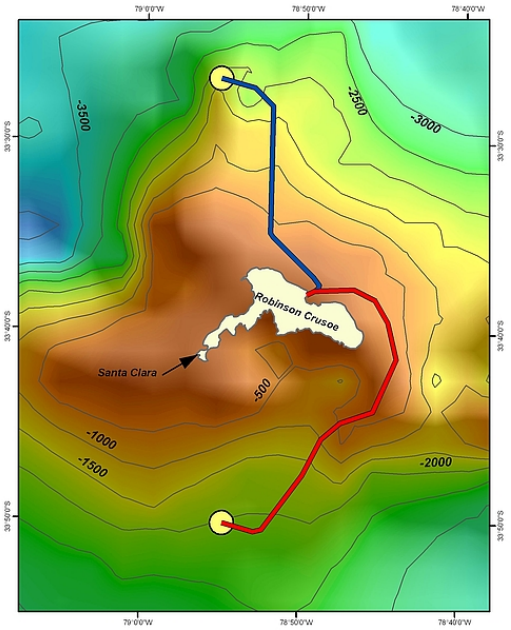


Figure 115 - CTBT Hydrophone Submarine Cable Locations

L3 – Easter Island, CL

None.

L4 – Auckland, NZ

Southern Cross Next and Southern Cross Cable Network both land at Auckland and are crossed by this system.

L5 – Sydney, AU

Hawaiki, Southern Cross Cable Network and Tasman Global Access Cable land near this system and are likely crossed along with other charted cables; however, the charts do not specify ownership and was not obtainable for this study.

10.1.2. Out of Service Cables

L1 – Valparaiso, CL

In 1875, the India Rubber & Gutta Percha & Telegraph Co made and laid a cable for the West Coast of America Telegraph Co. It was a coastal festoon that ran from Lima via Mollendo, Iquique, Caldera and La Serena to Valparaiso. The operating company went bankrupt and the was bought out by John Pender and became under the Eastern & Associated Telegraph Cos umbrella in 1877. Shortly afterwards, in 1881 the Central & South American Telegraph Co was formed, and they laid a competing cable down the west coast of South America. (Burns, 2020)

Between 1 Jan and 6 Feb 1906 Siemens Brothers' ship Faraday laid two new cables for the Central & South American Telegraph Co: 902nm Valparaiso – Inguique and 757nm Iquinque – Chorrillos. Faraday remained off Valparaiso as part of the contract warranty arrangements, so she was there at anchor on 16 August 1906 when an earthquake destroyed Valparaiso.

A sample of known OOS cables in the vicinity of Valparaiso:

- 1875 West Coast of America Telegraph Co Telegraph Cable
- 1881 Central & South American Telegraph Co Telegraph Cable
- 1906 Central & South American Telegraph Co Telegraph Cable

L2 - Juan Fernández, CL

There are two (2) unknown OOS cables landing at Juan Fernández. This System will cross at last one of the cables. Identification of the owners of the OOS cables was not achieved during this Study.

L3 – Easter Island, CL

None.

L4 – Auckland, NZ

None identified at the time of this study but the presence of OOS telegraph and fiber cables may be identified after consultation with current and previous system owner's RPLs and/or cable route survey results.

A sample of known OOS cables in the vicinity of Auckland:

- 1963 COMPAC, 0.990", 1.2Mhz coaxial system surface laid
- 1975 TASMAN 0.990", 5Mhz coaxial system surface laid
- 1982 ANZCAN 1.47" coax 14Mhz coaxial system, surface laid

L5 – Sydney, AU

There does appear to be OOS cables on the nautical charts and one is crossed in deep water in the Tasman Sea. Quantity and identification of OOS telegraph and fiber cables may be identified after consultation with current and previous system owner's RPLs and/or cable route survey results.

A sample of known OOS cables in the vicinity of Sydney:

- 1963 COMPAC, 0.990", 1.2Mhz coaxial system surface laid
- 1975 TASMAN 0.990", 5Mhz coaxial system surface laid
- 1982 ANZCAN 1.47" coax 14Mhz coaxial system, surface laid

10.1.3. Existing and Future Pipelines

No known future or existing pipelines will be crossed by the System.

10.2. UXO

The presence of unexploded ordinance (UXO) is possible along any segment of the System, but the likelihood of occurrence increases on the approaches to each landing site. There are charted and uncharted UXO originating from World War I onwards. Clearance surveys for the harbors of Juan Fernández, Auckland and Sydney are highly recommended based on historical naval activity and charted dumping areas.

10.3. Restricted and Development Areas

The approaches to both Auckland and Sydney harbors contain submarine cable restricted areas within which the System will traverse, per permitting and governmental regulations. Valparaiso, Juan Fernández and Easter Island do not have charted restricted or development areas that overlap the planned cable route.

10.4. Offshore Mineral Resource Activities

No known offshore mineral resource lease blocks will be crossed by the System.

10.5. Oil and Gas Resources

No known oil and gas resources or lease blocks will be crossed by the System.

10.6. Dumping Dredge and Reclamation

The System route did not encounter mapped or documented dumping, dredge, and reclamation zones. Dredging authorities in Chile, New Zealand and Australia should be consulted prior to survey and installation activities. Note that the Sydney and Auckland landings and approaches are located within submarine cable protection corridors, which prohibit any potentially hazardous activities.

10.7. Military Activities

No charted military activity areas were discovered during this study; however, military activities could be performed anywhere along the System's route. Governmental submarine cable stewards should be consulted by the System owner to ensure uncharted military assets are not impacted by the route placement.

10.8. Obstructions and Wrecks

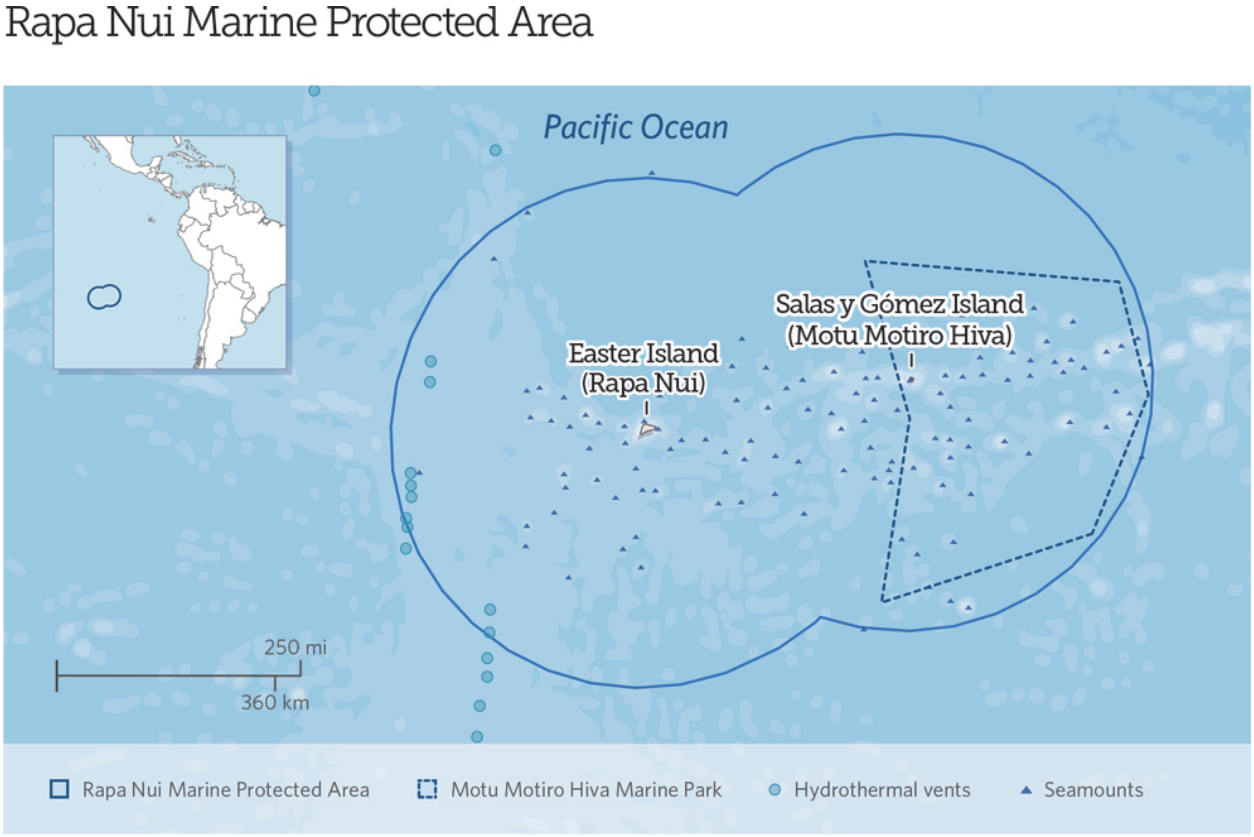
Uncharted bottom features and wrecks may be encountered during the marine survey. The currently available survey data is sparse and out of date across much of the cable route, most notably between Valparaiso and New Zealand, where the marine survey will likely be the first to survey that part of the Pacific Ocean.

10.9. Artificial Reefs

No known artificial reefs will be crossed by the System.

10.10. Coastal and Marine Protected Areas

The whole of Easter Island's EEZ is protected under the Rapa Nui Marine Protected Area. Similarly, all the islands of the Juan Fernández archipelago are designated as an MPA by the Chilean government using the Chile EEZ as the boundary.



Note: The Rapa Nui Marine Protected Area safeguards the 720,000-square-kilometer (277,994-square-mile) exclusive economic zone that surrounds Easter Island, Chile, and includes the already established Motu Motiro Hiva Marine Park.

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Figure 116 - Rapa Nui marine Protected Area

10.11. Summary of Impacts on the Submarine Cable by Hazards and Obstructions

The largest impact to the cable system would be from encountering uncharted subsea obstructions, wrecks and debris causing the route to be diverted by some unknown number of kilometers. While a cost and schedule risk, this tends to be manageable using industry standard route deviation procedures.

The identification and seabed placement of OOS cables, especially older telegraph cables, for the Valparaiso, Auckland and Sydney landings will require coordination with current and previous owners and access to their RPLs, as task not feasible during this phase of the project due to privacy concerns by both parties. Route clearance could be required depending on these results, increasing both survey and installation time.

11. Cable Route Engineering

11.1. Overview

Cable Route Engineering (CRE) is defined as the process to ensure the physical security of the Subsea Cable System from natural and man-made hazards through route selection, slack allocation, cable type (including armor) choice, and the use of industry-standard cable burial and protection practices. Further, it includes the use of trawl-resistant design practices for all seafloor systems installed in waters that may reasonably be expected to be fished over the lifetime of the Subsea Cable System. In addition, CRE considers the viability of areas identified for the placement of seabed plant components such as nodes, repeaters, and BUs.

CRE will be the responsibility of the chosen supplier of the Subsea Cable System. However, it is recognized that, the final CRE plan will be subject to the permits obtained from State/Provincial and Federal agencies.

As part of the study, a preliminary level of CRE has been accomplished; however, this has been necessarily limited to the data available. It will be the responsibility of the chosen supplier of the Subsea System to conduct a detailed marine survey of the route and independently research available data to verify or modify the information contained in this Study.

11.2. Cable Types

Cable types are selected to provide appropriate mechanical protection to the system noting that there are physical limitations to the installation of, for example, heavy cable in deep water. The table below outlines the general cable types by water depth recommended for the system but may be substituted by the Supplier based on product offerings, allowances for Pacific geological and tectonic conditions and results of survey.

Table 12 - Cable Types by Water Depth

Name	Code	Start Depth (m)	End Depth (m)
Single Armor	SA	HDD Start, 100	HDD End, 300
Double Armor	DA	HDD End, 0	100
Light Weight Protected	LWP	300	1500
Light Weight	LW	1500	Full Ocean Depth

11.3. Cable Slack

Slack values are based upon normal industry standards. Values of 1% have been applied to all routes. These generally applied percentages may vary over the finally surveyed route, due to local seabed profiles and soil strengths.

No cable allowances have been made at this stage for splices, BU deployment, repeater deployment or installation methodology.

11.4. Branching Unit Locations

All branching units are provisionally placed in water depths greater than 1500 meters and within supposed low-slope seabed. If localized slopes are discovered during the cable route survey, there is plenty of room within the deep-water survey corridor to adjust as needed.

11.5. Burial Recommendations

Burial will likely be required at all landings to satisfy permitting requirements and protection against external aggression (fishing and anchoring). The cable route survey will determine the suitability of the seabed for burial using seabed classification, sub-bottom sonar, and most importantly Cone Penetrometer Tests (CPT). The survey results coupled with the permitting and overall risk matrix will determine locations of burial between the BMH and approximately 1500 meters water depth. Given the high volume of fishing, commercial shipping, and recreational fishing/boating at all landing locations it is advisable to consider burial between the landing and 1500 meters water depth, wherever feasible and within business constraints.

11.6. Inshore Protection

In general, HDD should be considered to mitigate against external aggression and tsunami risks in shallow water. The use of abrasion-resistant materials, such as Uraduct, should be considered for all nearshore and harbor anchor, touchdown, and water entry/exit points. Cable armor selection and transitions will be dependent on the survey results.

11.7. Outreach

It will be important to convey the location of the System to all stakeholders through direct contact and general outreach. A project website with the location of the cable on downloadable maps and in GIS files is recommended from the earliest planning stages of the project up to final implementation. This will help to identify any conflicts and maximize the chances of protecting the System from incidental damage once installed. The risk of potential malicious uses of such data does not, in WFN Strategies' experience, outweigh the benefits of disclosure.

11.8. Cable Crossings

All charted cables have been crossed as close as possible to 90 degrees, but it is known that charted cable positions vary greatly from actual as-laid positions, making the acquisition of known or suspected cable system route position lists a high priority before survey operations commence.

11.9. Pipeline Crossings

No known future or existing pipelines will be crossed by the System.

12. Marine Maintenance

The proposed DGASA route will cross the ocean in areas currently covered by South Pacific Maintenance Agreement (SPMA) in the south-western Pacific and by the Atlantic Cable Maintenance Agreement (ACMA) or the Atlantic Private Maintenance Agreement (APMA) along the western coast of South America. The base port for the SPMA ship is Upola, Samoa and the base port for the ACMA/ APMA ships is Willemstad in Curacao, accessing the Pacific via the Panama Canal.

The passage distances from Upola to the south-west Pacific clear in ports for the DGASA proposed landings are as follows:

1) Upola to Sydney = 4,533km (2,433nm)
2) Upola to Auckland = 3,004km (1,619nm)
3) Upola to Easter Island = 6,607km (3,561nm)
4) Upola to Isla Juan Fernández = 9,446km (5,091nm)

The passage distances from Willemstad to the east Pacific clear in ports for the DGASA proposed landings are as follows:

a) Willemstad to Valparaiso = 6,520km (3,370nm)
b) Willemstad to Juan Fernández = 6.093km (3.384nm)
c) Willemstad to Easter Island = 6,783km (3.656nm)

The shore-ends and continental shelves of the proposed DGASA landings will be the most vulnerable to cable faults. The transit speed for a repair cableship is typically 12 knots in good weather. Therefore, the passage time to proposed DGASA landings from the SPMA and ACMA /APMA base ports would be, in good weather, as follows:

1) Upola to Sydney = 8.5 days
2) Upola to Auckland = 5.6 days
3) Upola to Easter Island = 12.4 days
4) Upola to Isla Juan Fernández = 17.8 days

For the ACMA ship 2 additional days have been allowed for passage of the Panama Canal.

a) Willemstad to Valparaiso = 11.7 + 2 = 13.7days
b) Willemstad to Isla Juan Fernández = 11.4 + 2 = 13.4 days
c) Willemstad to Easter Island = 12.7 + 2 = 14.7 days

It can be seen that the passage times to Juan Fernandez and Easter Island are large and it is debatable whether either SPMA and or ACMA /APMA would be prepared to extend the zone coverage to these islands. Also given the planned high traffic carrying capacity of the DGASA system, the down time involved, if a fault off of Valparaiso was repair by an ACMA or APMA ship, would be significant, so a repair ship based in Valparaiso is worthy of consideration.

For a repair ship based in Valparaiso all the continental shelves would be in Chilean territory, so the vessel would not need to clear in and the passage distances to the fault area would be as follows:

1) Valparaiso = 110km (55nm)
2) Juan Fernández = 672km (362nm)
3) Easter Island = 3,688km (1,988nm)

This would require passage times at 12 knots of:

a) Valparaiso = < 1 day
b) Juan Fernández = 1.3 days
c) Easter Island =6.9 days

Clearly, a Valparaiso based repair ships would offer significant benefits to the DGASA system and other submarine cable systems in the region, in terms of response time to cable faults compared with the current service provided by ACMA / APMA. This will be discussed further in the Section 6 of the Main Report.

13. Risks Summary

13.1. System-Wide

There are logistical and schedule risks associated with potential adverse weather conditions across the entire System. These risks can be reasonably mitigated by scheduling seagoing operations between November and February and maintaining forecasts and nowcasts during the months leading up to operations.

There are other risks associated with the seabed topography/roughness, seismic events, currents, hydrothermal vents, subsea volcanoes, seamounts and knolls, tectonic plate boundaries and other geophysical and oceanographic processes that will be encountered between Chile and Australia. These types of risks are well known to the submarine cable industry with successful mitigation techniques. The cable route survey will identify and categorize these and other risks to the cable as it lies on the seabed.

13.2. Landing Sites

Provides landing site-specific risk analysis.

13.2.1. L1 – Valparaiso, CL

The chosen landing location is already congested with in-service and out-of-service cables. Negotiating a landing route and BMH will be critical prior to survey operations.

The BMH and CLS will require fortification against potential seismic events and resulting tsunami threats.

13.2.2. L2 - Juan Fernández, CL

The approach to the landing north of the harbor is largely unknown. Small vessel survey should validate possible rock outcrop and seabed obstructions prior to larger vessel operations.

The BMH and CLS will require fortification against potential seismic events and resulting tsunami threats.

13.2.3. L3 – Easter Island, CL

The approach to the landing north of the harbor is largely unknown. Small vessel survey should validate possible rock outcrop and seabed obstructions prior to larger vessel operations.

The BMH and CLS will require fortification against potential seismic events and resulting tsunami threats.

13.2.4. L4 – Auckland, NZ

Special care in cable placement within the cable protection zone and ensuring a route capable of achieving 1.5 meters of burial is advised.

13.2.5. L5 – Sydney, AU

Special care in cable placement within the cable protection zone and ensuring a route capable of achieving 1.5 meters of burial is advised.

13.3. Trunk Segments

Provides a risk analysis for each trunk segment.

Planning the execution of cable route survey and installation activities will likely require separate yet coordinated subcontracts and thus teams working different locations. The System Supplier may use these identifiers or define their own as part of their proposal.

The direction of the System route position list and the following route description of the trunk segments is from East to West, so Valparaiso, Chile to Sydney, Australia.

Note that some maps in this section are rotated to align the route horizontally on the page.

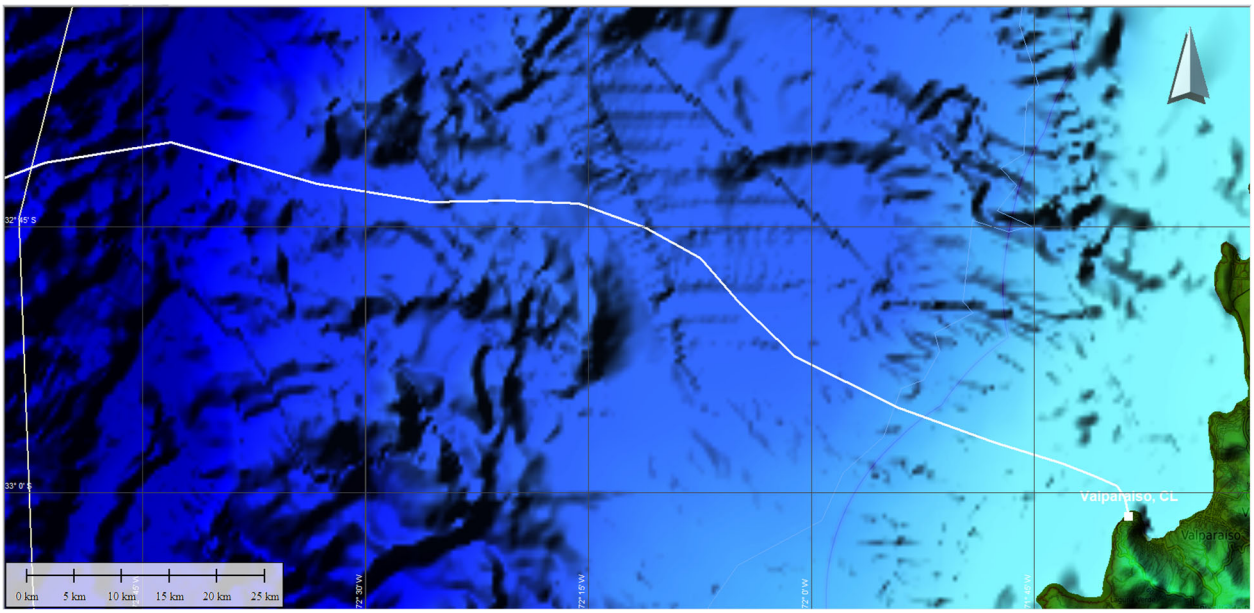


Figure 19 - Valparaiso to Peru-Chile Trench

The System trunk starts in the city of Valparaiso, a World Heritage Site and historic seaport, with a proposed BMH located at 33° 01.351' S, 71° 38.640' W near the current Google cable system Curie. The route traverses via HDD to an exit point where it will be buried until reaching the slope of the continental shelf, just before entering the Peru-Chile Trench.

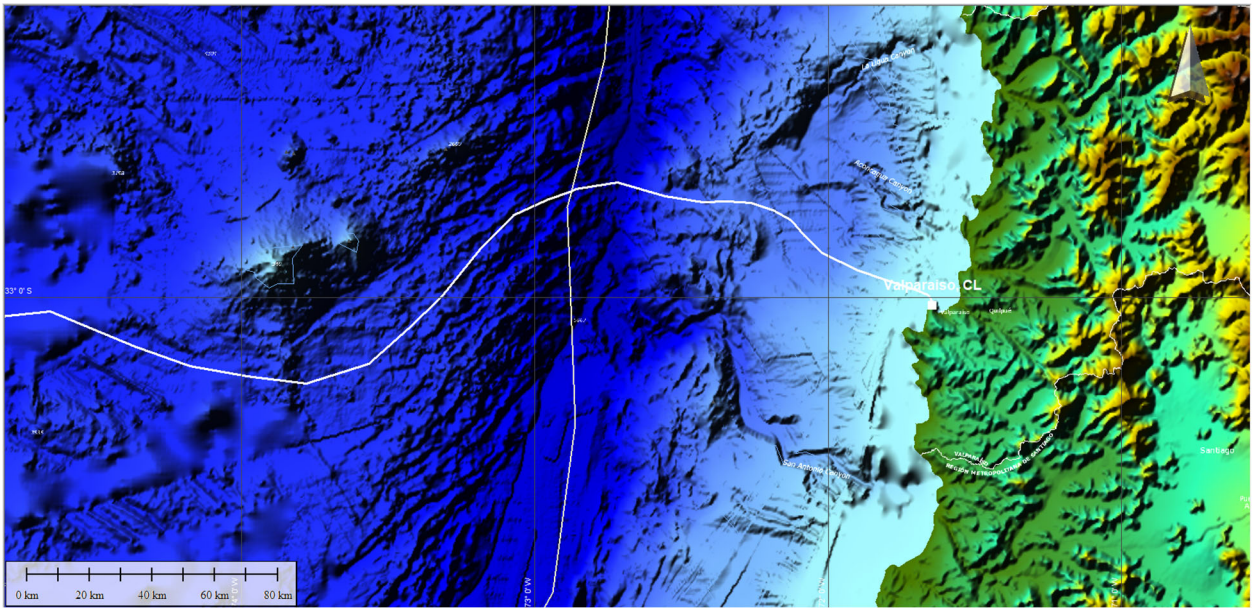


Figure 20 - Valparaiso across Peru-Chile Trench

The crossing of the Peru-Chile Trench is coincident with the plate transition from the South America Plate to the Nazca Plate at 32° 41.37724' S, 72° 51.54689' W in approximately 5700 meters water depth. The Peru-Chile Trench crossing is relatively standard until the upslope, where the route deviates to the south-west to avoid a set of seamounts before turning due West towards the Juan Fernandez BU located at 33° 16.390' S, 78° 34.278' W in approximately 4000 meters of water.

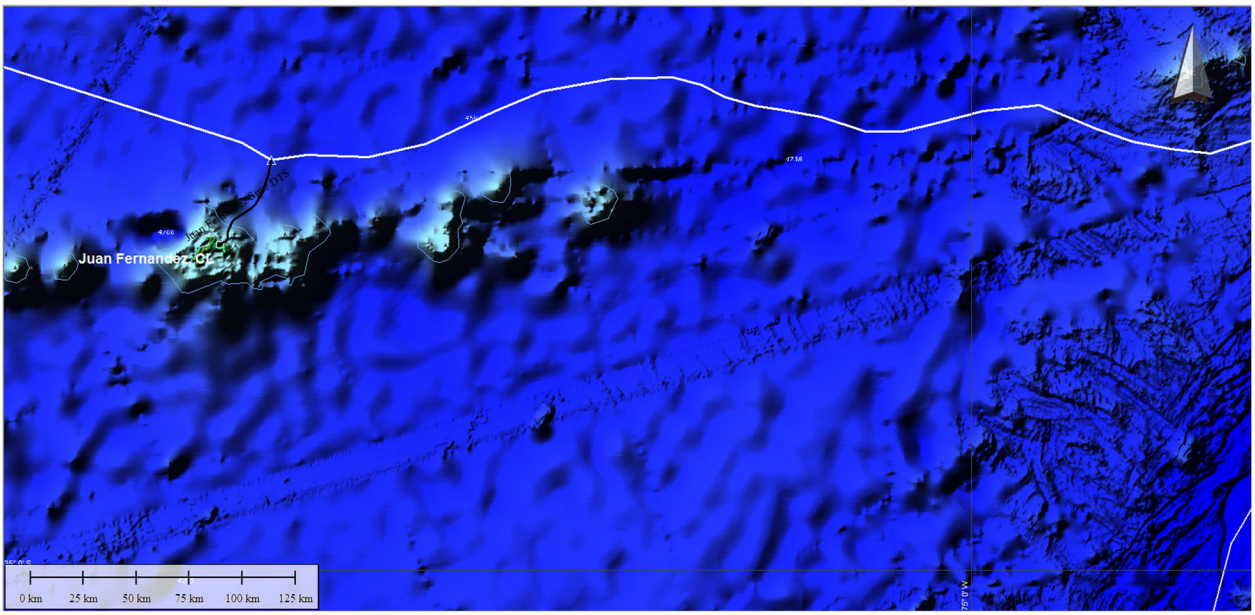


Figure 21 - Peru-Chile Trench to Juan Fernandez

The route then continues west-north-west towards the Easter Island BU, crossing the Chile EEZ at position 31° 56.68495' S, 84° 10.32648' W, continuing due west until crossing back into the Chile EEZ of Easter Island.

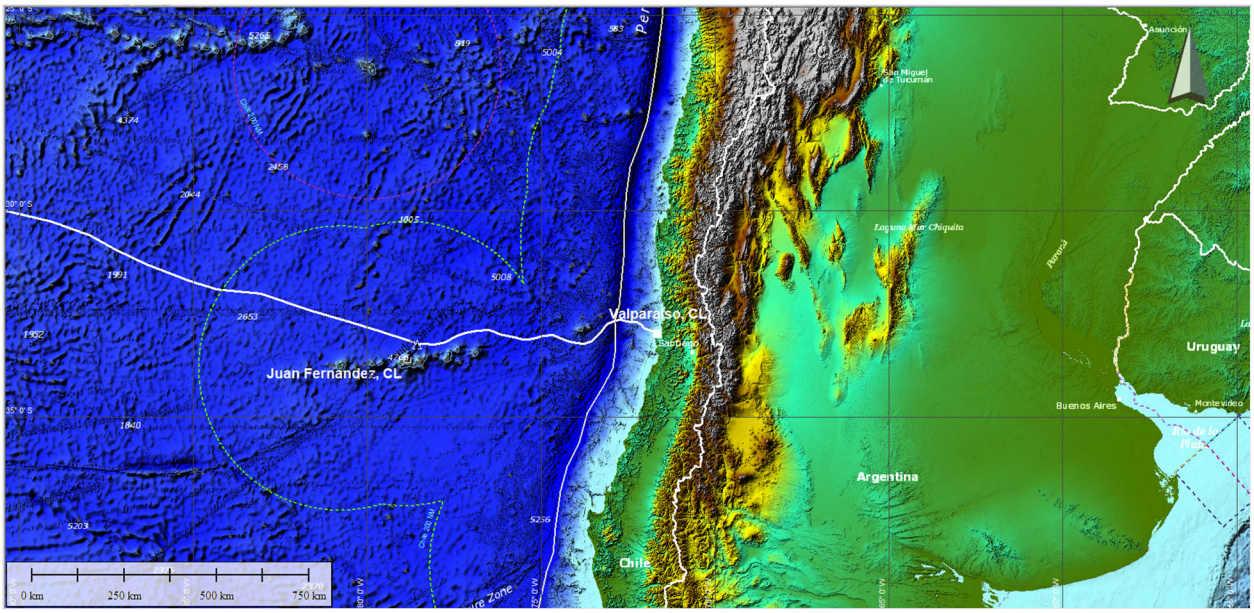


Figure 22 - Valparaiso, Juan Fernandez Overview

The Easter Island BU is located at 29° 58.184' S, 109° 17.138' W in approximately 3200 meters water depth within the Chile EEZ surrounding Easter Island. The route continues to the East Pacific Rise, located at 30° 1.13458' S, 111° 44.43583' W, where it must cross a vertical structure of seabed surrounded by hydrothermal vents due to the coincident boundary between the Nazca Plate and Pacific Plate.

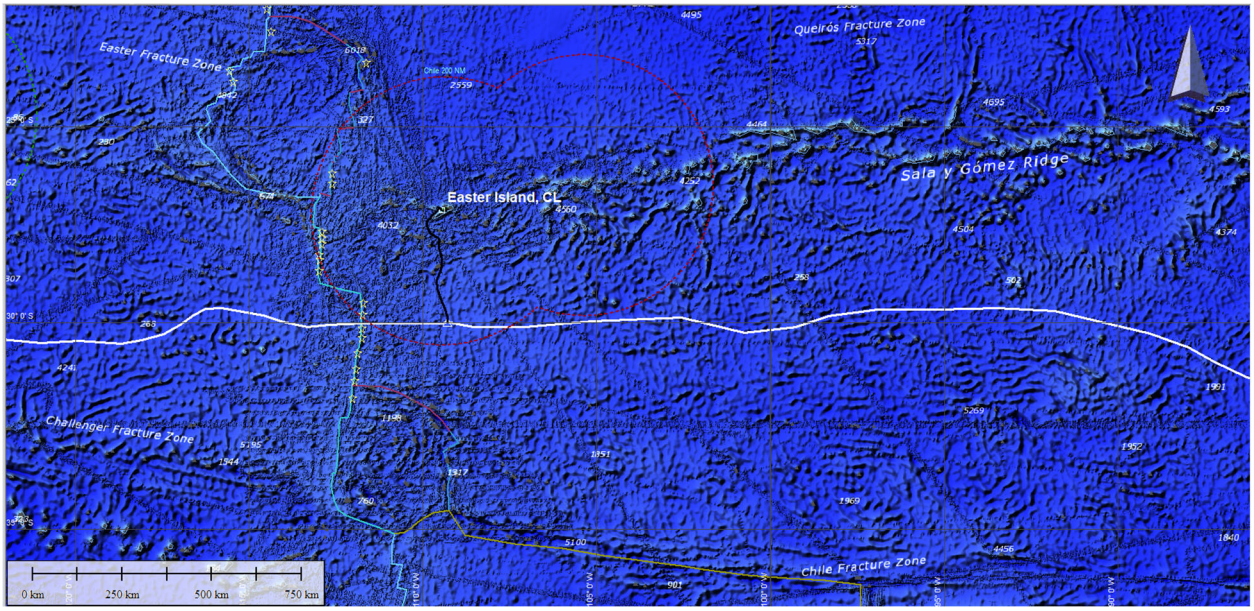


Figure 23 - Easter Island and East Pacific Rise

From the East Pacific Rise, the route continues West towards Auckland navigating around the Austral Seamounts and between the Challenger Fracture Zone and Resolution Fracture Zone while keeping out and South of the French Polynesia (France) EEZ.

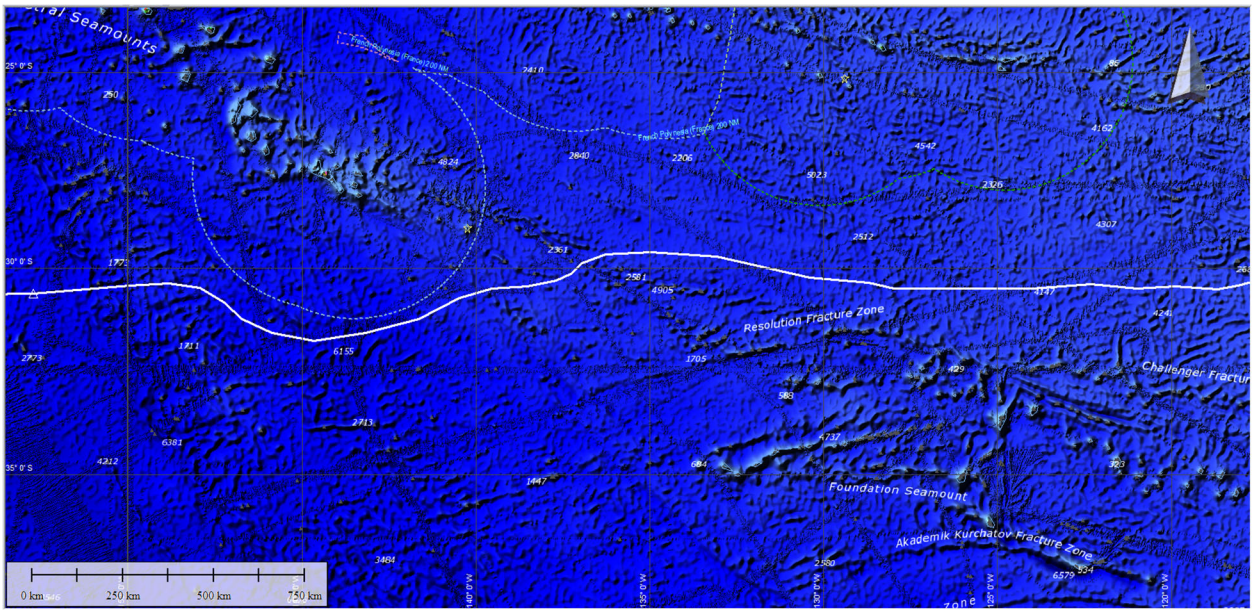


Figure 24 - Challenger and Resolution Fracture Zones

Before continuing towards Auckland, a Future BU located at 30° 37.12961' S, 152° 43.84573' W in approximately 5300 meters water depth was placed for the provision of connecting to other islands to the North of the trunk.

The route continues from the Future BU West crossing the Louisville Ridge at 34° 23.17952' S, 171° 20.99691' W and eventually the New Zealand EEZ at 36° 32.96437' S, 177° 29.77971' W.

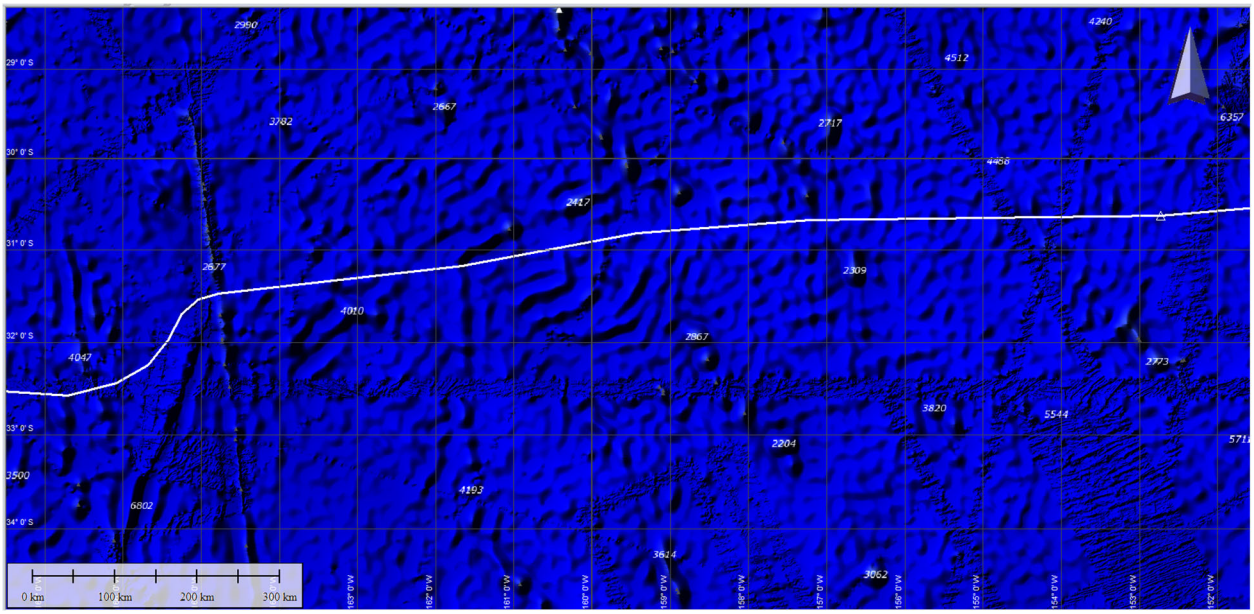


Figure 25 - Future BU

At this point, the route deviates south-west to approach and traverse the Kermadec Trench, which is the boundary for the Pacific Plate and Australian Plate, located at 36° 39.54645' S, 179° 28.81738' W in approximately 5000 meters water depth.

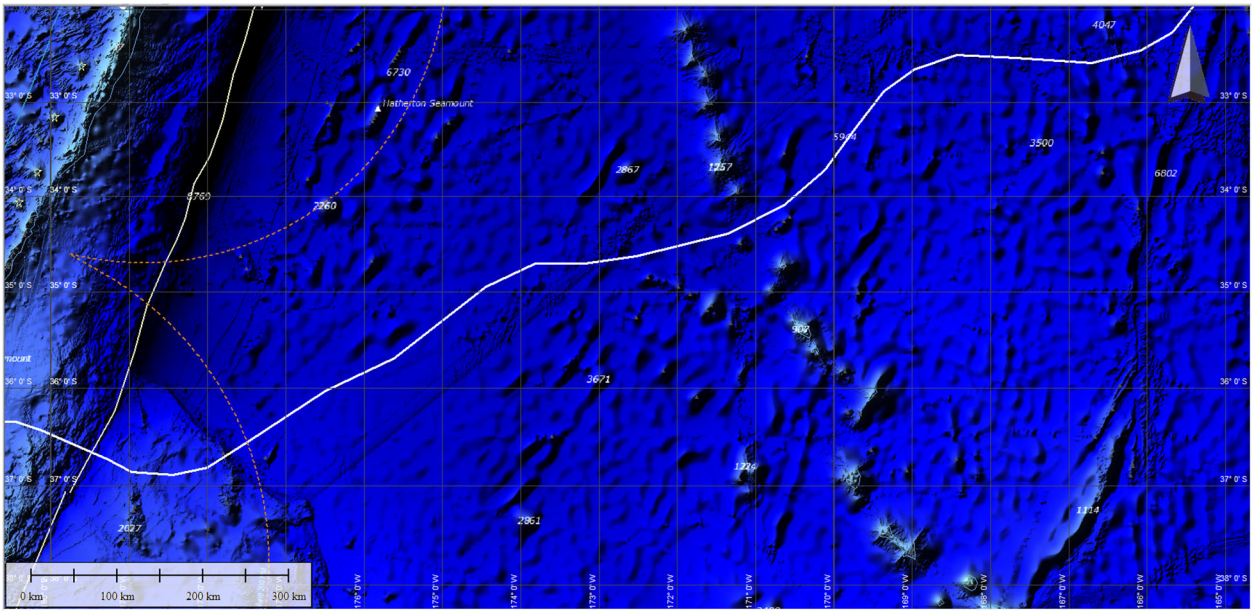


Figure 26 - Approach to Kermadec Trench and NZ

The route crosses the Kermadec Trench and continues up the continental shelf, crossing the Raukumara Plain south of the Rumble III and Lillie seamounts, and north of Rumble V seamount until reaching the Auckland BU at 34° 36.191' S, 175° 01.496' E in approximately 1850 meters water depth.

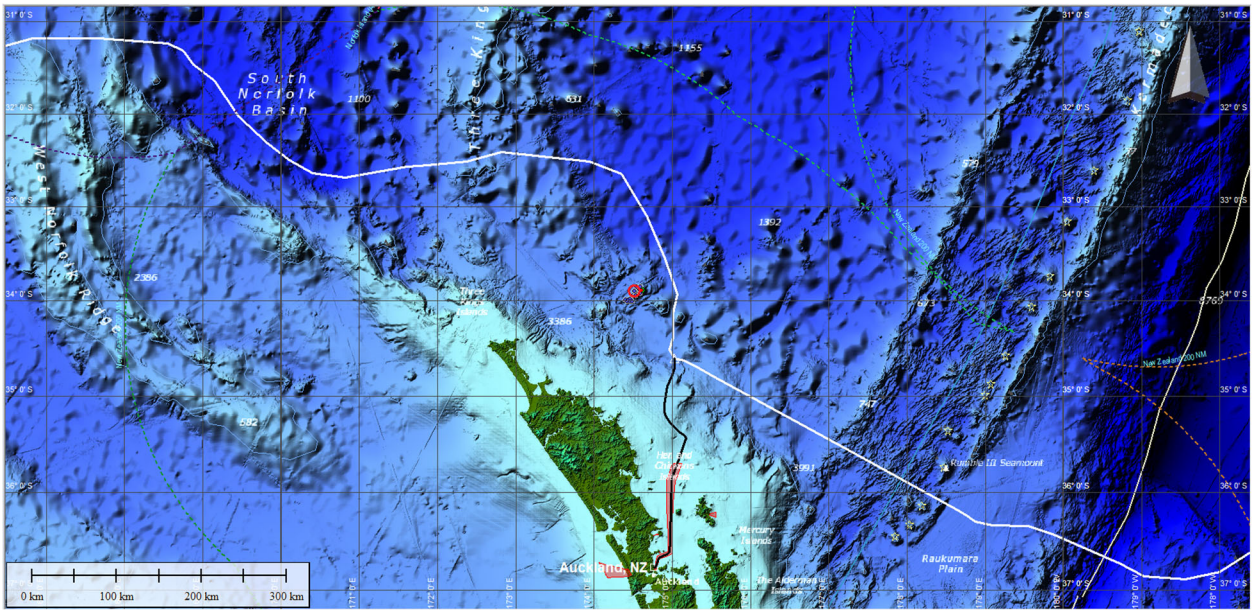


Figure 27 - Auckland Approaches Overview

The traversal of the route from the Auckland BU to Sydney is complicated by numerous basins and rises that must be crossed. The route leaves the Auckland BU due north, keeping east of the Pururua Seamount, and heads into South Fiji Basin. From there, the route turns west again into South Norfolk Basin and then swings north of Wanganella Bank, crossing into the Australian EEZ at 31° 58.80985' S, 169° 24.93457' E.

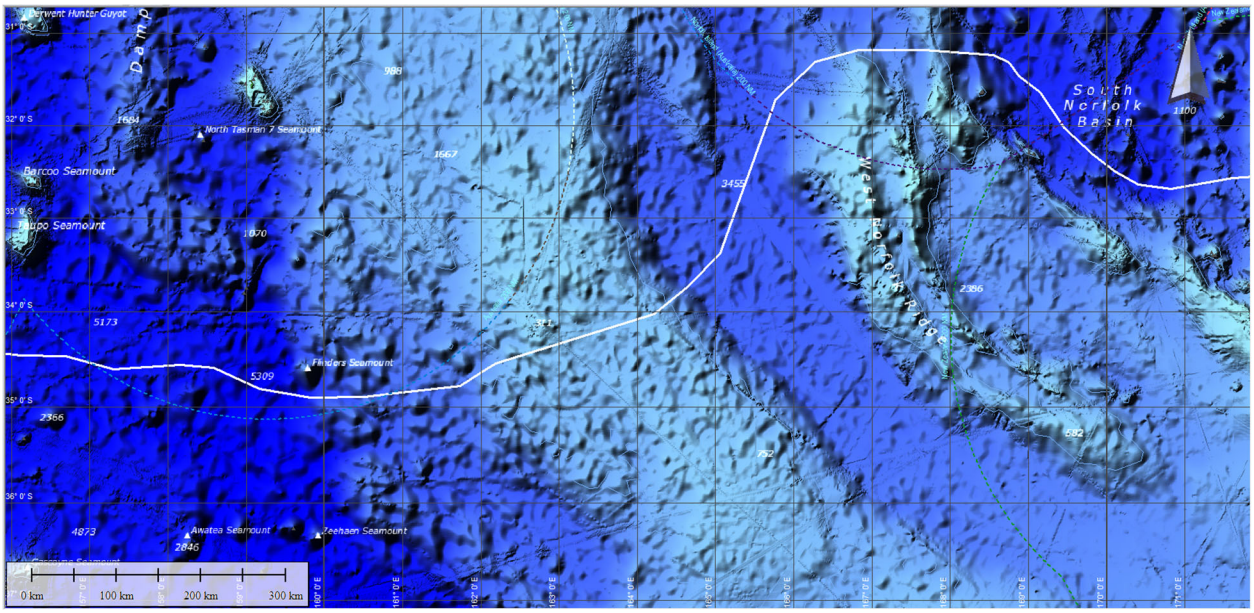


Figure 28 - Lord Howe Rise Overview

The route heads south between Wanganella Bank and Lord Howe Rise, crossing back into the New Zealand EEZ at 31° 51.16888' S, 165° 42.67808' E before turning West again to traverse Lord Howe Rise.

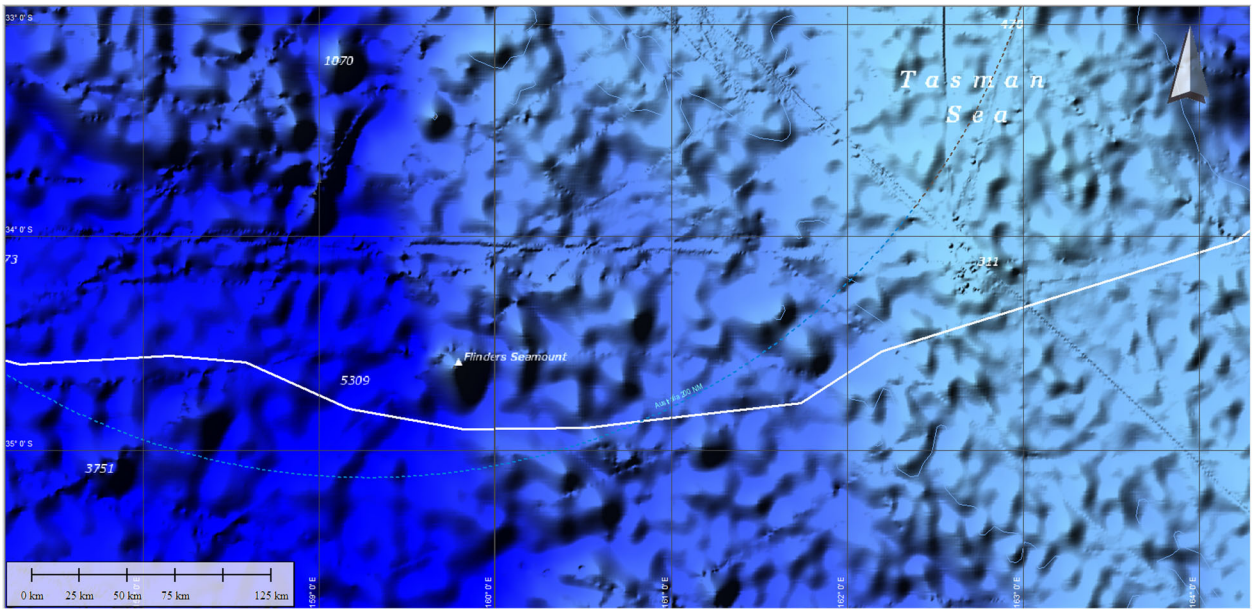


Figure 29 - Lord Howe Rise

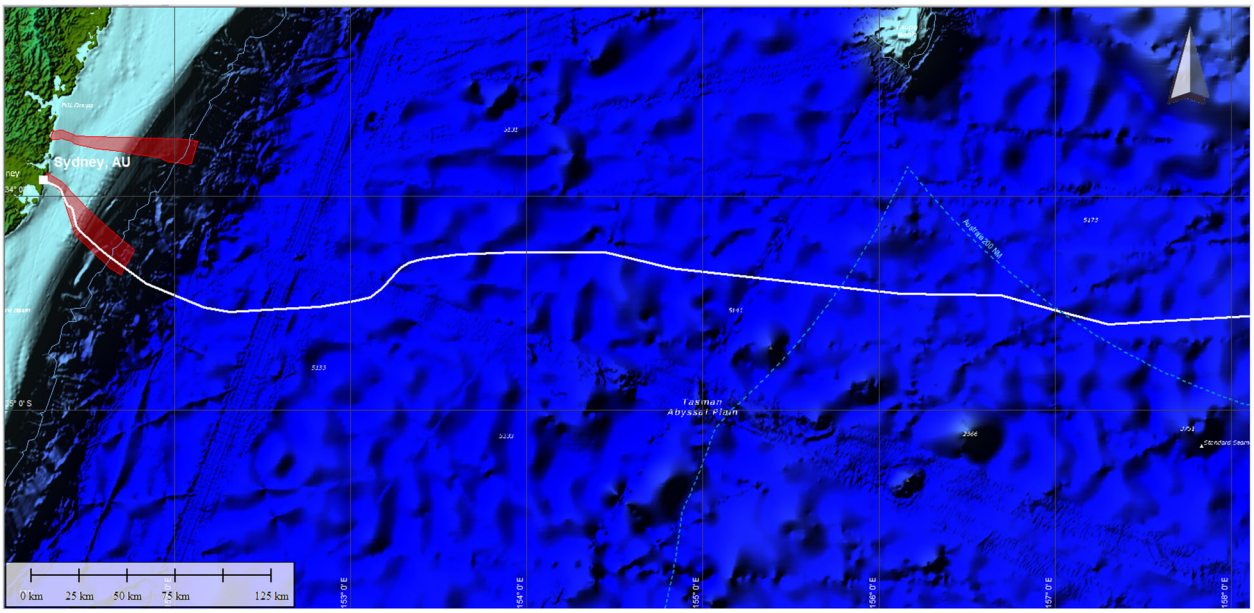


Figure 30 - Approaches to Sydney

After crossing Lord Howe Rise, the route continues due west towards Sydney, just south of Flinders Seamount, across the Tasman Sea.

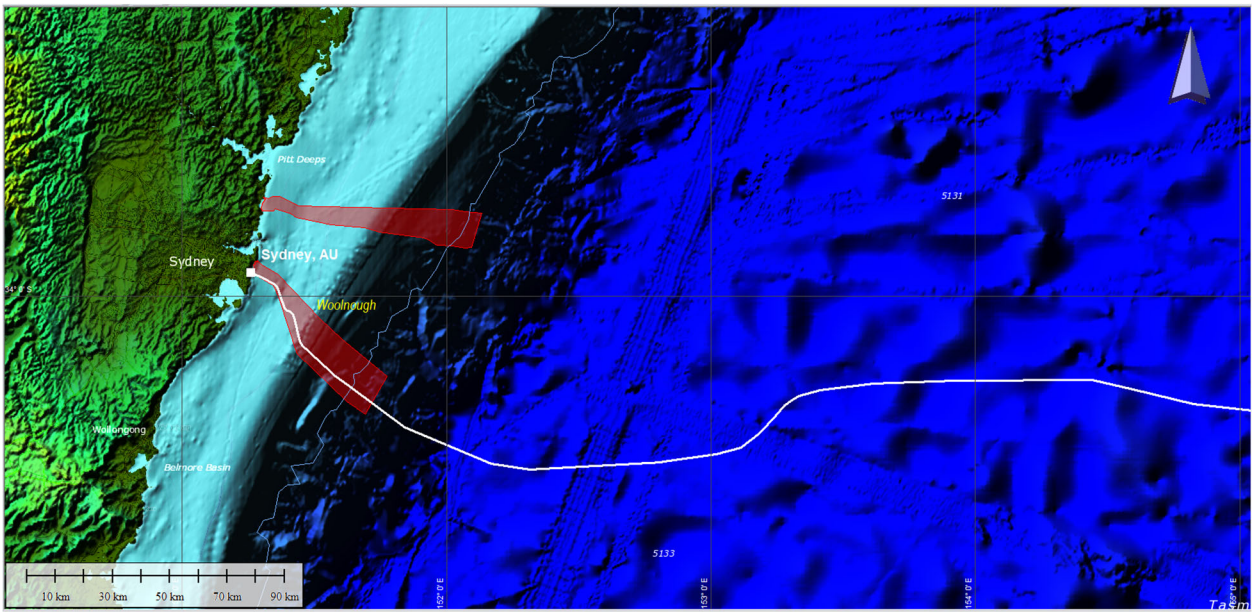


Figure 31 - Sydney Continental Shelf

The route continues up the Australian continental shelf, south of Woolnough Knoll, into the southern Sydney cable protection corridor, following the other cables into the landing at Sydney located at 33° 55.580' S, 151° 15.571' E.

13.3.1. T1 – Valparaiso BMH to Juan Fernández BU

The continental shelf to Peru-Chile Trench crossing, New Zealand ingress and egress as well as approaches to Sydney will require detailed sediment thickness and mobility analysis during the cable route survey to mitigate cable burial requirements due to fishing activity and cable movement risk due to currents and sediment transport and mass movement.

Seamounts, knolls, and hydrothermal vents are prominent along the route. Detailed mapping of seabed features and detail oriented CRE efforts must be employed to navigate these features and their inherent risks to the cable.

13.3.2. T2 – Juan Fernández BU to Easter Island BU

Seamounts, knolls, and hydrothermal vents are prominent along the route. Detailed mapping of seabed features and detail oriented CRE efforts must be employed to navigate these features and their inherent risks to the cable.

13.3.3. T3 – Easter Island BU to Future BU

Seamounts, knolls, and hydrothermal vents are prominent along the route. Detailed mapping of seabed features and detail oriented CRE efforts must be employed to navigate these features and their inherent risks to the cable.

13.3.4. T4 – Future BU to Auckland BU

Seamounts, knolls, and hydrothermal vents are prominent along the route. Detailed mapping of seabed features and detail oriented CRE efforts must be employed to navigate these features and their inherent risks to the cable.

13.3.5. T5 – Auckland BU to Sydney BMH

Seamounts, knolls, and hydrothermal vents are prominent along the route. Detailed mapping of seabed features and detail oriented CRE efforts must be employed to navigate these features and their inherent risks to the cable.

Rock outcrops and steep localized slopes in the vicinity of Lord Howe Rise will likely be encountered.

13.4. Branches

Provides a risk summary for each branch.

13.4.1. B1 – Juan Fernández

Finding suitable BU placement in deep water.

The lack of mapping data to plan from during this Study can result in CRS route development, a cost and schedule risk.

Tsunami and seismic damage.

13.4.2. B2 – Easter Island

Finding suitable BU placement in deep water.

The lack of mapping data to plan from during this Study can result in CRS route development, a cost and schedule risk.

Tsunami and seismic damage.

13.4.3. B3 – Future

Finding suitable BU placement in deep water.

13.4.4. B4 – Auckland

Finding suitable BU placement in deep water.

Tsunami and seismic damage.

Negotiation of seafloor space within the cable protection area.

14. Recommendations

14.1. Further Study

The waters offshore Chile and Juan Fernández were not compared against nautical charts created by the Chilean government due to purchasing restrictions related to non-Chilean citizens unable to obtain and thus provide a tax id that is specific to the individual making the purchase. These charts should be provided by SUBTEL to the CRS contractor and System Supplier prior to pre-survey CRE activities.

There are several submarine cable crossings offshore Auckland and Sydney; however, this study could only identify the existence of a crossing, not the ownership or name of each crossing. There are other OOS cables that are generally known about but not charted or identified during this study. Offshore Valparaiso, it is expected there to be crossings, but none were specifically identified due to the lack of nautical charts. Coordination with current and previous cable owners and access to their RPLs would help identify the presence of OOS cables.

14.2. Cable Route Survey

Planning the cable route survey should include sub-bottom and magnetometer to help identify cable crossings and seabed suitable for plough burial down to 1500 meters water depth.

If possible, deep water towed or AUV assets should be brought to bear to image high-risk plate boundary crossings and complex continental slope transitions.

14.3. Outreach

A dedicated website should be designed to convey the location of the System from the planning phase through decommissioning.

Local, national, and international nautical charting authorities should be provided the as-laid RPL immediately after RFS for inclusion on relevant nautical charts.

Local and national fishing organizations should be approached as part of the overall permitting process, from planning to RFS. Plan on providing GPS unit compatible RPL position downloads and instructions.

The science community will be extremely interested in the survey results encountered. Providing a version of the CRS data after RFS to an international data clearinghouse has proven to be effective capital during the permitting process.

Appendices

Appendix A. Cable Route Engineering

The System cable summary, straight line diagrams and route position lists are shown below for reference and included as a separate set of files in Excel and Google KMZ format.

ASIA - SOUTH AMERICA DIGITAL GATEWAY (DGASA) SYSTEM

Valparaiso, CL to Sydney, AU

Cable Summary - Desktop Study

Segment	Cable Type	Issue 2: Revision 0
Valparaiso - Sydney Trunk	DA	23.155
Valparaiso - Sydney Trunk	SA	60.137
Valparaiso - Sydney Trunk	LWP	2975.308
Valparaiso - Sydney Trunk	LW	11045.772
Juan Fernández Spur	DA	1.755
Juan Fernández Spur	SA	8.571
Juan Fernández Spur	LWP	5.025
Juan Fernández Spur	LW	34.255
Easter Island Spur	DA	1.465
Easter Island Spur	SA	2.130
Easter Island Spur	LWP	3.087
Easter Island Spur	LW	368.497
Auckland Spur	DA	11.695
Auckland Spur	SA	242.571
Auckland Spur	LWP	12.360
Auckland Spur	LW	0.000
Total DA Length		38.070
Total SA Length		313.410
Total LWP Length		2995.780
Total LW Length		11448.524
Total Subsea System Length		***14795.784***
DA (5% Spare)		1.904

tmg

wfnstrategies

SA (5% Spare)		15.670
LWP (5% Spare)		149.789
LW (5% Spare)		572.426
Total Spare		***739.789***
Contract Length		***15535.573***
* All lengths are in kilometers DA = Double Armor (Submarine) SA = Single Armor (Submarine) LWP = Light Weight Protected (Submarine) LW = Light Weight (Submarine)		

Trunk Valparaiso, CL (L1) - Sydney, AU (L5)													**Total Length (km):**		14104.372 km
	Cable type	SA	DA	SA	LWP	LW	LWP	LW	LWP	LW	LWP	SA	DA	SA	
Valparaiso, CL															Sydney, AU
	km	0.169	9.583	18.481	227.163	3723.087	117.011	6561.443	2606.439	761.242	24.695	40.963	13.572	0.523	

Branch (B1) - Juan Fernandez, CL (L2)				**Total Length (km):**	49.607 km
	Cable type	LW	LWP	SA	DA	
BU						JF
	km	34.255	5.025	8.571	1.755	

Branch (B2) - Easter Island, CL (L3)				**Total Length (km):**	375.179 km
	Cable type	LW	LWP	SA	DA	
BU						Easter Island
	km	368.497	3.087	2.130	1.465	

Branch (B4) - Auckland, NZ (L4)				Total Length (km):		266.626 km
	Cable type	LWP	SA	DA	SA	
BU						Auckland
	km	12.360	241.389	11.695	1.182	

Branch (B3) - Future			
	Cable type	LW	
BU (B3)			Tail End
	km	18.000	

wfnstrategies

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
1	Valparaiso, CL Landing Site (L1)	33 ° 01.351 ' S	71 ° 38.640 ' W			0.000			0.000		0.000	-3	Proposed approximate BMH, no site visit performed.
				157.08 °	0.168		1.00	0.169		SA			
2	HDD Exit	33 ° 01.267 ' S	71 ° 38.681 ' W			0.168			0.169		0.169	18	TR SA/DA, Plough Down
				168.76 °	1.994		1.00	2.014		DA			
3	AC001	33 ° 00.209 ' S	71 ° 38.931 ' W			2.162			2.183			113	
				142.17 °	1.352		1.00	1.365		DA			
4	AC002	32 ° 59.631 ' S	71 ° 39.463 ' W			3.514			3.549			124	
				115.36 °	2.267		1.00	2.290		DA			
5	AC003	32 ° 59.106 ' S	71 ° 40.779 ' W			5.781			5.839			128	
				111.31 °	3.875		1.00	3.913		DA			
6	AC004	32 ° 58.344 ' S	71 ° 43.096 ' W			9.656			9.752		9.583	155	TR DA/SA
				270.00 °	7.559		1.00	7.634		SA			
7	AC005	32 ° 57.136 ' S	71 ° 47.730 ' W			17.214			17.386			402	
				109.83 °	10.739		1.00	10.847		SA			
8	AC006	32 ° 55.165 ' S	71 ° 54.211 ' W			27.954			28.233		18.481	1476	TR SA/LWP, Plough Up
				116.05 °	11.962		1.00	12.082		LWP			
9	AC007	32 ° 52.323 ' S	72 ° 01.103 ' W			39.916			40.315			2411	
				133.63 °	7.974		1.00	8.054		LWP			
10	AC008	32 ° 49.346 ' S	72 ° 04.802 ' W			47.890			48.369			2487	

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
				139.05 °	6.376		1.00	6.440		LWP			
11	AC009	32 ° 46.740 ' S	72 ° 07.480 ' W			54.266			54.809			2496	
				118.57 °	6.640		1.00	6.706		LWP			
12	AC010	32 ° 45.022 ' S	72 ° 11.213 ' W			60.906			61.515			2466	
				109.97 °	7.377		1.00	7.451		LWP			
13	AC011	32 ° 43.659 ' S	72 ° 15.652 ' W			68.283			68.966			2491	
				92.48 °	7.602		1.00	7.678		LWP			
14	AC012	32 ° 43.482 ' S	72 ° 20.513 ' W			75.885			76.644			2481	
				88.44 °	8.038		1.00	8.118		LWP			
15	AC013	32 ° 43.600 ' S	72 ° 25.656 ' W			83.923			84.762			2950	
				99.42 °	12.051		1.00	12.172		LWP			
16	AC014	32 ° 42.533 ' S	72 ° 33.265 ' W			95.974			96.934			3672	
				105.55 °	15.944		1.00	16.104		LWP			
17	AC015	32 ° 40.221 ' S	72 ° 43.093 ' W			111.919			113.038			5844	
				80.81 °	13.387		1.00	13.521		LWP			
18	AC016	32 ° 41.377 ' S	72 ° 51.547 ' W			125.305			126.558			5504	
				69.86 °	1.556		1.00	1.572		LWP			
19	AC017	32 ° 41.667 ' S	72 ° 52.482 ' W			126.862			128.130			5470	South America - Nazca Plate Boundary
				69.86 °	8.470		1.00	8.555		LWP			
20	AC018	32 ° 43.245 ' S	72 ° 57.570 ' W			135.331			136.685			4905	
				66.06 °	11.740		1.00	11.857		LWP			
21	AC019	32 ° 45.822 ' S	73 ° 04.439 ' W			147.072			148.542			4384	

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
				43.84 °	15.478		1.00	15.632		LWP			
22	AC020	32 ° 51.862 ' S	73 ° 11.308 ' W			162.549			164.175			4183	
				39.56 °	19.139		1.00	19.331		LWP			
23	AC021	32 ° 59.844 ' S	73 ° 19.129 ' W			181.688			183.505			3822	
				46.49 °	14.745		1.00	14.893		LWP			
24	AC022	33 ° 05.337 ' S	73 ° 25.998 ' W			196.433			198.398			3807	
				47.94 °	16.602		1.00	16.768		LWP			
25	AC023	33 ° 11.354 ' S	73 ° 33.923 ' W			213.035			215.166			3786	
				72.64 °	20.815		1.00	21.023		LWP			
26	AC024	33 ° 14.713 ' S	73 ° 46.710 ' W			233.851			236.189			3826	
				96.91 °	19.017		1.00	19.207		LWP			
27	AC025	33 ° 13.476 ' S	73 ° 58.863 ' W			252.867			255.396		227.163	3848	
				100.66 °	18.547		1.00	18.733		LW			
28	AC026	33 ° 11.619 ' S	74 ° 10.593 ' W			271.415			274.129			3964	
				108.99 °	18.591		1.00	18.777		LW			
29	AC027	33 ° 08.346 ' S	74 ° 21.901 ' W			290.006			292.906			4009	
				112.40 °	29.018		1.00	29.308		LW			
30	AC028	33 ° 02.365 ' S	74 ° 39.143 ' W			319.023			322.214			3948	
				84.16 °	26.846		1.00	27.114		LW			
31	AC029	33 ° 03.843 ' S	74 ° 56.300 ' W			345.869			349.328			4634	
				75.72 °	22.262		1.00	22.485		LW			
32	AC030	33 ° 06.814 ' S	75 ° 10.165 ' W			368.131			371.813			4270	
				76.80 °	17.619		1.00	17.795		LW			

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
33	AC031	33 ° 08.991 ' S	75 ° 21.194 ' W			385.750			389.608			4458	
				89.19 °	17.274		1.00	17.446		LW			
34	AC032	33 ° 09.123 ' S	75 ° 32.303 ' W			403.024			407.054			4605	
				108.01 °	22.485		1.00	22.709		LW			
35	AC033	33 ° 05.362 ' S	75 ° 46.050 ' W			425.509			429.764			4473	
				100.64 °	19.835		1.00	20.033		LW			
36	AC034	33 ° 03.381 ' S	75 ° 58.576 ' W			445.343			449.797			4361	
				98.22 °	11.524		1.00	11.639		LW			
37	AC035	33 ° 02.490 ' S	76 ° 05.903 ' W			456.867			461.436			4336	
				105.97 °	15.312		1.00	15.465		LW			
38	AC036	33 ° 00.211 ' S	76 ° 15.356 ' W			472.179			476.901			4264	
				116.46 °	12.750		1.00	12.877		LW			
39	AC037	32 ° 57.138 ' S	76 ° 22.683 ' W			484.929			489.778			4262	
				105.25 °	13.937		1.00	14.076		LW			
40	AC038	32 ° 55.154 ' S	76 ° 31.309 ' W			498.866			503.854			4315	
				88.22 °	29.489		1.00	29.784		LW			
41	AC039	32 ° 55.650 ' S	76 ° 50.217 ' W			528.355			533.638			4155	
				79.80 °	33.119		1.00	33.450		LW			
42	AC040	32 ° 58.823 ' S	77 ° 11.133 ' W			561.473			567.088			4259	
				67.81 °	24.245		1.00	24.488		LW			
43	AC041	33 ° 03.777 ' S	77 ° 25.550 ' W			585.719			591.576			4310	
				64.69 °	36.796		1.00	37.164		LW			

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
44	AC042	33 ° 12.288 ' S	77 ° 46.939 ' W			622.515			628.740			4186	
				77.12 °	27.870		1.00	28.149		LW			
45	AC043	33 ° 15.648 ' S	78 ° 04.428 ' W			650.385			656.889			3994	
				91.98 °	29.272		1.00	29.565		LW			
46	AC044	33 ° 15.103 ' S	78 ° 23.265 ' W			679.657			686.453			4292	
				82.08 °	17.267		1.00	17.439		LW			
47	Juan Fernández BU (B1)	33 ° 16.390 ' S	78 ° 34.278 ' W			696.923			703.893			3961	B1
				120.98 °	16.208		1.00	16.370		LW			
48	AC045	33 ° 11.876 ' S	78 ° 43.223 ' W			713.131			720.263			4011	
				107.40 °	101.524		1.00	102.539		LW			
49	AC046	32 ° 55.452 ' S	79 ° 45.465 ' W			814.655			822.802			4106	
				107.61 °	80.695		1.00	81.502		LW			
50	AC047	32 ° 42.243 ' S	80 ° 34.742 ' W			895.350			904.303			4073	
				106.17 °	105.719		1.00	106.776		LW			
51	AC048	32 ° 26.309 ' S	81 ° 39.618 ' W			1001.068			1011.079			3956	
				108.69 °	138.934		1.00	140.323		LW			
52	AC049	32 ° 02.220 ' S	83 ° 03.402 ' W			1140.002			1151.402			3806	
				95.54 °	105.904		1.00	106.963		LW			
53	AC050	31 ° 56.685 ' S	84 ° 10.326 ' W			1245.907			1258.366			3875	CL EEZ
				95.54 °	14.906		1.00	15.055		LW			
54	AC051	31 ° 55.906 ' S	84 ° 19.741 ' W			1260.812			1273.421			3950	

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
				106.82 °	75.116		1.00	75.868		LW			
55	AC052	31 ° 44.144 ' S	85 ° 05.314 ' W			1335.929			1349.288			3801	
				111.00 °	127.165		1.00	128.437		LW			
56	AC053	31 ° 19.485 ' S	86 ° 20.318 ' W			1463.094			1477.725			3901	
				115.04 °	92.093		1.00	93.014		LW			
57	AC054	30 ° 58.394 ' S	87 ° 12.821 ' W			1555.187			1570.739			3645	
				119.05 °	84.072		1.00	84.913		LW			
58	AC055	30 ° 36.303 ' S	87 ° 58.894 ' W			1639.260			1655.652			3587	
				109.45 °	112.794		1.00	113.922		LW			
59	AC056	30 ° 15.979 ' S	89 ° 05.326 ' W			1752.054			1769.575			3751	
				103.18 °	270.787		1.00	273.495		LW			
60	AC057	29 ° 42.570 ' S	91 ° 49.263 ' W			2022.841			2043.069			3375	
				93.10 °	159.274		1.00	160.867		LW			
61	AC058	29 ° 37.915 ' S	93 ° 27.839 ' W			2182.115			2203.936			3517	
				88.79 °	162.573		1.00	164.199		LW			
62	AC059	29 ° 39.777 ' S	95 ° 08.559 ' W			2344.688			2368.135			3769	
				89.70 °	171.411		1.00	173.126		LW			
63	AC060	29 ° 40.262 ' S	96 ° 54.796 ' W			2516.100			2541.261			3522	
				83.11 °	139.893		1.00	141.292		LW			
64	AC061	29 ° 49.342 ' S	98 ° 20.943 ' W			2655.993			2682.553			4149	
				70.26 °	92.402		1.00	93.326		LW			

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
65	AC062	30 ° 06.234 ' S	99 ° 15.007 ' W			2748.395			2775.879			3218	
				83.67 °	143.719		1.00	145.156		LW			
66	AC063	30 ° 14.816 ' S	100 ° 43.990 ' W			2892.114			2921.035			3663	
				103.45 °	182.282		1.00	184.105		LW			
67	AC064	29 ° 51.869 ' S	102 ° 34.295 ' W			3074.396			3105.139			3107	
				87.60 °	245.970		1.00	248.430		LW			
68	AC065	29 ° 57.441 ' S	105 ° 06.981 ' W			3320.366			3353.569			3365	
				85.26 °	186.678		1.00	188.545		LW			
69	AC066	30 ° 05.790 ' S	107 ° 02.701 ' W			3507.044			3542.114			3298	
				89.59 °	44.800		1.00	45.248		LW			
70	AC067	30 ° 05.964 ' S	107 ° 30.587 ' W			3551.844			3587.362			3199	Chile EEZ
				89.59 °	99.554		1.00	100.549		LW			
71	AC068	30 ° 06.351 ' S	108 ° 32.556 ' W			3651.397			3687.911			3226	
				101.03 °	54.155		1.00	54.696		LW			
72	AC069	30 ° 00.743 ' S	109 ° 05.630 ' W			3705.552			3742.607			3170	
				104.33 °	19.103		1.00	19.294		LW			
73	Easter Island BU (B2)	29 ° 58.183 ' S	109 ° 17.138 ' W			3724.655			3761.901			3195	B2
				70.21 °	12.494		1.00	12.619		LW			
74	AC070	30 ° 00.473 ' S	109 ° 24.447 ' W			3737.148			3774.520			3180	
				89.69 °	201.944		1.00	203.964		LW			
75	AC071	30 ° 01.067 ' S	111 ° 30.041 ' W			3939.092			3978.483		3723.087	2956	Chile EEZ
				89.69 °	23.145		1.00	23.377		LWP			

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
76	AC072	30 ° 01.135 ' S	111 ° 44.436 ' W			3962.238			4001.860			2568	Nazca - Pacific Plate Boundary
				88.35 °	92.708		1.00	93.635		LWP			
77	AC073	30 ° 02.575 ' S	112 ° 42.080 ' W			4054.945			4095.495		117.011	2841	
				84.51 °	59.476		1.00	60.070		LW			
78	AC074	30 ° 05.652 ' S	113 ° 18.921 ' W			4114.421			4155.565			2947	
				101.34 °	69.211		1.00	69.903		LW			
79	AC075	29 ° 58.285 ' S	114 ° 01.133 ' W			4183.632			4225.468			3010	
				107.84 °	58.724		1.00	59.311		LW			
80	AC076	29 ° 48.545 ' S	114 ° 35.856 ' W			4242.356			4284.779			3246	
				99.90 °	117.583		1.00	118.759		LW			
81	AC077	29 ° 37.606 ' S	115 ° 47.684 ' W			4359.939			4403.538			3461	
				85.78 °	44.621		1.00	45.067		LW			
82	AC078	29 ° 39.381 ' S	116 ° 15.258 ' W			4404.560			4448.605			3519	
				63.55 °	39.235		1.00	39.627		LW			
83	AC079	29 ° 48.840 ' S	116 ° 37.045 ' W			4443.794			4488.232			3521	
				54.11 °	44.628		1.00	45.074		LW			
84	AC080	30 ° 03.001 ' S	116 ° 59.513 ' W			4488.422			4533.306			3525	
				270.00 °	52.281		1.00	52.804		LW			
85	AC081	30 ° 16.540 ' S	117 ° 28.108 ' W			4540.704			4586.111			3511	
				74.06 °	61.269		1.00	61.881		LW			
86	AC082	30 ° 25.647 ' S	118 ° 04.873 ' W			4601.972			4647.992			3390	
				80.85 °	57.946		1.00	58.525		LW			

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
87	AC083	30 ° 30.635 ' S	118 ° 40.617 ' W			4659.918			4706.517			3463	
				94.03 °	115.786		1.00	116.944		LW			
88	AC084	30 ° 26.234 ' S	119 ° 52.786 ' W			4775.704			4823.461			3609	
				86.91 °	107.841		1.00	108.919		LW			
89	AC085	30 ° 29.382 ' S	121 ° 00.064 ' W			4883.545			4932.380			3697	
				94.64 °	126.493		1.00	127.758		LW			
90	AC086	30 ° 23.840 ' S	122 ° 18.818 ' W			5010.037			5060.138			3679	
				86.39 °	162.423		1.00	164.047		LW			
91	AC087	30 ° 29.382 ' S	124 ° 00.073 ' W			5172.461			5224.185			3870	
				89.73 °	381.595		1.00	385.411		LW			
92	AC088	30 ° 30.341 ' S	127 ° 58.564 ' W			5554.056			5609.597			3990	
				103.81 °	71.564		1.00	72.280		LW			
93	AC089	30 ° 21.095 ' S	128 ° 41.968 ' W			5625.621			5681.877			4096	
				94.86 °	163.520		1.00	165.155		LW			
94	AC090	30 ° 13.599 ' S	130 ° 23.583 ' W			5789.140			5847.032			4292	
				102.64 °	265.984		1.00	268.644		LW			
95	AC091	29 ° 42.104 ' S	133 ° 04.922 ' W			6055.124			6115.675			4207	
				94.01 °	184.609		1.00	186.455		LW			
96	AC092	29 ° 35.120 ' S	134 ° 59.034 ' W			6239.733			6302.131			4177	
				87.02 °	125.104		1.00	126.355		LW			
97	AC093	29 ° 38.642 ' S	136 ° 16.428 ' W			6364.837			6428.486			4195	
				69.47 °	69.550		1.00	70.245		LW			
98	AC094	29 ° 51.844 ' S	136 ° 56.831 ' W			6434.387			6498.731			4209	

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
				46.27 °	44.319		1.00	44.762		LW			
99	AC095	30 ° 08.427 ' S	137 ° 16.746 ' W			6478.706			6543.493			4195	
				65.00 °	43.394		1.00	43.827		LW			
100	AC096	30 ° 18.354 ' S	137 ° 41.256 ' W			6522.100			6587.321			4174	
				79.43 °	79.889		1.00	80.688		LW			
101	AC097	30 ° 26.284 ' S	138 ° 30.276 ' W			6601.989			6668.009			4261	
				86.68 °	98.633		1.00	99.619		LW			
102	AC098	30 ° 29.375 ' S	139 ° 31.796 ' W			6700.622			6767.628			4135	
				74.04 °	94.862		1.00	95.811		LW			
103	AC099	30 ° 43.496 ' S	140 ° 28.862 ' W			6795.484			6863.439			4222	
				62.39 °	125.582		1.00	126.838		LW			
104	AC100	31 ° 14.989 ' S	141 ° 38.767 ' W			6921.066			6990.277			4754	
				75.60 °	149.334		1.00	150.827		LW			
105	AC101	31 ° 35.088 ' S	143 ° 10.037 ' W			7070.400			7141.104			5312	
				81.02 °	142.862		1.00	144.291		LW			
106	AC102	31 ° 47.159 ' S	144 ° 39.333 ' W			7213.262			7285.394			5214	
				100.62 °	116.677		1.00	117.844		LW			
107	AC103	31 ° 35.523 ' S	145 ° 51.906 ' W			7329.939			7403.238			4846	
				115.53 °	89.680		1.00	90.576		LW			
108	AC104	31 ° 14.606 ' S	146 ° 42.969 ' W			7419.619			7493.815			4934	
				131.95 °	67.728		1.00	68.405		LW			
109	AC105	30 ° 50.105 ' S	147 ° 14.628 ' W			7487.346			7562.220			4969	

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
				119.97 °	77.811		1.00	78.589		LW			
110	AC106	30 ° 29.068 ' S	147 ° 56.827 ' W			7565.157			7640.809			4605	
				98.67 °	86.654		1.00	87.520		LW			
111	AC107	30 ° 21.994 ' S	148 ° 50.326 ' W			7651.811			7728.329			4402	
				86.56 °	107.817		1.00	108.895		LW			
112	AC108	30 ° 25.500 ' S	149 ° 57.519 ' W			7759.628			7837.225			5063	
				85.38 °	266.927		1.00	269.596		LW			
113	Future BU (B3)	30 ° 37.130 ' S	152 ° 43.846 ' W			8026.555			8106.821			5298	18 km BU Tail to accommodate 3.5x WD
				89.24 °	429.493		1.00	433.788		LW			
114	AC109	30 ° 40.218 ' S	157 ° 12.656 ' W			8456.048			8540.608			5162	
				85.72 °	212.354		1.00	214.478		LW			
115	AC110	30 ° 48.790 ' S	159 ° 25.338 ' W			8668.402			8755.086			5054	
				79.50 °	217.424		1.00	219.598		LW			
116	AC111	31 ° 10.239 ' S	161 ° 39.634 ' W			8885.825			8974.684			5564	
				83.49 °	298.398		1.00	301.382		LW			
117	AC112	31 ° 28.559 ' S	164 ° 46.524 ' W			9184.224			9276.066			4723	
				73.94 °	25.449		1.00	25.703		LW			
118	AC113	31 ° 32.368 ' S	165 ° 01.970 ' W			9209.672			9301.769			5646	
				50.11 °	26.312		1.00	26.575		LW			
119	AC114	31 ° 41.500 ' S	165 ° 14.736 ' W			9235.984			9328.344			5479	
				27.26 °	35.175		1.00	35.527		LW			
120	AC115	31 ° 58.419 ' S	165 ° 24.949 ' W			9271.160			9363.871			5320	
				39.34 °	39.277		1.00	39.669		LW			

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
121	AC116	32 ° 14.855 ' S	165 ° 40.778 ' W			9310.436			9403.541			5428	
				60.76 °	44.071		1.00	44.512		LW			
122	AC117	32 ° 26.503 ' S	166 ° 05.288 ' W			9354.508			9448.053			4984	
				75.61 °	60.165		1.00	60.767		LW			
123	AC118	32 ° 34.590 ' S	166 ° 42.500 ' W			9414.673			9508.820			5388	
				94.03 °	90.552		1.00	91.458		LW			
124	AC119	32 ° 31.147 ' S	167 ° 40.201 ' W			9505.225			9600.277			5508	
				92.39 °	72.139		1.00	72.861		LW			
125	AC120	32 ° 29.518 ' S	168 ° 26.222 ' W			9577.364			9673.138			5615	
				71.65 °	53.047		1.00	53.578		LW			
126	AC121	32 ° 38.555 ' S	168 ° 58.391 ' W			9630.412			9726.716			5458	
				54.58 °	44.893		1.00	45.342		LW			
127	AC122	32 ° 52.632 ' S	169 ° 21.817 ' W			9675.304			9772.058			5523	
				37.86 °	53.096		1.00	53.627		LW			
128	AC123	33 ° 15.312 ' S	169 ° 42.752 ' W			9728.401			9825.685			5484	
				36.57 °	63.717		1.00	64.354		LW			
129	AC124	33 ° 42.994 ' S	170 ° 07.263 ' W			9792.118			9890.039			5551	
				49.62 °	63.158		1.00	63.790		LW			
130	AC125	34 ° 05.125 ' S	170 ° 38.475 ' W			9855.276			9953.829			5268	
				62.92 °	73.329		1.00	74.062		LW			
131	AC126	34 ° 23.179 ' S	171 ° 20.997 ' W			9928.605			10027.891			5752	
				76.10 °	71.530		1.00	72.246		LW			
132	AC127	34 ° 32.474 ' S	172 ° 06.340 ' W			10000.135			10100.137			5708	
				76.08 °	39.256		1.00	39.649		LW			

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
133	AC128	34 ° 37.581 ' S	172 ° 31.259 ' W			10039.392			10139.786			5756	
				81.76 °	60.558		1.00	61.164		LW			
134	AC129	34 ° 42.275 ' S	173 ° 10.492 ' W			10099.950			10200.949			5660	
				90.00 °	58.208		1.00	58.790		LW			
135	AC130	34 ° 42.275 ' S	173 ° 48.654 ' W			10158.158			10259.739			5586	
				65.05 °	64.173		1.00	64.815		LW			
136	AC131	34 ° 56.913 ' S	174 ° 26.817 ' W			10222.331			10324.554			5665	
				52.47 °	134.274		1.00	135.617		LW			
137	AC132	35 ° 41.148 ' S	175 ° 37.079 ' W			10356.605			10460.171			5549	
				64.47 °	88.064		1.00	88.945		LW			
138	AC133	36 ° 01.672 ' S	176 ° 29.864 ' W			10444.669			10549.116			5564	
				57.17 °	106.754		1.00	107.822		LW			
139	AC134	36 ° 32.964 ' S	177 ° 29.780 ' W			10551.423			10656.938		6561.443	5352	NZ EEZ
				57.17 °	54.304		1.00	54.847		LWP			
140	AC135	36 ° 48.882 ' S	178 ° 00.411 ' W			10605.728			10711.785			4345	
				77.74 °	39.783		1.00	40.181		LWP			
141	AC136	36 ° 53.448 ' S	178 ° 26.567 ' W			10645.511			10751.966			4185	
				94.33 °	47.319		1.00	47.792		LWP			
142	AC137	36 ° 51.516 ' S	178 ° 58.320 ' W			10692.830			10799.758			4012	
				117.39 °	31.896		1.00	32.215		LWP			
143	AC138	36 ° 43.583 ' S	179 ° 17.358 ' W			10724.726			10831.973			4505	
				113.62 °	18.629		1.00	18.816		LWP			
144	AC139	36 ° 39.546 ' S	179 ° 28.817 ' W			10743.355			10850.789			4983	Pacific - Australia Plate Boundary

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
				127.11 °	42.756		1.00	43.184		LWP			
145	AC140	36 ° 25.600 ' S	179 ° 51.666 ' E			10786.112			10893.973			2874	
				251.43 °	30.009		1.00	30.309		LWP			
146	AC141	36 ° 20.431 ' S	179 ° 32.645 ' E			10816.120			10924.282			2705	
				269.51 °	41.271		1.00	41.684		LWP			
147	AC142	36 ° 20.240 ' S	179 ° 05.063 ' E			10857.392			10965.966			2516	
				256.50 °	18.989		1.00	19.179		LWP			
148	AC143	36 ° 17.842 ' S	178 ° 52.726 ' E			10876.381			10985.144			2477	
				236.94 °	13.311		1.00	13.444		LWP			
149	AC144	36 ° 13.915 ' S	178 ° 45.278 ' E			10889.691			10998.588			2481	XING
				236.94 °	9.717		1.00	9.814		LWP			
150	AC145	36 ° 11.049 ' S	178 ° 39.845 ' E			10899.408			11008.402			2477	
				241.54 °	129.078		1.00	130.369		LWP			
151	AC146	35 ° 37.792 ' S	177 ° 24.414 ' E			11028.486			11138.771			2276	XING
				241.55 °	196.440		1.00	198.404		LWP			
152	AC147	34 ° 47.176 ' S	175 ° 30.607 ' E			11224.926			11337.175			1654	XING
				241.55 °	20.583		1.00	20.789		LWP			
153	AC148	34 ° 41.873 ' S	175 ° 18.750 ' E			11245.509			11357.964			1697	XING
				241.55 °	17.314		1.00	17.487		LWP			
154	AC149	34 ° 37.411 ' S	175 ° 08.785 ' E			11262.824			11375.452			1773	

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
				258.56 °	11.368		1.00	11.482		LWP			
155	Auckland BU (B4)	34 ° 36.191 ' S	175 ° 01.496 ' E			11274.192			11386.934			1850	
				209.34 °	11.246		1.00	11.359		LWP			
156	AC150	34 ° 30.888 ' S	174 ° 57.893 ' E			11285.439			11398.293			1853	
				165.56 °	6.265		1.00	6.328		LWP			
157	AC151	34 ° 27.607 ' S	174 ° 58.914 ' E			11291.704			11404.621			1873	XING
				165.56 °	8.934		1.00	9.023		LWP			
158	AC152	34 ° 22.928 ' S	175 ° 00.369 ' E			11300.637			11413.644			1910	
				180.08 °	28.433		1.00	28.717		LWP			
159	AC153	34 ° 07.548 ' S	175 ° 00.343 ' E			11329.070			11442.361			1676	
				270.00 °	23.157		1.00	23.389		LWP			
160	AC154	33 ° 55.417 ' S	175 ° 04.087 ' E			11352.227			11465.750			2365	
				200.18 °	45.724		1.00	46.181		LWP			
161	AC155	33 ° 32.201 ' S	174 ° 53.875 ' E			11397.951			11511.931			2690	
				203.60 °	52.791		1.00	53.318		LWP			
162	AC156	33 ° 06.031 ' S	174 ° 40.258 ' E			11450.742			11565.249			3608	
				210.64 °	58.348		1.00	58.932		LWP			
163	AC157	32 ° 38.870 ' S	174 ° 21.195 ' E			11509.090			11624.181			3658	
				249.11 °	41.625		1.00	42.041		LWP			
164	AC158	32 ° 30.838 ' S	173 ° 56.344 ' E			11550.715			11666.222			3363	

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
				263.97 °	106.201		1.00	107.263		LWP			
165	AC159	32 ° 24.806 ' S	172 ° 48.941 ' E			11656.916			11773.486			2047	
				284.32 °	42.940		1.00	43.370		LWP			
166	AC160	32 ° 30.551 ' S	172 ° 22.388 ' E			11699.857			11816.855			2066	
				275.45 °	57.359		1.00	57.933		LWP			
167	AC161	32 ° 33.496 ' S	171 ° 45.919 ' E			11757.216			11874.788			2711	XING
				275.45 °	14.678		1.00	14.825		LWP			
168	AC162	32 ° 34.250 ' S	171 ° 36.583 ' E			11771.894			11889.613			3147	
				279.60 °	74.880		1.00	75.628		LWP			
169	AC163	32 ° 41.003 ' S	170 ° 49.378 ' E			11846.773			11965.241			4033	
				262.78 °	39.343		1.00	39.736		LWP			
170	AC164	32 ° 38.328 ' S	170 ° 24.414 ' E			11886.116			12004.977			4130	
				240.53 °	32.095		1.00	32.416		LWP			
171	AC165	32 ° 29.785 ' S	170 ° 06.561 ' E			11918.211			12037.393			4029	
				233.38 °	33.249		1.00	33.581		LWP			
172	AC166	32 ° 19.056 ' S	169 ° 49.540 ' E			11951.459			12070.974			3762	
				227.44 °	47.946		1.00	48.426		LWP			
173	AC167	32 ° 01.510 ' S	169 ° 27.072 ' E			11999.406			12119.400			4010	
				214.00 °	6.021		1.00	6.081		LWP			
174	AC168	31 ° 58.810 ' S	169 ° 24.935 ' E			12005.426			12125.480			4046	NZ EEZ

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
				214.00 °	45.522		1.00	45.977		LWP			
175	AC169	31 ° 38.389 ' S	169 ° 08.803 ' E			12050.948			12171.458			4095	
				233.78 °	32.053		1.00	32.373		LWP			
176	AC170	31 ° 28.139 ' S	168 ° 52.463 ' E			12083.001			12203.831			4083	
				214.38 °	20.387		1.00	20.591		LWP			
177	AC171	31 ° 19.034 ' S	168 ° 45.201 ' E			12103.388			12224.422			4059	
				243.98 °	21.244		1.00	21.456		LWP			
178	AC172	31 ° 13.991 ' S	168 ° 33.173 ' E			12124.632			12245.878			3871	
				265.83 °	83.849		1.00	84.688		LWP			
179	AC173	31 ° 10.691 ' S	167 ° 40.521 ' E			12208.481			12330.566			1945	
				270.35 °	80.721		1.00	81.528		LWP			
180	AC174	31 ° 10.958 ' S	166 ° 49.714 ' E			12289.202			12412.094			1988	
				284.28 °	53.959		1.00	54.499		LWP			
181	AC175	31 ° 18.162 ' S	166 ° 16.778 ' E			12343.161			12466.593			2439	
				313.39 °	66.750		1.00	67.418		LWP			
182	AC176	31 ° 42.976 ' S	165 ° 46.140 ' E			12409.912			12534.011			2925	
				340.15 °	16.097		1.00	16.258		LWP			
183	AC177	31 ° 51.169 ' S	165 ° 42.678 ' E			12426.008			12550.269			3012	NZ EEZ
				340.15 °	114.969		1.00	116.118		LWP			
184	AC178	32 ° 49.679 ' S	165 ° 17.800 ' E			12540.977			12666.387			3142	

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
				339.77 °	64.185		1.00	64.827		LWP			
185	AC179	33 ° 22.261 ' S	165 ° 03.536 ' E			12605.162			12731.214			3067	
				316.60 °	53.424		1.00	53.958		LWP			
186	AC180	33 ° 43.260 ' S	164 ° 39.823 ' E			12658.586			12785.172			2934	
				308.55 °	53.154		1.00	53.686		LWP			
187	AC181	34 ° 01.181 ' S	164 ° 12.867 ' E			12711.740			12838.858			1191	
				287.18 °	194.678		1.00	196.625		LWP			
188	AC182	34 ° 32.286 ' S	162 ° 11.676 ' E			12906.419			13035.483			1585	
				302.46 °	22.075		1.00	22.296		LWP			
189	AC183	34 ° 38.694 ' S	161 ° 59.494 ' E			12928.494			13057.779			1913	XING
				302.46 °	27.849		1.00	28.128		LWP			
190	AC184	34 ° 46.777 ' S	161 ° 44.102 ' E			12956.343			13085.906			2513	
				276.58 °	84.021		1.00	84.861		LWP			
191	AC185	34 ° 51.980 ' S	160 ° 49.359 ' E			13040.364			13170.768			2771	AU EEZ
				276.58 °	27.641		1.00	27.918		LWP			
192	AC186	34 ° 53.692 ' S	160 ° 31.338 ' E			13068.005			13198.685			2578	
				270.85 °	64.050		1.00	64.691		LWP			
193	AC187	34 ° 54.207 ' S	159 ° 49.296 ' E			13132.056			13263.376		2606.439	4109	
				259.81 °	60.323		1.00	60.926		LW			
194	AC188	34 ° 48.433 ' S	159 ° 10.343 ' E			13192.379			13324.303			4854	

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
				246.02 °	59.221		1.00	59.813		LW			
195	AC189	34 ° 35.416 ' S	158 ° 34.908 ' E			13251.600			13384.116			4710	
				264.98 °	39.353		1.00	39.746		LW			
196	AC190	34 ° 33.554 ' S	158 ° 09.274 ' E			13290.953			13423.862			4542	
				273.35 °	78.533		1.00	79.319		LW			
197	AC191	34 ° 36.037 ' S	157 ° 18.006 ' E			13369.486			13503.181			4758	
				255.01 °	25.403		1.00	25.657		LW			
198	AC192	34 ° 32.483 ' S	157 ° 01.961 ' E			13394.889			13528.838			4636	AU EEZ
				255.01 °	32.317		1.00	32.640		LW			
199	AC193	34 ° 27.963 ' S	156 ° 41.566 ' E			13427.206			13561.478			4700	
				269.16 °	51.960		1.00	52.480		LW			
200	AC194	34 ° 27.548 ' S	156 ° 07.638 ' E			13479.166			13613.957			4692	
				263.61 °	32.159		1.00	32.481		LW			
201	AC195	34 ° 25.612 ' S	155 ° 46.773 ' E			13511.325			13646.438			4743	AU EEZ
				263.61 °	88.369		1.00	89.252		LW			
202	AC196	34 ° 20.290 ' S	154 ° 49.480 ' E			13599.694			13735.691			4902	
				256.47 °	22.694		1.00	22.921		LW			
203	AC197	34 ° 17.418 ' S	154 ° 35.097 ' E			13622.388			13758.612			4745	XING
				256.47 °	13.396		1.00	13.530		LW			
204	AC198	34 ° 15.723 ' S	154 ° 26.611 ' E			13635.784			13772.142			4873	

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
				270.30 °	47.955		1.00	48.435		LW			
205	AC199	34 ° 15.858 ' S	153 ° 55.370 ' E			13683.740			13820.577			4949	
				272.31 °	28.579		1.00	28.865		LW			
206	AC200	34 ° 16.481 ' S	153 ° 36.765 ' E			13712.318			13849.442			4901	
				276.86 °	18.530		1.00	18.715		LW			
207	AC201	34 ° 17.678 ' S	153 ° 24.777 ' E			13730.848			13868.157			4930	
				284.72 °	7.523		1.00	7.598		LW			
208	AC202	34 ° 18.712 ' S	153 ° 20.034 ' E			13738.371			13875.755			4819	
				302.79 °	2.972		1.00	3.002		LW			
209	AC203	34 ° 19.583 ' S	153 ° 18.405 ' E			13741.344			13878.757			4775	XING
				302.78 °	3.157		1.00	3.188		LW			
210	AC204	34 ° 20.507 ' S	153 ° 16.675 ' E			13744.500			13881.945			4795	
				318.01 °	4.669		1.00	4.716		LW			
211	AC205	34 ° 22.384 ' S	153 ° 14.638 ' E			13749.170			13886.661			4842	XING
				318.01 °	8.311		1.00	8.394		LW			
212	AC206	34 ° 25.726 ' S	153 ° 11.010 ' E			13757.480			13895.055			4863	XING
				307.44 °	8.259		1.00	8.342		LW			
213	AC207	34 ° 28.441 ' S	153 ° 06.729 ' E			13765.739			13903.397			4867	
				283.98 °	8.729		1.00	8.817		LW			
214	AC208	34 ° 29.582 ' S	153 ° 01.196 ' E			13774.469			13912.213			4852	

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
				278.49 °	18.348		1.00	18.532		LW			
215	AC209	34 ° 31.047 ' S	152 ° 49.339 ' E			13792.817			13930.745			4853	
				273.32 °	0.800		1.00	0.808		LW			
216	AC210	34 ° 31.072 ' S	152 ° 48.817 ' E			13793.617			13931.553			4863	
				273.32 °	45.994		1.00	46.454		LW			
217	AC211	34 ° 32.512 ' S	152 ° 18.809 ' E			13839.611			13978.007			4872	
				260.98 °	13.445		1.00	13.579		LW			
218	AC212	34 ° 31.373 ' S	152 ° 10.130 ' E			13853.056			13991.586			4770	
				247.24 °	32.705		1.00	33.032		LW			
219	AC213	34 ° 24.530 ' S	151 ° 50.435 ' E			13885.760			14024.618		761.242	2904	
				233.84 °	24.451		1.00	24.695		LWP			
220	AC214	34 ° 16.727 ' S	151 ° 37.562 ' E			13910.211			14049.313		24.695	1355	XING
				233.84 °	5.206		1.00	5.258		SA			
221	AC215	34 ° 15.065 ' S	151 ° 34.824 ' E			13915.417			14054.571			911	
				227.60 °	14.302		1.00	14.445		SA			
222	AC216	34 ° 09.849 ' S	151 ° 27.949 ' E			13929.718			14069.016			224	
				223.59 °	1.566		1.00	1.582		SA			
223	AC217	34 ° 09.235 ' S	151 ° 27.246 ' E			13931.285			14070.597			187	
				211.65 °	1.544		1.00	1.559		SA			
224	AC218	34 ° 08.525 ' S	151 ° 26.719 ' E			13932.828			14072.156			164	

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
				193.32 °	8.543		1.00	8.629		SA			
225	AC219	34 ° 04.028 ' S	151 ° 25.440 ' E			13941.372			14080.785			145	
				201.13 °	1.481		1.00	1.496		SA			
226	AC220	34 ° 03.280 ' S	151 ° 25.093 ' E			13942.853			14082.281			143	
				227.21 °	0.682		1.00	0.689		SA			
227	AC221	34 ° 03.030 ' S	151 ° 24.767 ' E			13943.535			14082.970			142	
				241.47 °	0.615		1.00	0.622		SA			
228	AC222	34 ° 02.871 ' S	151 ° 24.416 ' E			13944.150			14083.592			141	
				254.81 °	0.425		1.00	0.430		SA			
229	AC223	34 ° 02.810 ' S	151 ° 24.149 ' E			13944.576			14084.022			140	XING
				254.81 °	0.487		1.00	0.492		SA			
230	AC224	34 ° 02.741 ' S	151 ° 23.844 ' E			13945.063			14084.514			139	
				232.83 °	0.704		1.00	0.711		SA			
231	AC225	34 ° 02.511 ' S	151 ° 23.479 ' E			13945.767			14085.225			138	
				213.46 °	0.605		1.00	0.611		SA			
232	AC226	34 ° 02.238 ' S	151 ° 23.263 ' E			13946.372			14085.836			137	
				202.31 °	4.396		1.00	4.440		SA			
233	AC227	34 ° 00.038 ' S	151 ° 22.178 ' E			13950.769			14090.276		40.963	125	
				197.80 °	3.474		1.00	3.509		DA			
234	AC228	33 ° 58.249 ' S	151 ° 21.489 ' E			13954.243			14093.785			86	

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
				215.66 °	0.773		1.00	0.781		DA			
235	AC229	33 ° 57.909 ' S	151 ° 21.196 ' E			13955.016			14094.566			92	
				270.00 °	0.876		1.00	0.885		DA			
236	AC230	33 ° 57.618 ' S	151 ° 20.747 ' E			13955.892			14095.451			86	
				243.96 °	3.614		1.00	3.650		DA			
237	AC231	33 ° 56.760 ' S	151 ° 18.639 ' E			13959.506			14099.102			58	
				241.14 °	1.923		1.00	1.942		DA			
238	AC232	33 ° 56.258 ' S	151 ° 17.546 ' E			13961.429			14101.043			43	
				245.69 °	1.907		1.00	1.926		DA			
239	AC233	33 ° 55.833 ' S	151 ° 16.419 ' E			13963.336			14102.969			27	
				248.32 °	0.870		1.00	0.879		DA			
240	HDD Exit	33 ° 55.659 ' S	151 ° 15.894 ' E			13964.206			14103.848		13.572	13	
				253.61 °	0.518		1.00	0.523		SA			
241	Sydney, AU Landing Site (L5)	33 ° 55.580 ' S	151 ° 15.571 ' E			13964.724			14104.372		0.523	-10	Proposed approximate BMH, no site visit performed.

B1 – Juan Fernández

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
1	Juan Fernandez BU (B1)	33 ° 16.390 ' S	78 ° 34.278 ' W			0.000			0.000		0.000	3961	
				9.22 °	4.647		1.00	4.694		LW			
2	AC001	33 ° 18.872 ' S	78 ° 34.758 ' W			4.647			4.694			3836	
				11.69 °	3.249		1.00	3.281		LW			
3	AC002	33 ° 20.593 ' S	78 ° 35.182 ' W			7.896			7.975			3735	
				17.76 °	3.389		1.00	3.423		LW			
4	AC003	33 ° 22.339 ' S	78 ° 35.848 ' W			11.285			11.398			3627	
				21.31 °	4.265		1.00	4.308		LW			
5	AC004	33 ° 24.488 ' S	78 ° 36.848 ' W			15.550			15.706			3505	
				29.69 °	3.981		1.00	4.021		LW			
6	AC005	33 ° 26.359 ' S	78 ° 38.120 ' W			19.531			19.727			3338	
				270.00 °	3.362		1.00	3.395		LW			
7	AC006	33 ° 27.850 ' S	78 ° 39.362 ' W			22.893			23.122			3288	
				48.04 °	2.831		1.00	2.859		LW			
8	AC007	33 ° 28.874 ' S	78 ° 40.721 ' W			25.724			25.981			3174	
				57.42 °	8.192		1.00	8.274		LW			
9	AC008	33 ° 31.261 ' S	78 ° 45.178 ' W			33.916			34.255		34.255	2058	TR LW/LWP
				42.71 °	2.351		1.00	2.374		LWP			
10	AC009	33 ° 32.195 ' S	78 ° 46.208 ' W			36.267			36.629			1771	
				26.78 °	2.625		1.00	2.651		LWP			
11	AC010	33 ° 33.463 ' S	78 ° 46.972 ' W			38.892			39.281		5.025	1236	TR LWP/SA
				22.60 °	1.572		1.00	1.588		SA			
12	AC011	33 ° 34.248 ' S	78 ° 47.362 ' W			40.464			40.869			793	
				12.51 °	1.827		1.00	1.845		SA			
13	AC012	33 ° 35.213 ' S	78 ° 47.618 ' W			42.291			42.714			366	
				1.56 °	0.767		1.00	0.775		SA			

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
14	AC013	33 ° 35.628 ' S	78 ° 47.632 ' W			43.058			43.489			267	
				348.99 °	0.655		1.00	0.661		SA			
15	AC014	33 ° 35.975 ' S	78 ° 47.551 ' W			43.713			44.150			211	
				5.43 °	0.544		1.00	0.549		SA			
16	AC015	33 ° 36.268 ' S	78 ° 47.584 ' W			44.256			44.699			201	
				32.20 °	1.945		1.00	1.965		SA			
17	AC016	33 ° 37.158 ' S	78 ° 48.254 ' W			46.201			46.663			151	
				44.22 °	0.183		1.00	0.185		SA			
18	AC017	33 ° 37.229 ' S	78 ° 48.337 ' W			46.384			46.848			143	
				69.36 °	0.163		1.00	0.164		SA			
19	AC018	33 ° 37.260 ' S	78 ° 48.435 ' W			46.547			47.012			149	
				92.92 °	0.161		1.00	0.162		SA			
20	AC019	33 ° 37.256 ' S	78 ° 48.539 ' W			46.707			47.175			161	HA03 CTBTO XING
				96.95 °	0.203		1.00	0.205		SA			
21	AC020	33 ° 37.243 ' S	78 ° 48.669 ' W			46.910			47.380			158	
				76.02 °	0.186		1.00	0.188		SA			
22	AC021	33 ° 37.267 ' S	78 ° 48.786 ' W			47.097			47.568			150	
				47.08 °	0.281		1.00	0.284		SA			
23	AC022	33 ° 37.371 ' S	78 ° 48.919 ' W			47.378			47.852		8.571	126	TR SA/DA
				41.24 °	0.279		1.00	0.282		DA			
24	AC023	33 ° 37.484 ' S	78 ° 49.038 ' W			47.657			48.134			83	
				42.09 °	0.297		1.00	0.300		DA			
25	AC024	33 ° 37.603 ' S	78 ° 49.167 ' W			47.955			48.434			45	
				41.83 °	0.518		1.00	0.523		DA			
26	AC025	33 ° 37.812 ' S	78 ° 49.391 ' W			48.473			48.957			35	
				60.76 °	0.561		1.00	0.567		DA			
27	AC026	33 ° 37.960 ' S	78 ° 49.707 ' W			49.034			49.524			20	
				81.22 °	0.060		1.00	0.061		DA			
28	AC027	33 ° 37.965 ' S	78 ° 49.746 ' W			49.094			49.585			5	
				92.71 °	0.022		1.00	0.022		DA			

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
29	Juan Fernandez, CL Landing Site (L2)	33 ° 37.965 ' S	78 ° 49.760 ' W			49.116			49.607		1.755	-2	Proposed approximate BMH, no site visit performed.

B2 – Easter Island

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx. Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
1	Easter Island BU (B2)	29 ° 58.184 ' S	109 ° 17.138 ' W			0.000			0.000		0.000	3195	
				176.55 °	12.475		1.00	12.600		LW			
2	AC001	29 ° 51.444 ' S	109 ° 17.605 ' W			12.475			12.600			3150	
				163.98 °	21.798		1.00	22.016		LW			
3	AC002	29 ° 40.103 ' S	109 ° 21.337 ' W			34.272			34.615			3103	
				156.33 °	36.305		1.00	36.668		LW			
4	AC003	29 ° 22.104 ' S	109 ° 30.357 ' W			70.578			71.284			3060	
				161.97 °	27.679		1.00	27.955		LW			
5	AC004	29 ° 07.857 ' S	109 ° 35.645 ' W			98.256			99.239			3024	
				178.06 °	22.369		1.00	22.592		LW			
6	AC005	28 ° 55.755 ' S	109 ° 36.111 ' W			120.625			121.831			3103	
				270.00 °	9.955		1.00	10.054		LW			
7	AC006	28 ° 50.580 ' S	109 ° 34.400 ' W			130.580			131.886			3152	
				209.86 °	10.306		1.00	10.409		LW			
8	AC007	28 ° 45.742 ' S	109 ° 31.247 ' W			140.886			142.295			3275	
				202.08 °	18.138		1.00	18.319		LW			
9	AC008	28 ° 36.642 ' S	109 ° 27.061 ' W			159.024			160.615			3204	
				177.88 °	24.200		1.00	24.442		LW			

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx. Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
10	AC009	28 ° 23.550 ' S	109 ° 27.610 ' W			183.225			185.057			2983	
				166.34 °	18.652		1.00	18.839		LW			
11	AC010	28 ° 13.737 ' S	109 ° 30.305 ' W			201.877			203.896			2840	
				164.09 °	11.760		1.00	11.878		LW			
12	AC011	28 ° 07.614 ' S	109 ° 32.275 ' W			213.637			215.774			3011	
				179.60 °	11.282		1.00	11.395		LW			
13	AC012	28 ° 01.506 ' S	109 ° 32.323 ' W			224.920			227.169			2739	
				185.69 °	11.953		1.00	12.073		LW			
14	AC013	27 ° 55.066 ' S	109 ° 31.600 ' W			236.873			239.242			2599	
				161.20 °	5.051		1.00	5.102		LW			
15	AC014	27 ° 52.477 ' S	109 ° 32.592 ' W			241.924			244.343			2984	
				127.42 °	5.420		1.00	5.475		LW			
16	AC015	27 ° 50.694 ' S	109 ° 35.214 ' W			247.344			249.818			3165	
				114.21 °	11.985		1.00	12.105		LW			
17	AC016	27 ° 48.032 ' S	109 ° 41.871 ' W			259.330			261.923			3034	
				121.87 °	8.324		1.00	8.408		LW			
18	AC017	27 ° 45.653 ' S	109 ° 46.175 ' W			267.654			270.331			2865	
				146.91 °	7.085		1.00	7.156		LW			
19	AC018	27 ° 42.439 ' S	109 ° 48.528 ' W			274.739			277.486			2837	

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx. Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
				157.39 °	10.068		1.00	10.169		LW			
20	AC019	27 ° 37.406 ' S	109 ° 50.882 ' W			284.807			287.655			2555	
				164.57 °	15.534		1.00	15.689		LW			
21	AC020	27 ° 29.299 ' S	109 ° 53.392 ' W			300.340			303.344			3002	
				186.82 °	3.107		1.00	3.138		LW			
22	AC021	27 ° 27.628 ' S	109 ° 53.168 ' W			303.448			306.482			3021	
				194.11 °	3.333		1.00	3.367		LW			
23	AC022	27 ° 25.878 ' S	109 ° 52.675 ' W			306.781			309.849			3070	
				221.94 °	1.877		1.00	1.896		LW			
24	AC023	27 ° 25.122 ' S	109 ° 51.914 ' W			308.658			311.744			3132	
				244.32 °	2.247		1.00	2.270		LW			
25	AC024	27 ° 24.595 ' S	109 ° 50.685 ' W			310.905			314.014			3187	
				236.71 °	6.596		1.00	6.662		LW			
26	AC025	27 ° 22.634 ' S	109 ° 47.340 ' W			317.501			320.676			2908	
				213.16 °	1.757		1.00	1.774		LW			
27	AC026	27 ° 21.838 ' S	109 ° 46.758 ' W			319.257			322.450			2913	
				191.37 °	1.875		1.00	1.894		LW			
28	AC027	27 ° 20.843 ' S	109 ° 46.533 ' W			321.133			324.344			2834	
				190.06 °	3.810		1.00	3.848		LW			

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx. Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
29	AC028	27 ° 18.812 ' S	109 ° 46.130 ' W			324.942			328.192			2972	
				222.29 °	2.088		1.00	2.109		LW			
30	AC029	27 ° 17.975 ' S	109 ° 45.278 ' W			327.030			330.301			3053	
				245.14 °	5.951		1.00	6.011		LW			
31	AC030	27 ° 16.620 ' S	109 ° 42.006 ' W			332.981			336.311			2696	
				209.38 °	2.111		1.00	2.132		LW			
32	AC031	27 ° 15.624 ' S	109 ° 41.378 ' W			335.093			338.444			2640	
				218.31 °	2.626		1.00	2.652		LW			
33	AC032	27 ° 14.508 ' S	109 ° 40.392 ' W			337.719			341.096			2941	
				239.88 °	2.053		1.00	2.074		LW			
34	AC033	27 ° 13.950 ' S	109 ° 39.316 ' W			339.772			343.170			2826	
				233.62 °	4.026		1.00	4.066		LW			
35	AC034	27 ° 12.658 ' S	109 ° 37.353 ' W			343.798			347.236			2777	
				225.50 °	3.983		1.00	4.023		LW			
36	AC035	27 ° 11.146 ' S	109 ° 35.632 ' W			347.781			351.259			2242	
				219.24 °	2.085		1.00	2.106		LW			
37	AC036	27 ° 10.271 ' S	109 ° 34.834 ' W			349.867			353.365			2255	
				203.83 °	2.428		1.00	2.452		LW			
38	AC037	27 ° 09.069 ' S	109 ° 34.240 ' W			352.294			355.817			2186	

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx. Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
				206.32 °	4.139		1.00	4.180		LW			
39	AC038	27 ° 07.060 ' S	109 ° 33.129 ' W			356.433			359.998			2315	
				208.02 °	1.103		1.00	1.114		LW			
40	AC039	27 ° 06.532 ' S	109 ° 32.816 ' W			357.536			361.112			2301	
				226.75 °	1.003		1.00	1.013		LW			
41	AC040	27 ° 06.160 ' S	109 ° 32.374 ' W			358.539			362.124			2387	
				249.93 °	1.570		1.00	1.585		LW			
42	AC041	27 ° 05.869 ' S	109 ° 31.482 ' W			360.109			363.710			2256	
				273.30 °	1.040		1.00	1.050		LW			
43	AC042	27 ° 05.901 ' S	109 ° 30.854 ' W			361.148			364.760			2143	
				288.68 °	0.879		1.00	0.888		LW			
44	AC043	27 ° 06.053 ' S	109 ° 30.350 ' W			362.027			365.648			2009	
				314.85 °	2.821		1.00	2.850		LW			
45	AC044	27 ° 07.131 ' S	109 ° 29.140 ' W			364.849			368.497		368.497	1537	
				329.84 °	3.056		1.00	3.087		LWP			
46	AC045	27 ° 08.562 ' S	109 ° 28.211 ' W			367.905			371.584		3.087	1009	
				319.61 °	1.286		1.00	1.299		SA			
47	AC046	27 ° 09.092 ' S	109 ° 27.706 ' W			369.191			372.883			501	
				305.61 °	0.411		1.00	0.415		SA			

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx. Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
48	AC047	27 ° 09.222 ' S	109 ° 27.504 ' W			369.602			373.298			367	
				291.47 °	0.412		1.00	0.416		SA			
49	AC048	27 ° 09.303 ' S	109 ° 27.272 ' W			370.014			373.714		2.130	285	TR SA/DA
				284.99 °	0.960		1.00	0.969		DA			
50	AC049	27 ° 09.438 ' S	109 ° 26.711 ' W			370.973			374.683			58	
				275.50 °	0.305		1.00	0.308		DA			
51	AC050	27 ° 09.454 ' S	109 ° 26.527 ' W			371.278			374.991			15	
				261.71 °	0.103		1.00	0.104		DA			
52	AC051	27 ° 09.446 ' S	109 ° 26.465 ' W			371.382			375.095			10	
				270.49 °	0.083		1.00	0.084		DA			
53	Easter Island, CL Landing Site (L3)	27 ° 09.446 ' S	109 ° 26.415 ' W			371.465			375.179		1.465	-10	Proposed approximate BMH, no site visit performed.

B4 – Auckland

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx. Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
1	Auckland BU (B4)	34 ° 36.191 ' S	175 ° 01.496 ' E			0.000			0.000		0.000	1850	
				1.96 °	12.237		1.00	12.360		LWP			
2	AC001	34 ° 42.806 ' S	175 ° 01.770 ' E			12.237			12.360		12.360	1745	TR LWP?SA
				338.70 °	9.983		1.00	10.082		SA			
3	AC002	34 ° 47.836 ' S	174 ° 59.394 ' E			22.220			22.442			1151	
				333.96 °	11.422		1.00	11.536		SA			
4	AC003	34 ° 53.386 ' S	174 ° 56.104 ' E			33.641			33.978			778	
				351.27 °	21.989		1.00	22.208		SA			
5	AC004	35 ° 05.141 ' S	174 ° 53.911 ' E			55.630			56.186			564	
				0.00 °	9.397		1.00	9.491		SA			
6	AC005	35 ° 10.223 ' S	174 ° 53.911 ' E			65.027			65.678			455	
				270.00 °	6.133		1.00	6.194		SA			
7	AC006	35 ° 13.285 ' S	174 ° 55.464 ' E			71.160			71.872			413	
				37.53 °	5.917		1.00	5.976		SA			
8	AC007	35 ° 15.822 ' S	174 ° 57.840 ' E			77.077			77.848			395	
				44.91 °	18.300		1.00	18.483		SA			
9	AC008	35 ° 22.832 ' S	175 ° 06.365 ' E			95.377			96.331			448	
				56.69 °	2.829		1.00	2.857		SA			
10	AC009	35 ° 23.672 ' S	175 ° 07.926 ' E			98.206			99.188			453	
				52.23 °	2.597		1.00	2.623		SA			

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx. Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
11	Cable Crossing	35 ° 24.532 ' S	175 ° 09.282 ' E			100.803			101.811			457	XING - Southern Cross Next
				35.94 °	2.220		1.00	2.242		SA			
12	AC010	35 ° 25.504 ' S	175 ° 10.143 ' E			103.023			104.053			455	
				12.78 °	1.495		1.00	1.510		SA			
13	AC011	35 ° 26.292 ' S	175 ° 10.362 ' E			104.518			105.563			449	
				351.60 °	1.617		1.00	1.633		SA			
14	AC012	35 ° 27.157 ' S	175 ° 10.206 ' E			106.135			107.196			436	
				339.34 °	16.090		1.00	16.251		SA			
15	AC013	35 ° 35.299 ' S	175 ° 06.451 ' E			122.225			123.447			313	
				340.80 °	26.682		1.00	26.949		SA			
16	Cable Crossing	35 ° 48.926 ' S	175 ° 00.635 ' E			148.907			150.396			127	XING - Southern Cross Cable Network (SCCN)
				340.80 °	5.728		1.00	5.786		SA			
17	AC014	35 ° 51.851 ' S	174 ° 59.384 ' E			154.635			156.181			121	
				358.83 °	31.362		1.00	31.675		SA			
18	AC015	36 ° 08.806 ' S	174 ° 58.956 ' E			185.996			187.856			53	
				0.20 °	9.804		1.00	9.902		SA			
19	AC016	36 ° 14.107 ' S	174 ° 58.979 ' E			195.800			197.758			51	
				355.82 °	14.629		1.00	14.776		SA			
20	AC017	36 ° 21.996 ' S	174 ° 58.267 ' E			210.430			212.534			49	
				0.69 °	15.230		1.00	15.382		SA			
21	AC018	36 ° 30.231 ' S	174 ° 58.389 ' E			225.660			227.917			50	

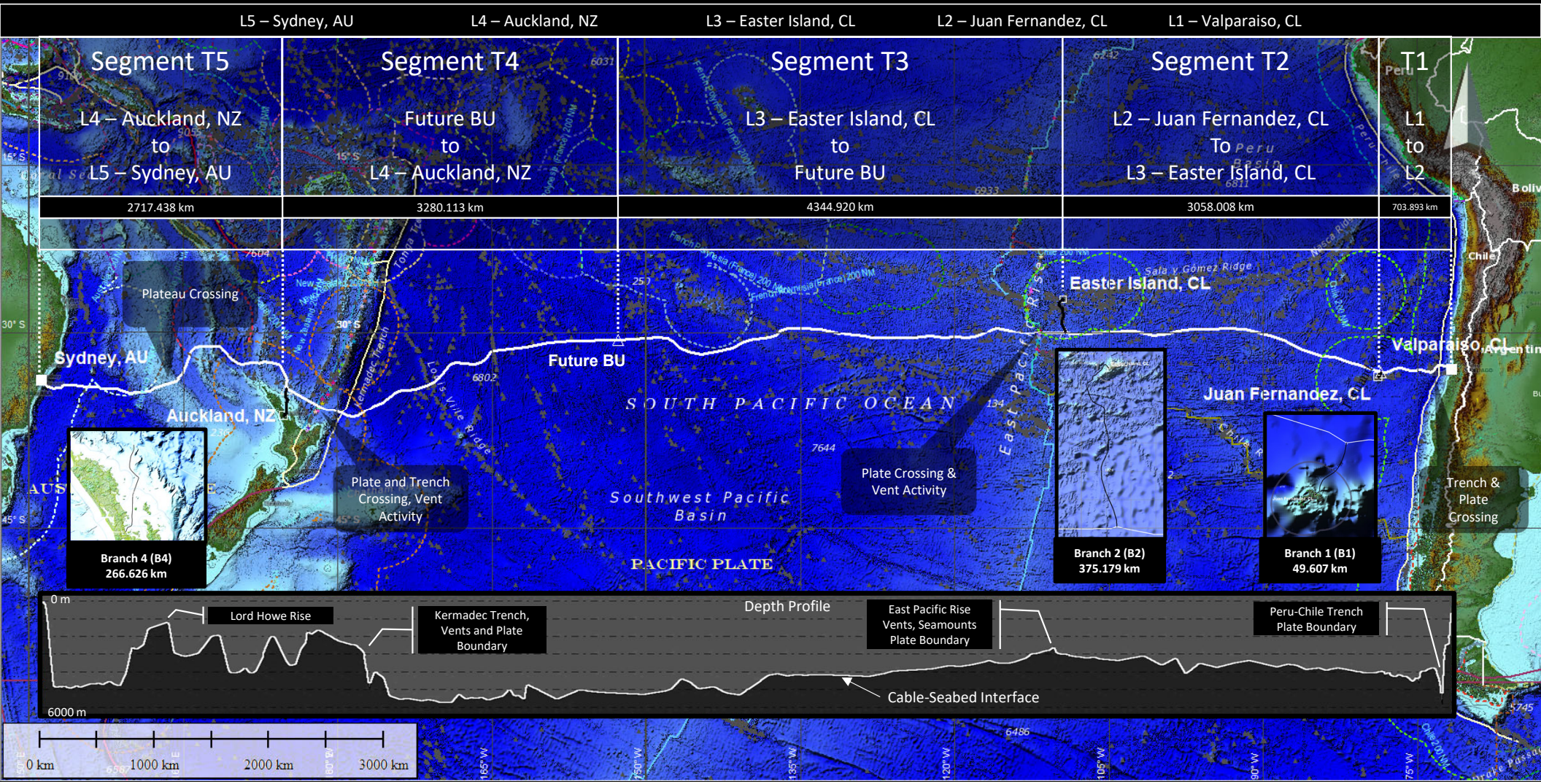
Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx. Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
				356.93 °	10.711		1.00	10.818		SA			
22	AC019	36 ° 36.014 ' S	174 ° 58.005 ' E			236.371			238.735			40	
				343.47 °	1.736		1.00	1.754		SA			
23	AC020	36 ° 36.914 ' S	174 ° 57.674 ' E			238.108			240.489			39	
				310.93 °	1.559		1.00	1.574		SA			
24	AC021	36 ° 37.466 ' S	174 ° 56.884 ' E			239.666			242.063			37	
				294.74 °	10.119		1.00	10.220		SA			
25	AC022	36 ° 39.756 ' S	174 ° 50.718 ' E			249.785			252.283			21	
				303.16 °	1.451		1.00	1.466		SA			
26	AC023	36 ° 40.185 ' S	174 ° 49.903 ' E			251.236			253.749		241.389	20	TR SA?DA
				323.31 °	1.461		1.00	1.476		DA			
27	AC024	36 ° 40.818 ' S	174 ° 49.317 ' E			252.697			255.224			19	
				342.68 °	7.524		1.00	7.600		DA			
28	AC025	36 ° 44.702 ' S	174 ° 47.812 ' E			260.222			262.824			11	
				335.67 °	2.099		1.00	2.120		DA			
29	AC026	36 ° 45.736 ' S	174 ° 47.231 ' E			262.321			264.944			10	
				325.40 °	0.494		1.00	0.499		DA			
30	HDD Exit	36 ° 45.956 ' S	174 ° 47.042 ' E			262.815			265.443		11.695	10	TR DA/SA
				297.52 °	0.588		1.00	0.594		SA			

Pos No.	Event	Latitude	Longitude	Bearing °T	Distance (km)		Slack %	Cable Distance (km)		Cable Type	Cable Totals By Type (km)	Approx. Depth (m)	Comments
					Between Positions	Cumulative Total		Between Positions	Cumulative Total				
31	Cable Crossing	36 ° 46.103 ' S	174 ° 46.692 ' E			263.404			266.038			8	XING - SCCN Intended bore under existing cable.
				297.52 °	0.582		1.00	0.588		SA			
32	Auckland, NZ Landing Site (L4)	36 ° 46.249 ' S	174 ° 46.345 ' E			263.986			266.626		1.182	-4	Proposed approximate BMH, no site visit performed.

Appendix B. Maps and Charts

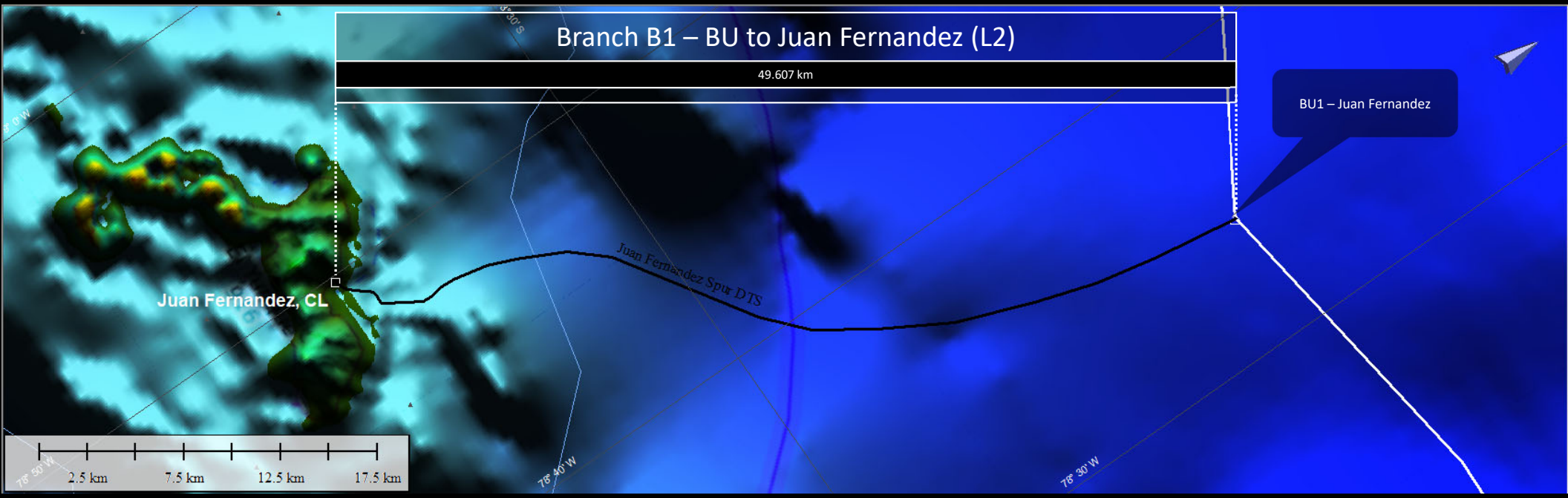
Asia-South America Digital Gateway (DGASA)

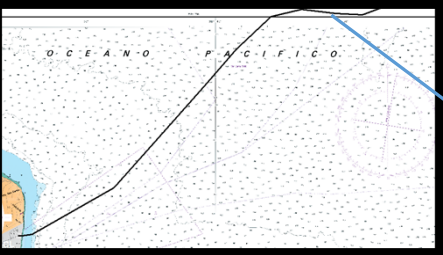
Total Subsea Length:
14,794.727

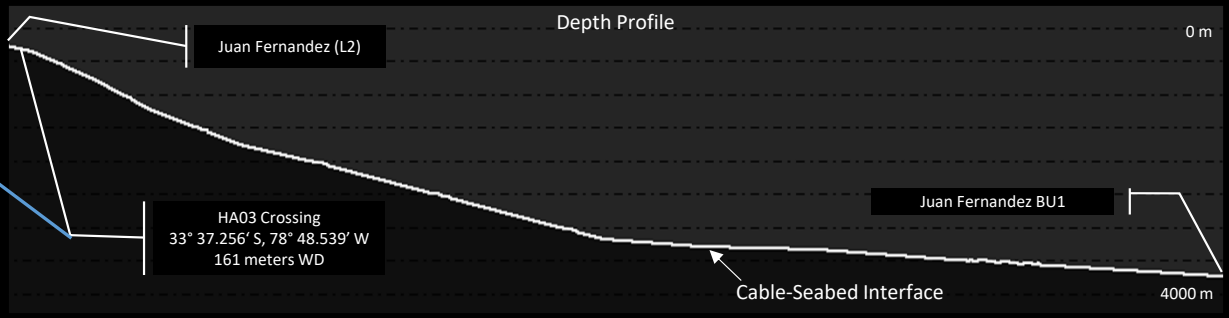


Asia-South America Digital Gateway (DGASA)

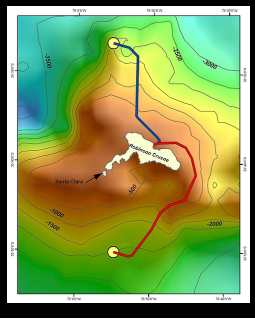
Total Subsea Length:
14,794.727





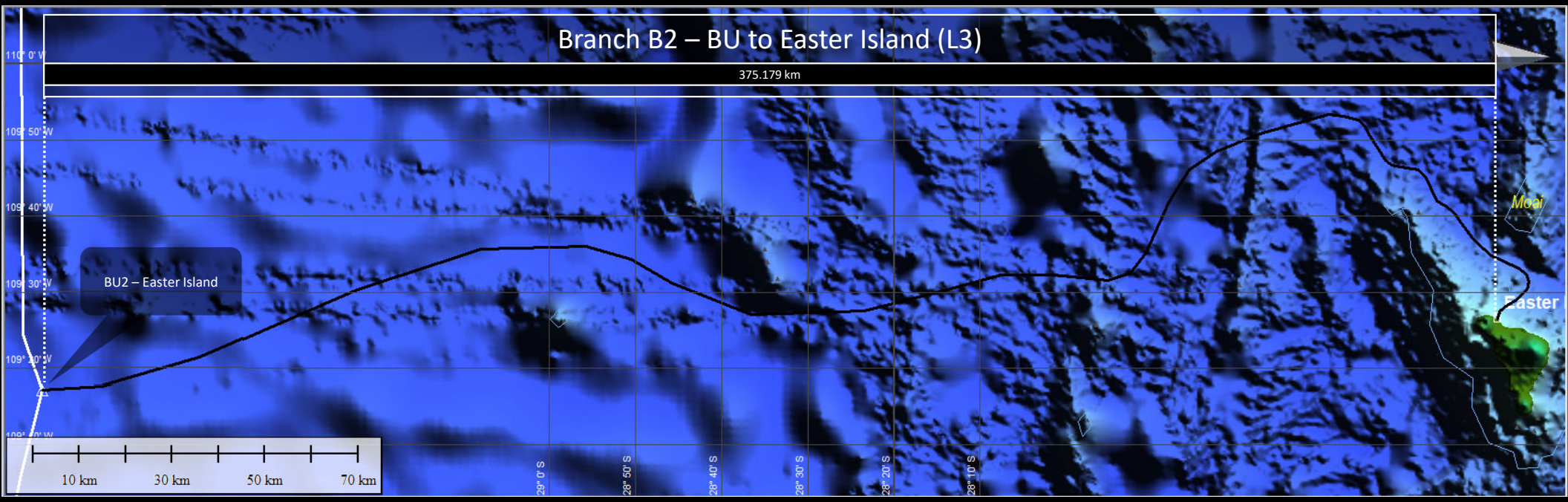


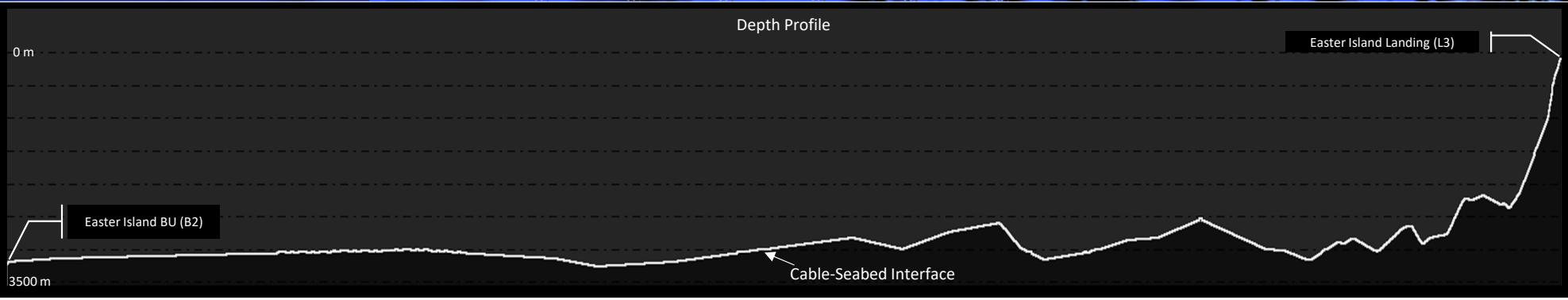
CTBTO HA03 Hydrophone Locations



Asia-South America Digital Gateway (DGASA)

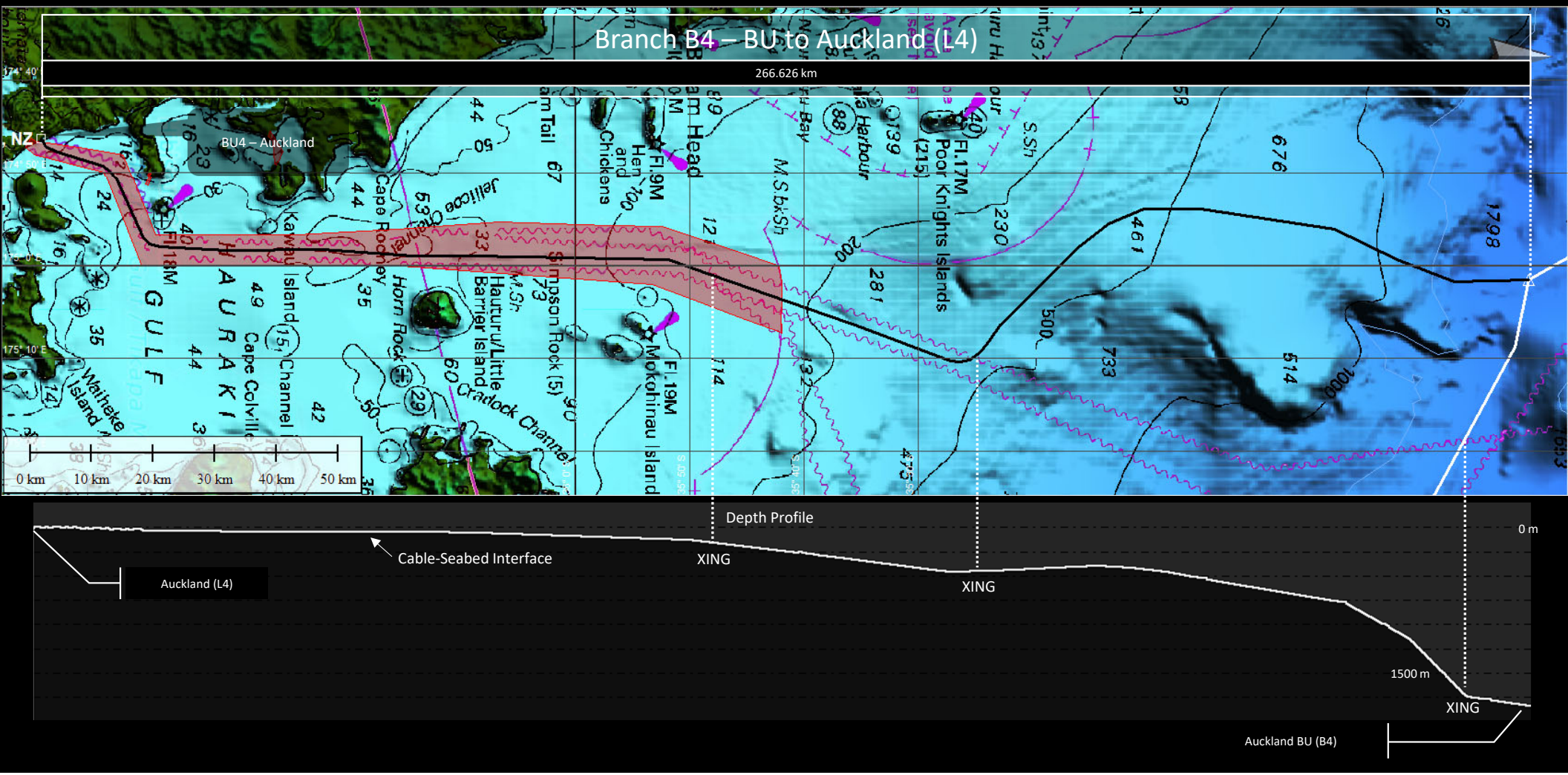
Total Subsea Length:
14,794.727





Asia-South America Digital Gateway (DGASA)

Total Subsea Length:
14,794.727



Appendix C. Data Sources and References

The below listed databases and information sources were searched, queried or utilized in the preparation of this DTS:

- Affiliated program of SCOR - Census of Marine Life (CoML) www.coreocean.org
- Convention on Biological Diversity (CBD) http://www.biodiv.org
- Global Biodiversity Information Facility (GBIF)
- Global Ocean Observing System (GOOS) www.ioc-goos.org
- Global Ocean Systems Information Center (GOSIC) www.gosic.org
- Intergovernmental Oceanographic Commission (IOC) of UNESCO http://ioc.unesco.org
- International Association of Port and Harbors (IAPH) www.iaphworldports.org
- International Cable Protection Committee (ICPC) www.iscpc.org
- International Harbour Masters Association (IHMA) www.harbourmaster.org
- International Maritime Organization (IMO) www.imo.org
- International Oceanographic Data and Information Exchange (IODE) www.iode.org
- International Seabed Authority (ISA)
- Lloyds Register – Fairplay www.portguide.com
- National Oceanic and Atmospheric Administration (NOAA) www.noaa.gov
- Naval Meteorology and Oceanography Command
- Naval Oceanographic Office, Stennis, MS
- NOAA World Ocean Atlas www.nodc.noaa.gov/OC5/indprod.html
- NOAA, Center for Operational Oceanographic Products and Services (CO-OPS)
- NOAA, National Climate Data Center (NCDC)
- NOAA, National Environmental Satellite Data and Information Service (NESDIS)
- NOAA, National Geophysical Data Center (NGDC) www.ngdc.noaa.gov
- NOAA, National Ocean Services (NOS)
- NOAA, National Weather Service (NWS)
- NOAA, Nautical Charts
- NOAA, Office of Coastal Survey
- Scientific Committee on Ocean Research http://ioc.unesco.org
- Scientific Committee on Oceanic Research (SCOR) www.jhu.edu/scor
- Southern African Data Centre for Oceanography (SADCO) http://sadco.csir.co.za/
- US Geological Survey, Coastal and Marine Geology

- US Geological Survey, Menlo Park, CA www.usgs.gov
- US Geological Survey, Woods Hole Science Center
- US Navy, Naval Oceanographic Office
- UNCLOS Maritime Boundaries Database
- United Kingdom Foreign and Commerce Office (FCO) www.fco.gov.uk
- United Kingdom Hydrographic Office (UKHO) www.ukho.gov.uk
- United Nations Atlas of the Oceans www.oceansatlas.org
- United Nations Convention on the Law of the Sea www.un.org/depts/los/index.htm
- United Nations Division for Ocean Affairs and the Law of the Sea (DOALOS)
- United Nations Environment Programme (UNEP) www.unep.org
- United Nations Food and Agriculture Organization (FAO) www.fao.org
- University of Miami, Rosenstiel School of Oceanography, www.rsmas.miami.edu
- US Central Intelligence Agency (CIA) Factbook www.cia.gov/cia/publications/factbook
- World Commission on Protected Areas (WCPA)
- World Conservation Monitoring Center (WCMC) www.unep-wcmc.org
- World Conservation Union (IUCN) www.iucn.org
- World Meteorological Organization (WMO) www.wmo.ch
- World Ocean Observatory www.southstseaport.org
- World Resources Institute (WRI) www.wri.org
- World Trade Organization (WTO) www.wto.org

Appendix D. Works Cited

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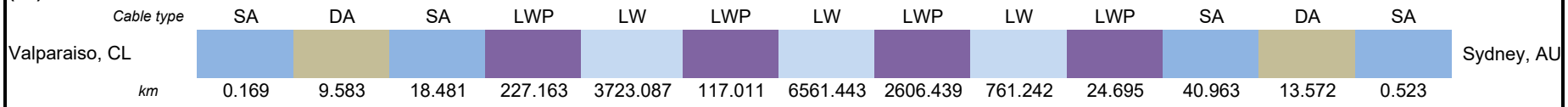
Appendix B. Straight Line Diagrams

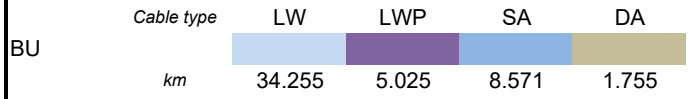
Trunk Valparaiso, CL (L1) - Sydney, AU (L5)

Total Length (km): 14104km



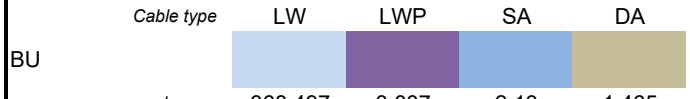
Branch (B1) - Juan Fernández, CL (L2)

Total Length (km): 49.607km



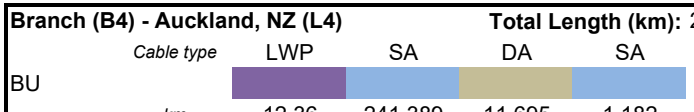
Branch (B2) - Easter Island, CL (L3)

Total Length (km): 375.179km



Branch (B4) - Auckland, NZ (L4)

Total Length (km): 266.626km



Appendix C. Permitting Matrix

Permits/Approvals	Government Department/Legislation	Procedure	Documents/Requirements	Time Schedule	Cost
Chile (Valparaíso, Hanga Roa, and San Juan Bautista)					
Intermediate Telecommunications Services License	Ministry of Transportation and Communications Subsecretaría de Telecomunicaciones (SUBTEL)	Consult directly with SUBTEL and also with local authorities	This will be determined in the consultation	5-6 weeks	This will be determined in the consultation meeting
Environmental Qualification Resolution (RCA)	The Ministry of the Environment The Environmental Evaluation Service (SEA) The Environmental Superintendence	The process may include: Environmental Impact Declaration (DIA) Environmental Impact Study (EIA) Projects and activities for which the law presumes they will have an environmental effect (Article 10, Environmental Law 19,300 and Article 3, New Statute for the SEIA Executive, Decree No. 40/2012) are assessed by the corresponding environmental authority. If the activity or project is approved, the RCA will not only contain the environmental permit for the activity itself, but also the environmental permit for all the specific parts and activities that project has by its corresponding RCA. However, concerning some of the parts or activities involved, a specific sectoral permit will be required, but only for technical purposes, allowing the corresponding sector-specific authority to verify that the analyzed work will comply with the requirements approved by the RCA. This is called the single window system, as the owner obtains all the environmental approvals a particular project needs in one single document (that is, the RCA). Under the new statute for the SEIA, there are two kinds of sectoral permit: •Permits with only environmental content. The favorable RCA authorizes all sectoral authorities to grant these permits if the requirements and conditions of that RCA are met. •Permits with both environmental and non-environmental content. The favorable RCA will verify compliance with the environmental requirements. The sectoral authorities will grant the permit if the non-environmental requirements are met, without imposing any additional requirements or conditions not considered within the RCA.	DIA •a project or activity description; •an indication of the legal framework applicable to the project; •an indication of permits that will be required. or EIA •a baseline development analysis to be provided by the owner of the project, describing the condition of approved projects in the same area that already have an RCA (that is, their emissions, impacts, and so on), even if they are not operating (see below); •an analysis of the environmental impact of the project or project modification, determining whether it produces any of the impacts outlined in Article 11 of the Environmental Law; •mitigation and compensation measures, which vary according to the nature of the project; •an indication of the legal framework applicable to each of the works and activities included in the project.	60-180 days This may depend on the intensity of the DIA or EIA	In general, no fees are required to process an environmental or sectoral permit. However, some sectoral p The cost of the DIA or EIA is circumstantial. This will be determined in a pre-consultation meeting.
New Zealand (Auckland)					
Network Utility Operator	Ministry of Business Innovation and Employment Telecommunications Act 2001	•Submission of application form •Once all required information is provided, a report for the Minister of Broadcasting, Communications and Digital Media is prepared •If the Minister is satisfied and application meets the specified criteria, they will declare applicant to be a network operator for the purposes of the Telecommunications Act 2001. This doesn't imply government endorsement of your business or business proposal. •Declarations can be revoked if you cease to provide telecommunication or broadcasting facilities. In such circumstances, a notice would be published in the New Zealand Gazette.	Include the following with application form: •why network operator status is necessary to your business •the actual business you will provide and your anticipated customer levels •a copy or details of your business plan that shows how your business will develop •costings and financial planning regarding your proposal's development and implementation •the geographic areas where cable laying will be necessary and the number of customers it will be reach •a copy of the company's certificate of incorporation •a list of the company managers, directors, and major shareholders •a brief company history.	It is estimated that the process may take 2-3 months	Cost will be discussed during consultation. There is no application fee.
Economic Exclusion Zone and Continental Shelf Act 2013 Approval	Environmental Protection Authority Economic Exclusion Zone and Continental Shelf Act 2013	Submarine cables are a permitted activity but the pre-notification to the appropriate authorities is essential. Pre-activity These are set out in Schedule 1 of the Regulations and include notifying the authority no later than 40 days before activity commences, and iwi no later than 25 days. A list of iwi to contact will be provided Authority contact with iwi must be reported no later than five days before activity and the notifications within 24 hours of commencement of the activity. Post-activity These are set out in Schedule 4 of the Regulations and include reporting on the activity to the authority within 60 days of completion. Notifications of completed activity must be submitted within 24 hours of completion of the activity. After applications are filed and presented at a hearing a decision and possible mitigation measures will be formulated.	Pre-activity requirements •Details of person on ship performing permitted activity •General description of the activity, including dates and locations It's possible that an initial environmental assessment and sensitive environment contingency plan be filed Post-Activity requirements •General description of activity •Details of the environment •Ecological footprint evaluation (this may include an estimation of the volume of material that was removed and the volume of seabed disturbed) •Details of measures taken to avoid, mitigate, or remedy adverse effects on sensitive environments.	This is dependent on the requirements	There is no application fee. Cost can increase depending on environmental assessment however, it is an ir
Marine Dumping Consent	Environmental Protection Authority Section 38 of the Exclusive Economic Zone and Continental Self Act (Environmental Effects) 2012	•Pre-lodgment meeting: it is strongly encouraged that applicants talk to the council before making an application. Pre-lodgment is an opportunity, through informal dialogue, to understand the consent application processes relevant to the activity. Pre-lodgment discussions can result in a timely and efficient process once the application is lodged. •Once application and environmental impact (a requirement) are lodged it is considered and may be returned to applicant with suggested changes. If it is accepted applicant will be notified. Other government departments or external advisors may be consulted to reach the decision. •If accepted a hearing will proceed, this may be public or private depending on the circumstance. •Applicant is notified of the decision •Appeals can be lodged	For an application to be complete it must: •be made using the marine consent application form •fully describe the proposal •include an impact assessment prepared in accordance with the requirements of section 39 of the EEZ Act. The following is information needed for the impact assessment: -Describe activity/activities for which consent is sought -Describe the current state of the area where it is proposed the activity will be undertaken and the environment surrounding the area -Identify persons whose existing interests are likely to be adversely affected -Identity the effects of the activity on the environment and existing interests -Identify the effects on the biological diversity and integrity of marine species ecosystems and processes -Identify effects on rare and vulnerable ecosystems and habitats of threatened species -Describe consultation with effected persons -Include copies of written approvals -Specify possible alternative possible locations and measures that could be taken to avoid, remedy or mitigate adverse effects -Describe effects on human health -Specify any practical opportunities to reuse, recycle, or treat the waste or other matter	2-6 months	This will be discussed at the pre-lodgment meeting
Marine Discharge Consent	Environmental Protection Authority Section 38 of the Exclusive Economic Zone and Continental Self Act (Environmental Effects) 2012	•Pre-lodgment meeting: it is strongly encouraged that applicants talk to the council before making an application. Pre-lodgment is an opportunity, through informal dialogue, to understand the consent application processes relevant to the activity. Pre-lodgment discussions can result in a timely and efficient process once the application is lodged. •Once application is lodged it is considered and may be returned to applicant with suggested changes. If it is accepted applicant will be notified. Other government departments or external advisors may be consulted to reach the decision. •If accepted a hearing will proceed, this may be public or private depending on the circumstance. •Applicant is notified of the decision •Appeals can be lodged	For an application to be complete it must: •be made using the marine consent application form •fully describe the proposal •include an impact assessment prepared in accordance with the requirements of section 39 of the EEZ Act. The following is information needed for the impact assessment: -Describe activity/activities for which consent is sought -Describe the current state of the area where it is proposed the activity will be undertaken and the environment surrounding the area -Identify persons whose existing interests are likely to be adversely affected -Identity the effects of the activity on the environment and existing interests -Identify the effects on the biological diversity and integrity of marine species, ecosystems and processes -Identify effects on rare and vulnerable ecosystems and habitats of threatened species -Describe consultation with effected persons -Include copies of written approvals -Specify possible alternative locations and measures that could be taken to avoid, remedy or mitigate adverse effects -Describe effects on human health	9 months	This will be discussed at the pre-lodgment meeting Evidence of actual costs will be recorded in the following ways: • EPA staff will fill in weekly timesheets recording their time spent on an application/marine consent or pr activity. The timesheets will be signed off by the relevant manager. • Staff hourly rates are set in regulations made under the EEZ Act (hourly rates as at xx are provided in Ap • EEZ decision making committee members rates will be calculated in accordance with a Group 4, Level 1 bodies in which the Crown has an interest. • The EPA or EEZ decision making committee may commission various reports and services to help them i and invoices will be paid on receipt of the deliverables. • EEZ decision making committee members will log their time spent and provide evidence of any expense • Hearing and pre-hearing costs, such as venues and transcription services, will be paid on receipt of invoi • Other relevant disbursements will be based on invoices paid. For further information and current rates refer to: https://www.epa.govt.nz/assets/Uploads/Documents/
Emergency Spill Response Plan (ESRP) Approval	Environmental Protection Authority Economic Exclusion Zone and Continental Shelf Act 2015	•Submit application •Await approval	•Applicant details •Project description and related marine consents •Full description of the ESRP which may include: -Information about harmful substances on board the offshore installation -Guidance to ensure safety of personnel -Measures to prevent the occurrence of a spill -Information to help personnel at the installation deal with a spill -Details of the response options available for the offshore installation -Procedure by which any pollution incident is to be recorded -Organizational emergency response structure -Inventory and location of response equipment -List of 24-hour contact information -Personnel responsibilities for the deployment, survey, and maintenance of the equipment.	This can be approved by the EPA for a period of up to 3 years	Tno fee is required
Craft Risk Management Plan (CRMP)	Ministry for Primary Industries (MPI)	•Application form is completed and submitted •Proposal for the vessels CRMP •Application received •MPI reviews and responds with any possible changes •Once approved each vessel must submit documentation providing that it has followed actions outlined in CRMP	Preparing your proposal The CRMP proposal is the most important part of the application as it details the specific management actions the vessel has been subjected to in order to manage the risks to an acceptable level. The proposal should outline specific management actions and the timeframes under which each will performed. The proposal should also indicate what types of records will be retained by the vessel to prove that it has followed the approved CRMP. Information that an applicant should submit in their proposal, includes, but is not limited to: •Maintenance and voyage history of individual craft or fleet. • Typical operating profile of individual craft or fleet. •Identification of the main biosecurity risks posed by the individual craft or fleet. •Outline the measures the operator will take to mitigate the risks posed by individual craft or fleet. •Proposed length of time the CRMP will be valid (for example, number of seasons). This will ultimately be decided at MPI's discretion based on the actions outlined in the CRMP and the vessels' operating profiles. •Record keeping and reporting. For further details refer to: https://www.mpi.govt.nz/dmsdocument/28134-guidance-document-for-the-development-of-craft-risk-management-plans-for-vessels-guidance-document	Application processing is approximately 40 days	All applications will incur a time-calculated charge of eight hours of work as a deposit for application proc continuation of work previously requested. If the application is complicated and cannot be processed within the eight hours, MPI will contact the app application. MPI's application processing deposit will not be refunded should the applicant choose to with MPI is unable to give an estimate or quote for the final charge of any application due to the variability of t charge per 15-minute increments over and above the initial 8 hours. Hourly charges: NZ$ 117.61 (including GST)
Submarine cable protection zone approval	Ministry of Transport Submarine Cables and Pipelines Protection Act 1996	If the existing cable protections zone is used an amendment order may need to be granted to allow the working vessels to anchor in the area in order to lay the cable. The actions required to amend the current cable protection order are: •Apply to the ministry of transportation •Confirm cable can co-locate in the cable protection area •Consult with the ministry of transportation on proposed application to determine preliminary view and any particular information is required •Engage with ministry of transportation during consultation and submission process with affected parties	The application should include details about: •the area to be protected •the proposed construction of the cable or pipeline •the purpose for the cable or pipeline •the timeframe for laying the cable or pipeline •the consultation undertaken by the operator to satisfy the requirements of section 12(2) of the Act	Amendment of existing area: 12 months	No fee for application however, there might be a fee associated with using the current protection zone. TI

Permits/Approvals	Government Department/Legislation	Procedure	Documents/Requirements	Time Schedule	Cost
Environmental Impact Assessment (EIA)	Department of Conservation (DOC)	Submarine cable systems are considered a very large scale activity with significant, potential effects, such as a significant structure. An EIA of this type may require assistance from specialists in various fields and it is your responsibility to provide this information. •Arrange and complete a pre-application meeting with department staff to help scope environmental effects that need to be considered •Send the completed application form to the department •Department will audit the application within 5 days of receipt •If the application is complete enough for further processing applicant will be personally advised that application has been accepted. If there is not enough information the application will be returned with advice on where improvement is necessary. •Once the application is accepted, additional information/permits needed will be discussed and consultation with the DOC will commence	The following should be included in an EIA: •Describe the environment: The applicant will need to consider the natural, historic, recreational, and cultural values of the site and surrounding areas. In order to complete an assessment of the cultural, spiritual, and cultural values the native people (Tangata Whenua) may need to be contacted. During the pre-application meeting the DOC will provide a list of contacts if necessary. •Scope the potential effects of the activity: When the concession staff is met in the pre-application meeting both should consider the total environment. All the potential impacts and what adverse effects are likely to be more significant should be noted. These may require more detailed consideration in the application. For very high impact activities this step may involve considerable work and a field visit. Undertaking this step properly will save time and expense later in the process. •Identify the effect of the activity: The applicant must determine the direct, indirect, and cumulative effects where at all possible. The positive, beneficial of adverse effects should also be mentioned. This should be based on the environmental description the applicant has completed. •Describe measures to avoid, remedy, or mitigate: List the measures that will be undertaken to ensure that every adverse effect identified will be minimized as far as possible. All adverse effects should if possible be avoided first, then remedied, and finally mitigated. •Identify alternative designs: Alternative designs, locations or timing of activities are fundamental impact mitigation measures and should be considered at the very outset. Alternative locations are a mandatory consideration for applications that require a lease, such as buildings. •Outline monitoring program: Monitoring simply attempts to test the validity of the predictions made earlier in the EIA process after an operation has been allowed to proceed. Monitoring is a fundamental step that the applicant and the Department will use to determine whether obligations are being met to manage the balance between preservation and use.	Application processing minimum of 5 days, approval depends on the amount of information provided	Will be discussed in pre-application meeting
Resource Management Approval	Ministry for the Environment Resource Management Act 1991	Stage 1 •It is imperative that a pre-application meeting with the regional council be conducted before submitting an application as this will reduce cost and time. This will determine if resource consents are necessary, how the activity is classified, and what type of consent is needed. The applicant will also be informed of the required information to be provided, processing timeframe, cost, and whether the application for resource consent is needed for both regional and district/city council. •After pre-lodgment meeting, application can be submitted along with an AEE which is a requirement and should be seen as part of the process of shaping the proposal rather than a task to do once plans are prepared. Stage 2 •Council officers will review the application for completion. The application may be returned and further information required. •Council will decide if public should be notified or non-notified •If submissions are made against the application or the applicant wants to be heard a hearing will be held. Stage 3 •Council makes decision: If approval is awarded there may be certain conditions attached. Work can commence after the 15-day appeal period.	•Details of applicant •Application authority •Requirement for requiring authority status •Network utility operator status •Description of project of work or network utility operation •Details of applicant •Financial responsibilities •Evidence that the applicant gives proper regard to the interests of the environment: This may include: Environmental manuals, environmental policies, plans, protocols, assessments of environmental effects, examples of environmental monitoring, industry standards in relation to the environment, codes of practice in relation to the environment. •Evidence that the applicant gives proper regard to the interests of those affected which may include, consultation documents including any consultation policies/plans/protocols, stakeholder or media consultation documents, terms of reference and meeting notes from community meetings and the outcomes of such meetings, industry standards for consultation. This may include consultation with community groups, local iwi, government authorities and others affected by the proposal.	If the Minister approves an application, it is published in the New Zealand Gazette and comes into force 28 days after the publication of the gazette notice.	These deposit fees are approximate. Other fees may be necessary depending on project specifics. Pre-application meeting: $505 Hourly consultation rate: $111-$206.40 Coastal structure deposit fee: $7000 https://www.aucklandcouncil.govt.nz/building-and-consents/resource-consents/Pages/resource-consent
Assessment for Environmental Effects (AEE)	Northland Regional Council Resource Management Act 1991	Lodge Application Once application is lodged it will be processed and accepted, or more information will be requested. Public notification will occur if necessary. A council decision will be made as well as the option to appeal.	The following criteria should be considered when composing an AEE: •Identify activity or activities for which consent is sought •Conduct a site inspection: This will help to determine if there are any environmentally sensitive areas. It is suggested for a local inspector to conduct the inspection. The site surroundings should also be taken into consideration. •Talk to the regional/and or district council •Identify effects the project might have on area •Rank and address the effects: A specialist may need to be consulted •Re-evaluate the proposal •Finalize the AEE (include obtaining affected parties' approval) •Lodge the application	Approximately 45-90 days	When you apply for a resource consent you will need to pay a minimum initial fee. If the costs of processi required to pay the additional reasonable costs of processing your application. Please contact council con initial fee. A list of scheduled fees can be found: https://www.nrc.govt.nz/media/14515/schedule-of-minimum-estin
Coastal Permit	Auckland Council	•Engage relevant expert consultants to prepare application reports •Compile application •Meet with council •Finalize and file application	For large, complex projects it is recommended that an expert is found to help When preparing your AEE you will need to: •provide a good description of the proposal, the site and surroundings •confirm why you are applying for a consent and confirm compliance with the rules •discuss how your proposal fits with the Unitary Plan vision for that zone and how it meets the objectives and policies of the Plan •describe any effects on the environment •describe what effects your proposal may have on people •propose any conditions that may help mitigate any effects of the proposal •provide any specialist reports required to support the application.	Approximately 45-90 days. Dependent on AEE	$2243-4050
Australia (Sydney)					
Permit to install submarine cable in Australian waters	Australian Communications and Media Authority (ACMA) Telecommunications Act 1997	The process for the assessment of the Commonwealth Referral is as follows: •Carrier applies for permit •ACMA considers whether additional information is required (if required the information is requested). •ACMA requires application •ACMA consults Environment secretary •ACMA regards S matter •Considers listed environmental concerns •Decision made •Fill out appropriate application	Information required for the application should have been discussed in the pre-lodgment meeting and includes but is not limited to: •Installation information including desktop or hydrographic survey of the proposed route illustrating the exact location of the proposed cable installation. •Details of ownership and control of submarine cable installation •Proposed dates •Technical and economic aspects of installation •Status of regulatory approvals from other commonwealth bodies that are required to install the cable •Information about the proximity of proposed installation to other existing submarine cables.	ACMA is required to grant/refuse the non-protection zone installation permit within 180 days after the application was received. ACMA may extend this period by not more 90 days. The grant/refusal process is outlined below: • ACMA will acknowledge in writing the receipt of an application and nominate an ACMA contact officer for all further enquiries • ACMA contact officer will proceed to consideration of application OR request additional information • ACMA consults with Environment Secretary (and other relevant persons) • ACMA will proceed with regard to Clause 71, Schedule 3A (have regard to facilitation of carrier services, co-location of cables, environment/heritage, technical, economic, social and others deemed relevant by ACMA). Process of assessment is 20 business days but may take longer if previous required permits have not been obtained.	NOTE: The cost outlined below is specifically for the cable installation permit and does not include the ind Application fee: $4040
Referral of Proposed Action	Department of Agriculture, Water, and the Environment Environmental Protection of Biodiversity and Conservation 1999 (EPBC) Environmental Protection and Biodiversity 2000	The process for the assessment of the Commonwealth Referral is as follows: • Minister receives referral • Decision whether approval under the Act and on process of assessment within 20 business days • Minister determine level of assessment: 1. Controlled Action 2. Not Controlled Action 'Particular Manner' 3. Not Controlled Action As a Controlled Action the proposed will be subject to the assessment and approval of process under the EPBC Act.	The proposed route does not appear to be in the path of an area of national significance however, it is suggested that a meeting be held with the Department to ensure no approvals are necessary. If it is decided that an approval is needed the appropriate information will be discussed at the meeting. An Environmental Assessment or Environmental impact statement may be required.		Application fee: $6,577 (only if approval is needed)
Environmental Assessment (EA)	Department of Agriculture, Water, and the Environment New South Wales Environmental Protection Authority Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	Decide if proposed action needs to be referred (if no approval is not required) If action needs to be referred: •Referral proposal submitted to minister •Minister makes a decision on whether approval is required and on what type of assessment process is necessary •Preparation for assessment •Submission of assessment •Approval or refusal of project Preparation of Assessment: •Scoping •Environmental Impact Statement •Public Exhibition •Responding to submissions •Assessment •Determination •Compliance	The EIS plays a critical role in the process of identifying, predicting, assessing, evaluating and mitigating the environmental, social, economic and other relevant effects of development proposals. When constructing an EIS document the following must be included… •Declaration •Glossary and abbreviations •Executive summary •Introduction •Project description •Strategic and statutory context •Engagement •Environmental impact assessment •Mitigation measures •Evaluation and conclusion	Can take up to 17 months depending on location and activates however, the approval process may take up to 60 days	This will be determined in the consultation meeting and is dependent on the assessment
Listed Species and ecological community permit	Department of Agriculture, Water, and the Environment Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	Note that if a species or community is not intended for harm this permit is not necessary however, if any of the listed potential impacts occur accidentally it is required the impact be reported to the department •Application submission •Application Processed •Decision made	Information required on application: •General information •Description of reason for application of desired permit	Dependent on affects	To be discussed in pre-application meeting

Appendix D. CapEx Cost by Segment

DGASA System - 8 Fiber Pair System - Estimated Cost for Installation, by segment

1000	Valparaiso, Chile to Juán Fernández BU T1	Juán Fernández BU - Juán Robinson Crusoe Island, Chile B1	Juán Fernández BU - Easter Island BU T2	Easter Island BU - Easter Island, Chile B2	Easter Island BU - Future BU T3	Future BU - Future CLS Stub B3	Future BU - Auckland BU T4	Auckland BU - Auckland, New Zealand B4	Auckland BU - Sydney, Australia T5	Spares	NOC	Total
Permitting	$ 652	$ 652	$ -	$ 652	$ -	$ -	$ -	$ 354	$ 316	$ -	$ -	$ 2,625
Marine Route Survey	$ 385	$ 38	$ 1,212	$ 546	$ 2,491	$ 8	$ 1,634	$ 369	$ 1,465	$ -	$ -	$ 8,148
Submerged Plant	$ 11,899	$ 2,890	$ 39,034	$ 10,700	$ 78,317	$ 692	$ 41,427	$ 7	$ 36,028	$ -	$ -	$ 220,995
Spare Submerged Plant	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 8,379	$ -	$ 8,379
Marine Operations	$ 2,695	$ 763	$ 6,420	$ 3,506	$ 13,195	$ 43	$ 8,597	$ 6,103	$ 8,689	$ -	$ -	$ 50,011
Civil Works	$ -	$ 542	$ -	$ 542	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,084
Land Cable Installation	$ 401	$ 401	$ -	$ 401	$ -	$ -	$ -	$ 401	$ 401	$ -	$ -	$ 2,003
Cable Landing Station	$ -	$ 1,215	$ -	$ 1,215	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,430
Station Landing Terminal Equipment	$ 17,867	$ 1,172	$ -	$ 3,111	$ -	$ -	$ -	$ 3,133	$ 17,236	$ -	$ 40	$ 42,559
Spare SLTE	$ 221	$ 167	$ -	$ 243	$ -	$ -	$ -	$ 243	$ 167	$ -	$ -	$ 1,039
Engineering & Project Management Services	$ 1,041	$ 256	$ 2,941	$ 767	$ 5,955	$ 30	$ 3,410	$ 681	$ 2,959	$ -	$ 2	$ 18,041
System Test & Commissioning	$ 93	$ 93	$ -	$ 93	$ -	$ -	$ -	$ 97	$ 97	$ -	$ 8	$ 480
Training	$ 86	$ 86	$ -	$ 86	$ -	$ -	$ -	$ 86	$ 86	$ -	$ -	$ 432
Documentation	$ 49	$ 49	$ -	$ 49	$ -	$ -	$ -	$ 49	$ 49	$ -	$ -	$ 246
Test Equipment	$ 203	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 203	$ -	$ -	$ 405
Totals	$ 35,591	$ 8,324	$ 49,607	$ 21,911	$ 99,958	$ 773	$ 55,067	$ 11,523	$ 67,694	$ 8,379	$ 49	$ 358,876

DGASA System - 16 Fiber Pair Solution - Estimated Cost for Installation, by segment

1000	Valparaiso, Chile to Juán Fernández BU T1	Juán Fernández BU - Juán Robinson Crusoe Island, Chile B1	Juán Fernández BU - Easter Island BU T2	Easter Island BU - Easter Island, Chile B2	Easter Island BU - Future BU T3	Future BU - Future CLS Stub B3	Future BU - Auckland BU T4	Auckland BU - Auckland, New Zealand B4	Auckland BU - Sydney, Australia T5	Spares	NOC	Total
Permitting	$ 652	$ 652	$ -	$ 652	$ -	$ -	$ -	$ 354	$ 316	$ -	$ -	$ 2,625
Marine Route Survey	$ 385	$ 38	$ 1,212	$ 546	$ 2,491	$ 8	$ 1,634	$ 369	$ 1,465	$ -	$ -	$ 8,148
Submerged Plant	$ 17,566	$ 3,335	$ 58,309	$ 12,347	$ 117,371	$ 798	$ 65,507	$ 8,299	$ 55,019	$ -	$ -	$ 338,552
Spare Submerged Plant	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 8,379	$ -	$ 8,379
Marine Operations	$ 2,695	$ 763	$ 6,420	$ 3,506	$ 13,195	$ 43	$ 8,597	$ 6,103	$ 8,689	$ -	$ -	$ 50,011
Civil Works	$ -	$ 542	$ -	$ 542	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,084
Land Cable Installation	$ 401	$ 401	$ -	$ 401	$ -	$ -	$ -	$ 401	$ 401	$ -	$ -	$ 2,003
Cable Landing Station	$ -	$ 1,215	$ -	$ 1,215	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,430
Station Landing Terminal Equipment	$ 17,867	$ 1,172	$ -	$ 3,111	$ -	$ -	$ -	$ 3,133	$ 17,236	$ -	$ 40	$ 42,559
Spare SLTE	$ 221	$ 167	$ -	$ 243	$ -	$ -	$ -	$ 243	$ 167	$ -	$ -	$ 1,039
Engineering & Project Management Services	$ 1,041	$ 256	$ 2,941	$ 767	$ 5,955	$ 30	$ 3,410	$ 681	$ 2,959	$ -	$ 2	$ 18,041
System Test & Commissioning	$ 93	$ 93	$ -	$ 93	$ -	$ -	$ -	$ 97	$ 97	$ -	$ 8	$ 480
Training	$ 86	$ 86	$ -	$ 86	$ -	$ -	$ -	$ 86	$ 86	$ -	$ -	$ 432
Documentation	$ 49	$ 49	$ -	$ 49	$ -	$ -	$ -	$ 49	$ 49	$ -	$ -	$ 246
Test Equipment	$ 203	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 203	$ -	$ -	$ 405
Totals	$ 41,259	$ 8,769	$ 68,882	$ 23,557	$ 139,012	$ 879	$ 79,148	$ 19,815	$ 86,685	$ 8,379	$ 49	$ 476,434

Appendix E. Financial Model

This appendix provides a brief description of the DGASA financial model to enhance the user's navigation experience. A description of each sheet, functionality and how sheets interact with other linked sheets is provided. The model itself, "DGASA Financial Model v12 11 01 21.xlsx", is submitted together with this Report.

E.1. Introductory Sheets

These sheets are designed to facilitate administration and presentation of results. They include:

- Cover, which includes statements regarding confidentiality, scope and no duty of care to third parties;
- Change Control, which allows the user to track the changes made to the model from one version to the next;
- Sources, which indicates the source of all the assumptions found in the Input Parameters sheet;
- Lists, allows the user to change various lists recurring in the model at once;
- Charts presents all the charts that are used in the report; and
- Dashboard presents a view of important financial information of the business case. Information provided includes:
  - Financial outcomes and key indicators – includes IRR, payback, return on sales, etc.
  - Profit and loss
  - Projected cashflow
  - Waterfall diagrams

E.2. Input Parameters

This sheet is used to set various key characteristics of the case. Information driving various aspects of the case are entered in dark blue cells. Of these, values in black lettering are hard-coded, in red lettering are endogenously determined. Values in green letting are used for sensitivity analysis. Values in light blue cells are presented for information purposes.

E.3. Financials

This sheet provides the output of useful financial reports and analysis for the six stakeholder entities (Consortium, Chilean SPV, SPV Investors, SPV OpCo and other consortium partners. These include:

1. Income Statement;
2. Balance Sheet; and
3. Cash Flow Statement.

E.4. Costs

These sheets summarize and present all CapEx and OpEx amounts derived from the project costs and payment timing and conditions. They include:

- CapEx, which presents expert-assessed cable and non-cable capital expenditures as well as the timing and amounts for CapEx payments;

- OpEx, which captures expert assessed costs and shows the line-by-line workings to allocate the annualized OpEx throughout the lifetime of the project;
- Total Costs, which collects all CapEx and OpEx figures over the period; and
- Depreciation, which shows the detailed depreciation working allocating CapEx over the life of the project. Input flow from the CapEx sheet.

E.5. Revenues

These sheets contain all the calculations determining revenues associate with the project. They include:

- Demand, which contains the demand from the Report 1 analysis as well as exclusions from the Asia Transit;
- Segment Demand, which identifies demand for individual segments of the cable and disaggregates by quantities lease and IRU quantities;
- Product Demand, which reformats the segment and product data for use with the price data;
- Prices, which calculates the prices to be applied to the products sold;
- Total Revenue, which calculates the revenue from the Product Demand and Price Sheets;
- Asia Transit Module, which allows the user to calculate competitive Asian Onward Connectivity 100G IRU prices; and
- SA Transit Module, which calculates competitive DGASA 100G IRU prices.

Note in presenting demand, prices and revenues, the model classifies routes in terms of “origination” and “termination” geographies. The terms “origination” and “termination” refer to the end points of the capacity purchased. “Origination” refers to where the purchase of capacity takes place.

Note that capacity between the Chilean mainland and Easter Island and Juan Fernandez are assumed all to originate in the Chilean mainland. Based on discussions we believe that the overwhelming sales of capacity to these islands will be sold to carriers based on the mainland.

E.6. Debt Financing

This sheet captures details of potential sources of project debt funding and produces relevant analysis and outputs to the ‘financials’ sheet.

E.7. Estimated Tax

Tax workings are shown on this sheet.

Appendix F. Fiber Pair Comparison

F.1. Executive Summary

TMG/WFNS have been requested to prepare an annex document to the DGASA Feasibility Study – Final Report, which will provide options to reduce the project CapEx investment. This document provides several options to accomplish the goal of reducing the project capex requirements. These options include the following

a) Reduce System Design Requirement from 16 fiber Pair to 8 Fiber Pair
b) Select SDM technology over DWDM technology

The following sections will explain the differences associated with each option as it is compared to the base design plan, which is currently reflected in the DGASA Feasibility Study Final Report. In addition, each section will also explain the approximate cost differences and which system elements are impacted.

An additional scenario was built into the financial model which allows the user to calculate results for an 8 Fiber Pair system. Model results show that there may be some benefit to deploying an 8 Fiber Pair system over a 16 Fiber Pair system in net present value terms. This is due to the fact that the savings in CapEx benefits the investors immediately, while the reduction in revenue associated with the constraint on capacity does not occur until later in the lifetime of the cable.

F.2. 8 Fiber Pair System

One option to reduce CapEx requirements for the project would be to consider an 8 fiber pair design vs a 16 fiber pair system, which represents the baseline design plan included in the DGASA feasibility study Final Report.

The following describes the implication of this change in design plan

a) Capacity is reduced from 259.2 Tbps to 129.6 Tbps (50% reduction)
b) Falls short in fulfilling system capacity requirement of 270 Tbps
c) Approximate CapEx reduction from baseline only 25%

The following describes which cost elements would change

a) Cost of fiber cable (8 FP vs 16 FP)
b) Repeater costs reduced for less fiber pair capacity repeaters

Projected Cost Savings (approximate)

8 FP Savings		
Fiber Cost Reduction	$	56,244
Repeaters	$	61,314
Total	$	117,557

Conclusion

Changing the system design plan from 16 FP to 8 FP would reduce the CapEx requirement by $117,557 million, but the system capacity would be reduced to 129.6 Tbps, which is 50% of the baseline system design (16 FP). This option does not make sense unless the capacity requirement is reduced by 50% and Chile would expect to invest in another system at some later point in time, perhaps 10 years from RFS.

F.3. SDM vs DWDM Optical Transmission Technology

Another option to reduce the CapEx requirement would be to consider utilizing SDM optical transmission technology vs DWDM, which is how the current or baseline design plan is configured. SDM is the trending technology that spreads greater capacity over more fiber pair, instead of squeezing more capacity out of each fiber pair. Historically, systems were design with 2 -4 fibers, now Suppliers are pushing the idea of installing more fiber pairs to spread the cost and ultimately reduce the cost per bit.

The following describes the implication of this change in design plan

a) DWDM capacity in the baseline design plan is 259.2Tbps for 16FP
b) SDM capacity would reduce system capacity to 214.4Tbps for 16FP

The following describes which cost elements would change

a) Fiber type for SDM is different than that used for DWDM
b) Repeater types would also be different

Projected Cost Savings (approximate)

SDM Savings		
SDM Technology	$	72,400
Total	$	72,400

Conclusion

Considering SDM technology over DWDM does offer some efficiencies and may reduce the CapEx requirement by approximately 15%. The trade will be system capacity, which is reduced from 259.2Tbps to 214.4Tbps (17% reduction). Benefits of utilizing an SDM design include greater repeater power efficiency and lower overall system cost per bit. However, there is a capacity trade off, which will create a greater gap to meet the forecasted capacity requirement.

F.4. Financial Comparison: 16 Fiber Pair vs. 8 Fiber Pair

The Financial model was adjusted to include different System Scenarios, which allows the user to compare, the results of the 1) the 16 Fiber Pair DGASA system with the possibility of future upgrades to 400 Gbps cards for both DGASA and Asian Onward Connectivity (Note these are the results given in Section 9.3 of this Report) with 2) a 16 Fiber Pair DGASA system and Asian Onward Connectivity that are limited to 200 Gbps cards throughout the lifetime of the cable, 3) a 8 Fiber Pair DGASA system and Asian Onward Connectivity that is limited to 200 Gbps cards and 4) a 8 Fiber Pair DGASA system and Asian Onward Connectivity that makes use of future upgrades to 400 Gbps cards.

In order to ensure the comparability between the results, for the purposes of this Report, we have only altered the system FPs available and the allocation of the FPs to the Chilean SPV. In particular, in the 8 FP scenarios, the system is deployed with 8 Fiber Pairs, instead of 16, and the Chilean SPV is allocated 4 Fiber Pairs, instead of 8.

	Final Report System Scenario	**16 Fiber Pair System with 200 Gbps card limit**	**8 Fiber Pair System with 200 Gbps card limit**	**8 Fiber Pair System Mixed Tech**
System Fiber Pairs	16	16	8	8
Allocation of Fiber Pairs to Chilean SPV	8	8	4	4
Assumption on Card Technology	Flexibility to upgrade to 400 Gbps	200 Gbps cards throughout cable lifetime	200 Gbps cards throughout cable lifetime	Flexibility to upgrade to 400 Gbps
Overall Project NPV ($ 000s)	$131,730	$139,403	$135,819	$146,696
Overall Project Payback (years)	2.55	2.50	2.29	2.29
Chilean SPV Project NPV ($ 000s)	$76,901	$78,954	$74,846	$85,031

Thus, the consortium may be able to improve the business case slightly by economizing CapEx upfront by opting for a 8 Fiber Pair system.

F.5. Overall Conclusion

There is a path to reduce the CapEx requirement. The result in each case will be the reduction of system capacity, which will fall short of the capacity requirements set forth by the demand study; however, that CapEx savings more than offsets the reduction in revenue associated with the constraint on demand in later years of the cable's lifetime.

Based on TMG/WFNS' efforts and the work conducted in collaboration with Subtel in developing technical requirements for this study and understanding the sensitivities associated with the business case, the cable owner will have to decide which option is in their best interest at the time of procurement and potential partners are selected and associated benefits are known.

System CapEx Requirement Comparison

Estimated Capital Expenses	($1000) US 16 Fiber Pair (base)	8 Fiber Pair	SDM
Permitting	$ 2,625	$ 2,625	$ 2,625
Marine Route Survey	$ 8,148	$ 8,148	$ 8,148
Submerged Plant	$ 338,552	$ 220,995	$ 266,152
Spare Submerged Plant	$ 8,379	$ 8,379	$ 8,379
Marine Operations	$ 50,011	$ 50,011	$ 50,011
Civil Works	$ 1,084	$ 1,084	$ 1,084
Land Cable Installation	$ 2,003	$ 2,003	$ 2,003
Cable Landing Station	$ 2,430	$ 2,430	$ 2,430
Station Landing Terminal Equipment	$ 42,559	$ 42,559	$ 42,559
Spare SLTE	$ 1,039	$ 1,039	$ 1,039
Engineering & Project Management Services	$ 13,541	$ 13,541	$ 13,541
System Test & Commissioning	$ 480	$ 480	$ 480
Training	$ 432	$ 432	$ 432
Documentation	$ 246	$ 246	$ 246
Test Equipment	$ 405	$ 405	$ 405
Permits*	$ 1,500	$ 1,500	$ 1,500
Land Acquisition *	$ 2,000	$ 2,000	$ 2,000
Project Management*	$ 1,000	$ 1,000	$ 1,000
Subtotal	$ 476,434	$ 358,876	$ 404,034
Contingency (10%)	$ 47,643	$ 35,888	$ 40,403
Grand Total	$ 524,077	$ 394,764	$ 444,437
Variance from base			
Subtotal		$ 117,557	$ 72,400
Contingency (10%)		$ 11,756	$ 7,240
Grand Total		$ 129,313	$ 79,640
		25%	15%

* Purchaser Direct Costs

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