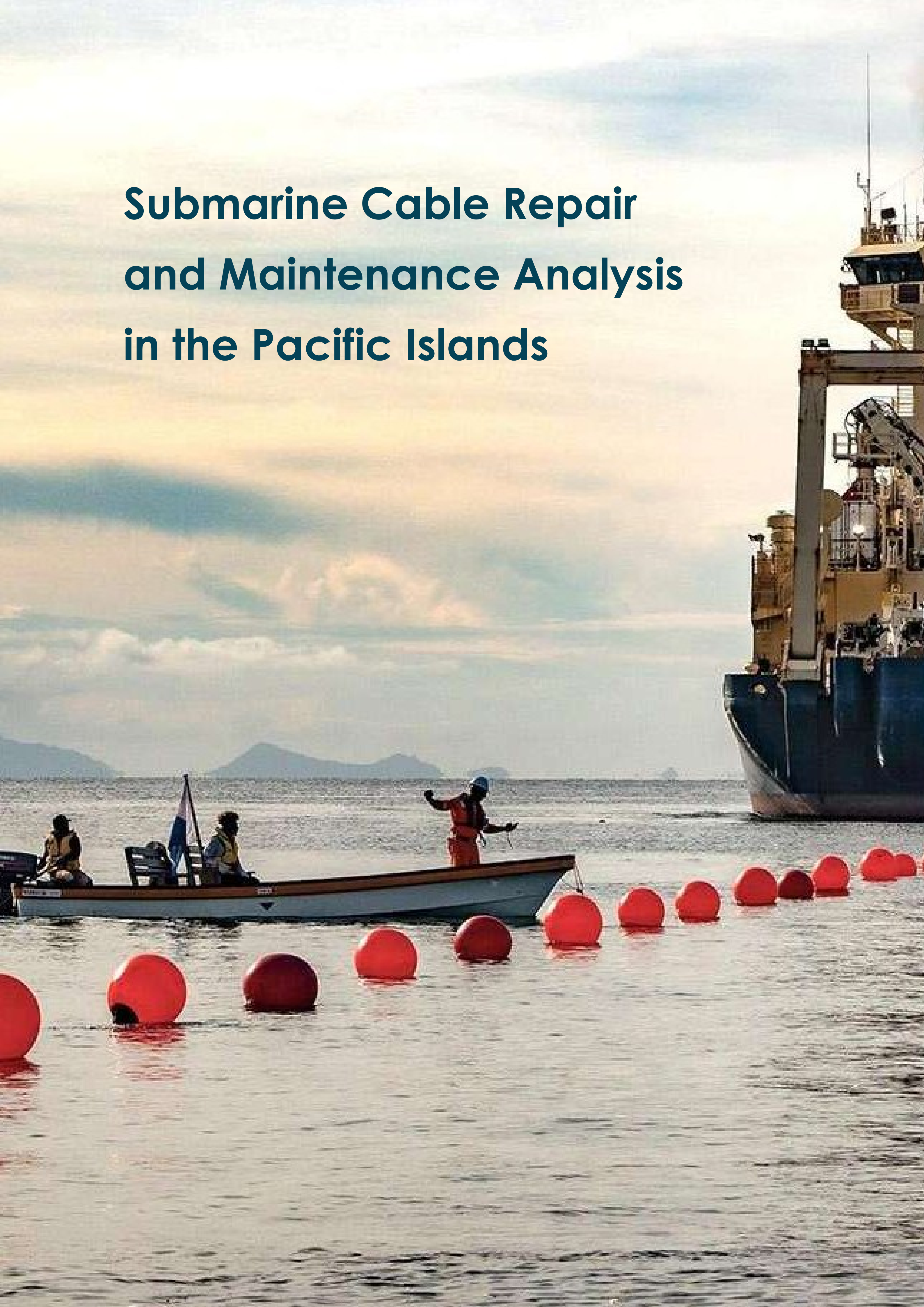
Submarine Cable Repair and Maintenance Analysis in the Pacific Islands



Acknowledgement

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About the Author

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ABBREVIATIONS & ACRONYMS

AIS	Automatic Identification System
APMMSA	Asia Pacific Marine Maintenance Agreement
BMH	Beach Manhole
CLS	Cable Landing Station
Dry Plant	All plant that resides on land including CLS equipment
EEZ	Exclusive Economic Zone
Fronthaul	Collectively the PVC ducts, terrestrial fibre optic cable and power cable components that connects a BMH to a CLS
ICPC	International Cable Protection Committee
IMO	International Maritime Organisation
KPI	Key Performance Indicator
Nearshore Region	The area between a beach and water depth of 10- 12 metres
Outside Work	Activities undertaken by the cable repair vessel that are not captured within the SPMMA agreement
OMS	Optic Marine Services, the maintenance provider to SPMMA
Pacific Islands Forum	A regional forum of 18 member and 4 associate countries and territories
PNG	Papua New Guinea
SPMMA	South Pacific Marine Maintenance Agreement
Sub-Regions	Melanesia, Micronesia, Polynesia
Terrestrial Infrastructure	All cable infrastructure that resides on land (CLS, fronthaul and BMH)
UNCLOS	The United Nations Convention of the Law of the Sea (1982)
Wet Plant	All cable components that reside underwater
UJ	Universal Joints
YZ	Yokohama Cable Maintenance Zone

1. EXECUTIVE SUMMARY: KEY THEMES & RECOMMENDATIONS

1.1. General

Pacific island countries are highly dependent on submarine cable connectivity to facilitate international communications. Small island nations face unique challenges to secure a resilient cable network architecture, largely due to geographic isolation, limited telecommunications markets and cable investment challenges. The impact of connectivity disruption is closely tied to each island's cable infrastructure, treats, redundancy and network resilience profile. Although submarine cables are by their nature vulnerable to disruption, strengthening network resilience can be accomplished by methods other than investing in more cables, which can further strain the operating budgets of cable owners.

Natural hazards pose the main threat to cables in the Oceania region, unlike other regions where human intervention is the primary cause of cable faults. Natural hazards are prone to cause wide area damage that can impact several islands and multiple cables at the same time. Several measures can be employed to enhance cable infrastructure protection, expedite repairs, expand repair vessel capacity and develop local cable infrastructure restoration capabilities.

The ability to effect timely repairs resides with the South Pacific Cable Maintenance Agreement (SPMMA), that governs and provides the overarching submarine cable repair resources for the Oceania region. Although repair services exclude land-based infrastructure, the SPMMA agreement is structured and resourced to meet the future needs of the region under a business-as-usual cable repair scenario. The calculus changes if multiple cable outages occur concurrently that result in a queue for cable repairs. External vessel support options are available from adjacent maintenance agreements but come with accessibility and other limitations. Replacing the Lodbrog, SPMMA's designated repair vessel and relocating the cable depot are near term necessities.

1.2. Commission Capability and Risk Assessment Research

The overriding challenge when evaluating Oceania's threat profile and network resilience is that each sub-region (Melanesia, Micronesia, Polynesia) and Pacific island archipelago have unique physical environments, exposure to natural and human threats, cable infrastructure, diversity and redundancy measures. In addition, individual governments and cable operators have differing levels of expertise, fiscal reserves and budget constraints.

To assess the cost-benefit of measures that are designed to expedite repair timeframes and strengthen cable protection requires a detailed risk evaluation customised to each nation's threat profile, existing cable infrastructure and specific needs. Adopting a universal approach for all Pacific island countries is not an effective use of resources.

Natural hazards have potential to impact cable infrastructure on a region wide basis. Other threats are localised and therefore will impact individual island infrastructure only. Assessing the risk of either scenario is prudent, with consideration given to the resource capacities of both the public and private sectors.

A capability and risk assessment should encompass:

- Reviewing existing infrastructure connectivity against with localised and regional threats
- Evaluating the efficacy and costs of additional cable protection measures
- Determining sub-region and local abilities to effect restoration of terrestrial infrastructure

A research programme of this nature should be initiated in two phases.

Phase one consists of a comprehensive questionnaire designed to identify among other issues, relevant threats, fault causes, local capabilities, resources and cable infrastructure protection and architecture. Participants will include cable owners, relevant government agencies and non-government stakeholders. Analysis of responses will allow individual baselines to be established for each sub-region and Pacific island country.

Phase two will identify the need for on-site risk assessments that are supported by independent specialists to ground-truth local capabilities and risk realities with the objective to determine viable cable protection options to implement. External support is essential particularly where government stakeholders and or cable operators lack sufficient knowledge and expertise in cable protection and resilience measures.

Assessment should prioritise sub-regions and individual Pacific island countries lacking cable redundancy or resilient international connectivity. Research outputs will help determine fiscal support, subsidies, workforce training or other measures that regional powers can support to strengthen Oceania's cable infrastructure and network resilience.

1.3. Develop Public Private Sector Collaboration

The Oceania Subsea Cable Association (OSCA) is an established organisation that can promote collaboration, information sharing and alignment between the public and private sectors. Understanding OCSA's available resources or potential constraints will help determine capability gaps and opportunities to support this organisation by funding or other measures to achieve the following objectives.

- support the capability and risk evaluation programme recommended above
- communicate regional and specific local issues to government and non-government stakeholders
- support evaluation of options to expand repair vessel capacity in the event of multiple cable outages
- develop sub-region and individual island cable awareness programmes
- expand OSCA membership, knowledge and collaboration with the International Cable Protection Committee (ICPC)

Although analysis indicates that a SPMMA single repair vessel can address projected cable repairs in the future, additional repair vessel capacity beyond the existing APMMSA-SPMMA collaboration mechanism should be carefully considered, even if activated under a multiple repair event scenario. Evaluation should cover the (ad-hoc) use of additional third-party vessels from NTT WEM that support the Philippines domestic repair agreement. Vessels of opportunity that can be quickly mobilised with appropriate repair equipment is another solution but requires ownership considerations, capital and workforce training. Expanding vessel capacity also needs to be considered within the context of recent and planned cable investments that will advance Oceania's regional network resilience.

Direct government engagement with SPMMA stakeholders can facilitate greater alignment between public sector interests and the commercial objectives of the private sector. However, financial support to introduce state-owned repair vessels will likely undermine the foundational economics of the SPMMA model.

Government support of SPMMA should not be discounted if structured to align with the interests of all parties. One area that should be explored is increasing SPMMA's repair vessel availability by reducing or eliminating the provision to undertake outside work. Changes to outside work provisions will ensure the repair vessel is dedicated to cable repair duties year-round that will indirectly speed repair timeframes but will not change the calculus associated with a multiple cable outage event. To offset the loss of outside work revenues, compensation may be required to preserve the agreement's commercial viability.

1.4. Champion and Sponsor Regulatory Reform

Establishing a unified regulatory framework across Oceania is a complex and challenging process that will require regional power's leadership and guidance. Collaboration among the numerous governments in the region can be facilitated by the Pacific Islands Forum that can also serve as an effective platform to foster cooperation and oversee potential regulatory reforms.

An independent research project commissioned to identify government stakeholders in each jurisdiction will help develop clear allocation of responsibilities among government agencies, reveal gaps or legislative needs with the goal to identify a single point of interface for all cable related matters.

Achieving unified reform across all jurisdictions will be challenging, so reforms should initially centre on reviewing permit approvals for cable repairs and customs, immigration and other vessel clearances that will help expedite cable repairs and streamline repair vessel operations. Granting priority access to port infrastructure should also be considered. Regulatory reforms should also address the implementation of cable protection and security measures for CLS and other land-based cable infrastructure. Not all reforms will be appropriate for all jurisdictions.

Clear connections exist between exploring regulatory reforms and the capacity and risk evaluation programme advocated above. Undertaking these programmes in parallel or integrating them into a single programme has advantages and should be considered.

2. METHODOLOGY

Background research for this publication involved desk-based research, consultation with specific regional stakeholders, publicly available data, and the authors knowledge of repair and maintenance economics, and offshore operational experience. Details of cable repairs are considered commercially sensitive by industry stakeholders. These include the location, cause and cable ownership details.

This report does not address the implications of grey zone activities observed in the Baltic, South China Sea and other areas, nor does it cover related Indo-Pacific geopolitical concerns.

3. INTRODUCTION

"Small islands are among the most telecommunications-dependent communities on Earth, yet often the least resilient to network disruption"

Clare et al., 2026[1]

This report examines the unique challenges that Pacific Islands face to secure affordable, timely submarine cable repair and maintenance services. It also outlines measures that regional powers such as Australia and Japan can do to further support and strengthen submarine cable protection and cable network resilience within the region.

The submarine cable industry is undergoing a period of transition including the nature of investment, ownership, routing and user applications. In parallel, government economic and national security concerns amplify the criticality and resilience of international connectivity that submarine cables provide. The structural misalignment between public sector dependency is growing as private ownership, control and commercial interests concentrate into a handful of cable investors and maintenance providers.

Submarine cables are highly vulnerable to outages that are caused by human influences and natural phenomena. Island nations are more exposed due to their geographic isolation, limited redundancy, vulnerability to natural hazards, small economies and telecommunications markets. The Pacific island countries rely heavily on submarine cable infrastructure for international communications as not all have access to complementary satellite connectivity. Recent cable investment programmes supported by regional powers and private investors such as Google have enhanced cable redundancy to many islands and increased regional network resilience.

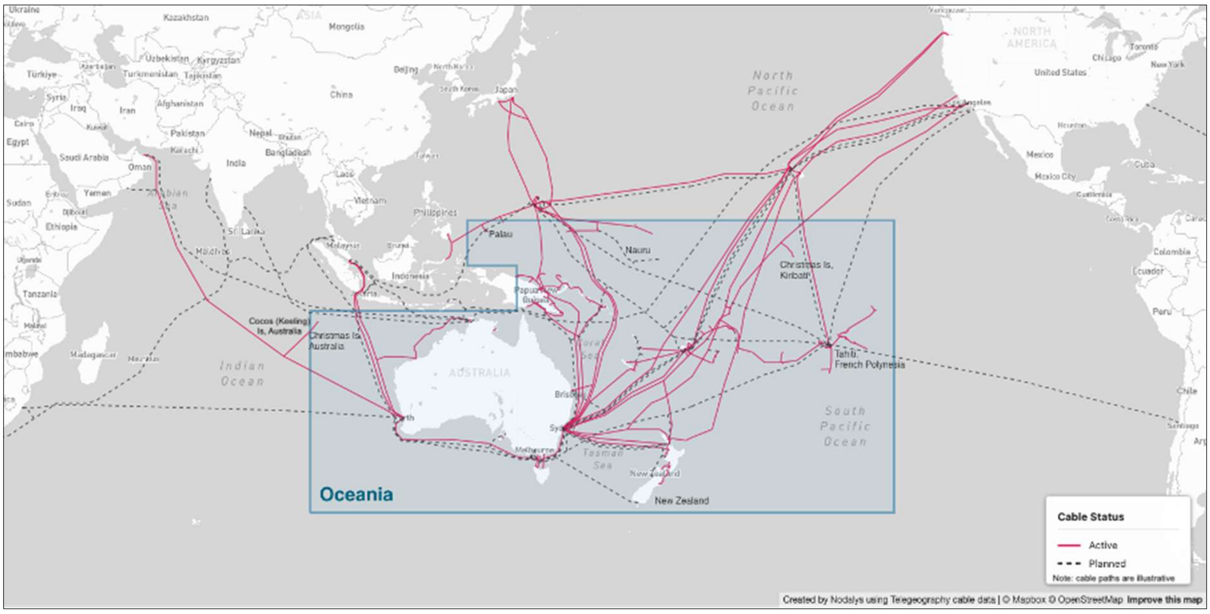
The ability to repair the network of cables is critical to ensure connectivity resilience and infrastructure security. Repair and maintenance services are secured by a single repair vessel stationed in Fiji that covers the c.100,000+ kilometers of cable infrastructure. However, the terrestrial components of submarine cables, and nearshore areas do not have a similar, single overarching repair and maintenance solution.

The low fault environment enables the existing repair model to effectively address the typical number of annual repairs even as the region anticipates a projected increase in cable kilometres. However, the model is challenged in the event of multiple concurrent or simultaneous cable outages. This event scenario will impact cable repair timeframes but is a common occurrence across many regions and zone-based maintenance agreements.

Several measures can be applied to strengthen cable protection, security and network resilience. Many have cost implications that may challenge cable operating budgets. Financial support can expand in-region repair capabilities and protection measures, while regulatory reform can streamline repair operations to advance a resilient cable infrastructure environment.

[1] Clare et al. Hazards and resilience of subsea communications connections for small islands. International Journal of Disaster Risk Reduction 2026.

4. FOCUS AREA



Oceania Region: Source: Kang, Nodalys

This publication focuses on the Oceania region that includes 18 members and 4 associate members of the Pacific Islands Forum. Nations and territories are located across the sub-regions of Micronesia, Melanesia and Polynesia.

Forum Members comprise Australia, the Cook Islands, the Federated States of Micronesia, Fiji, French Polynesia, Kiribati, Nauru, New Caledonia, New Zealand, Niue, Palau, Papua New Guinea, the Republic of Marshall Islands, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu.

Associate Members comprise Tokelau, Wallis and Futuna, Guam, and American Samoa.

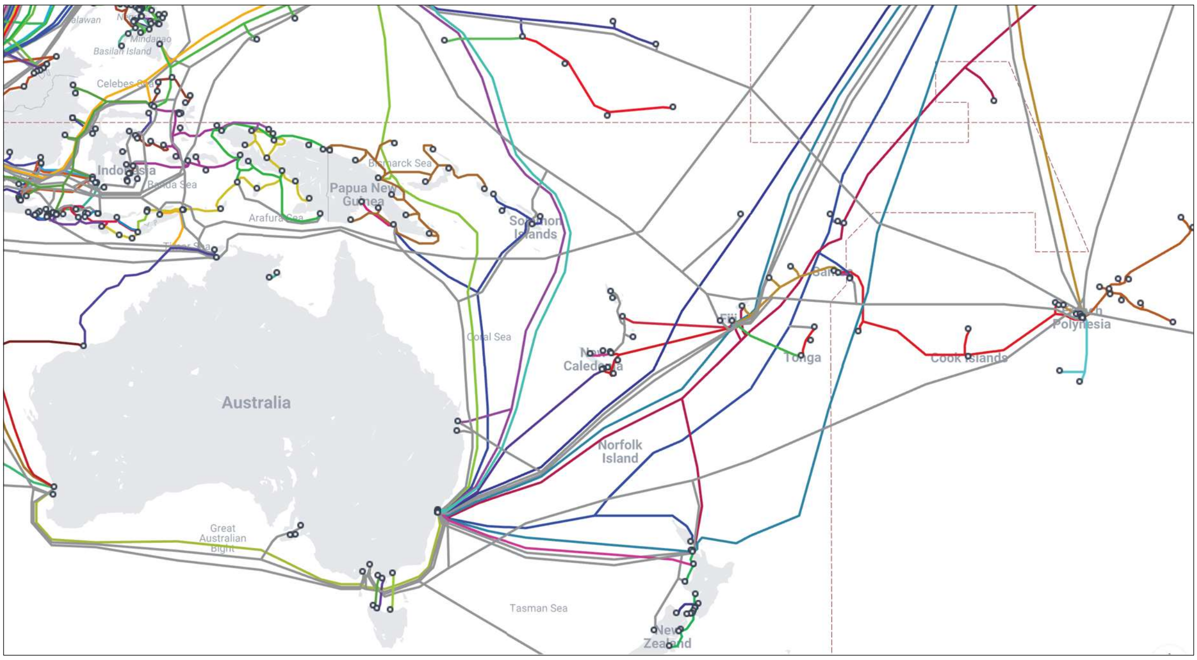
The region is collectively referred to as Oceania.

5. CABLE NETWORK ARCHITECTURE

Submarine cables rarely constitute a single point-to-point architecture (a single path with landings in two locations). Individual cables should be viewed parts of a submarine cable ‘network’, created by multiple cables that together form a regional network architecture and connectivity platform.

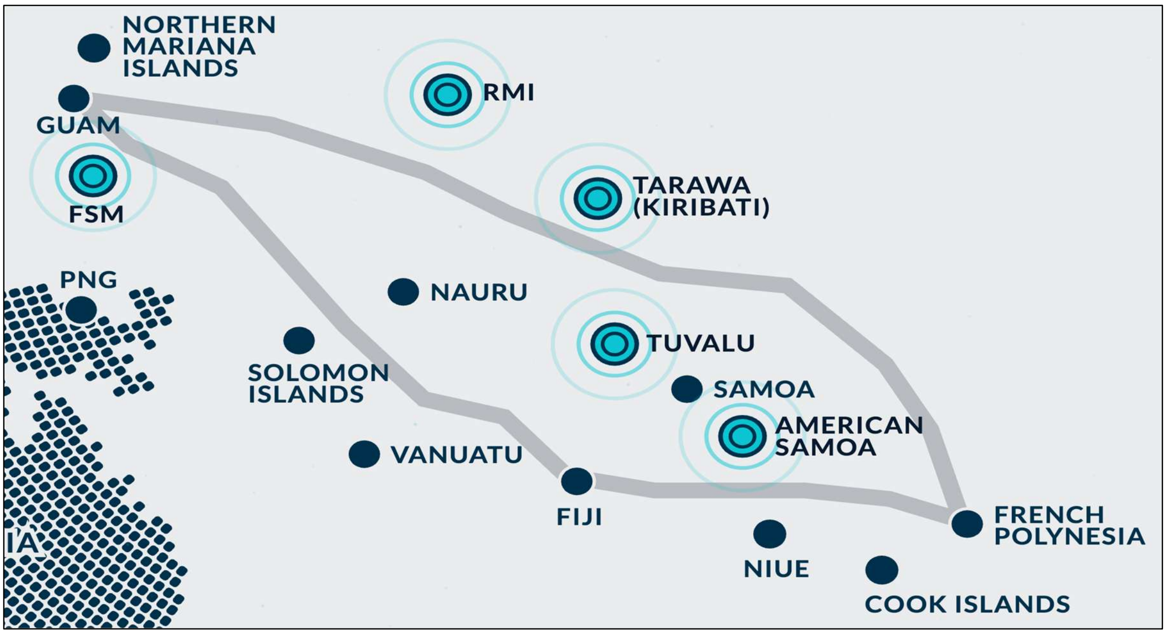
The network concept is particularly relevant to Oceania as numerous islands have cables that branch off trans-Pacific cable trunks that connect the continental landmasses of the United States and Australia, and Japan that is a North Asia connectivity hub. The region’s network resilience is enhanced by cables that link mid-Pacific regional hubs such as Fiji, Guam and French Polynesia. The network concept means that cable faults that occur on trans-ocean cable trunks, thousands of kilometres from Oceania can disrupt Pacific island countries’ international communications. For clarity, faults that occur on individual island branches do not impact the trans-ocean cable trunks.

Figure 1: Oceania Cables Source: TeleGeography Submarine Cable Map



Cable investment has centred on establishing primary island connections and improving cable redundancy by adding supplementary cables connections between various islands. Google’s Central Pacific Connect initiative exemplifies efforts to strengthen regional resilience by linking Oceania’s cable hubs in Fiji and French Polynesia to the mid-Pacific hubs of Guam and Hawaii (Figures 1 and 2).

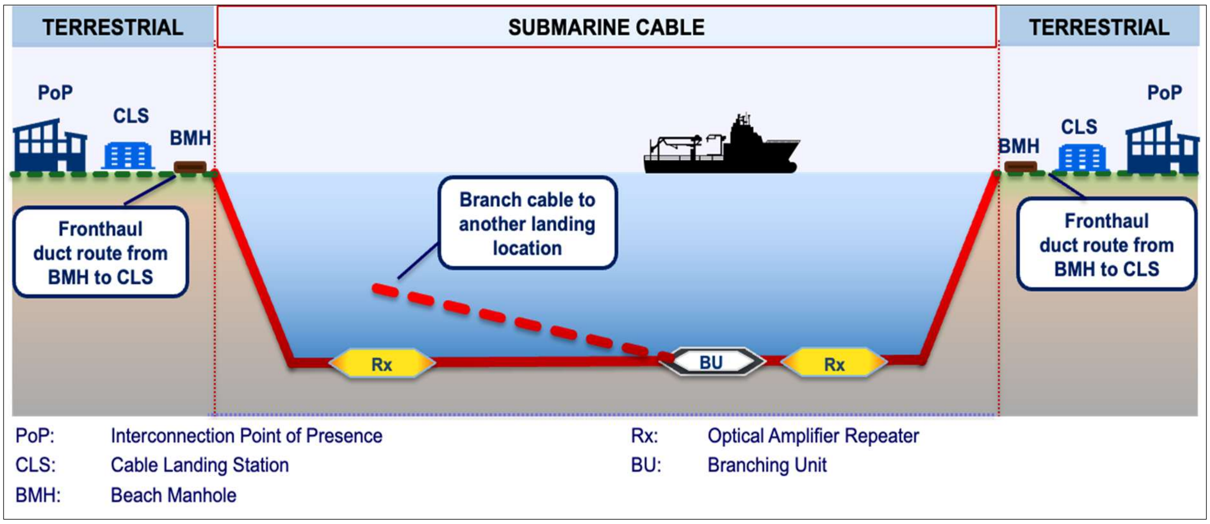
Figure 2: Central Pacific Connect. Source: Central Pacific Connect Initiative



5.1. Cable System Infrastructure

A submarine cable system comprises both underwater (wet plant) and terrestrial (dry plant) infrastructure components. Infrastructure components have unique repair and maintenance requirements, vulnerabilities and protection measures.

Figure 3: Cable System Infrastructure



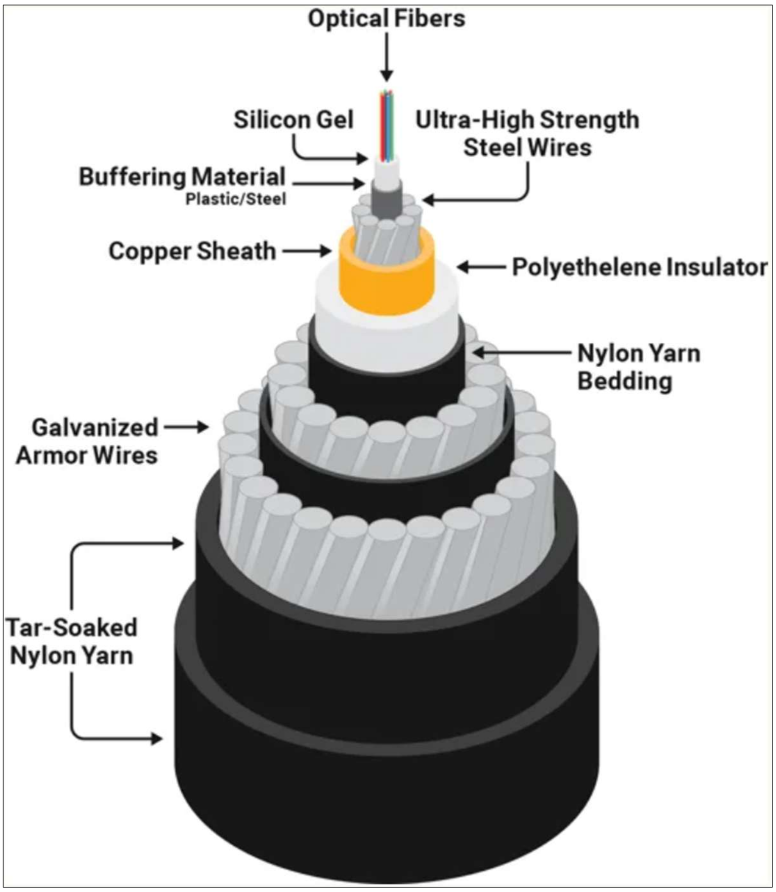
Source: Adapted from Hardiman Telecommunications Submarine Cable Installation and Maintenance Market Overview 2026.

5.2. Submarine Infrastructure

Wet plant refers to all underwater components, including the optical fibre cable, signal-amplifying repeaters, and branching units that facilitate multiple branches and cable landings off a single cable trunk. The cable is built to withstand harsh ocean conditions, using steel armour to protect high-density polyethylene that surrounds the fibres. Armoured cable is used in high-risk shallow waters, while unarmoured cable is deployed in deeper, safer waters.

Cable routing and protection are determined during the cable design phase in conjunction with analysis of historical cable repair and marine survey data.

Figure 4: Submarine Cable Cross Section



Source: TeleGeography

5.3. Terrestrial Infrastructure

Terrestrial components are parts of the cable system installed on land. These components connect the wet plant to Cable Landing Stations (CLS) that is the interface between the cable system and local networks. CLS's house equipment for controlling and monitoring the cable that includes fault detection across both wet and dry plant components. CLS facilities require physical protection, security systems and back-up power solutions (generators and batteries) to ensure uninterrupted data transmission. CLS personnel interface with a cable repair vessel to support repair operations.

Figure 5: Cable Station Equipment & Modular Cable Landing Station

Sources: https://www.ciena.com/insights/articles/The-Cable-Landing-Station-Is-Critical-Infrastructure.html

Other land-based infrastructure includes the Beach Manhole (BMH), which serves as the connection point between the wet plant and dry plant. Dry plant includes the terrestrial fibre cable and power cable components that leads to the CLS via 'fronthaul.' Fronthaul refers to underground conduits that protect the terrestrial fibre and power cable components that connect a BMH to a CLS. The length of fronthaul can range from a few hundred meters to over five kilometers.

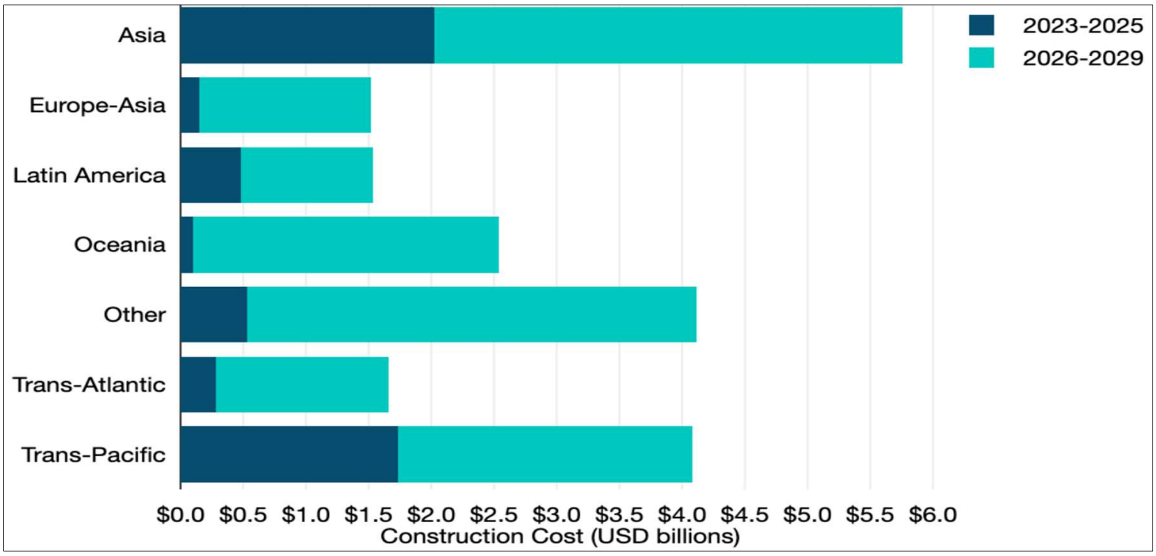
6. CABLE INVESTMENT

The demand for capacity remains a key factor influencing investments in new cable infrastructure. In 2025, global international bandwidth increased by 23%, reflecting growth rates observed in Oceania. Industry projections indicate the need for at least one new trans-Pacific cable per year between 2026 and 2040, adding significant cable kilometers in the Pacific Ocean.

At the same time many aging cables deployed during the late 1990's to the early 2000's are nearing retirement. Approximately 25% of the global cable network (c.400,000 kilometres) will be decommissioned in the next five years and will not require repair and maintenance services.2 Most cables in the Pacific, particularly those connecting the Pacific island countries are relatively new and therefore expected to remain in service for considerable time.

Route diversity is another factor influencing cable investment. As network architecture evolves from connecting population centres to a data centre-oriented network architecture, new cable routes are being developed. Diverse cable routes are important to strengthening network resilience because capacity consumers can secure bandwidth across multiple cables to create a connectivity network, that ensures a high-level of resilience.

Figure 6: Estimated Submarine Cable Investment



Source: TeleGeography 2026

Despite the substantial level of new cable investment that enhances network diversity, redundancy and resilience, 80% of cable owners when polled, stated that cable repair timeframes will remain as important in the future, as they are now.[3]

6.1. The Influence of Hyperscalers

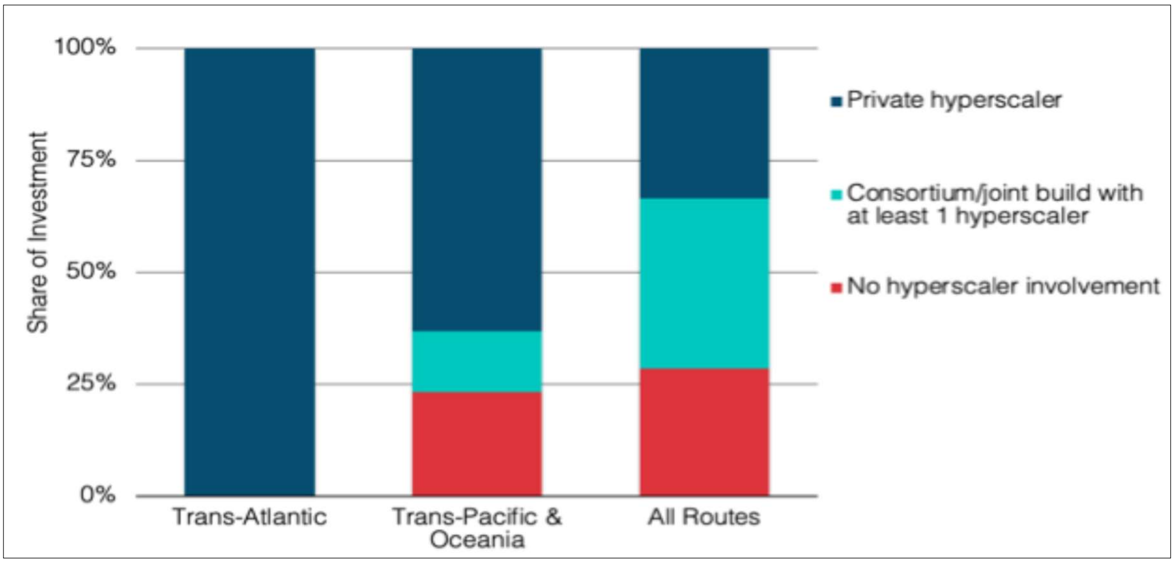
Hyperscalers (Google, Meta, AWS, and Microsoft) account for over two-thirds of internet traffic. Their substantial investment dominates the market, determining when and where new cables are deployed (Figure 7). Their vast network footprints give them a rising influence over maintenance agreements, including if, or how, agreement models and structures will evolve.

[2] Constable et al. The Future of Submarine Cable Maintenance. SubOptic Association. 2025

[3] Constable et al. The Future of Submarine Cable Maintenance. SubOptic Association. 2025

In some regions structural inefficiencies are evident while other regions will experience repair vessel shortages over the next 10-15 years.[4]

Figure 7: Hyperscalers Cable Investment By Region 2025-2029



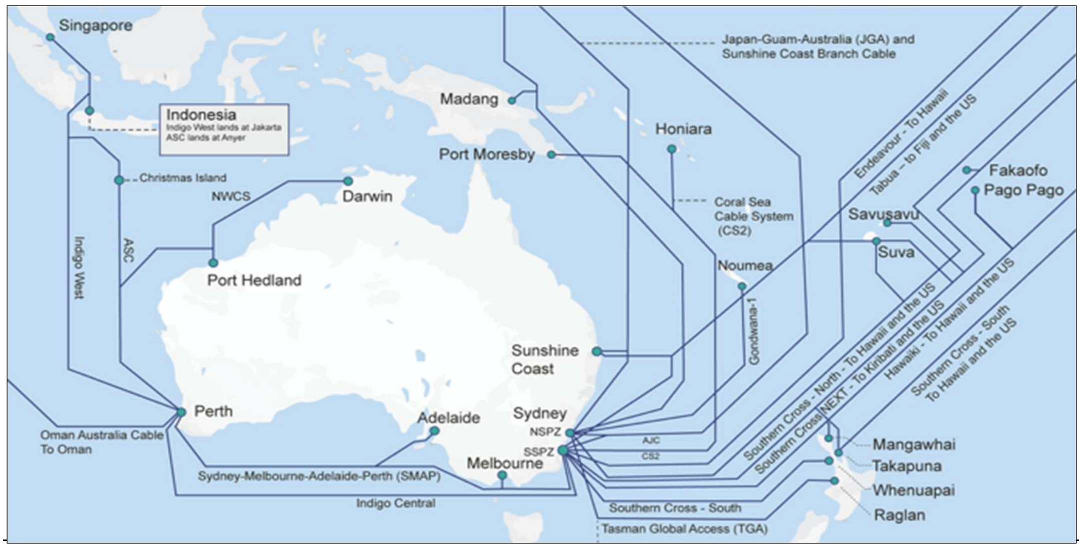
Source: Boudreau, Strong, et al. TeleGeography Workshop, Pacific Telecommunications Council, 2026.

Google's Pacific Ocean network footprint is significant, as many of their trans-Pacific cables serve as the primary cable trunk from which cable branches land in several Pacific Islands, notwithstanding their central role in the Pacific Connect Initiative. Google's trans-Pacific cable investments will give them substantial weight in SPMMA and the adjacent North American Zone (NAZ) maintenance agreement.

6.2. The Role of Australia and Japan

Trans-Pacific cable investment has reinforced Australia as the primary Southern Ocean connectivity hub, that anchors multiple cables that facilitate connectivity within Oceania.

Figure 8: Australia's Submarine Cables (international and Domestic)



Source: Australian Communications and Media Authority (ACMA)

[4] Constable et al., The Future of Submarine Cable Maintenance. SubOptic Association. 2025

Australia's numerous international cables that land on the east coast connect to the US and mid-Pacific hubs like Fiji, French Polynesia and Hawaii. Northward routes run directly to Papua New Guinea (PNG), Solomon Islands, Guam and Japan (Figure 8).

Japan serves as an Asia-Pacific nexus, with a dozen cables to the US West Coast, several intra-Asia cables, and two connections to Australia via Guam. More than 20 international CLS facilities support over 30 active and planned cables. Japan has been influential to enhancing cable developments including maintenance assistance and training for Kiribati and Naoero.[5]

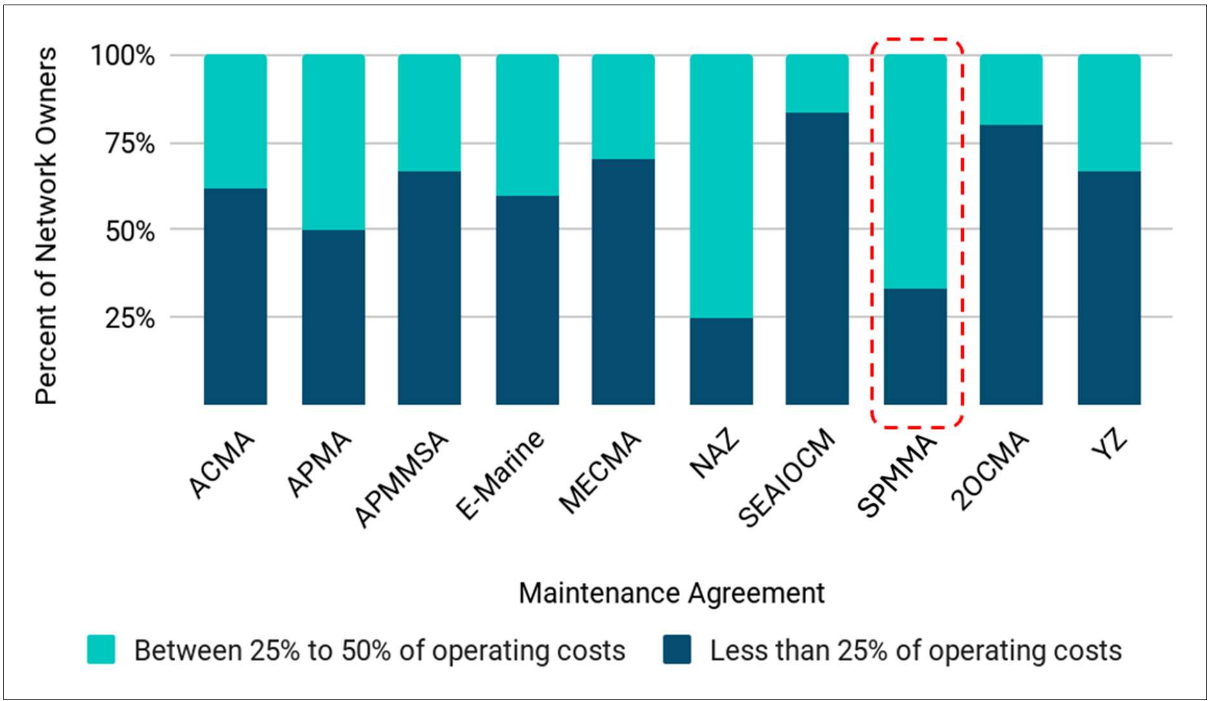
6.3. Regional Investment Challenges

Pacific island countries face unique challenges financing submarine cable infrastructure. Their small geographically dispersed populations and limited domestic markets can struggle to generate sufficient returns to finance international cables that connect to major markets in the US, Australia or Japan; in addition to funding domestic cables that are needed to connect their vast island archipelagos. Regional governments, multilateral banks, hyperscalers and cable owners have been instrumental in overcoming the economic challenges of developing island cable connectivity and redundancy for many of the Pacific island countries. However, two or more cables double the cable owner's operational expenses and the risk of cable faults, which is often not supported by external finance.[6]

"The need for submarine cable diversity can create a real challenge for a country. A second cable rarely generates any more traffic, making it impossible to justify on the grounds of additional revenue"

J. Hibbard and P. McCann 2023[7]

Figure 9: Cable Owners Marine Maintenance Operating Costs by Maintenance Agreement



Source: Constable et al., The Future of Submarine Cable Maintenance, SubOptic Association, 2025.

[5] Murphy, Bryja. The Strategic Future of Subsea Cables. Japan Case Study. Centre for Strategic & International Studies (CSIS). 2025

[6] McCann, Hibbard. Commercial Challenges for Pacific Island Cables. Subtel Forum Issue 137. 2024

[7] Hibbard, McCann, Opinion: The Pacific - Securing the Future 2023. https://islandsbusiness.com/features/opinion-the-pacific-securing-the-future/

Marine repairs and maintenance expenses constitute a significant portion of a cable's operating expense. Approximately 70% of SPMMA's cable owners polled state that cable maintenance costs are between 25-50% of their cable's operating expenses (Figure 9).

6.4. Satellite Connectivity

Strengthening regional connectivity and resilience is not the domain of submarine cables alone. Low Earth Orbit (LEO) satellite systems provide an important, complementary technology to submarine cables. Despite the technical gains that expand the capacity of satellites, the economics associated with the total cost of ownership, lifespan and operational costs places cables firmly as the foundational infrastructure for high-capacity connectivity.[8] Research analysis indicates the comparative cost of a megabyte of capacity on a LEO satellite versus a submarine cable, is a factor of approximately 2800x.[9] Despite the unfavourable unit-costs, several Pacific island countries have launched satellite connectivity or have government approved access but services are not commercially available as local resellers and retailers are yet to be established.[10]

[8] CCRC Low Orbit Satellites in the Pacific: Opportunities, Risks and Governance for resilient connectivity 2026

[9] TeleGeography. Presentation at SubOptic Association Conference, Lisbon 2025

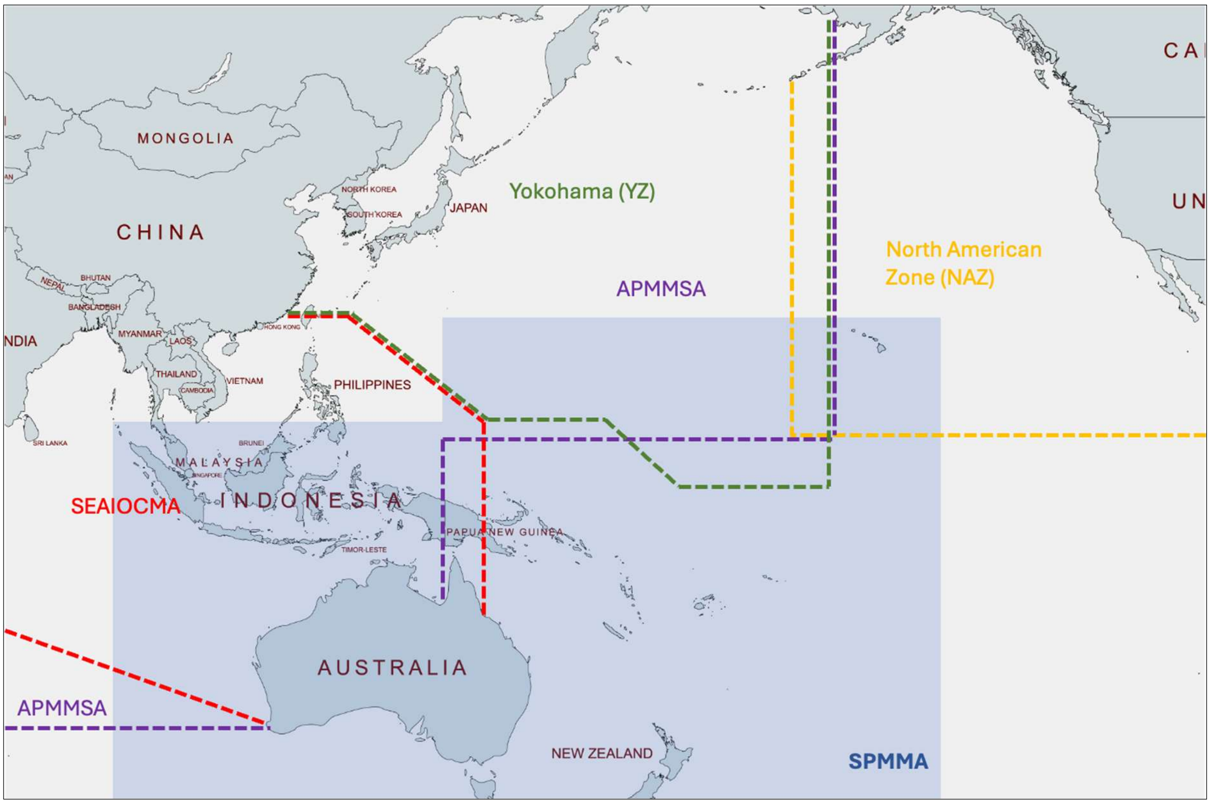
[10] https://theconversation.com/starlink-is-transforming-pacific-internet-access-but-in-some-countries-its-still-illegal-257905

7. CABLE MAINTENANCE AGREEMENTS

The submarine cable industry relies on a comprehensive arrangement of cable maintenance agreements, structured under a regional or 'zone-based' commercial model.

Zone agreements are effective cost-sharing models for cable owners, enabling them to jointly cover expenses for dedicated repair vessels stationed at specified base ports and cable depots for storing spare wet plant. Zone boundaries tend to overlap due to competitive dynamics that can offer a choice between agreements. Long trans-oceanic cables that cross agreement boundaries will be signatories to more than one maintenance agreement.

Figure 10: Pacific Ocean Maintenance Zones



Agreements cover five-year terms, usually with options to extend. Renewals with the incumbent service provider are common, as little competition exists due to the specialised nature of marine maintenance, established relationships, lack of new market entrants and expansion of the repair vessel fleet.

Three economic foundations are used to reach a commercial agreement that is tailored for each region: annual fixed fees, variable fees and outside work provisions. In areas with few cable faults, vessel providers will look to increase cable owner's fixed fees to compensate for reduced profits derived from the variable fees applied to each repair operation. However, where vessel repair activity is historically low, agreements include the provision for vessel operators to conduct 'outside work' to offset repair vessel standby (idle) time, which helps to reduce the annual fixed fees.[11] The opportunity and risk to secure additional revenue from outside work lies with the vessel operator and therefore in low fault regions, annual fixed fees are generally higher than areas with a significant number repairs. Figure 9 demonstrates this trend as SPMMA and NAZ agreements have low cable fault rates.

[11] Outside work is generally defined as work activities that does not involve cable repairs for cable owners that are signatories to the repair and maintenance agreement such as cable installation work.

Cable fault frequency and the extent of agreement boundaries determine how many repair vessels are assigned to a maintenance agreement. Some regions have competing agreements with multiple repair vessels, while others including SPMMA and NAZ, have a single repair vessel. Cable owners consider repair vessel capabilities such as age, size, endurance, weather tolerance and equipment specifications when agreeing to the designated repair vessel.

Agreements include Key Performance Indicators (KPI's) to ensure service level performance, covering mobilisation timeframes and vessel transit speeds among others. Financial or other penalties may apply if KPIs are not met. Many agreements including SPMMA, appoint management committees to represent all cable owners' interests. Management committee members are typically chosen from cable owners with the most contracted cable kilometres.

Maintenance agreements offer service providers long-term contracts, a predictable inflation-adjusted fixed revenue stream, and upside from outside work revenue. This contrasts with the utilization and construction risk associated with cable ships that service the cable installation sector.

7.1. Agreement Exclusions

Large repair vessels provide maintenance services, but their ability to operate is restricted in waters shallower than about 10-12 meters because of draft and safety concerns. Maintenance agreements address these operational limitations by excluding repairs in (shallow) waters where designated vessels cannot operate. As a result of this technical constraint, cable owners may be required to establish separate commercial agreements to conduct shallow water repairs. This risk is particularly pronounced in regions where extensive shallow water areas exist. However, repair vessels can undertake a cable replacement operation rather than a cable repair in shallow or nearshore waters, if the vessel can be positioned within two or three kilometers of the coast.

Commercial practicalities, spare wet plant inventory and the specific environmental conditions are weighed to determine the optimal method to restore cable connectivity. If the designated repair vessel is unable to perform a cable replacement operation, a smaller repair vessel or shallow draft barge is used. This may be sourced from the maintenance service provider if available, or third-party resources must be found.

Most cable owners do not prepare for shallow water repairs before faults occur, often only responding after a fault. This can cause significant delays if repair platforms are unavailable or not located in reasonable proximity to the fault location.

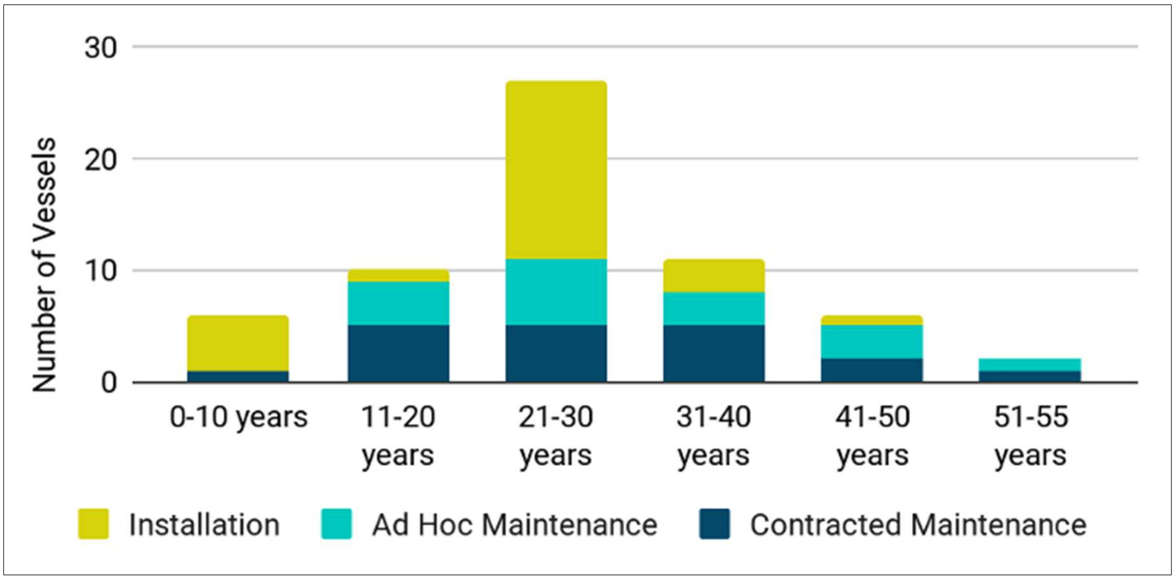
Repairs for terrestrial infrastructure are also excluded from marine maintenance agreements.

7.2. Maintenance Vessel Fleet

Fleet analysis undertaken in 2025, indicates that 19 vessels (~31%) of the global cable ship fleet are contracted full time to maintenance agreements. Another 17 (~27%) perform repairs on an ad-hoc basis, mixing installation work with occasional repair work when called upon. Maintenance vessels are typically older than installation vessels, reflecting an industry trend to re-purpose older installation vessels to maintenance duties (Figure 11). The average age of the repair vessel fleet is 29 years. Using an expected 35 to 40-year service life, the calculus suggest two-thirds of the global maintenance fleet will need to be replaced within the next 10-15 years.[12]

[12] Constable et al. The Future of Submarine Cable Maintenance. SubOptic Association 2025.

Figure 11: Global Fleet by Age and Function 2025



Source: Constable et al. The The Future of Submarine Cable Maintenance. SubOptic Association 2025.

Seven new purpose-built cable ships have been formally commissioned in the past two years bit will not be delivered until 2028/29. Six are multi-purpose and therefore have the capability to conduct both cable installation and maintenance activities. Five vessels are likely to replace existing assets that are due for retirement, including the Lodbrog that supports the SPMMA agreement. The net impact of this investment is a fleet expansion of two vessels, that has little impact on the concentrated vessel supply chain.

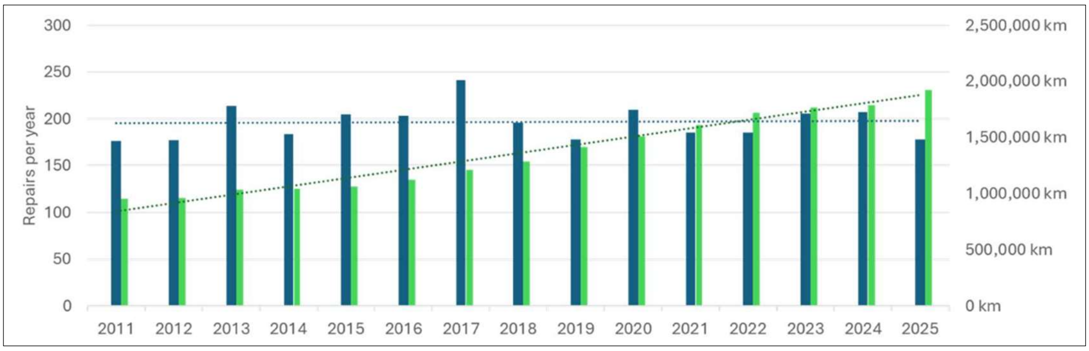
Modern purpose-built maintenance vessels are equipped with advanced propulsion systems that offer greater energy efficiency than older vessels. Reduce operating costs should benefit cable owners. However, capital investment returns may require higher annual fixed fees, further straining the operating budgets of cable owners.

7.3. Cable Faults

The International Cable Protection Committee (ICPC) compiles the number, cause and location of cable faults. Over the past decade, on average between 190 - 200 cable repairs are performed each year. Despite a growth in total cable kilometers deployed over the past decade, the number of repairs has shown a slight decline (Figure 12).

Not all cable faults disrupt data transmission. Nearly half are shunt faults caused by electrical shorting due to damage to the outer cable sheath. Because shunt faults do not require immediate repair, cable owners can coordinate repairs with other vessel operations to reduce repair costs.

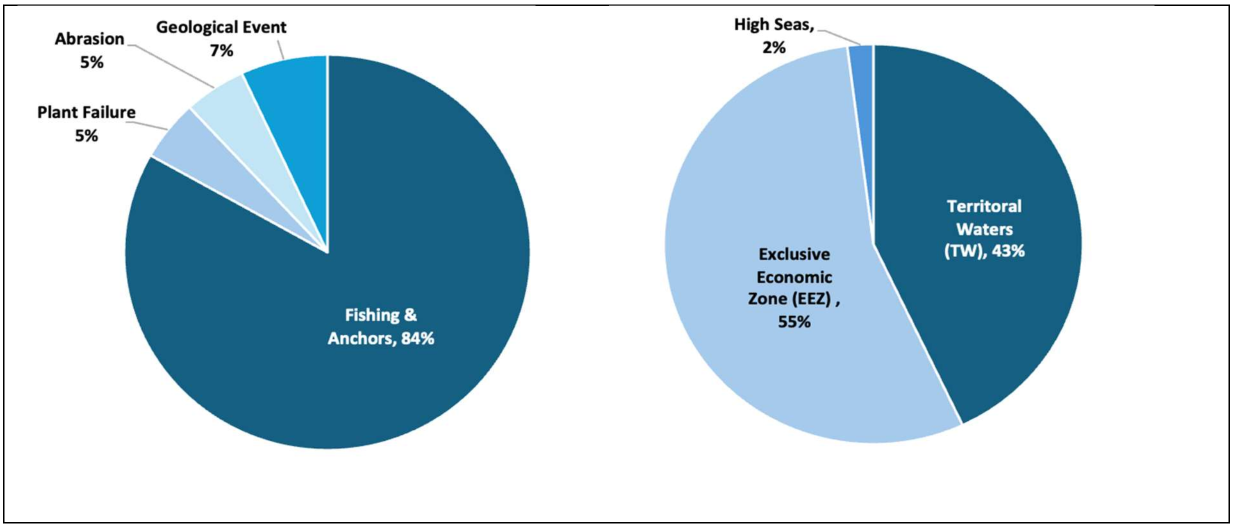
Figure 12: Cable km versus repairs per year.



Source: ICPC 2026

ICPC data shows most cable faults are caused by human intervention, with seabed trawling and anchor damage leading factors. Other factors are due to environmental or natural hazards (Figure 13).

Figure 13: Global Causes and Distribution of Cable Faults.

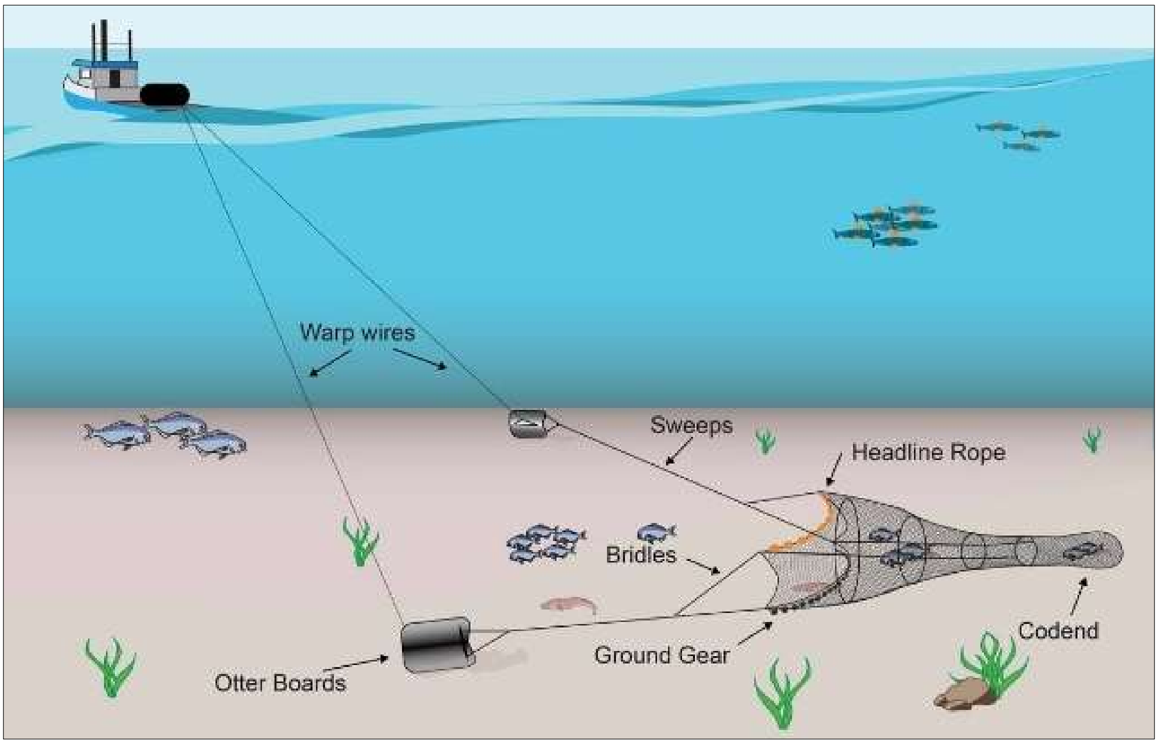


Source: ICPC 2026

Threats from fishing activity is confined to water depths ranging from 1,000 to 1,800 metres, depending on the region. Vessel anchors for the largest container ships are limited to water depths of 80–100 meters. Cable routes are planned to avoid designated anchorages and maritime traffic areas, but faults occur where uncontrolled or unregulated anchoring takes place.

The distribution of cable faults also reflects water depths. Deep ocean areas typical of the high-seas (or international waters) have a lower threat profile, than the shallow water regions often found within territorial and Exclusive Economic Zone (EEZ) waters (Figure 13).

Figure 14: Seabed Trawling



Source: Southeast Trawl Fishing Association (SETFIA)

Invasive seabed trawling is uncommon in the Pacific, primarily due to deep waters and the absence of extensive continental shelves The predominance of volcanic island chains, which result in steep seabeds and canyon systems near island coastlines also prohibit seabed trawling. Regional fishing activities are generally small-scale, employing long line, troll, and purse seine methods, as well as artisanal pole-and-line techniques near island shores. As a result, several cables connecting Pacific Islands countries have remained fault free. An exception exists along the southern coast of Papua New Guinea, Australia and New Zealand where industrial fishing fleets are active.

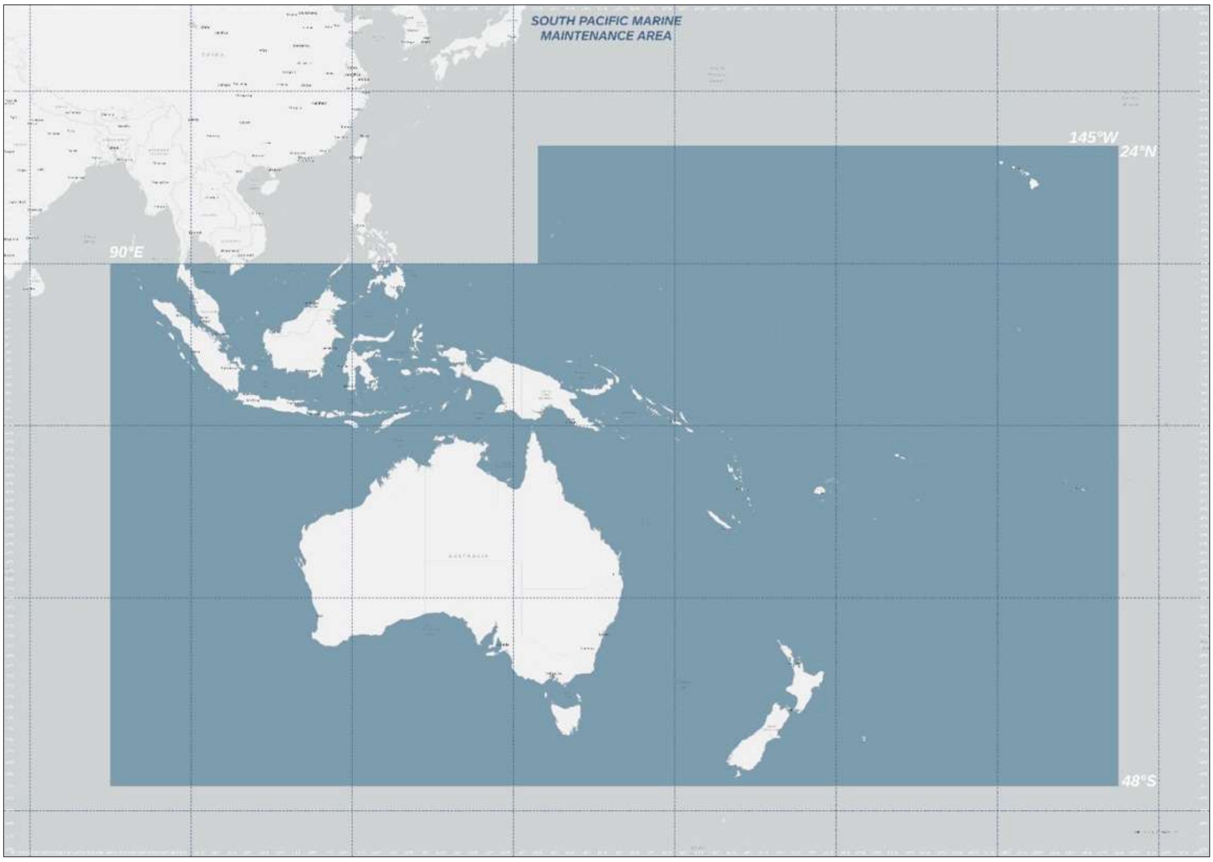
8. SPMMA MAINTENANCE AGREEMENT

SPMMA is the sole maintenance agreement that covers the whole of Oceania. SubCom, a cable system supplier serviced SPMMA until its 2022 renewal but withdrew to focus on cable installation work. Optic Marine Services (OMS) a Malaysian headquartered vessel operator was the only organisation that had an available repair asset to service SPMMA and therefore secured the agreement.

SPMMA renewal is set for 2028/29, but it remains uncertain whether OMS will continue as the preferred maintenance provider or if competitive bids will emerge from other established providers. Few alternatives are expected due to the concentrated supply chain. Established relationships, limited offshore expertise, and a shortage of new market entrants restricts competition during renewal periods.

Every trans-Pacific cable connecting Oceania and the United States is also a signatory of the North American Zone (NAZ) agreement. Meanwhile, cables between Oceania and Japan can choose to contract with either the Asia Pacific Marine Maintenance Agreement (APMMSA) or the Yokohama Zone (YZ) agreement.

Figure 15: SPMMA Zone Boundaries.[13]



Source: Optic Marine Services (OMS)

Around 20 cable owners are signatories to SPMMA, contributing over 100,000km of cable to the agreement. SPMMA's single repair vessel covers approximately 60% of the Pacific Ocean.[14]

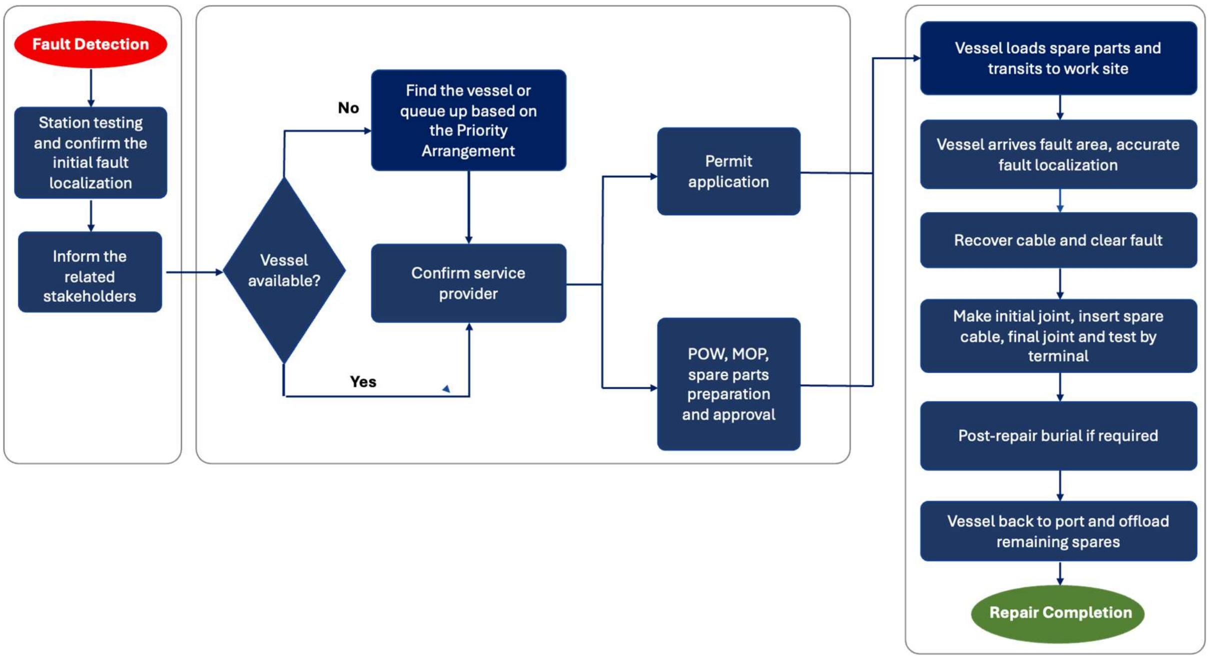
[13] SPMMA's boundaries are indicative, and open to adjustment to allow new cables to enter the zone upon agreement with the existing signatories.

[14] c.98 million square kilometers

8.1. Repair Timeframes

The duration needed to repair cable faults differs widely across the globe and within Oceania. According to ICPC, the main causes of repair delays are waiting for a repair vessel and the time required to obtain permits. Additional factors can also affect repair durations (Figure 16).

Figure 16: Cable Repair Operational Framework



Source: S.B Submarine Systems/ITU Advisory Body 2026.[15]

The global average repair vessel mobilisation timeframe from notification to departure is 23 days.[16] Within Oceania, vessel mobilisation durations also vary. ICPC data indicates the following averages:

- < 7 days for Australia and New Zealand
- 14 - 30 days for Pacific island countries
- > 60 days for PNG and Solomon Islands[17]

Upon arrival at the fault location site, OMS estimates the average deep water repair timeframe ranges from 12 to 16 days. Actual repair durations depend on water depth, cable re-burial (if required), weather and other operational factors.

8.2. Repair Vessel Availability

The Oceania region has few faults, averaging only three cable repairs annually. SPMMA's annual vessel repair utilisation rate is approximately 20%, one of the world's lowest and comparable to the adjacent NAZ agreement.18 While low utilisation helps prevent delays, if the vessel is engaged elsewhere under outside work provisions, delays are inevitable as the repair vessel will not be immediately available.

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[15] International Advisory Body on Submarine Cable Resilience Working Group Report. ITU 2026.

[16] International Cable Protection Committee (ICPC) Plenary Athens 2026

[17] PNG delays are attributed to a two -three week period for permit approvals in Territorial Waters.

[18] Data averaged from 2020-2025. For comparison, APMMSA and YZ agreements average 40-50% annually.

OMS is also one of two APMMSA maintenance providers. APMMSA overlaps SPMMA's northern and western boundaries. This arrangement enables flexible use of repair vessels from either agreement when needed, subject to cable owner approval.

8.3. Permit Approvals

Several Pacific island countries, motivated by the need to safeguard the sovereignty and interests of their extensive EEZ territories, were among the first nations to ratify the 1982 United Nations Convention of the Law of the Sea (UNCLOS) treaty. The treaty stipulates that repair permits must be obtained for vessel operations within territorial waters, but only notifications are required for EEZ waters.

OMS notes that except for PNG and Solomon Islands, permit approval timelines do not significantly impact repair schedules, due in part to the relatively small government administrations of the Pacific Island countries. When repair operations occur within territorial waters, vessels must comply with national customs and immigration clearance regulations, that often add two or more days to the repair duration. It's important to highlight that ICPC advocates a single point of government contact to facilitate all cable related matters, including permits approvals.[19]

8.4. Mobilisation and Transit

Vessel mobilisation requires time for vessel preparation, including loading fuel, other provisions and spare wet plant. Spare wet plant is generally stored in depots that are co-located at the vessel base port. SPMMA is distinctive as it does not incorporate depot services. Depot services are captured in a separate agreement between cables owners and the Samoa Cable Company which administers a spares depot in Samoa. The geographic separation between the vessel base port and the spares depot adds a transit period of approximately two days.

To help streamline mobilisation, some wet plant ('strategic spares') are stored on the repair vessel to eliminate the additional transit time from Fiji (or elsewhere) to the Samoa depot.[20] This is a unique arrangement that is not widely practiced in other agreements.

OMS reports that mobilisation is frequently delayed because Samoa lacks enough quayside berths, leading to queues for these facilities that slows wet plant loading. At the time of writing, OMS is considering alternative depot locations to improve mobilisation times.

Severe tropical cyclones often impact the Pacific Ocean that can delay all offshore operations including vessel transit times and cable repair activities.

8.5. Repair Priority

Maintenance agreements including SPMMA govern the repair priority on a first-come, first-served basis. This foundational principle is reinforced by additional rules designed to address critical faults in the event multiple faults occur concurrently. SPMMA's repair priority parameters are influenced by several factors:

- traffic impacting versus non-traffic impacting (shunt faults)
- connectivity factors and impact on an island nation
- availability and limitations of redundant traffic paths

Cable owners maintain close collaboration to determine repair priorities. Often cable owners pool cable repair spares such as Universal Joint (UJ) equipment but the unique design

[19] ICPC Government Best Practice Recommendations version 1.2. ICPC 2021

[20] Strategic spares comprise spare wet plant for cables that have a greater frequency of faults.

characteristics of each cable typically preclude pooling or sharing of other wet plant components.

8.6. Repair Vessel CS. Lodbrog

The Lodbrog is the designated repair vessel contracted to the SPMMA agreement.

Figure 17: CS Lodbrog

Source: Optic Marine Services

The Lodbrog is over 140 metres long with a cable capacity of 5,000 tonnes which is larger than typical maintenance vessels.[21] It's size, cable capacity and plough burial system makes it a versatile platform to perform a range of outside work activities, even during the region's severe weather conditions.

Vessel endurance (time at sea without the need to refuel or re-provision) is 32 days, notably less than similar sized peers that range from 45-60 days. Reduced endurance restricts operational capacity, a consideration where long transits or extended operations are required due to a multi-repair event.

At 41 years old, the Lodbrog exceeds the typical 35 to 40-year cable ship service life and is among the oldest in OMS' fleet. Older vessels require more allowance for unplanned maintenance that can impact vessel availability.[22] Although not confirmed, the Lodbrog is expected to be decommissioned when the two new OMS vessels arrive in 2028/29. A new, purpose-built vessel will have greater fuel efficiency and increased endurance.

8.7. Executing Shallow and Nearshore Water Repairs

Repairs in shallow or nearshore waters that cannot be performed by the Lodbrog have often led to a cable replacement operation rather than a repair operation. Repair expediency and commercial practicalities will influence this decision. Smaller, shallow draft vessels like the CS Peter Faber or CS Teneo (both owned by OMS), offer alternative solutions. Non-powered shallow draft barge platforms are available in Asia but will require extensive transit times and support vessels to reach the Oceania region.

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[21] The Lodbrog was converted from a roll on-roll off ferry in 2000 and re-purposed from installation to maintenance, which explains it's large cable capacity but low endurance.

[22] Off-hire periods for vessel planned maintenance are captured in the maintenance agreement

Shallow draft barge platforms may exist within Oceania, but mobilising cable repair equipment and skilled expertise is necessary. This solution is viable only if a modular repair spread is readily available, and OMS (or other experienced operators) provide the offshore personnel and expertise. Fiji is the most likely location to source a suitable platform owing to its relatively advanced maritime support industry. Port Moresby (PNG) and Honiara (Solomon Islands) may also be viable locations.

Evaluating the need for local repair capabilities and investment in repair equipment is prudent although cable replacement is often the optimal solution for nearshore repairs, however a sufficient inventory of spare armoured cable inventory is required as cable replacement lengths can exceed two or more kilometers.

8.8. Regional Port Infrastructure

Adequate port infrastructure and quayside support services are fundamental to the effective operating capability of a repair vessel. Cable depots also require similar quayside facilities and support services, if not collocated with the vessel base port, including a customs-controlled bonded storage facility that eliminates import/export fees and bureaucracy associated with spare wet plant storage, replenishment and use in repair operations.

The Oceania region offers limited options for centralised base port and spares depot location. Many Pacific island countries lack basic port infrastructure. A 2023 World Bank report assessed port infrastructure throughout the region describing low port traffic volumes, and economic pressures that pose limitations on the development, maintenance, management, efficiency, range and quality of port services.[23] Port congestion experienced in Samoa, is also common in the larger ports including Fiji.

8.9. Is SPMMA Structured for the Future?

A significant volume of new, planned and forecast cable kilometers will be deployed in the central and southern Pacific Ocean over the next 10-15 years. Estimates range from an additional 100,000 to 140,000 kilometres which analysis suggests that a single repair vessel will have sufficient capacity to manage the anticipated number of SPMMA repairs associated with this cable kilometer increase.[24] This conclusion is drawn from the net increase in cable kilometres, while considering historically low cable fault rates, and the repair vessel utilization capacity that is available under a normal repair rate scenario. Repair delays will arise due to repair queues caused by simultaneous or concurrent multiple cable outage events. All maintenance zones have experienced multiple cable fault events resulting in repair queues, often regardless of the number of repair vessels allocated to the zone.

The influence of Google and other hyperscalers that contract with SPMMA is significant. The zone-based cost-sharing model has proven to be an efficient structure to ensure timely access to repair services, but structural changes and/or consolidation of agreements could affect SPMMA and the Pacific Ocean region. It is difficult to determine the shape (if any) of potential change that may occur in the future.

Although the Lodbrog is an adequate repair platform, its age and likelihood of unplanned maintenance will require OMS to replace it soon to maintain SPMMA's repair capability. Likewise moving SPMMA's depot is a near-term necessity to address the quayside congestion problems identified in Samoa.

Problems with port infrastructure and congestion will continue to hinder vessel repair operations unless investment capital is allocated to expand and upgrade port facilities or regulatory changes are made to prioritise cable repair vessels.

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[23] The World Bank. A Blue Transformation for Pacific Maritime Transport, 2023.

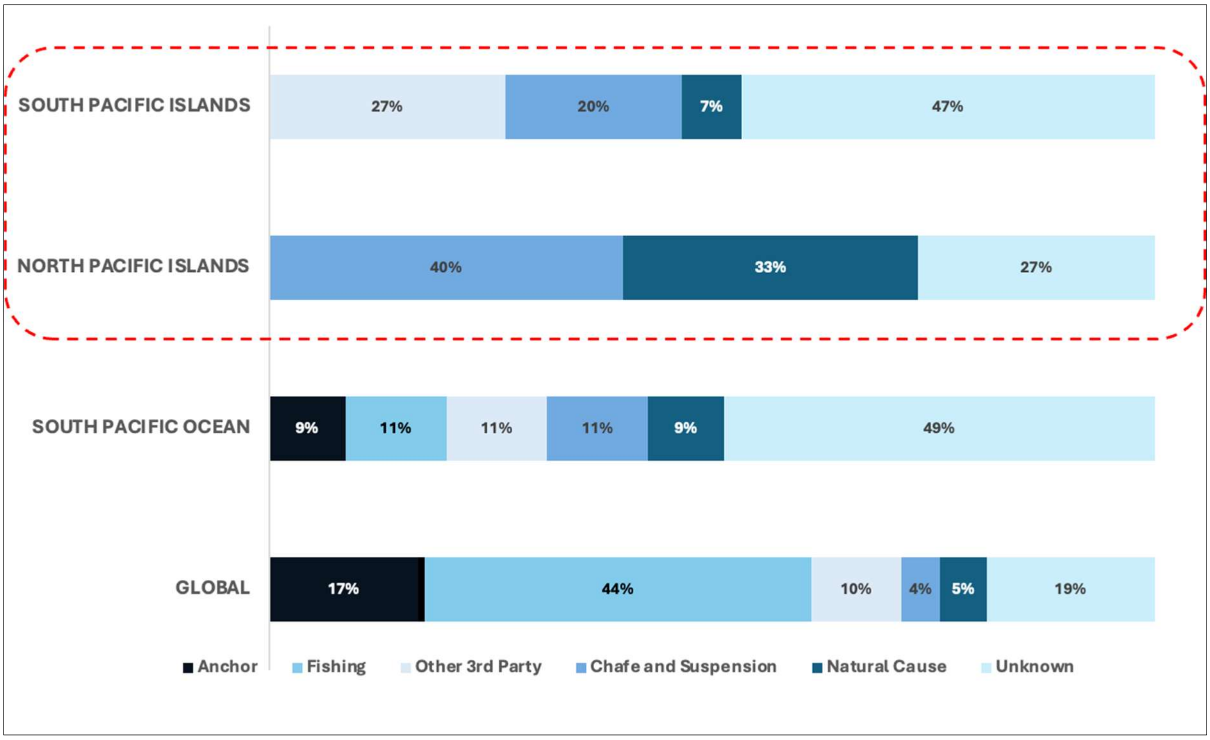
[24] Constable, et al. The Future of Submarine Cable Maintenance. SubOptic Association, 2025.

9. THREAT ASSESSMENT

Cable infrastructure faces a range of threats, which are influenced by both environmental hazards and human interference. These threats apply to both terrestrial and submarine cable components.

Research on the vulnerability of small island cable connectivity provides insight into the unique hazards small islands face due to their remote ocean location, volcanic origins, climatic influences and maritime environments.[25] The geological formation of most Pacific island archipelagos means there is little coastal shallow water areas, as seabeds descend rapidly to deep waters close to island coastlines. This environment favours cable replacement versus repair operations in nearshore areas. Lagoons and coral reefs often surround small islands and atolls, that may increase the difficulty for repair vessel access.

Figure 18: Small Islands % of total Cable Faults by Cause

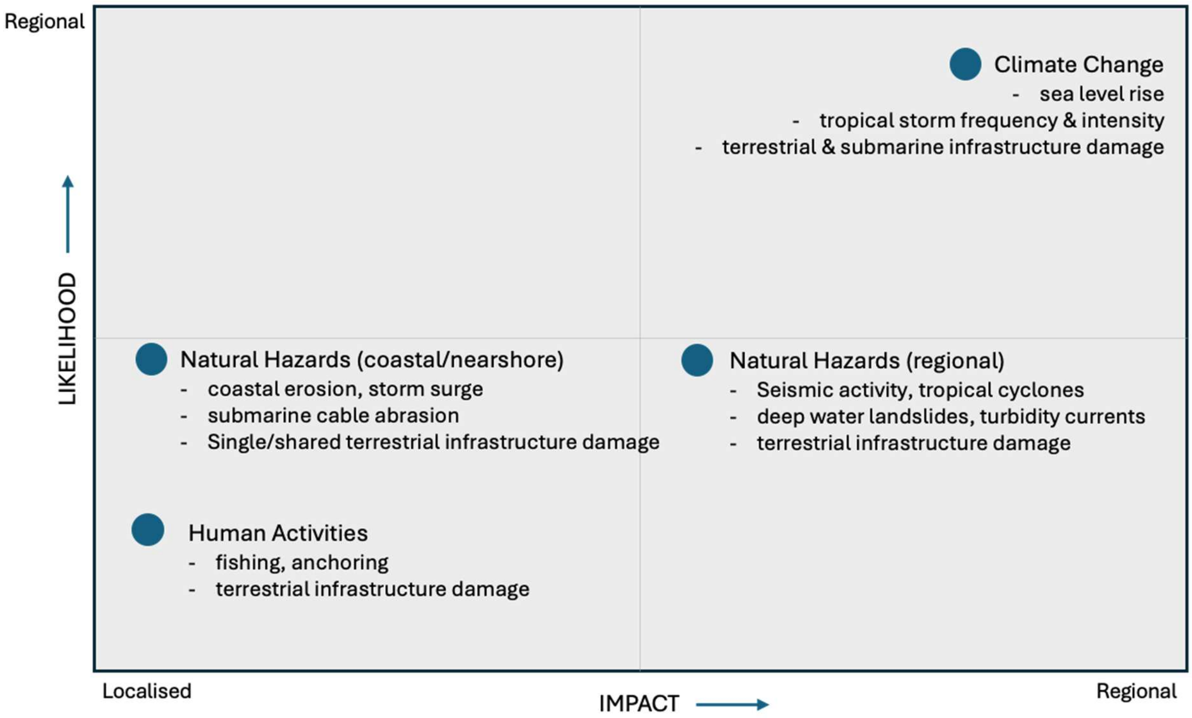


Source: Clare, et al. Hazards and Resilience of subsea telecommunications connections for small islands. 2026

In Melanesia and Polynesia nearly one-third of cable damage is caused by cable abrasion or natural causes, while in Micronesia these factors account for over 70% of cable faults (Figure 18). Fishing and anchor damage is negligible compared to global and Pacific Ocean averages. Australia and New Zealand's threat profile is considerably different than the Pacific island countries, due to more extensive continental shelves, higher maritime traffic and industrial fishing activities.

[25] Clare et al, Hazards and resilience of subsea telecommunications connections for small islands. International Journal of Disaster Risk Reduction, 2026.

Figure 19: Relative Risk Events. Likelihood and Impact



Damage to terrestrial infrastructure is not compiled by ICPC or other industry associations therefore the frequency or cause of damage is largely unknown. Several countries including Australia, require cable operators to report cable infrastructure outages, irrespective of whether in the terrestrial or maritime domain.

9.1. Natural Hazards

Natural hazards such as seismic events and tropical cyclones represent the primary risks for widespread area damage to both terrestrial and submarine cable infrastructure in both nearshore and deep-water environments.

Due to their proximity to beach areas, BMH's and fronthaul infrastructure are susceptible to damage from coastal erosion and sediment movement which is often caused by storm surges and wave action. Cable faults of this nature are typically localised impacting a single cable landing. Major natural events pose a particular risk to land-based infrastructure that can be simultaneously damaged across large areas.[26]

This threat is amplified where multiple cables rely on shared infrastructure at a single cable landing location. Sharing terrestrial infrastructure is common practice as it reduces both capital expenditure and operating costs. Except for Fiji and French Polynesia, most Pacific island countries with more than one cable share terrestrial infrastructure and CLS facilities. Each island has its own unique threat profile. Fiji has seven international cables terminating in one of the three CLS facilities.

CLS damage leading to cable system outages is rare, but the impact of significant natural events can affect facilities over a wide region. The 7.3 magnitude earthquake experienced by Vanuatu in 2024 did not disrupt cable infrastructure, but a resulting fire significantly

[26] Claire et al. Climate change hotspots and implications for the global subsea telecommunications network. Science Direct Earth Science Reviews, 2023.

damaged the CLS, causing an almost total telecommunications outage that took ten days to restore.[27]

9.2. Climate Change

Research conducted in 2023 regarding the effects of climate change on submarine telecommunications infrastructure points to the Pacific island countries being particularly vulnerable to pronounced sea-level rise.[28] Ocean temperate increases and other climate change influences are expected to intensify both the magnitude and frequency of natural hazards, that will compound the risk of cable damage across Oceania.

The small islands of Kiribati, Marshall Islands, Tokelau and Tuvalu are the lowest -lying atolls in Oceania with average elevations of 1-2 metres above sea level and therefore are particularly vulnerable to climate change. Many other Pacific island countries feature low-lying coastal plains where population centres and CLS facilities tend to be located that will be further exposed to coastal inundation, erosion and flooding.

9.3. Human Intervention

Damage to terrestrial infrastructure caused by human activities is usually localised and therefore likely to have a lower impact relative to natural hazards. As outlined above where infrastructure is shared, multiple cables are likely to be affected. Accidental incidents involving road and other construction work is common, especially since fronthaul infrastructure is often buried in or near roadways. Damaged infrastructure can be rapidly restored if there is local expertise, equipment and spare dry plant inventory available.

Damage to CLS facilities is a considerable concern. Their role as the critical link between a cable (or multiple cables) and local networks, cable management and control function, along with being a single point of failure, substantially increases their vulnerability. Significant damage to the facility or its transmission and related equipment may have a long-term impact since it is uncommon to maintain a complete backup inventory of all spare CLS equipment.

9.4. Coastal and Nearshore Threats

Coastal and nearshore regions are subject to the same natural hazards as land-based infrastructure. The high incidence of chafe damage is particularly prevalent in nearshore areas, where rocky seabeds or coral outcrops prevent cable burial, which combined with wave action or nearshore currents cause cable damage.[29] In such locations, protective piping is commonly employed to minimise this risk while also addressing threats posed by human activities (Figure 20).

[27] Clare et al. Hazards and resilience of subsea telecommunications connections for small islands. International Journal of Disaster Risk Reduction, 2026.

[28] Clare et al. Climate change hotspots and implications for the global subsea telecommunications network. Science Direct Earth-Science Reviews, 2023.

[29] Clare et al., cites a greater correlation between volcanic islands (versus non-volcanic) and the threat of natural hazards such as rough seabed, earthquakes and storms. Volcanic islands specifically referenced include Guam, Tonga, Solomons, Palau and Vanuatu.

Figure 20: Articulated pipe protection

Source: Permanent Steel Manufacturing Co. Ltd.

The absence of invasive fishing techniques creates a low-risk environment, as handline fishing is mainly conducted in lagoons and reef areas. Additionally, minimal maritime traffic reduces the threat of cable damage caused by anchors. Cables routes avoid designated vessel anchorages, but uncontrolled anchoring remains a threat in areas outside port authority control.

9.5. Deep Water Threats

The geological features of the Pacific island countries pose the main threat to cables in deep waters. Studies examining threats to small islands indicate that more than 75% of cable faults occur within submarine environments within 300km of island coastlines. [30]

Seamounts form many Pacific island archipelagos that feature steep submarine slopes and submarine canyons that cable routes must navigate to reach deep ocean areas. The unstable canyon systems are susceptible to underwater landslides, turbidity currents, and tsunamis that can cause cable damage over a substantial area.[31]

The 2022 underwater volcanic eruption near Tonga damaged over 100 kilometers of domestic and international cable infrastructure. International connectivity was restored quickly but a lack of spare wet plant inventory delayed repairs to domestic cables for more than a year, while new cable was manufactured, shipped, and deployed. [32]

[30] Clare et al. Hazards and resilience of subsea telecommunications connections for small islands. International Journal of Disaster Risk Reduction, 2026

[31] https://usa.oceana.org/infographic-seamounts/

[32] Due to the extent of damage, a five-month initial survey was conducted to determine the extent of cable damage. Cable manufacturing added a further seven months.

Tonga's experience illustrates that adequate spare wet plant inventory is critical to timely repairs but replenishing or increasing wet plant inventory is a substantial capital outlay. An industry guideline suggests that for every deep-water repair, the amount of cable required to complete the repair is approximately 3x the water depth of the repair location. Replenishing cable inventory for a single deep-water repair can cost between c. $50,000 to $120,000, excluding shipping costs.

9.6. Cable Protection Measures

Cable protection is integrated into the risk assessment processes conducted during early planning, design and engineering of a cable system. Several protection measures are established as best-practice standards and are widely adopted across all cable systems. The capability of cable owners to effect timely repairs is just as important as implementing cable protection measures. Given the size of some island populations and their level of socio-economic development, some Pacific island countries may lack local resources capable of restoring land-based infrastructure, or qualified expertise to repair dry plant components.

Capital budget limitations do however influence cable protection decisions particularly if external donor finance does not cover capital for terrestrial infrastructure. In some countries, regulatory requirements mandate specific infrastructure protection, such as burial of fronthaul or special protection measures for CLS facilities that are designated as critical infrastructure.[33]

Terrestrial Infrastructure

Cable owners recognise the criticality of CLS' and the need for uninterrupted power, fire safety systems and site security among other protection measures. Physical protection of fronthaul ducts by burial is industry standard, sometimes with concrete encasement protection but not always. The degree of protection relates to a cost calculus, at times at the expense of threat evaluations.

A less common protection strategy is a spatial separation of fronthaul routes to provide route diversity and redundancy. Fronthaul diversity in high-risk densely populated areas or where route lengths are excessive, (e.g. > five kilometers) mitigates the single point of failure and risk of localised damage. Spatial separation of BMH infrastructure where two or more cables land, also provides infrastructure diversity.

Routine physical inspections of fronthaul and BMH infrastructure that can be performed by CLS personnel, is an effective measure but is often overlooked or conducted infrequently. Fibre sensing can also be employed to monitor land cable components.

9.6.1. Cable Protection Zones

Regulating protection zones helps safeguard cables, but their effectiveness depends on regular policing and enforcing penalties. Without enforcement protection zones are less effective. Each Pacific island country will need to assess the cost-benefit of regulating cable protection zones and the manner that these are policed and penalties enforced. Not all Pacific island countries will have the maritime resources to police protection zones or possibly the political will to enforce economic penalties on local populations.

Requiring all future cables to land within designated protection zones will lead to further clustering of cables thereby elevating the risk for a single event to damage multiple cables. Protection zones need to be sized to ensure a sufficient spatial separation between existing and future cables to mitigate this threat.

Protection zones will likely work best in regional cable interconnectivity hubs like Fiji, French Polynesia, and the larger islands (Solomons, PNG) that already have multiple cables landing in

[33] Brewster et al, Bangladesh's undersea critical infrastructure. An assessment of risks and vulnerabilities. ANU National Security College 2025

a single location and exhibit greater maritime traffic and associated risks. The efficacy of establishing protection zones is less certain in smaller Pacific island countries such as Tuvalu, Kiribati, Niue, or Palau, that have single cable connections and where maritime activity is minimal.

9.6.2. Monitoring Systems and Fibre Sensing Technology

Many cable owners have proven the effectiveness of Automated Identification Systems (AIS) in highly trafficked maritime areas. AIS is integrated into cable management systems that are operated by CLS personnel. The International Maritime Organisation (IMO) rules restrict AIS signals to large vessels, making it impractical for Pacific island countries with small or minimal maritime traffic.

Fibre sensing represents an advanced technology that can be retrofitted to existing cables. Certain applications necessitate the use of a spare fibre pairs, which may not be available in some cables and are subject to distance limitations. The acoustic capabilities of fibre sensing enable the identification of nearby vessels as well as underwater seismic activity and other anomalies, including submarine landslides and turbidity currents. For optimal effectiveness, fibre sensing should be integrated with AIS to pinpoint specific vessels that may present a threat.

The advanced threat detection offered by AIS and fibre sensing systems allows cable operators the ability to directly contact vessels that pose a risk to cables. Detection of seismic anomalies can provide a pre-warning of potential cable damage but has little ability to practically mitigate cable damage threats. However indirect benefits of data captured by both systems will improve regional maritime domain awareness, provide greater insight into EEZ environments, and create opportunities to gather additional maritime security intelligence that can be integrated into the Pacific Fusion Centre.

9.6.3. Cable Spare Inventory

The Tonga earthquake caused unusually severe cable damage. Maintaining sufficient spare inventory for worst-case scenarios increases costs, so cable owners must weigh affordability against a high impact risk evaluation. This applies to both wet and dry plant inventory.

Spare cable inventory is supplied as part of the original cable construction contract. Quantities are determined during cable design processes and based on the theoretical 25-year cable design lifespan. Cable suppliers will reduce cable inventory to leverage price reductions to help budget-conscious cable owners meet their capital expenditure constraints. At the same time inventory details are often overlooked by inexperienced cable owners when negotiating complex cable construction contracts.

Pooling spare cable inventory is feasible for dry plant components, (terrestrial fibre cable and power cable components) but the unique design of each cable system prevents cable owners from sharing wet plant spares; the exception being Universal Joint (UJ) kits.

9.7. Regional Collaboration and Intelligence Sharing

Communicating the location of cables with seabed stakeholders is an effective protection measure that is widely adopted. Cable protection associations in Europe, North America and the Baltic among others collaborate with ICPC to address cable protection concerns, promote awareness, advocate policy, and coordinate with public and private stakeholders within their region of interest.[34] The Oceania Submarine Cable Association (OSCA) is an established member forum that is recognised by ICPC, yet very few cable owners belong to ICPC's group of 256 members or take part in its yearly meetings. The absence of representation from smaller

[34] European Subsea Cable Association (ESCA), North American Submarine Association (NASCA). The Danish Cable Protection Committee (DKCPC) covers the Baltic.

islands like Palau, Niue and Kiribati is likely to reflect budget constraints of cable owners. Cable awareness programmes that emphasise the importance of submarine cables helps promote community engagement but need to be customised for each Pacific island country to address the specific nature of the local environment and threat profile.

Formal reporting of cable outages raises government awareness of cable connectivity risks and promotes public-private sector information exchange. Sharing outage information across all Pacific island countries will provide a regional view of cable infrastructure threats and connectivity issues.

10. PARTNERSHIP SUPPORT OPTIONS

Numerous strategies can be applied to enhance cable protection and network resilience for Pacific island countries on a sub-region and individual island basis. While measures are not mutually exclusive, the implementation of many physical safeguards is often contingent upon the compatibility and alignment with regulatory frameworks.

10.1. Risk And Capability Evaluation

Each sub-region and Pacific island country within Oceania possesses distinct connectivity and threat profiles and varying degrees of governmental expertise and fiscal resources. Assessing appropriate focus areas and levels of support requires a thorough understanding of the unique attributes and capabilities inherent to each country.

A baseline risk assessment designed to identify and evaluate long-term strategies and near-term measures that are tailored to meet the needs of sub-regions and individual Pacific island countries is a practical first step. The interdependencies between implementing physical cable protection measures and changes required to regulatory frameworks also need to be identified and reconciled. Collaboration between the public and private sectors is essential to facilitate engagement and ensure effective oversight of this research initiative.

Funding support and guidance from regional powers will play a key role in implementing a programme of this nature, at the same time helping bridge any financial or other constraints of governments and cable owners. Prioritising sub-regions with limited redundancy and individual islands that have a single cable landing is prudent.

10.2. Expediting Cable Repairs

Establishing a unified regulatory framework among the Pacific island countries offers the potential to streamline repair operations and minimise repair delays. Identifying a single point of government contact for all cable-related matters requires an understanding of the various agencies that regulate, govern and secure telecommunications connectivity within each sovereign jurisdiction.

Mapping agency roles and responsibilities will help coordinate stakeholder interests, strengthen administrative oversight and align with industry best practice recommendations. The Pacific Islands Forum provides a platform that can facilitate and promote a comprehensive review of regulatory changes within Oceania that supports cable repair operations.

Regulatory reform needs to focus on expediting repair permit approvals, but also customs and vessel clearances, and immigration processes for repair vessel crews. While OMS have noted permit approvals are not overly onerous within most jurisdictions, vessel operational requirements and permit approval timeframes do vary between Pacific island countries, and between repairs located within territorial or EEZ waters.

Regulatory reform should encompass a post-approval repair permit process that allows vessel operators to apply for repair permits regardless of fault location, after actual repair operations have commenced. Reform of this nature is advocated by ICPC in their Government Best Practice Guidelines and has been successfully adopted by several nations.[35] Other regulatory measures will assist repair vessel operators tackle logistic complexities associated with operating within Oceania including establishing a priority mechanism that addresses repair vessel access to congested port facilities.

[35] The United Kingdom, Netherlands, France and South Africa

Cable protection zones will also likely require legislative and regulatory change, but their benefits will not be realised in all jurisdictions.

10.3. Expanding Repair Vessel Capacity

Sovereign support to expand repair vessel capacity should consider the sustainability of SPMMA and assess cross-agreement support alternatives offered by established maintenance providers to respond to events that cause damage to multiple cables.

Introducing another repair vessel to SPMMA or through an ad-hoc framework will weaken the SPMMA model. Fewer cable owners or reduced repair revenue increases risk for the maintenance provider and makes the model less attractive, potentially leading to higher costs for cable owners or a withdrawal from the region.

Cross-zone repair support provides optionality in the event of multiple cable outages but is limited by APMMSA's vessel availability and transit time, which is 18-20 days from base ports in Taiwan and Indonesia. Alternatively, NTT-WEM's repair vessel that serves the Philippines domestic cables is viable option, though transit times are comparable.[36] Japanese government support to facilitate and sponsor access to Japanese repair assets adds repair vessel capacity beyond the cross-zone arrangement, and solves the offshore expertise problem. This analysis contemplates a multiple cable damage scenario in Oceania but can also be applied to Australia and New Zealand despite their greater cable redundancy and connectivity resilience profiles.

While a single repair vessel meets the needs of the region under business-as-usual fault scenario. However should a government-backed repair asset be introduced to support government interests, in addition to supporting Oceania, the Australian east coast offers a faster eight-day transit to the Samoa cable depot; if a suitable platform is readily available and mobilised with mission-specific equipment and a trained crew.[37] A modular equipment solution that needs to be configured onto a vessel of opportunity will add at least a week of mobilisation time, and therefore does not extensively reduce deployment times relative to repair assets procured from APMMSA or NTT WEM. Capital investment for a modular equipment spread to address full ocean depth repair capability is estimated between US $20-25m.

10.4. Developing Regional Repair Capability

Not all Pacific island countries have the resources and expertise to restore terrestrial infrastructure. Few cable owners have experienced teams that can be mobilised to support the wider region. Others have test equipment but lack training and rely on third parties (such as cable system suppliers) to mobilise teams into the region to effect repairs. Since terrestrial infrastructure is frequently used by multiple cables, it's important to evaluate the restoration abilities of each sub-region. Sharing resources across sub-regions makes sense because investing in local development and workforce training for every Pacific island country is not an efficient approach. It is important that assessments include spare dry plant inventory which is essential for timely repairs. Reviewing inventory also helps evaluate the cost-benefit of pooling dry plant spares among cable owners to reduce operational costs.

Developing nearshore cable repair capability is a more costly and complex proposition, that at this stage does not warrant a priority focus given the options to replace nearshore cables (versus repair) and availability of alternative vessels within OMS' fleet. Nevertheless, a detailed analysis of the need and cost-benefit for developing nearshore cable repair capabilities should be considered in parallel to the terrestrial infrastructure evaluation process.

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[36] NTT WEM is a subsidiary of NTT.Com, a large Japanese telecommunications corporation

[37] Crew training can be conducted in advance by NTT WEM or KDDI Cableships and Subsea Engineering Inc., that provides repair services to the YZ agreement.

In the event analysis suggests a shallow water repair capability is warranted, a modular equipment solution has cost efficiencies as equipment can be transported within the region and mobilised onto a suitable shallow draft platform, where available. A partnership structure should prioritise reputable marine engineering organisations. A Fijian based partner offers a central location and logistical synergies with SPMMA's base port. Ownership and operational structures, multi-purpose capabilities, and other commercial considerations need to be weighed to offset capital expense, as does the practical benefit against the alternative solutions available.

10.5. Cable Protection and OSCA Subsidies

Similarly enhanced cable protection strategies should be assessed and customized for each Pacific island country according to their specific threat profiles and specific needs. Donor funds or subsidies will enable a preliminary risk assessment at both sub-regional and individual country levels. A two-stage process is recommended, starting with a detailed questionnaire that aims to identify connectivity issues and incorporate perspectives from both the public and private sectors.

Where appropriate, analysis of questionnaire results may be supplemented by on-site risk assessments supported by independent experts. This approach will help identify and budget practical, cost-effective cable protection measures tailored to each location.

OSCA's involvement in this process is important, however the organisation's current membership, capabilities, financial status and other resources are largely unknown.[38] Providing financial support to OSCA will enhance its ability to participate and address specific regional issues, develop stakeholder liaison programmes, promote cable awareness and expand ICPC engagement among OSCA members. Strengthening OCSA's capabilities will facilitate participation, promote cable protection awareness and facilitate intelligence sharing among public and private stakeholders.

10.6. SPMMA: Public-Private Sector Collaboration

In the absence of expanding repair vessel capacity, aligning the public sector's economic security and cable network resilience interests with the private sectors' commercially driven maintenance agreement structures, can help shape repair priorities in the event of a significant cable network outage.

Determining priority access to repair vessels is currently the sole domain of cable owners, but where cable owner interests do not align with government priorities, a common outlook needs to be developed.

Regional powers should consider a collaborative partnership with SPMMA's stakeholders to reconcile all parties' interests. This may include re-visiting repair priority mechanisms but also considers cable connectivity from a broader network resilience perspective, that includes back-up satellite capacity where available.

Structural changes to SPMMA that optimises repair vessel availability can be achieved by revisiting outside work provisions to increase repair vessel availability, but corresponding fiscal or other support needs to balance, not weaken SPMMA'S economic foundations.

[38] Several attempts were made to contact the OSCA chairman during this research with no response.

11. CONCLUSION

The risk profiles of Pacific island countries are closely interrelated with each island's connectivity and network resilience. International and domestic connectivity has seen notable advancement in recent years, with several Pacific Islands securing initial cable investments and others obtaining secondary cables to strengthen redundancy and regional network resilience. Nonetheless, the associated costs present ongoing challenges for the operating budgets of small island cable owners. Enhanced cable protection measures will boost network resilience but also comes with a cost. The efficacy of these measures to be evaluated on a sub-region and island-by-island basis. Additional benefits to maritime domain awareness and intelligence sharing can be derived from some cable protection measures that can be integrated into the Pacific Fusion Centre information systems.

Regulatory reform will streamline repair timeframes and simplify logistics for cable repair vessels. Ideally, a unified regulatory framework should be adopted across the region that incorporate perspectives from both public and private sector stakeholders. Regulatory reforms and alignment can be considered under the oversight of the Pacific island Forum.

SPMMA is cost-effective and operationally capable agreement given the historical low fault rates both now and in the future. However, replacement of the Lodbrog is needed. When multiple cable outages occur, sharing repair assets with those of APMMSA provides additional support, but several factors impact the immediacy of this solution. Expanding cross-agreement repair vessel capacity should also be explored with NTT WEM, the Japanese company that supports Philippines domestic cable maintenance. Government collaboration with SPMMA stakeholders can help align public sector interests, repair priorities with private sector commercial models.

SPMMA repair exclusions provide an opportunity to build independent in-region terrestrial infrastructure repair capability that lessens the current dependency on third parties. Expediting restoration of terrestrial infrastructure is a priority where multiple cables share this infrastructure at a single landing location. Local repair solutions will require local partnerships, specialised equipment and a trained workforce.

12. ANNEXES

12.1. Annex 1: Pacific Island EEZ Territories

Figure 21: Pacific Island EEZ boundaries

Source: Pacific Community https://cbfm.spc.int/resources/fishing-techniques

Estimates of the combined size of the PIC's excluding new Zealand and Australia is 40 million km2

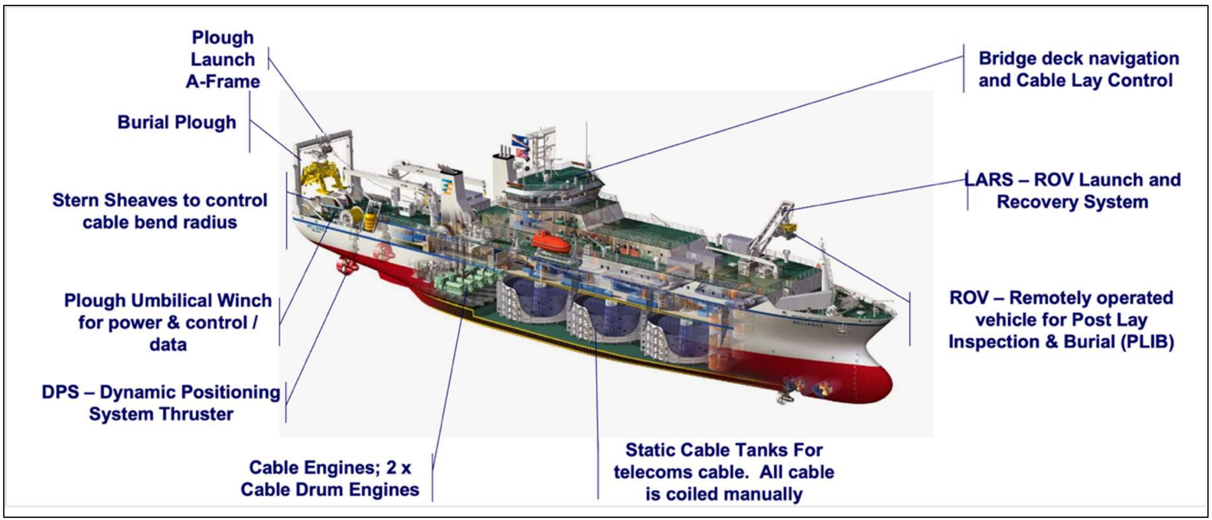
12.2. Annex 2: SPMMA Repair Vessel Transit Times

Estimated transit time from the Fiji (base port) to select primary ports within the SPMMA zone @ 14.5 knots, the nominal transit speed of Lodbrog.

Figure 22: Approximate Repair Vessel Transit Times

12.3. Annex 3: Cable Installation Vessel Diagrammatic

Figure 23: Cable Installation Vessel



Source: Adapted from SubCom Vessel Specifications.

Note: Repair vessels do not require a plough burial system (including launch A-Frame).

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