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The Future of Submarine Cable Maintenance:

Trends, Challenges, and Strategies

Authored by

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PURPOSE OF THIS STUDY

The study was released publicly in June 2025 with the goal to serve as a common, data-based reference for industry stakeholders to collectively understand and address the challenges related to future sustainability of the maintenance sector.

Analyses of datasets relating to the maintenance vessel fleet and cable investment projections were conducted to forecast how the anticipated increase of new cable kilometers and corresponding cable faults may influence the demand for repair vessels. The analysis also considers the context of the evolving regulatory and geopolitical macro-environment that will continue to shape the submarine cable ecosystem.

This study provides necessary context and crucial insights for industry professionals, government policy makers, and other external stakeholders to further understand the significance of this critical sector and its role in ensuring the security and resilience of submarine digital infrastructure.

This study does not seek to:

- Incorporate any commercial or other bias
- Advocate or prescribe a single solution to marine maintenance challenges
- Disclose any commercially-sensitive information

Although all models have inherent limitations, this study offers guidance for industry leaders to consider the future requirements and sustainability of the maintenance sector, to address the broad range of challenges faced by the sector.

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Thank you also to those across the cable operations and maintenance sectors who contributed data central to our work. These include OceanIQ, for providing historical repair rate data by region; our many survey respondents, and others across industry who provided feedback to the models and projections. Through various conversations and requests for data, we spoke with professionals from major cable operators, suppliers, and nearly every cable maintenance provider and vessel operator.

EXECUTIVE SUMMARY

Submarine cables are the vital backbone of the global digital economy and carry nearly all intercontinental data. Their crucial role necessitates significant investment and has prompted increased governmental concerns about the security, resilience, and supply chains of the subsea infrastructure ecosystem.

The industry is undergoing a major shift with new, high-capacity cable deployments coinciding with the anticipated retirement of a large portion of the aging global fleet. These trends will significantly impact the marine maintenance sector—influencing repair vessel demand and utilization—and raise important considerations regarding the long-term sustainability of maintenance agreements and the efficacy of existing operational structures.

Key Data Points

1. **1.6 million new cable kilometers are expected by 2040.**
2. **850,000 km of retired cable kilometers are expected by 2040, 50% of which could be retired by 2030.**
3. **Global cable kilometers will increase 48%, with annual repairs expected to increase 36% from 2025-2040.**
4. **15 maintenance vessels need to be replaced by 2040, including five within the next five years.**
5. **At least five additional maintenance vessels may be needed in Asia by 2040.**
6. **Investment of roughly $3 billion will be required to address vessel replacement and expansion needs.**

Trends and Challenges

- **Net Growth in Cable Kilometers:** Many legacy cables will be retired within the next five years. However, the large volume of new cable deployments driven by bandwidth demand and network redundancy will result in a 48% net increase in total cable kilometers by 2040. This growth increases the potential for cable faults. Forecast data shows the disproportionately high number of repairs in the Southwest Pacific that frequently creates repair queues are expected to continue. These factors, combined with global cable growth and an aging repair fleet, raises concerns about the adequacy of existing maintenance vessel capacity to maintain service quality.
- **Vessel Fleet Age and Investment:** By 2040, just under half (47%) of vessels in the global cable fleet will be nearing the end of their 40-year service lifespans. This issue is particularly pronounced for cable maintenance vessels, 64% of which will reach this milestone in the same period. Sporadic investment in new vessels and the prevailing

trend to introduce used or second-hand vessels to the maintenance fleet is a product of high capital costs, market uncertainty and maintenance agreement economics. This investment pattern contrasts markedly to the substantial investment in cable infrastructure.

- **Repair Forecasts and Maintenance Fleet Adequacy:** Historical data shows significant regional variations in cable damage. The Southwest Pacific and Northwest Pacific are expected to continue having a disproportionately high number of repairs. This, combined with global cable growth and an aging fleet, raises concerns about the adequacy of existing maintenance vessel capacity as annual repair numbers are anticipated to rise by 36%.
- **Government Scrutiny and Evolving Regulation:** Geopolitical tensions, increased awareness of digital infrastructure's strategic and economic importance have amplified government oversight of the submarine cable industry. International and regional initiatives by entities like the ITU, G7, EU, ASEAN, and Quad focus on network security and resilience. Their interest is expanding to include the cable maintenance sector, potentially leading to new regulations. It is essential that government-industry engagement is consistent and broadens to effectively address the interests of all stakeholders.
- **Sovereign Repair Capabilities:** Due to security concerns and reliance on foreign entities to provide maintenance services on critical infrastructure, some governments are exploring developing their own cable repair capabilities. This could alter the traditional commercial landscape with government-owned vessels supplementing existing maintenance providers.
- **Commercial Models and Competition Dynamics:** Maintenance agreements are broadly referred to as Consortium Zone or Private Agreements, with subtle differences between these commercial models. Although network owners express a degree of satisfaction with the performance of maintenance services, there are concerns regarding the capabilities of the repair fleet and its long-term effectiveness and sustainability. Competition for maintenance services is seen as beneficial but also raises concerns about price pressures and the financial challenges associated with deploying capital for new vessel investment.

Looking Ahead

The coming years are critical for cable maintenance. Ensuring the global cable network's resilience requires substantial and timely investment in new maintenance vessels. Adapting to evolving government regulations and security requirements is essential.

It may be necessary to adjust commercial and operational models to enhance the efficacy of maintenance agreement structures, ensuring that adequate investment in new assets meets long-term service quality requirements. The future of the maintenance sector hinges on balancing commercial viability, operational efficiency and the increasing demands for resilient, secure submarine cable infrastructure.

1. INTRODUCTION

The global digital economy and all internet users require physical infrastructure to connect network nodes and transmit data. For some, satellites can provide this connectivity. However, most of today's network relies on submarine cables to connect continents and other areas separated by large bodies of water. Over 570 of these cables traverse the seafloor.[1]

Unlike their copper predecessors—laid for the first time around 1860—modern systems transmit data over optical fibers, which are then wrapped in insulation materials and protective steel. The resulting cylinder is about the size of a garden hose. Together, the fibers inside provide enormous amounts of bandwidth which is measured in the tens or hundreds of terabits per second (Tbps).[2] Conservative estimates indicate that over 99% of intercontinental bandwidth travels over submarine cables, including nearly all long-distance phone calls, video content, and web traffic, as well as trillions of dollars in financial transactions.[3] Citizens, governments, and militaries alike rely on these shared international links, which often cross multiple jurisdictions and are owned by multiple entities.

Like all physical infrastructure, submarine cables eventually experience damage and require repair. International Cable Protection Committee (ICPC) statistics show an average of approximately 200 cable faults occur worldwide each year.[4] The marine maintenance sector has repair vessels and spare cable lengths in shore based depot facilities ready to repair cable faults as they arise. Not all cable faults are service-affecting, requiring immediate repair. Shunt faults caused by damage to cable insulation do not affect optical transmission paths.

Maintenance agreements are geographically defined with repair vessels operating out of "base ports," covering most of the globe. Their commercial models are broadly referred to as either Consortium Zone Agreements (also sometimes called "Club" Agreements) or Private Maintenance Agreements. Together they provide an element of competition and customer choice with boundary overlap in many regions.

The cable maintenance sector is now at an inflection point for future investment and fleet expansion. Many existing vessels are reaching the ends of their anticipated service life. Meanwhile, there are more cable kilometers in the water than ever before, and as cable systems expand in national security and economic importance, network operators have come under increased government regulation and scrutiny to ensure that networks are as resilient as possible. Repair assets represent significant long-term investments, requiring substantial capital and market certainty. These investments also come with commercial risk.[5]

TeleGeography data shows bandwidth demand is growing at a rapid rate.[6] Capacity to fulfil this need will be provided by cables using increasingly advanced optical technologies, which provide greater bandwidth per cable. The lifespan of existing cables may also vary due to many

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[1] Burdette, "How Many Submarine Cables Are There, Anyway?"
[2] TeleGeography, "Submarine Cable FAQs."
[3] Stronge and Mauldin, "Mythbusters IV"; Mauldin, "Do Submarine Cables Account For Over 99% of Intercontinental Data Traffic?"
[4] Palmer-Felgate, "Global Cable Repair Data Analysis."
[5] Kang and Jacob, "Connecting the Indo-Pacific: The Future of Subsea Cables and Opportunities for Australia."
[6] Mauldin, "International Bandwidth Demand Surpasses 6.4 Pbps."

commercial factors, as the decommissioning of cables is often a business decision not strictly tied to engineering capabilities.

Finally, improvements in cable route planning, burial techniques, implementation of cable protection initiatives and adoption of new technologies will likely reduce the fault rate of newer cables.

This study weighs these factors alongside industry perspectives to understand the current status of the maintenance sector to enable a view into the future. A broad, stakeholder-collaborative approach was taken with data collected through two primary methods:

1.1. Surveys

- **Industry Survey.** 62 individuals participated in the online survey, each representing a different organization or government agency. Respondents self-identified as either maintenance providers (16%), network owners (50%), legal experts or government authorities (15%), or others, including consultants (19%). Results are included throughout this report.

- **Consortium Zone and Private Maintenance Agreement Data Collection.** All agreements were approached to provide non-commercially sensitive statistical data including repair numbers, cable kilometers, and vessel utilization rates. All submitted the requested data with the following exceptions: No response was received from e-Marine's private agreement. Both Asian-based consortium agreements Yokohama Zone and SEAIOCMA Zone declined to participate in the study.

1.2. Models

- **Cable Kilometer Forecast Model.** Assessing the maintenance vessel requirements by 2040 began with assessing the amount of cable kilometers by region. The model considers the introduction of new cable kilometers and the reduction in cable kilometers due to retirements. See results in Section 4.1.

- **Cable Fault Forecast Model.** Future cable fault rates were forecasted using historical fault data from OceanIQ. See results in Section 4.2.

- **Vessel Requirements Forecast Model.** Finally, the model assessed the number of maintenance vessels required to accommodate future repairs. See results in Section 5.2.

Detailed methodologies for each of these are also available in Appendix A. All data was supplemented by feedback and discussions with industry professionals from across all functions within the submarine cable ecosystem.

2. REGULATORY AND GEOPOLITICAL ENVIRONMENT

Understanding the broader regulatory and geopolitical landscape is essential to comprehending the impact of regulatory changes and geopolitical influences that affect the cable maintenance sector. This section outlines recent developments in government oversight and regulation, offering essential context without delving into legislative specifics.

Several themes are apparent:

- Submarine cable infrastructure is gaining attention as part of broader Maritime Domain Awareness and critical infrastructure security issues.
- Government focus on secure and resilient network infrastructure is expanding to include cable maintenance repair capacity and capability.
- There is a need for improved and consistent collaboration between governments and the submarine cable industry.
- Some governments are actively considering sovereign repair capabilities to reduce reliance on foreign entities.

2.1. Government Awareness

States have a vested interest in ensuring resilient internet connectivity, now critical to their economies and citizens daily life. Submarine cables are an integral part of the digital infrastructure required for this connectivity (alongside terrestrial networks; and even satellite networks for some end users). Yet, most survey respondents identified government regulation as the biggest challenge facing the industry today.

The significance of submarine cables is reflected across various aspects of government foreign policy. Submarine cables may be source of soft power,[7] as data transmissions contain sensitive communications, provide an intelligence resource, or even required for remote military piloting capabilities. Recent events and heightened geopolitical tensions—along with a sharp increase in media coverage, have brought unprecedented attention to the industry, including the potential impacts of intentional damage.[8] Examples include the effects of the COVID-19 pandemic, the Russian Invasion of Ukraine, the 2022 disruption to the Nord Stream gas pipeline, and cable damage in notable areas like the Taiwan Strait, Red Sea and the Baltic Sea.

As far back as 2010, the United Nations General Assembly described fiber optic undersea cables as “vitally important to the global economy and the national security of all States.”[9] Fifteen years later, the significance of submarine cable infrastructure for national security is even higher, with digital communications transforming global commerce. Governments and the public are now acutely aware of the crucial role of submarine cable infrastructure in global connectivity and the digital economy.

Submarine communications cables haven’t always been in the spotlight. The liberalization and deregulation of the telecommunications sector in the 1980s shifted control of submarine cables

[7] Hillman, “Securing the Subsea Network.”
[8] Jamieson, “Subsea Cable Incidents.”
[9] “A/RES/65/37.”

from quasi-government ownership and control to the private sector, reducing government oversight. One official described this as a period of "benign neglect," during which economic reliance on submarine cable infrastructure soared as government awareness diminished.[10]

Even today's mixed awareness of submarine cables doesn't always lead to understanding. Many governments do not fully understand the nature or mechanisms of the submarine cable maintenance sector,[11] despite efforts to engage through industry bodies such as the ICPC and regional cable protection committees.[12] Government agencies with access to key industry partners (like locally-based cable suppliers) likely possess a more thorough understanding of industry maintenance structures, capabilities, and challenges. Even for these states, though, it is often unclear which government agencies are responsible for protecting submarine cables or what that mandate might require.

The chronic disconnect between industry and government is underpinned by "conflicting interests arising from the intersection of national security and commercial considerations."[13] The transnational and multi-faceted nature of cable ownership, operations, and maintenance is now almost entirely in the hands of the private sector. For some governments, dependence on third-party commercial agreements and foreign organizations operating foreign-flagged repair vessels within territorial waters on critical infrastructure raises national security concerns.[14] Neither entity can build international connections without the other. Permits are required to land cables as the private sector continues to fund and operate submarine cables.

2.2. International and Regional Government Initiatives

Escalating economic, strategic, and national security concerns, along with broader maritime security issues, have prompted various government-led cable security initiatives at both international and regional levels.

2.2.1. ITU

The recent formation of the ITU Advisory Body (in collaboration with the ICPC) in 2024, reflects the unique role and risks submarine cables hold within the broader international telecommunications ecosystem. The Advisory Body, populated with 40 government and industry figures, aims to "serve as a platform for international multistakeholder collaboration to identify, develop, and promote government and industry best practices for submarine cable resilience."[15] Goals publicized after the foundational summit held in February 2025 include:

- Strengthening cable protection through risk mitigation
- Promoting diverse routes and landings to enhance resilience and continuity

[10] Anonymous, Conversation with an embassy official.
[11] Kavanagh, Franken, and He, "Achieving Depth"; Channer, "Improving Public-Private Partnerships on Undersea Cables"; Bueger, Liebetrau, and Franken, "Security Threats to Undersea Communications Cables and Infrastructure."
[12] Examples include the North American Submarine Cable Association (NASCA), European Submarine Cable Association (ESCA), Danish Cable Protection Committee (DKCPC)
[13] Kania, "Enhancing the Resilience of Undersea Cables in the Indo-Pacific."
[14] Keller, "The Disconnect on Undersea Cable Security."
[15] "Terms of Reference - ITU International Advisory Body for Submarine Cable Resilience."

- Facilitating timely deployment and repair

The Advisory Body, with its broad mandate and diverse representation, aims to create a dedicated platform for international dialogue on submarine cables, bringing together government and industry stakeholders at an international level.

2.2.2. G7 Nations

The G7 nations recognized the significance of subsea communications infrastructure with joint statements in 2023 and 2024.[16] Recently, they released another statement which further incorporated submarine cables under a general maritime security umbrella, acknowledging their strategic importance and their role in economic prosperity. It emphasized the need for cooperation to secure undersea networks and aligned the G7 with EU action plans for cable security and the United Nations New York Principles detailed below. It also specifically mentioned the G7's desire to "enhance our cooperation with industry…while strengthening repair capacities."[17]

2.2.3. European Union (EU)

The European Union's (EU) emphasis on the security, protection, and resilience of subsea infrastructure has markedly increased over the last decade following the United Nation's 2010 decree. The focus on digital infrastructure security and resilience began in 2016 with the EU Commission's Network and Information Security (NIS1) Directive, which established the first cybersecurity and incident reporting legislation for digital infrastructure and other critical industry sectors.[18]

Between 2016 and 2022, the EU prioritized identifying critical infrastructure and coordinating information sharing among member states. The 2022 "Nevers Call" declared by EU Telecommunications Ministers called for risk analysis of core internet infrastructure but didn't mention submarine cables specifically.[19] The NIS2 Directive, also adopted in 2022, expands and strengthens the original NIS1 directive by enhancing requirements for risk management, incident reporting, and cybersecurity governance.[20]

Another EU report directly referenced marine maintenance capabilities in mid-2022:

[16] G7, "Ministerial Declaration," 2024; G7, "Ministerial Declaration," 2023.
[17] United States Department of State, "G7 Foreign Ministers Declaration on Maritime Security and Prosperity."
[18] European Commission, "Questions and Answers: Directive on Security of Network and Information Systems."
[19] European Union, "Nevers Call to Reinforce the EU's Cybersecurity Capabilities."
[20] European Commission, "NIS2 Directive."

> "A key and often neglected vulnerability of the cable infrastructure is the capabilities and regulations for repair. The capabilities within Europe are very limited, and the legal regulations of repair activities are not harmonized across Europe. The repair infrastructure is often not featured in risk analyses, although it is in larger-scale coordinated attack scenarios."[21]

Soon after, the June 2023 Joint Communications on EU Economic Security Strategy identified physical and cyber-related disruption to subsea cables as an economic risk.[22] A July report from the European Union Agency for Cybersecurity (ENISA) later promoted recommendations for cable operators and governments alike, including easing burdens in the permitting and licensing processes. The ENISA report acknowledged support from several prominent members of industry.[23] Finally, in a February 2024 follow-up to the Nevers Call, the NIS Cooperation Group referenced limited repair ships multiple times among vulnerabilities relating to communications security.[24]

The EU Action Plan on Cable Security, released in 2025, aims to integrate all EU strategic, security, and resilience policy frameworks into actionable requirements for member states. For example, it clarifies that NIS2 represents the primary risk management and incident reporting guidelines for digital infrastructure. The document mentions an 'Expert Group' consisting of the EU Commission, Member States, and ENISA, but does not explicitly reference industry participation. The EU's resilience cycle approach of "prevent, detect, respond, recover and deter"[25] underpins their mainstay strategy, along with a focus on submarine cable maintenance:

> "When an incident on submarine cable infrastructures occurs, it is paramount to intervene rapidly and repair the damaged cable. However, while today's vessels have proven effective to repair damaged cables with reasonable response time, their current number and capacity would be insufficient to timely intervene in case of systemic and simultaneous attacks to critical cables across different maritime areas of the Union. Maintenance and repair vessels are a major bottleneck for the capacity to recover from an incident. In addition, the availability of repair equipment and specialised workers is an issue…"[26]

Despite numerous EU Directives and recommendations advocating for active government-industry collaboration, coordinated outreach has been limited. An industry professional close to the matter disclosed that it was only in 2025 that an industry representative was first invited to participate in an expert group discussion.[27]

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[21] Bueger, Liebetrau, and Franken, "Security Threats to Undersea Communications Cables and Infrastructure."
[22] European Commission, "On European Economic Security Strategy."
[23] Bafoutsou, Papaphilippou, and Dekker, "Subsea Cables."
[24] The Network and Information Systems Cooperation Group, "Cybersecurity and Resiliency of Europe's Communications Infrastructures and Networks."
[25] European Commission, "EU Action Plan on Cable Security."
[26] European Commission.
[27] Anonymous, Conversation with an industry expert, April 2025.

2.2.4. Association of Southeast Asian Nations (ASEAN)

ASEAN, founded in 1967,[28] has a long history of interest and engagement with submarine cables. In 1986, telecommunications companies from ASEAN member states, six at the time, came together to establish ASEAN Cableship Pte Ltd, a cable maintenance and installation provider which now has three repair vessels contracted to SEAIOCMA and operates as a separate commercial entity.[29] (See Appendix C for a list of maintenance and installation vessels.)

As the importance of digital connectivity skyrocketed in the early 2000s, official ASEAN documents began recognizing the importance of submarine cables and internet connectivity for achieving economic growth.[30] One document outlining desired outcomes for ASEAN member states between 2016-2020 included developing "a framework among all [ASEAN Member States] to expedite repairs of submarine cables in their waters by minimising permit requirements and cost."[31] This framework was realized in ASEAN's 2019 Guidelines for Strengthening Resilience and Repair of Submarine Cables. The document's non-binding guidelines reference best practices, such as expediting the permit approval processes for cable repairs:

> "[ASEAN Member States] have different regulations and policies with regard to the repair of submarine cables within their territorial waters today…such barriers limit the efficiency and speed of the repair process, and prolonging the slowdown of Internet connectivity in the affected countries. Consequently, slower Internet communication would translate into significant disruptions to the economic and social activities in the affected ASEAN Member States."[32]

Progress on developing ASEAN's framework around submarine cables was noted in the ASEAN 2025 Digital Masterplan (released in 2021), along with further impetus to improve the permitting and licensing processes of member states.[33]

In 2024, ASEAN announced a working group on submarine cables "to facilitate regular exchanges and promote cooperation among ASEAN Member States," as well as update the 2019 Guidelines.[34] The working group participated in a February 2025 ASEAN Outlook on the Indo-Pacific Seminar on submarine cables[35] alongside one representative from the ICPC.[36] In his keynote address, Secretary-General of ASEAN Dr. Kao Kim Hourn encouraged participants to "move beyond dialogue to forge concrete partnerships, establish practical mechanisms for cable protection, and develop innovative solutions."[37]

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[28] "About ASEAN."
[29] Yadav, "ASEAN Cableship Announces Fourth Cable Ship"; "About Us."
[30] "ASEAN Economic Community Blueprint."
[31] "ASEAN ICT Masterplan 2020."
[32] "ASEAN Guidelines for Strengthening Resilience and Repair of Submarine Cables."
[33] "ASEAN Digital Masterplan 2025."
[34] Hourn, "AOIP Keynote Address."
[35] Hourn.
[36] "ICPC Spotlight News."
[37] Hourn, "AOIP Keynote Address."

The ICPC is working to improve regional engagement between government and industry in the ASEAN region. In 2024, the committee held a one day workshop in collaboration with the National University of Singapore's Centre for International Law (CIL) to discuss "Prospects for Collaboration between Governments and Industry on the Laying, Repair and Protection of Submarine Cables." The ICPC-CIL workshop was also sponsored by the Singaporean and Australian Governments.[38]

Delegates at the ICPC-CIL Workshop discussed several points that align with the ICPC's Government Best Practices.[39] They noted that many government agencies tend to operate in isolation, making inter-agency coordination crucial both within individual governments and across the region. The need for a single point of contact in government was reiterated. It was also noted that there is "no regional cable protection committee in Asia or the ASEAN region,"[40] despite data indicating just over 50% of all cable faults occur in the region and unique challenges faced in the South China Sea. An ICPC-led initiative aims to establish this body but would require strong support from regional stakeholders.

While cable maintenance is a focus of ASEAN's policies, most member states have not adopted legislation criminalizing the intentional damage of submarine cables in their territorial seas. This illustrates how:

> "Governments, like ASEAN, tend to work in silos only addressing certain components of resilience, whereas developing robust resilience of submarine cables requires a whole-of-government approach including national telecommunications authorities, defence agencies, maritime agencies and cybersecurity agencies."[41]

2.2.5. The Quadrilateral Security Dialogue (Quad)

Another notable regional collaboration is the Quad, which includes India, Australia, Japan, and the United States. The group has expanded from its humanitarian origin to strengthen regional security and economic cooperation in the Indo-Pacific, including maritime domain awareness.[42] The Quad's perspective towards submarine cables reflects a more securitized approach[43] driven by increased geological tensions and damage to seabed infrastructure in Europe.[44]

Following the Quad leaders summit in 2023, the group announced the Quad Partnership for Cable Connectivity and Resilience to "bring together public and private sector actors to address gaps in the infrastructure and coordinate on future builds."[45] Also noted at this time was the U.S.'s ongoing contribution through its $5 million CABLES program "providing technical assistance and capacity building on the security of undersea cable systems" and Australia's

[38] Beckman, Bressie, and Ong, "2024 ICPC – CIL Workshop Report."
[39] "ICPC Best Practices for Governments."
[40] Beckman, Bressie, and Ong, "2024 ICPC – CIL Workshop Report."
[41] Davenport, "The Protection of Submarine Cables in Southeast Asia."
[42] "Indo-Pacific Partnership for Maritime Domain Awareness."
[43] Cannon and Bhatt, "The Quad and Submarine Cable Protection in the Indo-Pacific: Policy Recommendations."
[44] Bashfield, "Seabed Warfare in a New Era of Geotech Conflicts."
[45] "Quad Leaders' Summit Fact Sheet."

commitment to develop its Cable Connectivity and Resilience Centre.[46] The Centre was established in 2024 and "works across the Indo-Pacific region…recognising each country has different systems, policies, regulations and stages of development relating to undersea cables."[47]

The 2024 Wilmington Declaration, following the Quad meeting in Delaware, indicated that the U.S. has now conducted over 1,000 capacity trainings for telecommunications officials across the Indo-Pacific. The Quad Action Plan to Protect Commercial Undersea Telecommunications Cables also appears to be underway.[48]

The United States has led efforts to address telecommunication network security among its allies. It has served as a central point for coordinating efforts to improve the resilience and security of submarine cable infrastructure. Quad nations have largely adopted U.S. initiatives, policy and emphasis on maritime security that includes cable infrastructure.

U.S.-China geopolitical factors influencing the subsea cable industry are extensively documented. The U.S. Government's Clean Network initiative, launched in 2020, primarily focused on security issues related to networks and subsea cable installation, but did not address the maintenance and repair processes,[49] but this focus appears likely to change. In a 2024 U.S. congressional hearing, concerns were expressed about "Chinese companies repairing or even having access to undersea cables that are owned by U.S. carriers." This view was shared by other cyber security officials.[50]

2.3.6. United Nations

Security concerns about maintenance activities continuing to gain traction at the United Nations. At the 2024 UN General Assembly, the U.S. hosted a meeting with several member states on the security and resilience of undersea cables. The resulting "New York Principles on Undersea Cables" outlined a joint approach to "ensure the security, reliability, interoperability, sustainability, and resiliency for the deployment, repair, and maintenance of undersea cable infrastructure."[51] The statement was endorsed by over thirty nations.[52]

The United Nations Institute for Disarmament Research has also produced a pair of reports on submarine cables in 2023 and 2025. The latest report considers marine maintenance as a key part of network resilience and restorative capacities.[53]

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[46] "Quad Leaders' Summit Fact Sheet."
[47] "Cable Connectivity and Resilience Centre."
[48] "Joint Statement from the Leaders of Australia, India, Japan, and the United States."
[49] Burdette, "Leveraging Submarine Cables for Political Gain."
[50] Dustin Volz et al., "U.S. Fears Undersea Cables Are Vulnerable to Espionage From Chinese Repair Ships."
[51] "New York Joint Statement on the Security and Resilience of Undersea Cables in a Globally Digitalized World."
[52] United States Department of State, "Multilateral Meeting on Security and Resilience of Undersea Cables during UN General Assembly High Level Week."
[53] Kavanagh, "Wading Murky Waters: Subsea Communications Cables And Responsible State Behaviour"; Kavanagh, Franken, and He, "Achieving Depth."

2.3. Sovereign Repair Capabilities

Several governments are now considering developing their own cable repair capabilities. This move away from private marine markets is driven by heightened interest in submarine cables generally and the slow pace of industry investment in new or converted repair assets. As one policy report noted:

> "the financial justification to replace traditional cable ships isn't compelling—small profit margins, particularly for repairs, increase the business risk. Uncertainty about the rate of growth of subcables has a ripple effect throughout the supply chain, particularly in the planning of new cable-laying vessels, which are decades-long projects. Shipowners remain cautious about expanding their fleets due to the high costs associated with idle ships, which can reach tens of thousands of dollars per day, and the painful lessons learned from oversupply following the dot-com crash in 2000."[54]

The EU's risk assessment of critical subsea infrastructure is evolving to include supply chain and repair capabilities. Recent statements highlight repair capabilities and mention the establishment of a fleet of emergency repair vessels. Other reports suggest that the EU is considering a public-private model to fund vessels capable of quickly repairing undersea infrastructure in case of damage or sabotage.[55]

The specifics of government funding or support to secure sovereign repair capabilities have not been disclosed. A 2022 EU Commission report examined potential collaboration with the European Defense Agency and the EU Permanent Structured Cooperation framework, to establish a contingency repair facility for larger subsea infrastructure attack scenarios.[56]

Indo-Pacific governments, observing maritime events in Europe and aligning with the QUAD's objectives, are exploring a variety of solutions to both safeguard and enhance the resilience of undersea infrastructure. Governments such as Taiwan, Japan and Australia are assessing the supply chain and repair capacity risks under a major event scenario that severely disrupts their international connectivity.

India appears to be more advanced with this strategic initiative. A 2020 Indian Government report argued that investing in an Indian-owned (and registered) maintenance vessel should be considered. Authors indicated that an Indian-owned vessel would speed the permitting process and lessen dependence on foreign operators.[57] In a feedback letter from Bharti Airtel, the company endorsed this view and noted that a repair vessel owned by an Indian entity would reduce inefficiencies.[58] This report led to a 2023 recommendation to establish a committee to

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[54] Kang and Jacob, "Connecting the Indo-Pacific: The Future of Subsea Cables and Opportunities for Australia."
[55] "EU Explores Funding for Fleet to Fix Damaged Undersea Cables."
[56] Bueger, Liebetrau, and Franken, "Security Threats to Undersea Communications Cables and Infrastructure."
[57] "Consultation Paper on Licensing Framework and Regulatory Mechanism for Submarine Cable Landing in India."
[58] Vatts, "Response to Consultation Paper," February 10, 2023.

explore viable financial models for an Indian-flagged cable repair vessel and local cable depots.[59]

In early 2025, India's Prime Minister and the U.S. President announced the Indian Ocean Strategic Venture. This bilateral initiative aims to advance economic connectivity and commerce, signaling India's intention to "invest in maintenance, repair and financing of undersea cables in the Indian Ocean, using trusted vendors."[60]

Australia's interest in sovereign repair capabilities acknowledges that maritime security is linked to subsea cable resilience but also encompasses cable repair capacity and capability. A 2024 report by the Australian Strategic Policy Institute points out the concentrated supply chains and the shortage of repair vessels in the submarine cable industry. The authors argue that, without owning or otherwise assuring a ship to lay and repair cables, Australia is "wholly dependent on market forces and foreign-controlled, privately-owned vessels."[61]

Japan has typically secured domestic repair capability through Japanese entities. However, recent reporting indicates that the Japanese Government plans to offer subsidies and other financial support to bolster sovereign capabilities and ensure supply chain independence.[62]

Government initiatives to secure repair capability via vessel investment are not without consequences, and have the potential to disrupt the industry established maintenance structure. Moreover, government investment capital is not a complete solution. For example, there are ongoing challenges in obtaining experienced offshore personnel and expanding the concentrated mission-specific equipment supply chain.

Roughly 20% of survey participants viewed government support for investment in maintenance vessels favorably. As one survey participant noted, "there is a strong argument for national governments to play a role in the investment/financing of new vessels as subsea cables are treated more and more as critical infrastructure," reflecting also that a suitable model could lower the cost of asset investment "making the argument for replacing aging vessels that much easier." Most participants, however, indicated that vessel operators or both vessel operators and system owners should bear the cost of new investment.

2.4. Expanding Scrutiny and Regulation

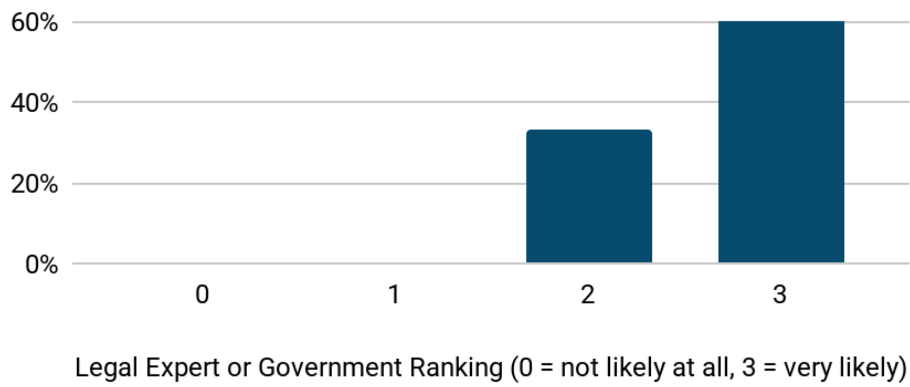
Government scrutiny, influenced by national and maritime security considerations and shaped by the geopolitical landscape, is evolving to include repair capabilities in risk analysis frameworks and policies. This strategy is being adopted across multiple regional partnerships and alliances.

However inconsistent messaging and industry engagement persists due to the transnational nature of submarine cable infrastructure, necessitating involvement from multiple government agencies. Not all governments are equally knowledgeable in cable maintenance or advanced risk analysis and implementation of cable protection policies.

[59] "TRAI Releases Recommendations on 'Licensing Framework and Regulatory Mechanism for Submarine Cable Landing in India.'"
[60] The White House, "United States-India Joint Leaders' Statement."
[61] Kang and Jacob, "Connecting the Indo-Pacific: The Future of Subsea Cables and Opportunities for Australia."
[62] Sugano, "Japan to Back Undersea Cable Investments for National Security."

The lack of government oversight prior to recent years may be attributed to the absence of any significant event since the industry's transition from public to private control. The details and structure of government oversight and future regulation remains an open question and will likely differ between governments, political unions and multilateral partnerships.

Figure 2.1. How likely is an overall increase in government scrutiny on the marine maintenance sector in the next ten years?



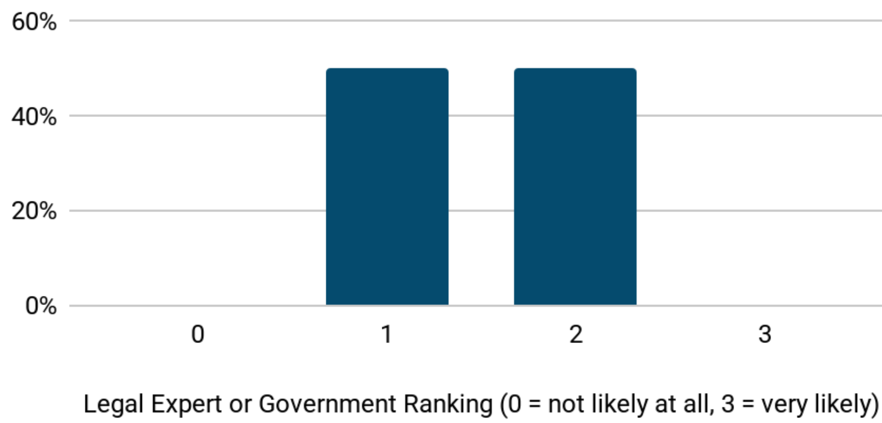
Source: Industry survey by TeleGeography and Infra-Analytics

All legal experts surveyed indicated that increased government scrutiny is likely (see Figure 2.1). Regulation may aim to ensure cable owners comply with predetermined maintenance and repair criteria. Potential measures include restrictions on the ownership or operational criteria of repair vessels, review or approval of contracted maintenance arrangements, cyber security protection for repair vessels and minimum levels of strategic spares or other operational parameters.

For example, industry experts view Indonesia's cabotage regulations as commercial protectionist measures designed to favour local shipping companies and appear less driven by national security concerns.[63] If national security concerns lead to the adoption of restrictive or cabotage policies similar to those in Indonesia, it will severely disrupt industry maintenance structures and operational capabilities. However, few survey participants consider an expansion in government cabotage-type restrictions or policies to be very likely (see Figure below).

[63] "Geopolitics, Digital Sovereignty, The Second Internet."

Figure 2.2. How likely are governments to restrict the operation of foreign flagged cable vessels in their territorial waters and/or Exclusive Economic Zone (EEZ) in the next ten years? (For example, through cabotage policies.)



Source: Industry survey by TeleGeography and Infra-Analytics

When asked in what ways (if any) government scrutiny might impact the cable maintenance sector, survey participants provided the following comments:

- "Better alignment with geopolitical interests and greater awareness of the relevance of such structures"
- "Likely increased security requirements on maintenance companies/vessels/crew to ensure trusted/security-vetted services"
- "Heightened emphasis on national security and supply chain protection"
- "Government overreach under the guise of security is my biggest concern"

The industry now has two key international forums for governmental engagement: the ICPC and the ITU Advisory Board. These forums aim to ensure that informed policy and other government decisions are balanced with industry interests. The ICPC, with its numerous government and industry members, serves as the most suitable, direct, and logical industry channel for engagement. Despite their extensive efforts, including the publication of specific government recommendations, significant challenges persist. ICPC collaboration with the ITU Advisory Body should expand and enhance engagement channels. At regional levels, various cable protection committees, where they are formed, are also essential for deepening engagement on region-specific issues. The lack of a cable protection committee in Asia needs urgent industry attention.

Due to the unique characteristics of subsea cables, effective government engagement is particularly challenging. However, the wider adoption of ICPC Government Best Practices, which advocate for a single point of contact for government policy,[64] should help to address this issue.

While industry leaders have expressed support for many EU action plans, a recent appeal for the entire subsea telecom ecosystem to be formally recognized as critical infrastructure, assistance

[64] "ICPC Best Practices for Governments."

to strengthen repair capacities, and a plea for government-industry engagement is summed up in an April 2025 open letter to the European Union, United Kingdom, and NATO:

> "it is crucial to engage industry stakeholders and establish a clear roadmap for implementation… Harmonised approaches must be developed for the subsea cables ecosystem, aiming to align security objectives with operational feasibility as well as a viable business model and based on proportionate and risk-based best practices, developed in close consultation with industry."[65]

The authors note that government regulations or guidelines do not specifically address cybersecurity protection for the repair fleet. Currently, it appears that fleet owners bear the responsibility for implementing cybersecurity protocols. Although the International Maritime Organisation (IMO) implemented cybersecurity regulations for new vessels in 2025,[66] these regulations do not apply to older vessels. This omission presents a significant gap in the risk analysis framework of the cable maintenance and repair supply chain.

[65] Alcatel Submarine Networks et al., "Open Letter from European Telecommunications Operators," April 9, 2025.
[66] International Maritime Organization, "Guidelines on Maritime Cyber Risk Management."

3. BACKGROUND

This section lays the groundwork for understanding the complexities of the submarine cable maintenance sector. It begins by detailing the primary causes of submarine cable faults and the intricate repair procedures involved in restoring service. The section examines the two main commercial models that underpin maintenance agreements: consortium and private agreements. It offers essential context to understand the industry's commercial models and operational structures and their challenges.

3.1. Cable Fault Causes and the Repair Process

When cables go out of service, they are often described as “broken” or “cut.” While this is sometimes true, it’s not always the case. Cables can be disrupted or experience “faults” without any damage to the optical data transmission fibers nestled within each cable.

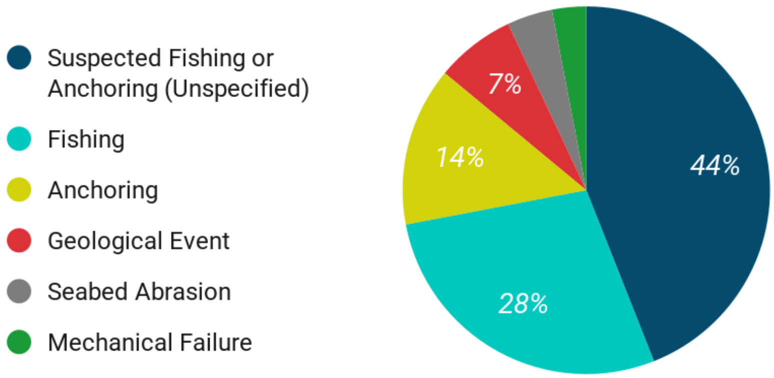
Today’s transoceanic submarine cables rely on optical amplifiers (or “repeaters”) placed along the length of a cable to enable data transmission across long distances. Repeaters require power which is provided from shore facilities. If a cable’s insulation is degraded at any point, this process can fail and cause a “shunt fault.” About half of all cable faults are shunt faults.[67]

The most common cause of cable faults are a result of external aggression that includes fishing activities and vessel anchoring but also includes damage from natural causes such as turbidity currents (undersea mudslides). Anchors can also be dropped accidentally or while under duress.[68]

Submarine cables are marked on maritime charts. In some countries, cable protection corridors regulate maritime activities to mitigate cable damage. Nearly all cable faults occur in shallower waters or near to shore, in well-trafficked areas.[69]

[67] Palmer-Felgate, “Global Cable Repair Data Analysis.”
[68] European Subsea Cables Association, “Anchors Damaging Cables Is Such a Drag.”
[69] Palmer-Felgate, “Global Cable Repair Data Analysis.”

Figure 3.1. Cable Fault Causes



Source: International Cable Protection Committee (ICPC)[70]

Repairing a subsea cable can be a lengthy process. When a submarine cable experiences a fault, Network Operations Centers (NOCs) note the service disruption and notify their maintenance provider that a repair is needed. Cable repair vessels are on stand-by and typically ready to mobilize within a 24-hour period. Repair time frames vary according to fault location, but the requirement to secure repair permits for faults within territorial or Exclusive Economic Zone (EEZ) waters can be burdensome and significantly delay the start of repair operations.

Vessel transit to the fault's location may take up to two weeks. ICPC date indicates average repair vessel transit time is seven to eight days. When the vessel is on location the cable is located and the cable is recovered to the surface. Spare wet plant (cable and/or repeaters) are then spliced to each end, to restore the cable's end-to-end connectivity. Adverse weather or technical issues can cause operational delays. Therefore the average time between service disruption and cable restoration varies by region.

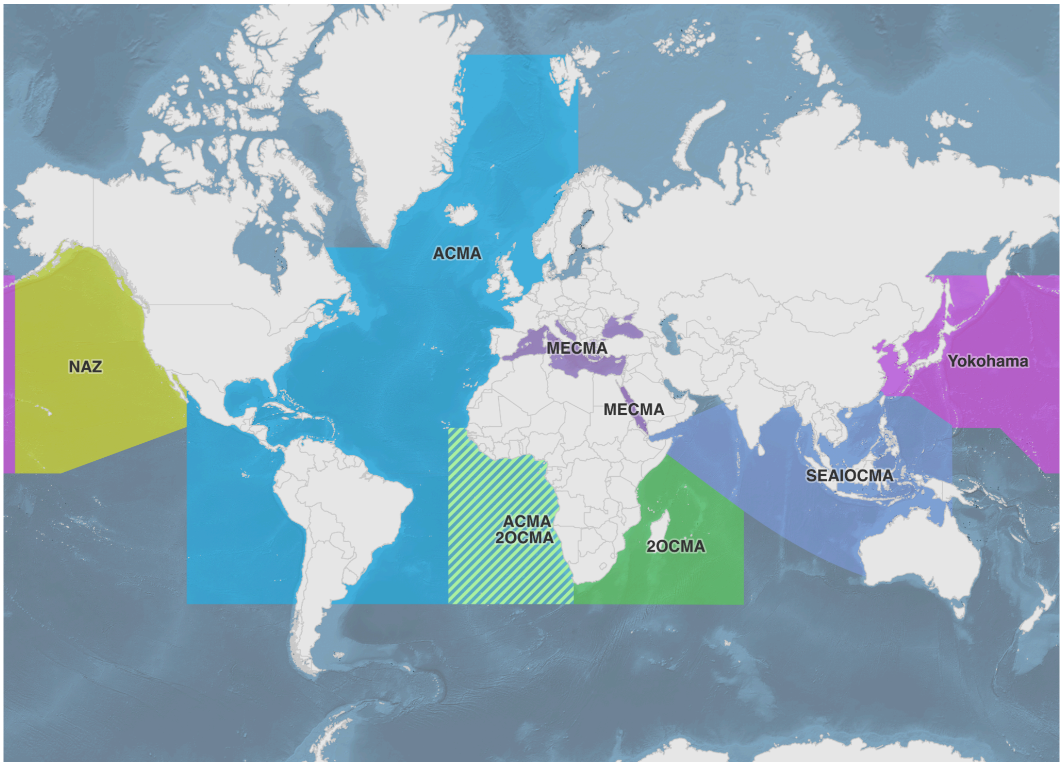
3.2. Commercial Models: Consortium and Private Agreements

Cable maintenance agreements can be consortium zone agreements or private agreements. Both agreements have the same objective, but differ in commercial terms, risk allocation, and organization. They often include unique terms like voting rights, revenue sharing models, and management committees that represent all cable owners' interests.

Consortium agreements ensure price transparency among cable owners, who bear the majority of commercial risk. Cable owners pay fixed annual fees (referred to as "standing charges") based on their proportional share of cable kilometers that lie within the agreement boundaries. An increase in cable kilometers entering the agreement reduces the standing charges for all owners. Conversely, a decrease in cable kilometers due to cable retirements or other factors increases the standing charges for all cable owners.

[70] Palmer-Felgate.

Figure 3.2. Map of Consortium Maintenance Agreements

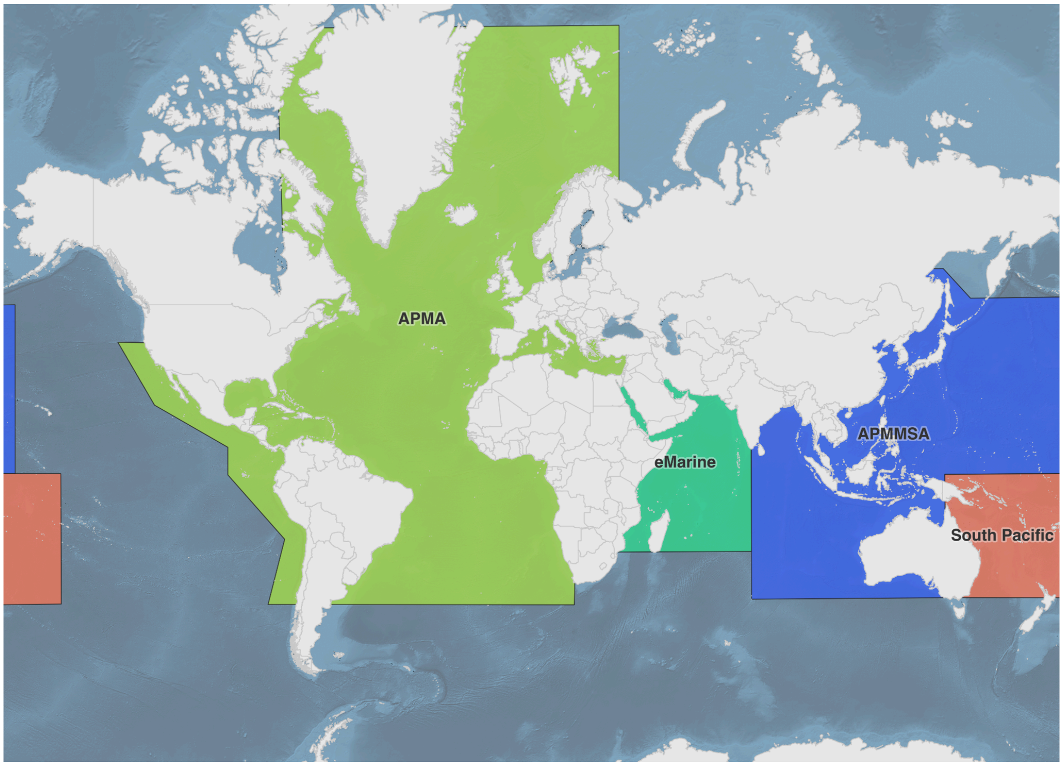


Source: TeleGeography

Cable owners share costs through fixed and variable fees. Standing charges are fixed annual fees that provide on-call access to repair vessels. Variable charges cover vessel running costs per call-out. Ancillary services, such as wet-plant spares storage are also on a variable fee basis.

Private agreements are comparable in terms of the principle of vessel cost-sharing. However, these agreements are not supported by the collaborative owner model, as each cable owner negotiates their own terms to achieve an optimal price and solution that meets their specific requirements. The commercial risk is borne by the maintenance provider(s) who must ensure a sufficient customer base and cable kilometer quantity to maintain profitability and a sustainable operating model. With private agreements, variations in cable kilometers do not affect the fixed fees of cable owners as this risk falls upon the service provider.

Figure 3.3. Map of Private Maintenance Agreements



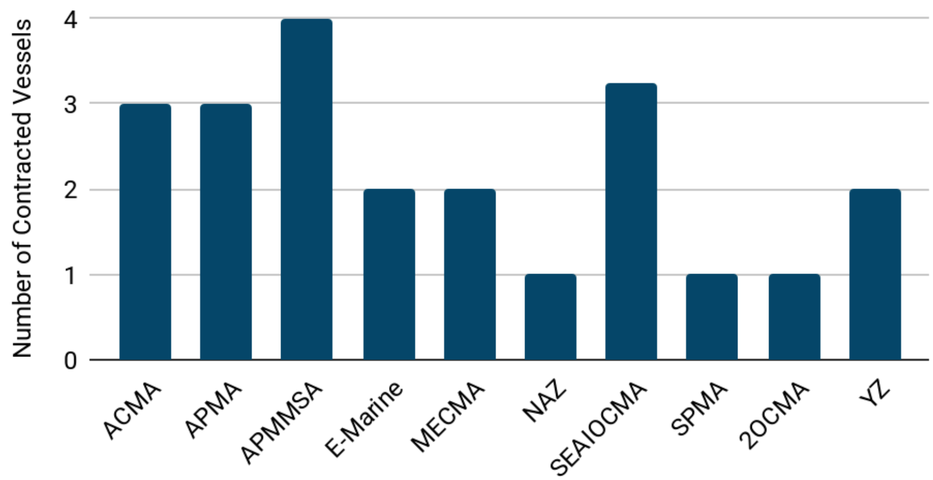
Source: TeleGeography

Both agreements typically have a five-year term with extension options though private agreements may allow for greater flexibility in contract negotiations.

Most agreements allow maintenance vessels to perform outside work, either interruptible or non-interruptible, under different terms and conditions. This provides extra revenue for vessel operators, which can offset reduced standing charges from cable owners.

The consortium zone structure was first established in 1965 in the Atlantic (ACMA), and in 1980's in Southeast Asia (e.g. SEAIOCMA). Around 2015, SubCom and Alcatel Submarine Networks (ASN) initiated competition by developing the private agreement model, and diverting installation vessels to offer additional marine services to their customer base.

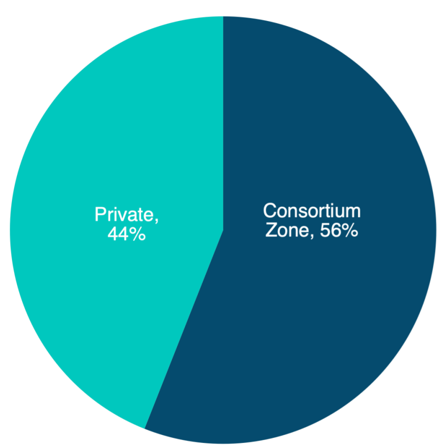
Figure 3.4. Share of Cable Vessels by Maintenance Agreement



Source: TeleGeography, Infra-Analytics
Notes: Some of the vessels in YZ and SEAIOCMA are not contracted for the entire year.

Figure 3.5 shows the respective share of total cable kilometers split by agreement model. Small bespoke maintenance arrangements for regional or domestic cables are handled by local or regional operators in the Baltic Sea, the Americas, Philippines, Indonesia, and Japan.

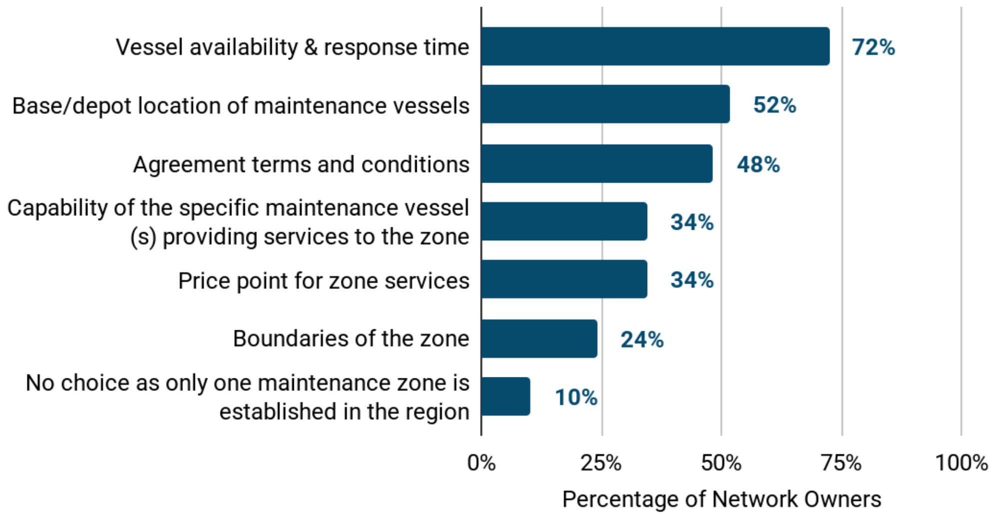
Figure 3.5. Share of Cable Kilometers by Agreement Model, 2025



Source: TeleGeography, Infra-Analytics

According to the survey, network operators identified vessel availability and response time as the paramount criteria in choosing either consortium or private agreement, with more than 72% placing these factors as their top priority. In contrast, only 34% of respondents regarded the price point as a primary consideration.

Figure 3.6. What factors most influence your organization's choice between a consortium or a private zone maintenance agreement?

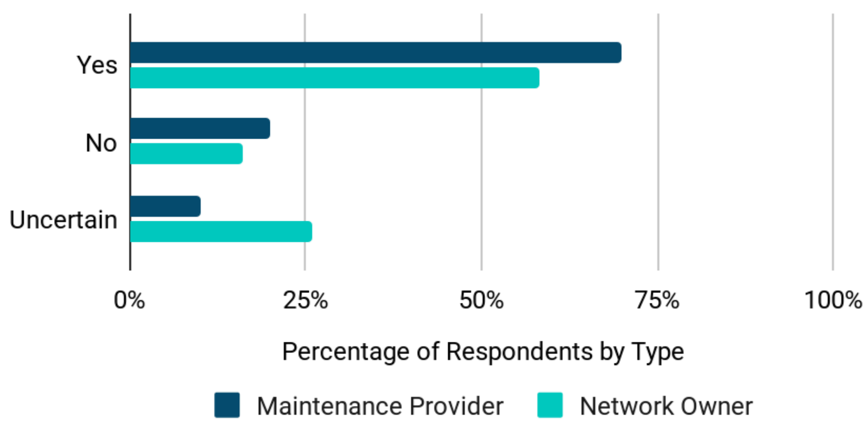


Source: Industry survey by TeleGeography and Infra-Analytics
Notes: Respondents selected up to three responses.

3.3. Cost Sharing Model

The submarine cable industry's cost sharing model is unique and not found in other sectors like offshore wind or power cables[71]. Survey results show 70% of maintenance providers, but only 58% of system owners, believe the current commercial models offer efficient and effective maintenance solutions.

Figure 3.7. Do current maintenance zone commercial models/structures provide an efficient and effective solution for cable maintenance?



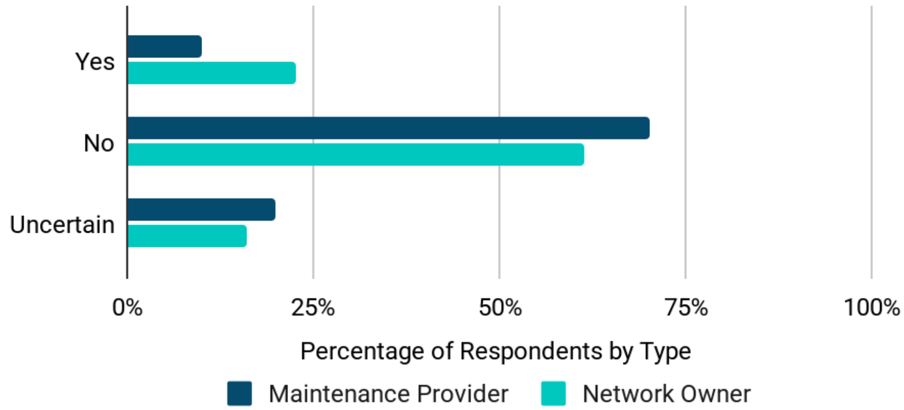
Source: Industry survey by TeleGeography and Infra-Analytics

Most network owners and maintenance providers support the existing maintenance model and structure. However, there are considerable challenges, notably the age of the current

[71] Some maintenance agreements include power cables.

maintenance fleet. 70% of maintenance providers and 61% of network owners question its capability to service the sector for the next 15 years.

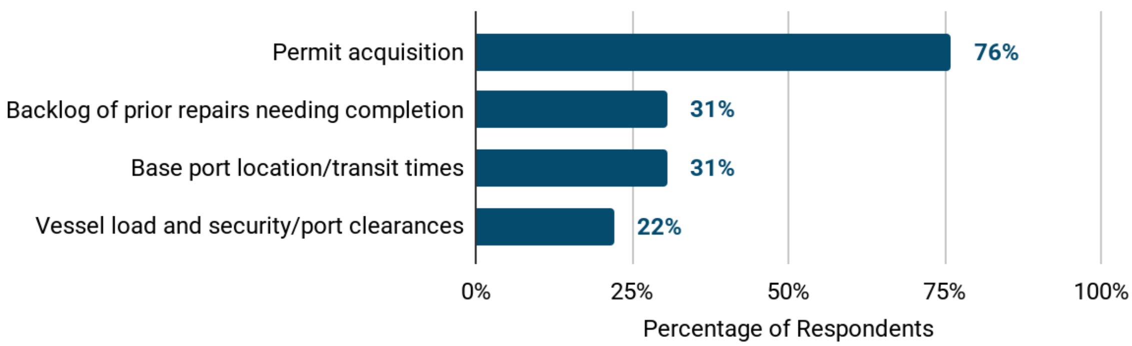
Figure 3.8. Do you believe existing marine maintenance vessels are capable to service the current zones for the next 15 years?



Source: Industry survey by TeleGeography and Infra-Analytics

Other concerns include the cost of maintenance services and the speed of repair. The latter is significantly influenced by the time frame required to obtain repair permits, which are issued by governments and are therefore beyond the industry's direct control. In some regions, additional requirements must be met as part of the permit acquisition process, such as the posting of corporate bonds in India.

Figure 3.9. What are the primary challenges to optimize repair timeframes in the regions where you operate?

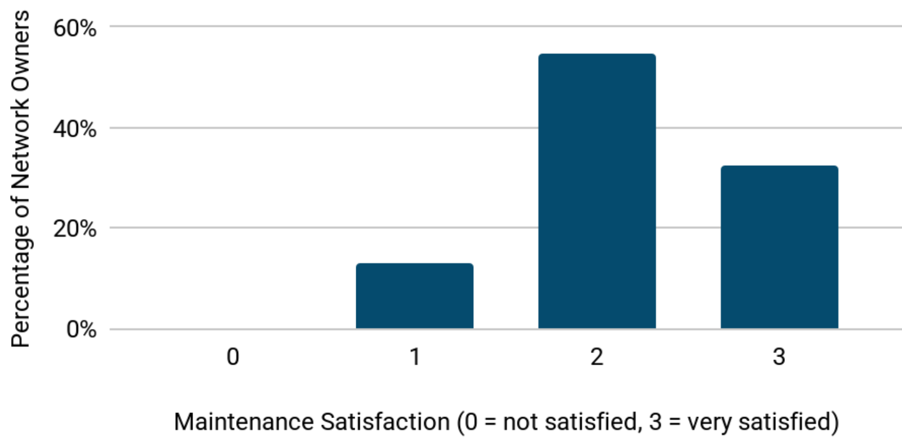


Source: Industry survey by TeleGeography and Infra-Analytics

Southeast Asia exhibits high repair vessel utilization rates that frequently lead to repair backlogs that also directly impact repair timeframes. Queues for repairs are directly within industry control. Factors like shallow waters, large fishing fleets, seismic and other seabed activity, and cable route choke points result in slightly more than half of all global repairs occurring within this region. These factors frequently drive annual vessel operations to exceed 80-90% of vessel utilization, causing repair queues or backlogs.

Increasing the number of repair vessels in a region to reduce repair backlogs has a cost implication. Who bears this cost depends on the agreement model. Either way, optimizing vessel assets to balance service quality with service cost is a complex matter.

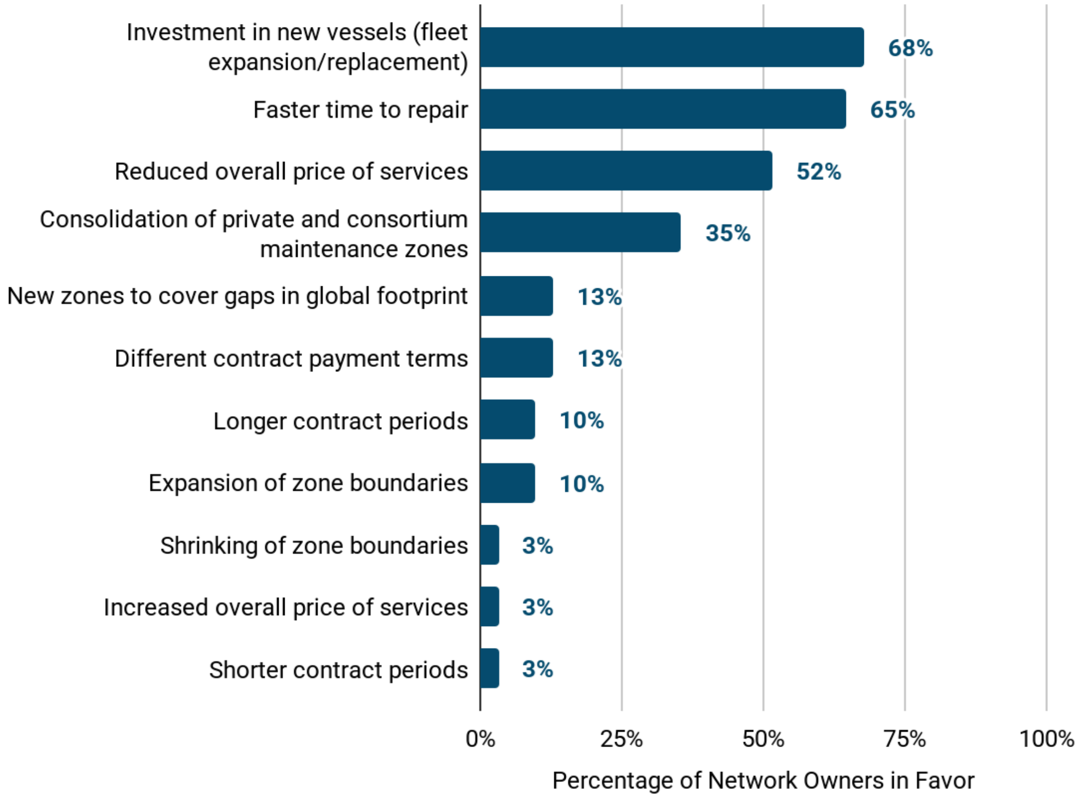
Figure 3.10. Are you satisfied with your current maintenance services?



Source: Industry survey by TeleGeography and Infra-Analytics

Network owners generally report high satisfaction with maintenance services, though they indicated a desire for fleet investment, faster repair times, and lower service prices as their primary concerns.

Figure 3.11. What changes (if any) would you most like to see from a marine maintenance zone agreement and/or structure perspective?

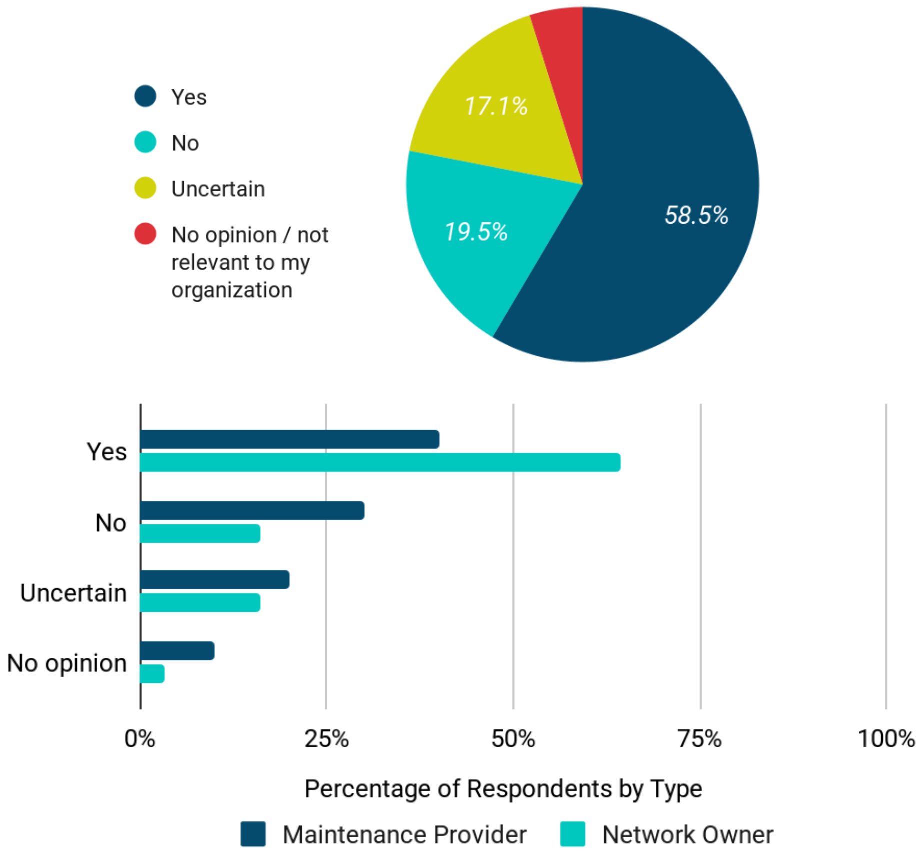


Source: Industry survey by TeleGeography and Infra-Analytics
Note: Respondents selected up to three options.

3.4. Competition

53% of survey respondents think competition between private and consortium zones is beneficial for the industry. This view is stronger among network owners, with 65% in favor. Despite this, investment in new vessels remains inconsistent, affecting long-term sustainability. Meanwhile, 30% of maintenance providers feel competition has driven negative outcomes in some regions.

Figure 3.12. Is competition between private and consortium zones an important factor for industry health and sustainability?



Source: Industry survey by TeleGeography and Infra-Analytics
Note: Only responses from maintenance providers and network owners are included.

Cable owners note differences in service quality, specifically highlighting communication and transparency of vessel operators as a distinguishing factor. Major network owners mitigate supply chain risk by employing both private and consortium agreement solutions. Some cable owners prefer agreements without formal repair priority provisions, indicating their preference for cable owners to agree to repair priorities when simultaneous cable faults occur.

3.5. Corporate Affiliations

Subsidiaries of cable operators provide maintenance services in Southeast Asia, the Middle East, and to a lesser extent in the Atlantic. This strategy was partly born out of necessity, due to the lack of specialized third-party organizations with specialized vessels that existed at the time to provide maintenance services in some regions.

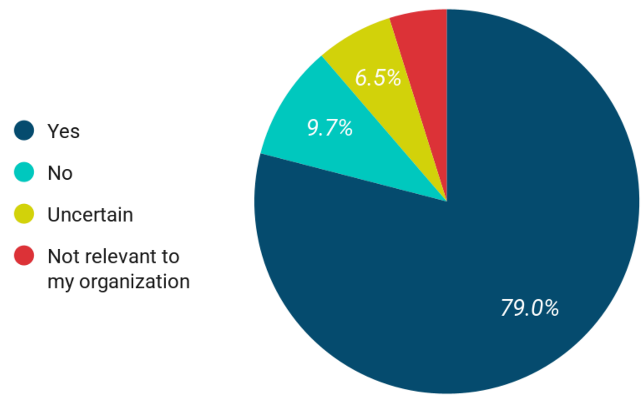
Maintenance agreement renewal negotiations between cable owners and vessel operators occur without competitive tender processes, limiting changes in service providers. Factors like capital expenditures (CAPEX), vessel operating expertise, and vessel supply-demand market forces also restrict vessel operator choices.

Corporate affiliations strengthen parent organizations' ability to fund repair vessels and support sustainable maintenance models. This is particularly relevant for Southeast Asia, as forecasts indicate that this region will have the greatest increase of cable kilometers and repairs over the next 15 years.

3.6. Future Service Levels

Enhancing diversity and redundancy in the global network topology is an important factor driving new cable investment. Despite increased infrastructure redundancy and broader collaboration between system owners, the majority of survey respondents indicate that future maintenance service levels and repair response times will remain as important as they are today.

Figure 3.13. Will the time taken to repair a subsea cable remain as important in the future as it is now?



Source: Industry survey by TeleGeography and Infra-Analytics

This service level baseline provides the analytical foundation for projecting the future needs of the maintenance sector, with respect to net cable kilometer growth, repair metrics, and future vessel requirements.

4. CABLE KILOMETER AND FAULT FORECASTS

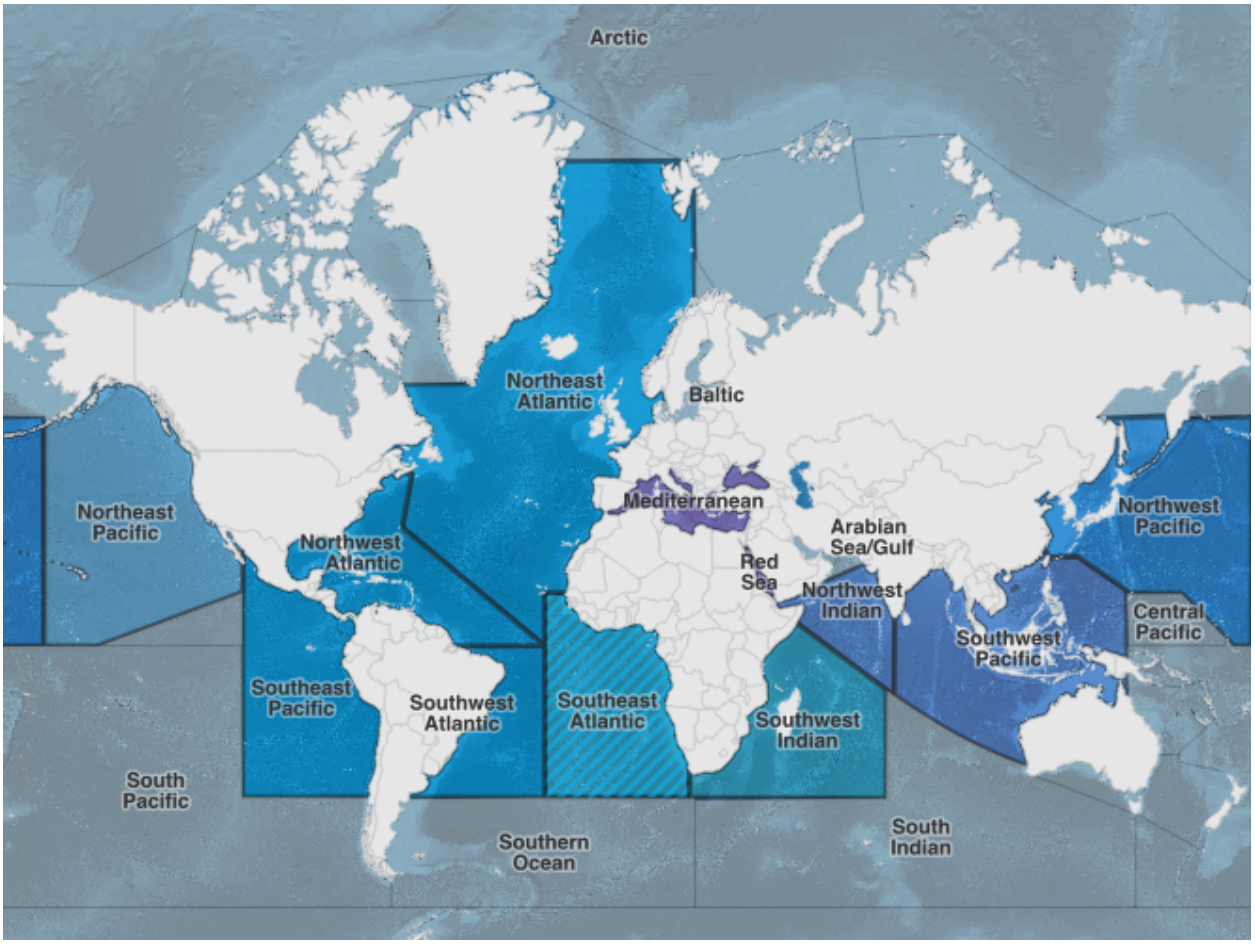
At the most basic level, the need for the marine maintenance sector will be influenced by the number of cable kilometers entering and leaving service in the coming years and the number of repairs likely to be required. The requirement for potential repairs ties directly into the number of maintenance vessels needed.

4.1. Cable Kilometer Forecast

A model was developed to project the net change in cable kilometers per geographic region at five-year intervals for 2030, 2035, and 2040. The projected cable kilometers in service at the close of 2025 were used as a starting point. Then, new kilometers from cables anticipated to become operational over the subsequent 15 years were added. Subsequently, kilometers of cables expected to be retired during this period were subtracted to derive the net change. A comprehensive description of the model's methodology can be found in Section 9.2.1.

The forecasts are based on major geographic regions. These regions roughly correspond to major maintenance zone boundaries. In some cases, the zones were disaggregated to provide greater visibility into regional changes. A map of the regions is depicted below.

Figure 4.1. Cable Kilometer Model Regional Assignments

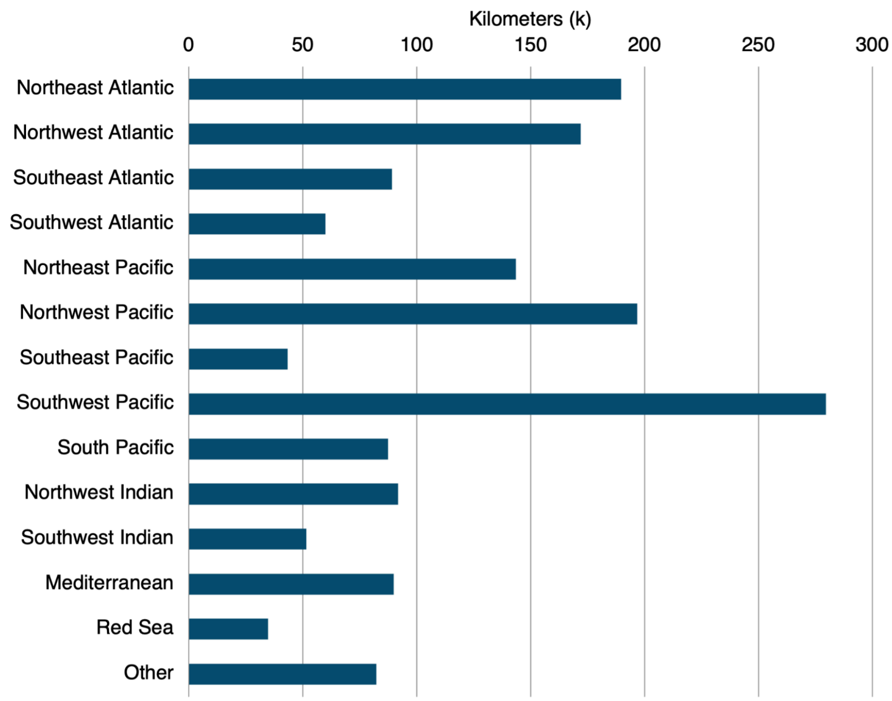


Source: TeleGeography, Infra-Analytics

4.1.1. Existing Cable Kilometers

According to TeleGeography's estimates, by the end of 2025 1.6 million kilometers of cables are anticipated to be in service around the world. The region with the most cable kilometers is the Southwest Pacific with 280,000, which amounts to 17% of global cable kilometers. The other regions with over 100,000 kilometers of cables are the Northeast Atlantic, Northwest Pacific, Northwest Atlantic, and Northeast Pacific.

Figure 4.2. Existing Cable Kilometers by Region, 2025

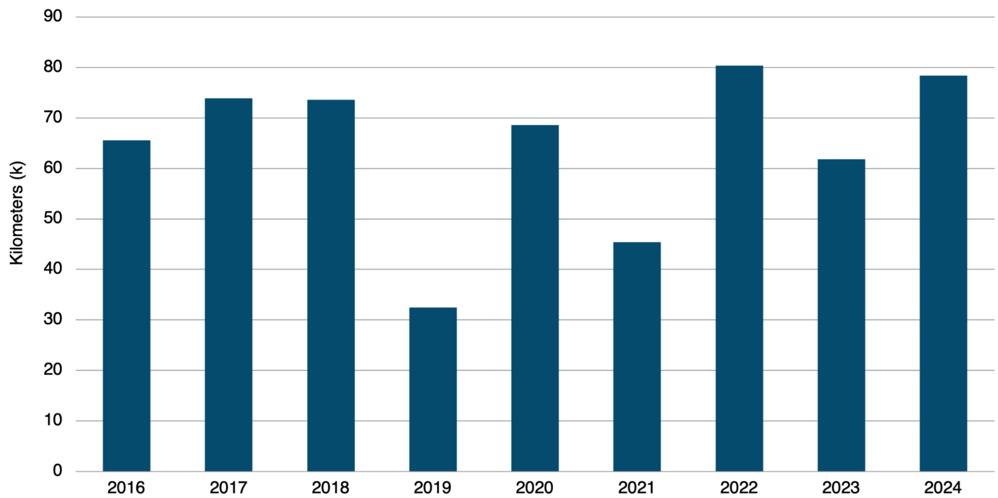


Source: TeleGeography, Infra-Analytics

4.1.2. New Cables

New submarine cables are routinely added to the global footprint. According to TeleGeography data, 185 new cables have entered service from 2016-2024. These systems amount to over 580,000 route kilometers (km).

Figure 4.3. New Cable Kilometers, 2016-2024



Source: TeleGeography
Notes: Years based on cable ready-for-service (RFS) year.

New cable deployments are driven by multiple factors. Some of the key drivers include:

- Increasing bandwidth requirements of existing and future applications
- Scarcity of potential capacity and fiber pairs
- Ownership economics
- Route and landing diversity
- Replacement of aging cables
- Industry-specific requirements

4.1.2.1. Model approach

New cable kilometers were predicted by combining results from three methods.

- **Near-term Builds.** A large number of cables have contracts in-force, with many others in the pipeline. The share of kilometers for these planned cables was estimated to fall into each geographic region.
- **Capacity Exhaustion**. For 12 major routes, which account for 72% of global cable kilometers, new cables were forecasted based upon when the existing and near-term planned cables would reach capacity exhaustion. TeleGeography's demand forecast was used as the baseline for assessing future demand requirements. This approach also accounted for reduction in capacity due to future cable retirements. It was assumed new cables would enter service three years in advance of the exhaustion point. In addition, increasing potential capacity levels for new cables over time were assumed.
- **Replacement**. For all other existing cables on routes not included in the exhaustion model, one-for-one replacements were assumed in the same year the cables would be

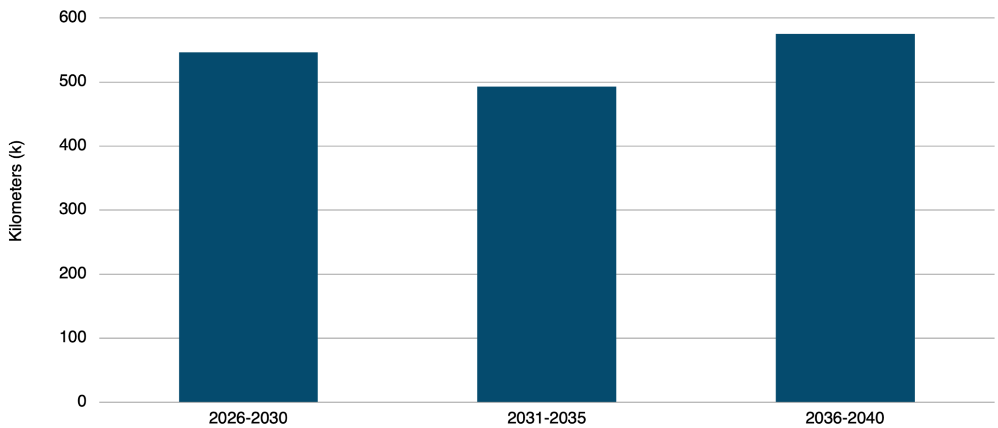
retired. While the replacement of a cable the same year as the original cable is retired is not realistic, the approach does prevent abnormal annual fluctuations in cable kilometers from occurring in the model.

More details on the model are found in Section 9. Appendix A.

4.1.2.2. Model results

The baseline model forecasts 1.6m km of new submarine cables entering service from 2026-2040.

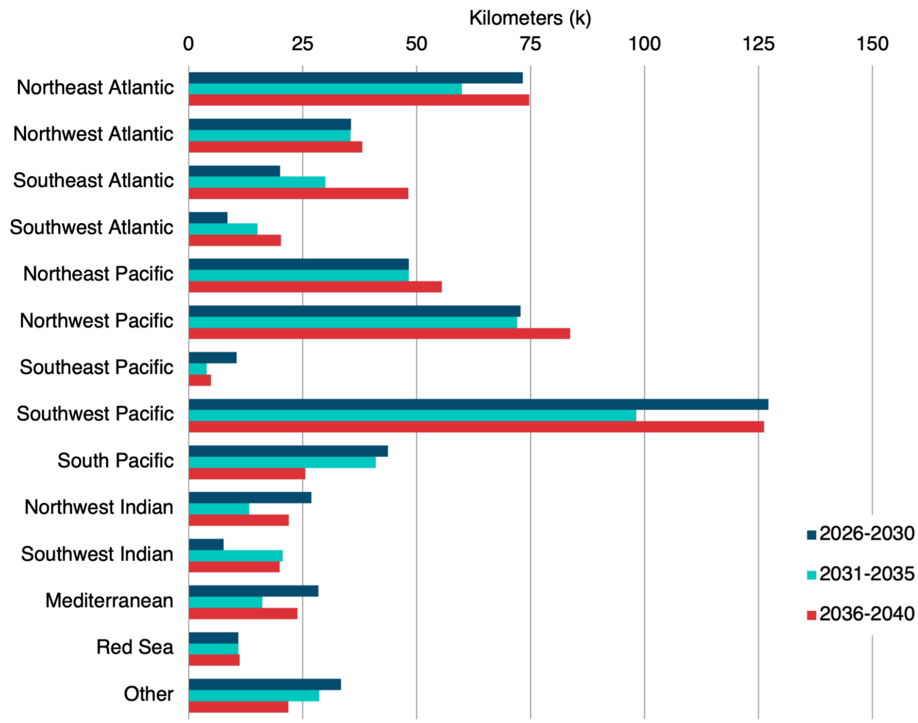
Figure 4.4. Baseline Forecasted New Cable Kilometers. 2026-2040



Source: TeleGeography, Infra-Analytics

The most new cable kilometers are forecasted for the Southwest Pacific, Northwest Pacific, and Northeast Atlantic regions, which will each see in excess of 200k kilometers of new cables from 2026-2040.

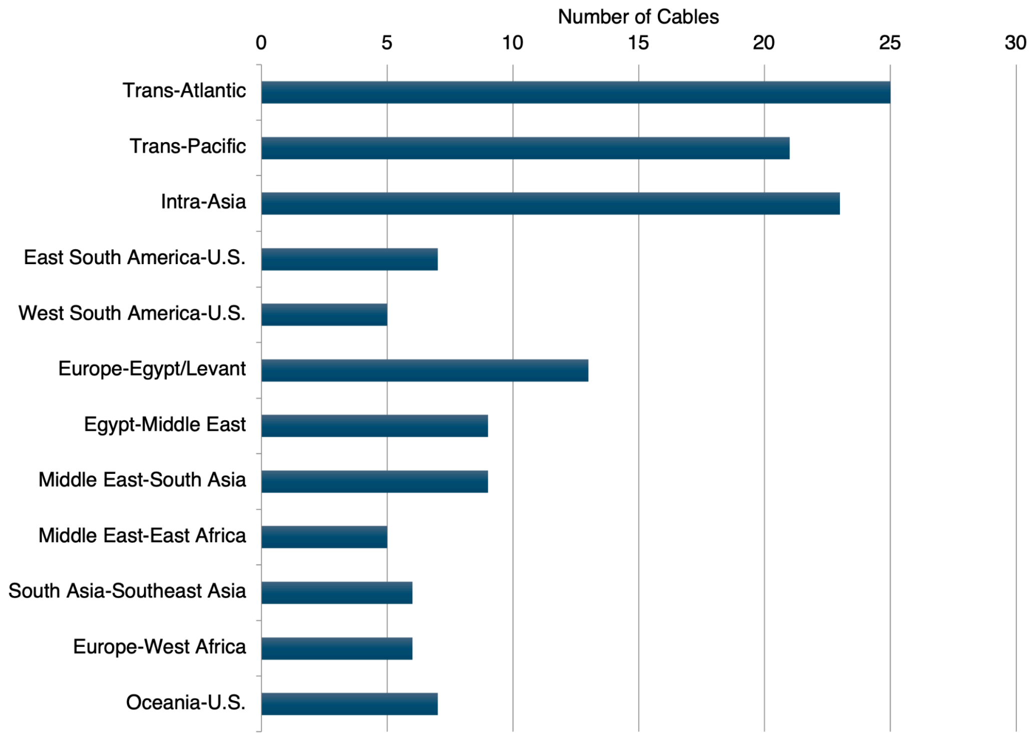
Figure 4.5. Baseline Forecasted New Cable Kilometers by Region, 2026-2040



Source: TeleGeography, Infra-Analytics

While the number of cable kilometers is the metric most relevant to marine maintenance, it's useful to understand just how many cables we are forecasting on major routes. The largest number of new cables are forecasted on the trans-Atlantic (25) and intra-Asia (23) routes from 2026-2040.

Figure 4.6. Baseline Forecasted New Cables by Route, 2026-2040



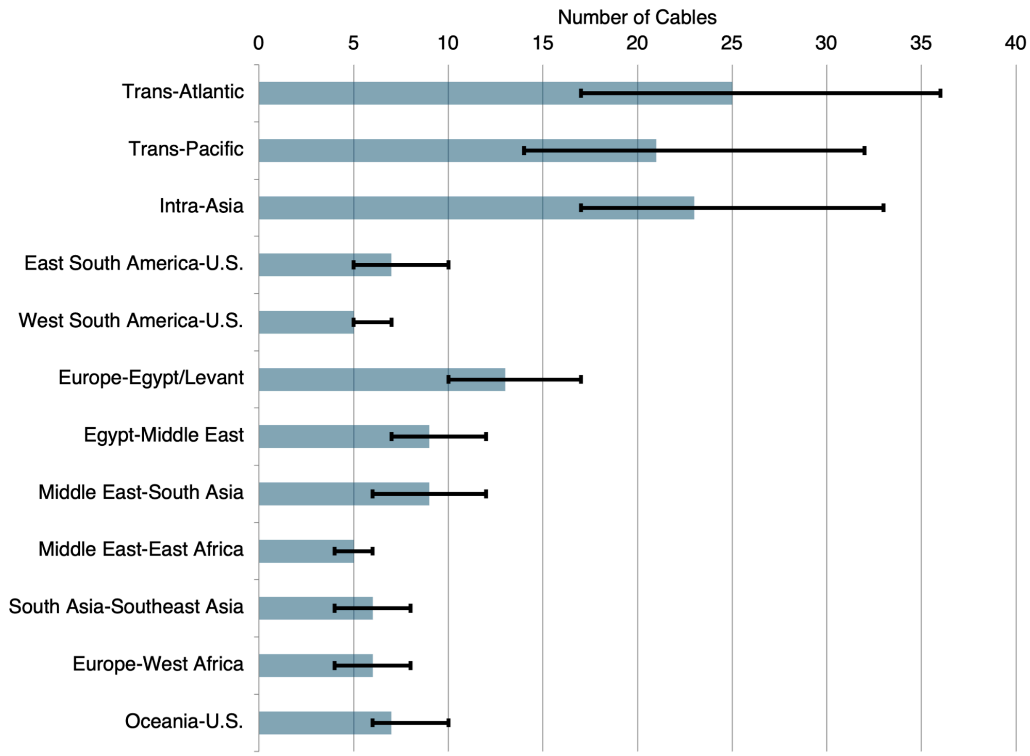
Source: TeleGeography, Infra-Analytics

4.1.2.3. New Cable Scenarios

Given the uncertainty surrounding future new cable construction it is instructive to examine how some alternative scenarios would impact the outcomes. The two variables that most directly affect kilometer growth are the assumptions related to demand growth and the timing on technological advances in cable capacity.

Varying Demand Growth - The pace of demand growth is based on TeleGeography's proprietary forecasting model. The impact of varying the growth rates +/-10% from the baseline growth rates is shown below. Even a small increase in annual growth rate has a substantial impact on the number of cables. In the case of the trans-Altantic and trans-Pacific routes, a 10% increase in annual growth rates would lead to the need for 11 more cables beyond the baseline levels.

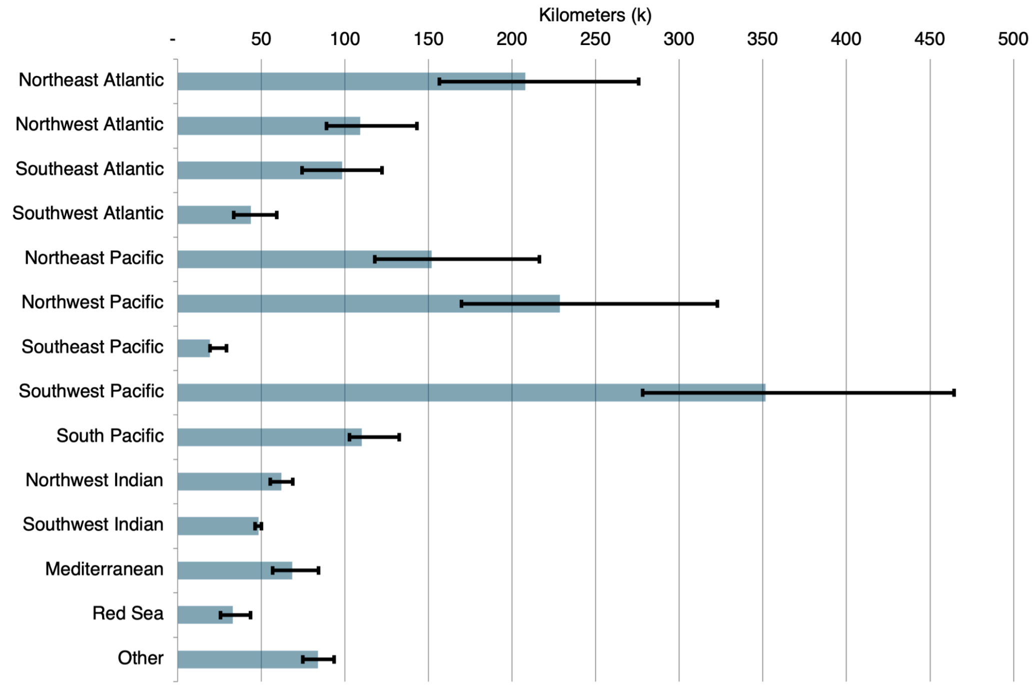
Figure 4.7. Scenario Analysis: Demand Growth +/- 10% versus Baseline Forecasted New Cables by Route, 2040



Source: TeleGeography, Infra-Analytics

When viewed in terms of the impact on cable kilometers, a 10% increase in baseline growth rates would lead to 113k more kilometers in the Southwest Pacific and 97k more kilometers in the Northwest Pacific by 2040. A 10% reduction in growth rates has the largest impact on these two regions as well.

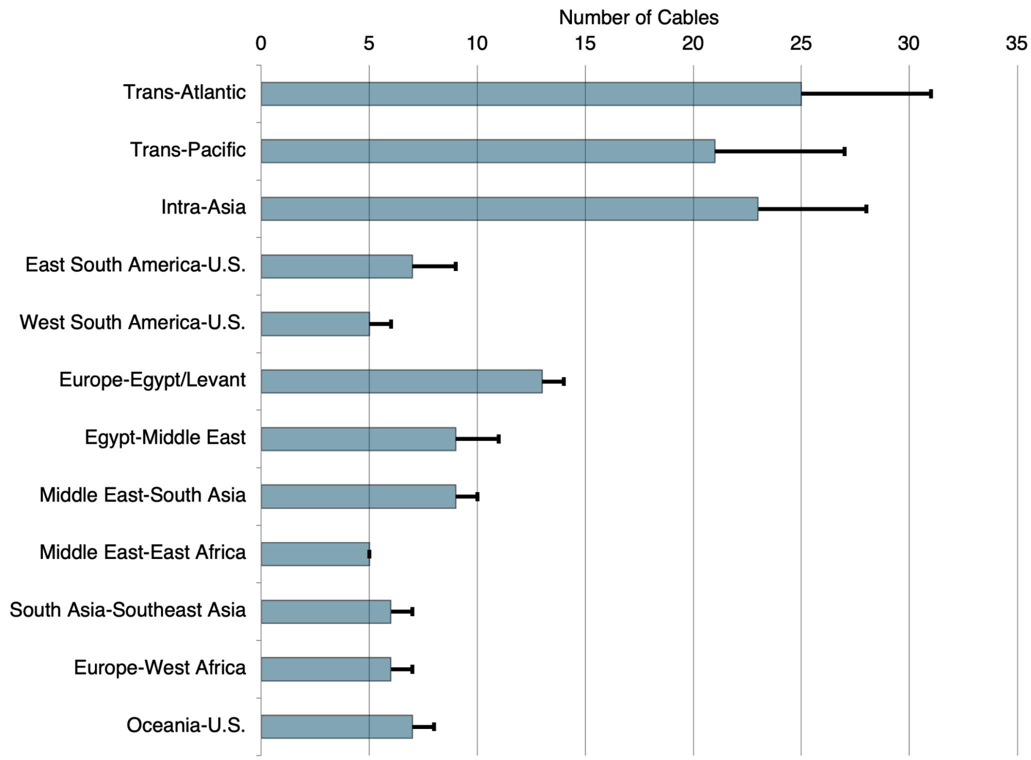
Figure 4.8. Scenario Analysis: Demand Growth +/- 10% versus Baseline Forecasted Cable Kilometers by Region, 2040



Source: TeleGeography, Infra-Analytics

Varying Pace of Technological Advancement - the rate at which higher-capacity cables will enter service is subject to considerable uncertainty. The baseline model assumes that a 1 Pbps cable would be capable of entering service on the trans-Atlantic route in 2030, with 500 Tbps improvements occurring every three years. Other routes assume lower baseline capacity levels than the Atlantic. If baseline cable capacity estimates are delayed by two years, there will naturally be an increase in the projected number of cables entering service by 2040. A two-year delay would lead to six more cables on both the trans-Atlantic and trans-Pacific routes above the baseline levels.

Figure 4.9. Scenario Analysis: Two-year Technology Delay versus Baseline Forecasted New Cables by Route, 2040

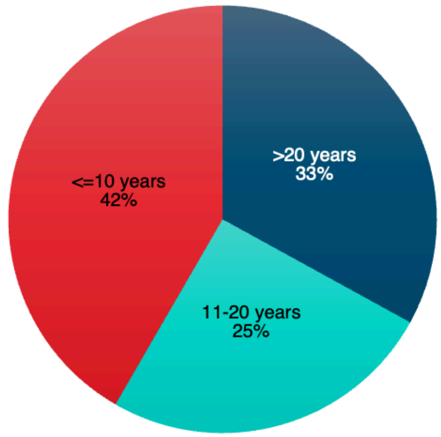


Source: TeleGeography, Infra-Analytics

4.1.3. Cable Retirements

To forecast the future amount of cable kilometers over time, the reduction in cable kilometers of cable systems that will be retired needs to be calculated. Existing subsea cables worldwide span a wide range of ages. By the end of 2025, it is estimated that cables over 20 years old account for 33% of total cable kilometers, with cables 11-20 years old at 25%.

Figure 4.10. Share of In Service Cable Kilometers by Age, 2025



Source: TeleGeography

Cables are engineered to have a minimum design life of 25 years, but what really matters is the *economic* life. A cable's economic life does not depend on a cable reaching its maximum capacity; a cable could see its end of economic life well before it has exhausted its capacity. The opposite is also true. Running out of upgradeable capacity does not mean immediate end of economic life, but it does signal that the cables may not have much more useful life remaining.

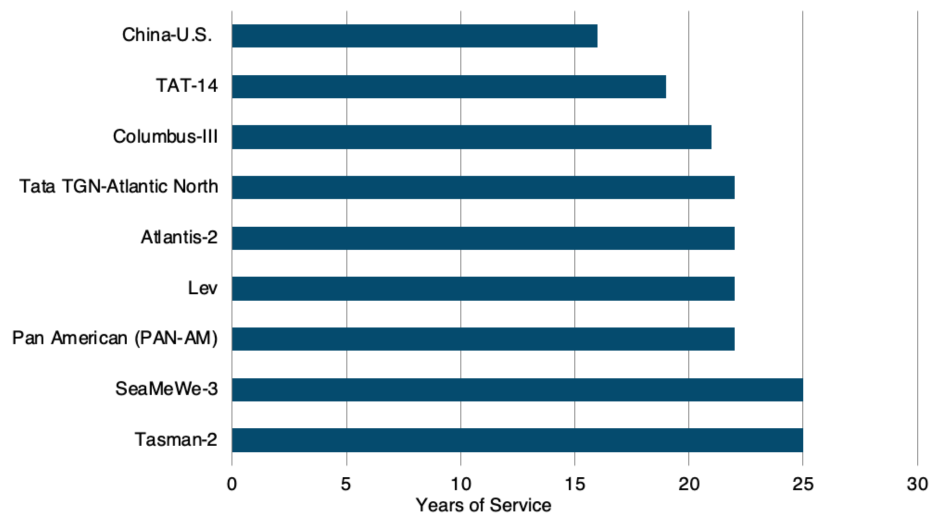
Several factors influence a cable's economic lifespan, including:

- Competition (number of higher-capacity alternative cables on a route)
- Pace of demand growth
- Capacity of the cable
- Capacity price erosion
- Cable ownership structure
- Existing IRU operations & maintenance (O&M) revenues
- Operational expenditures
- Upgrade costs

These factors vary significantly across different routes and cable generations. Even if a cable's economic life is over, it may remain in service. Operators also must assess the cable in the broader context of the role it plays in their global network. Does the cable connect a country that lacks numerous cables and thus retain value due to the diversity it offers? Other factors such as corporate strategy and national security considerations may also lead to cables remaining in service despite being economically obsolete.

With these factors in mind, it's instructive to examine the actual lifespans of recently retired cables. In the bar chart below it is clear that the lifespan of cables retired since 2015 varies widely. China-U.S. was retired after 16 years, while SeaMeWe-3 reached 25 years.

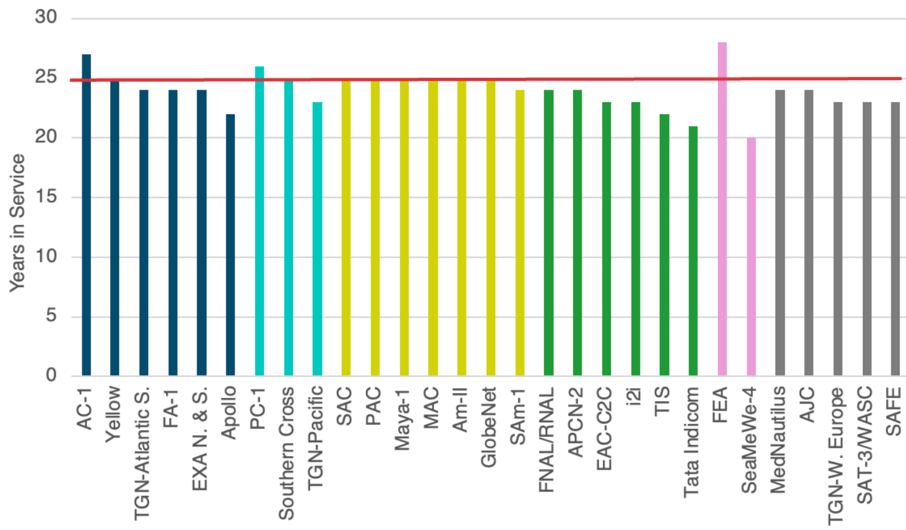
Figure 4.11. Lifespan of Selected Retired Cables, 2015-2024.



Source: TeleGeography

Cables built in the late 1990s and early 2000s benefited massively from advancements in technology which allowed them to increase their potential capacity far beyond initial levels. These advancements have helped extend their economic lifespans. In some cases, the potential capacity of cables increased more than 10-fold simply by installing new terminal equipment in cable stations. This helps explain why so many of these older cables are still in service. The chart below shows selected active repeatered cables that are 20 years old or older.

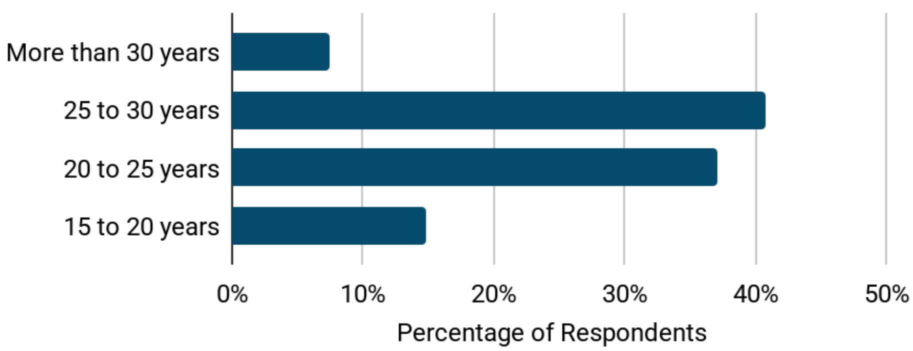
Figure 4.12. Selected in Service Cables with 20+ Years of Service in 2025



Source: TeleGeography

A survey of cable operators gathered views on the expected lifespan of their repeatered cables. The results are shown in the figure below. The categories of 20-25 years and 25-30 years combined accounted for 78%. Notably, 15% of respondents anticipate a cable lifespan of less than 20 years.

Figure 4.13. Expected Repeated Cable Lifespan by Survey Respondents



Source: Industry survey by TeleGeography and Infra-Analytics

4.1.3.1. Model Approach

In the baseline version of the cable kilometer model, cable lifespans assumptions were as follows:

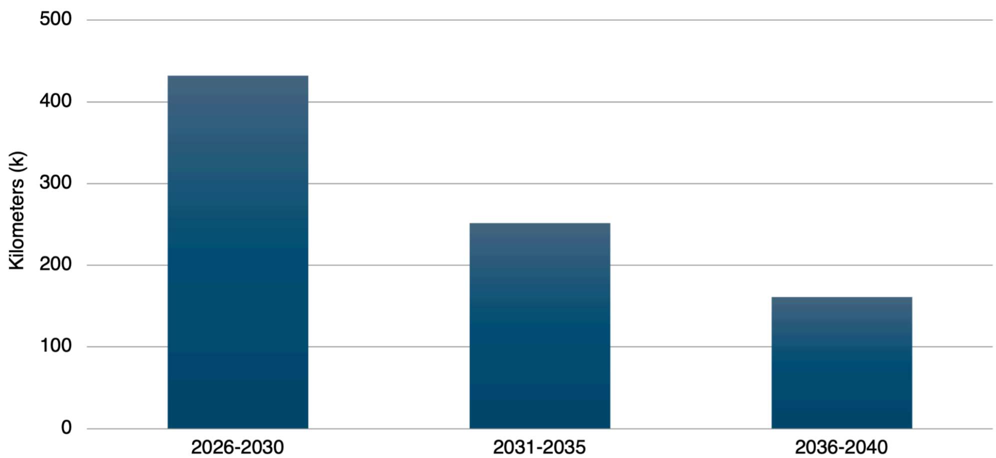
- Repeatered cables: 25 years
- Unrepeatered cables: 35 years

For cables already at or beyond these ages as of 2025, retirement for all of them by 2030 was assumed.

4.1.3.2. Model Results

In total, over 845,000 km of cables are forecast to be retired from 2026-2040. The forecasted reduction in cable kilometers will be the highest from 2026-2030 with 432k kilometers retired. This large amount is a reflection of the high number of cables deployed during the telecom boom period of the late 1990s/early 2000s that could be retired by 2030. The model indicates further reductions of 252,000 km for 2031-2035 and 161,000 km for 2036-2040.

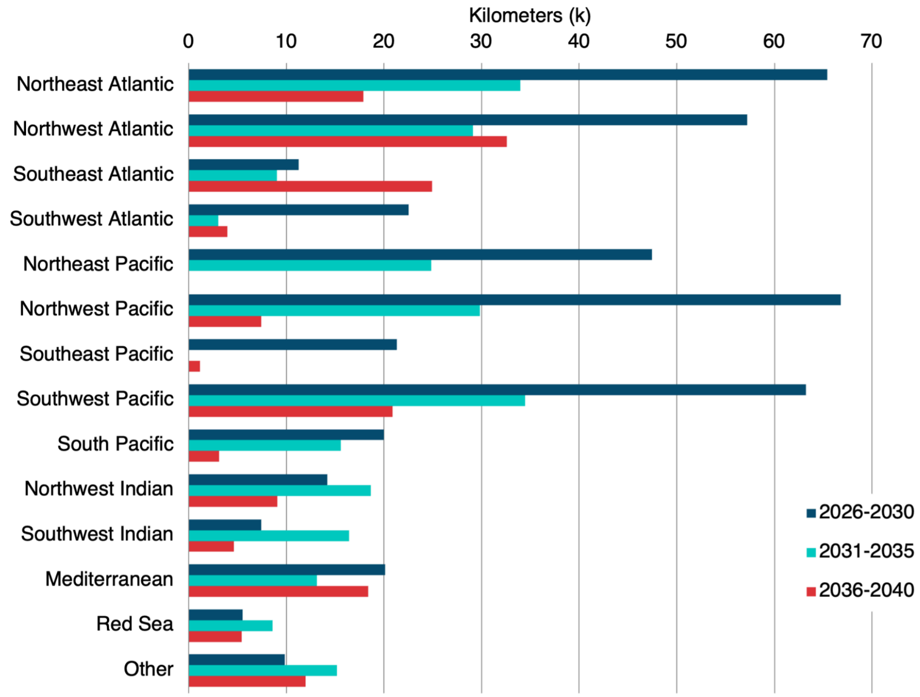
Figure 4.14. Baseline Forecasted Retired Cable Kilometers



Source: TeleGeography and Infra-Analytics

The regions with the greatest loss of cable kilometers due to retirements for 2026-2040 would be the Northwest Atlantic, Northeast Atlantic, Northwest Pacific, and Southwest Pacific. Each of these regions are forecasted to have over 100,000 km of cables retired during this period.

Figure 4.15. Baseline Forecasted Retired Cable Kilometers by Region

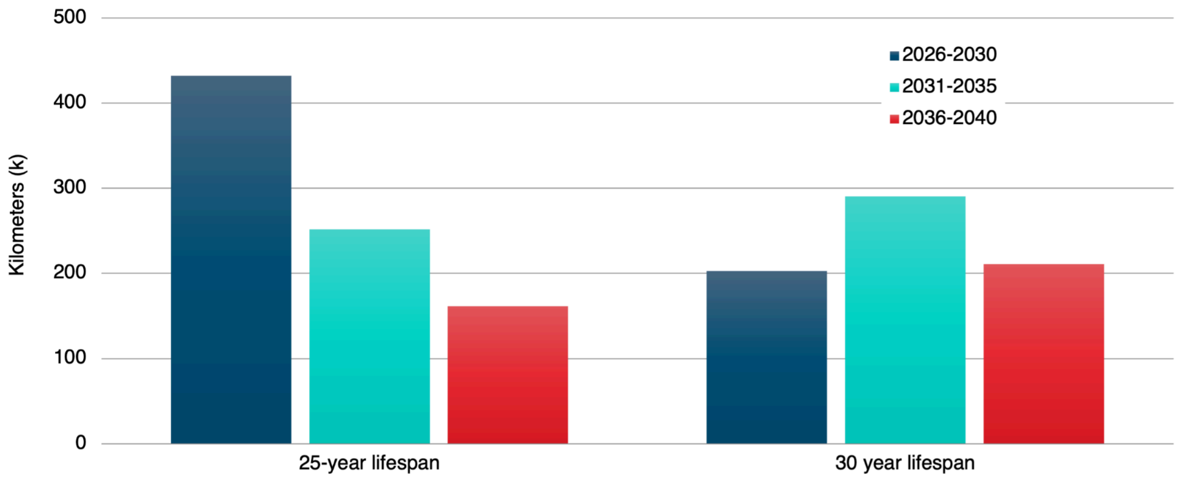


Source: TeleGeography, Infra-Analytics

4.1.3.3. Retirement Scenarios

With many repeatered cables already at or beyond 25 years of life, the impact of a 30-year lifespan for repeatered cables on the total cable retirements for each five-year period was also modeled. The following figure shows this impact.

Figure 4.16. Scenario Analysis: Forecasted Retired Cable Kilometers, 25-year vs 30-year Lifespan for Repeatered Cables



Source: TeleGeography, Infra-Analytics
Note: Data reflect total repeatered and unrepeatered cable kilometers. 35 year lifespan for unrepeatered cables was assumed in both scenarios

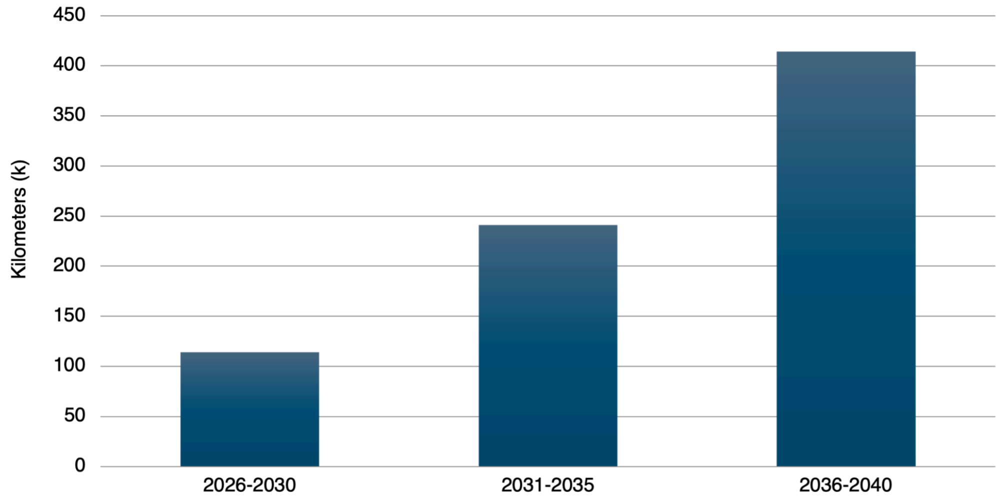
A few observations about this change:

- The projected cable retirements for 2026-2030 are expected to decrease from 432,000 km to 202,000 km. This reduction may seem less substantial than otherwise anticipated because the baseline model already assumes the retirement of repeatered cables aged 25 years or older by 2030.
- The 2031-2035 period sees an increase in kilometers retired from 252,000 km to 290,000 km. However, 76% (219,000 km) of this latter amount are forecast to be retired in the first two years of the 2031-2035 period. This is due to the large number of cable kilometers deployed in 2001 and 2002 which would be retired during these years. So while an increased life span appears to drastically lower cable kilometers retired, the impact is more muted when considering the first seven years with a 30-year lifespan would lead to only 12% fewer kilometers retired compared to a 25-year lifespan.

4.1.4. Net Change in Kilometers

Future cable kilometers were calculated by starting with the baseline number of kilometers per region for 2025. To this, new cable kilometers were added, and retired cables were subtracted. The result of this calculation is the net change in kilometers expected per region. The retirement of 845,000 km of cables and the addition of 1.6 million km of new cables leads to a net increase of 770,000 km between 2025 and 2040. In percentage terms, this equates to a 48% increase in cable kilometers for this 15-year period.

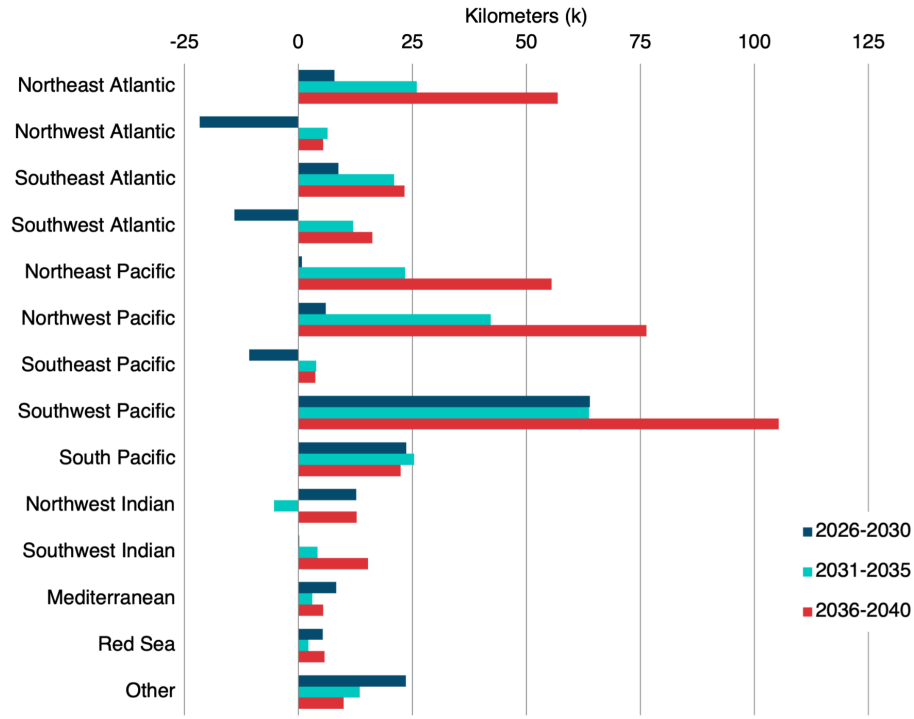
Figure 4.17. Baseline Forecasted Net Change in Cable Kilometers, 2026-2040



Source: TeleGeography, Infra-Analytics

The biggest net changes in kilometers will occur in five regions. The largest share will come in the Southwest Pacific region with 211,000 km, followed by the Northwest Pacific with 118,000 km. The other regions with at least a 75,000 km net increase include the Northeast Atlantic, Northeast Pacific, and South Pacific. A net *decrease* in cable kilometers occurs in a few five-year periods in selected regions. This situation occurs when anticipated cable retirements offset the deployment on new cables.

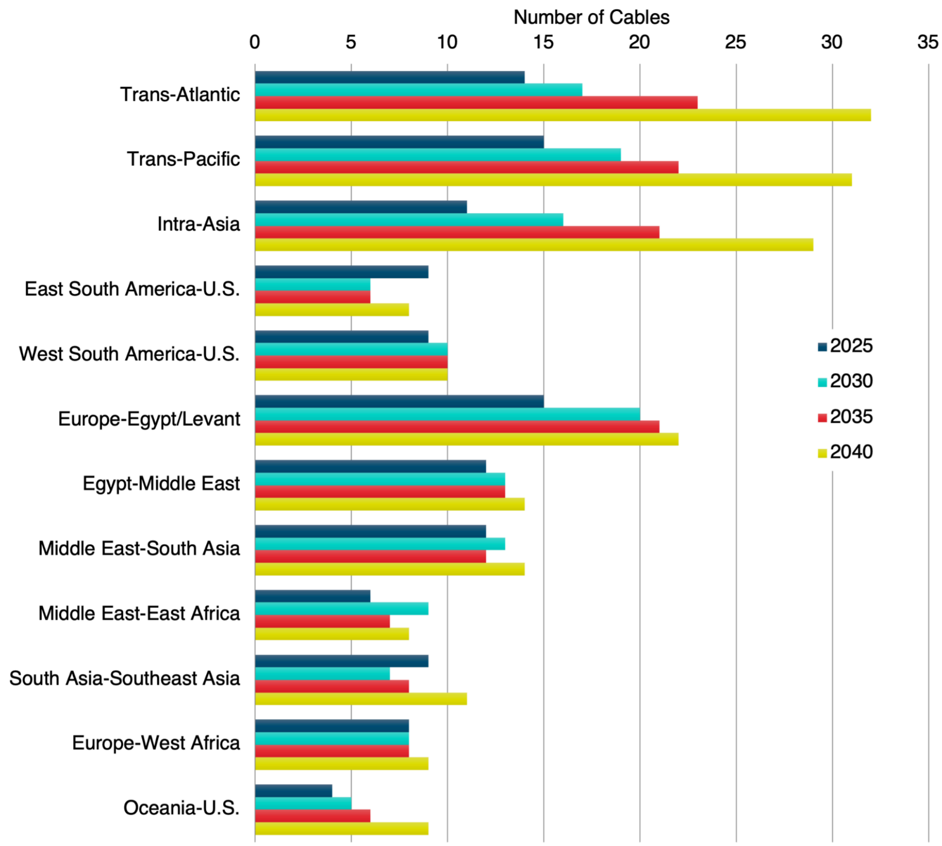
Figure 4.18. Baseline Forecasted Net Change in Cable Kilometers by Region, 2026-2040



Source: TeleGeography, Infra-Analytics

The figure below illustrates how new cable deployments and the decommissioning of older systems will affect the quantity of operational cables on key routes. The projections indicate that by 2040, the trans-Atlantic, trans-Pacific, intra-Asia, and U.S.-Oceania routes will experience a doubling in the number of active cables. All other primary routes are expected to maintain a comparable number of cables to 2025 levels. It's important to note that sustained demand for new cables on these routes is still anticipated; however, the retirement of older systems partially offsets the increase in the total number of active cables resulting from new deployments.

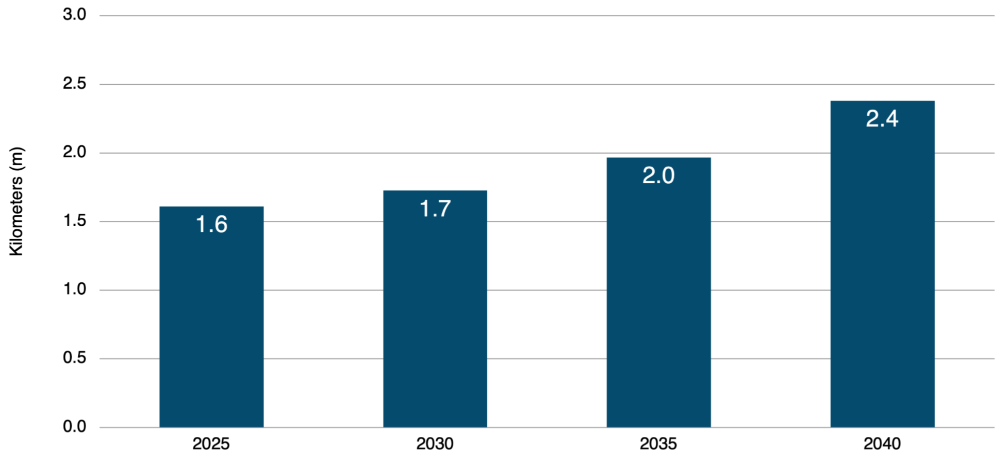
Figure 4.19. Baseline Forecasted Number of Cables in Service by Major Route, 2026-2040



Source: TeleGeography, Infra-Analytics

Globally, the net change in kilometers results in a substantial change in the cumulative kilometers in service. From 1.6m kilometers in 2025 up to 2.4m kilometers by 2040.

Figure 4.20. Baseline Forecasted Cumulative Global Cable Kilometers, 2025-2040

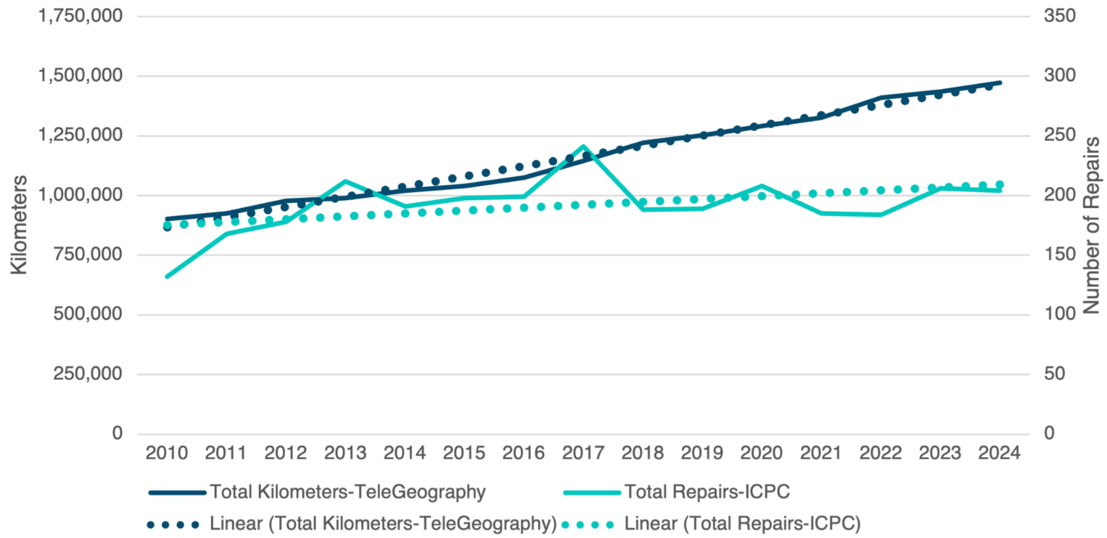


Source: TeleGeography, Infra-Analytics

4.2. Cable Repair Forecast

According to TeleGeography data, global cable kilometers increased 63% from 902,000 km to 1.5m km between 2010 and 2024. With such a substantial net increase in cable kilometers it seems logical to assume a corresponding rise in cable repairs. Global fault data provided by ICPC reveals an interesting trend. The number of repairs per year has *not* increased at a corresponding rate to cable kilometers. In fact, the average annual repair count from 2015-2024 is remarkably stable, averaging 200 repairs per year during this period, even while total global cable kilometers increased by 50%.

Figure 4.21. Historical Cable Kilometers and Repairs, 2010-2024



Source: International Cable Protection Committee (ICPC), TeleGeography

The recent stability in global annual repair rates may be a result of several factors including:

- Deeper cable burial in fault-prone areas
- Improved route planning
- Increased cable awareness
- Retirements of older, more fault-prone, cables.
- Use of DAS and AIS technology to alert vessel proximity

Even with the recent stability in annual repair tallies, the forecasted 48% net increase in cable kilometers by 2040 will certainly have some bearing on future repair requirements. Not all regions will be impacted evenly by changes in cable kilometers, nor do faults occur evenly across all regions.

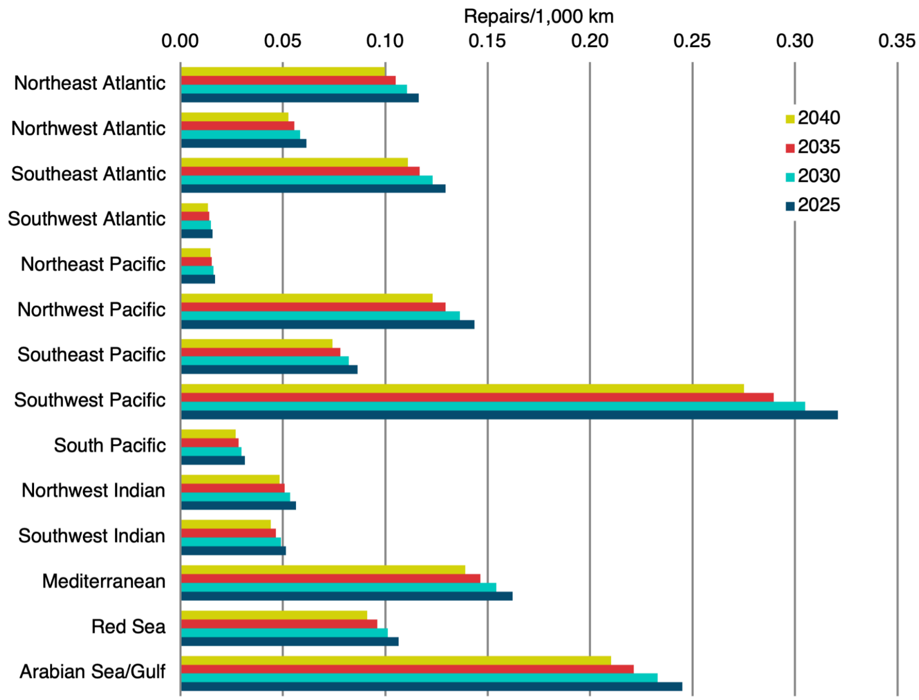
To account for regional variances in fault rates, OceanIQ provided assistance. Based on their proprietary datasets, OceanIQ provided historical data on annual repairs per kilometer for the geographic regions defined in this study for 2020-2024.

The data provided by OceanIQ does not reveal any clear trends across any regions in terms of decline in repairs per kilometer from 2020-2024. Nevertheless, the trend of declining overall fault rates at the global level seems likely to continue due to the factors listed above.

To model the future number of repairs, the average repairs per 1,000 km by region were reduced by 5% to establish a 2025 baseline. Summing the implied number of repairs for each region results in a total of 209 repairs for 2025.

A 5% deceleration rate to each subsequent five-year forecast period was applied to each region (equivalent to an annual deceleration of 1.02%) to continue the trend present in ICPC data. As observed in the figure below, the repair rates in the Southwest Pacific and Arabian Sea/Gulf regions are substantially higher than other regions. Thus, a 5% reduction in repair rate per five-year period leads to a considerable reduction in these locations compared to regions where repair rates are already low.

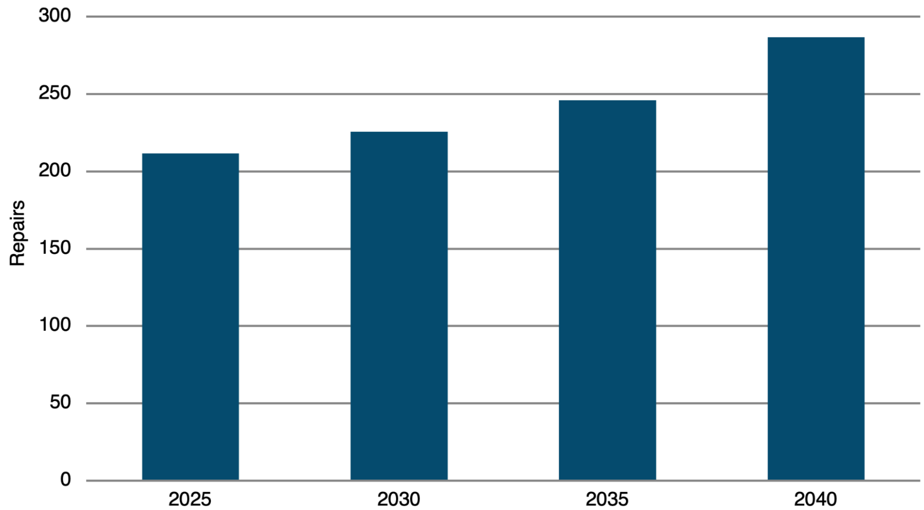
Figure 4.22. Baseline Forecasted Repair Rate for Selected Regions, 2025-2040



Source: TeleGeography, Infra-Analytics
Notes: Historical regional fault rate data from OceanIQ was used as a baseline for the forecasts.

Even though the fault rate is decreasing across all regions, the introduction of a large number of new cable kilometers leads to an increase in the number of repairs. This approach leads to a global total repair count of 287 by 2040. So while global kilometers increase 48% from 2025-2040, repairs would only increase 36%.

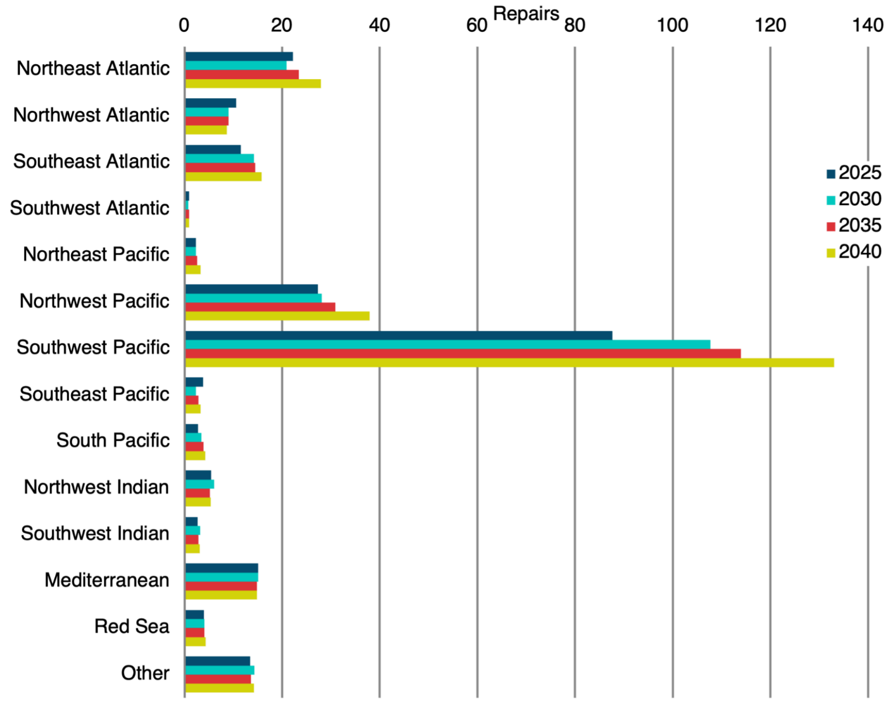
Figure 4.23. Baseline Forecasted Global Repairs, 2025-2040



Source: TeleGeography, Infra-Analytics
Notes: Historical regional fault rate data from OceanIQ was used as a baseline for the forecasts.

Total repair numbers show the vast differences in repair counts across regions. A few regions account for the vast majority of repairs. Notably, cables in the Southwest Pacific region (including the South China Sea, Singapore, and Indonesia) are forecasted to require 141 repairs, or 49% of global faults in 2040. The regions with the next highest repair numbers by 2040 are the Northwest Pacific, Northeast Atlantic, Southeast Atlantic, and Mediterranean. The four regions combined would account for 34% of global repairs.

Figure 4.24. Baseline Forecasted Repairs by Region, 2025-2040



Source: TeleGeography, Infra-Analytics
Notes: Historical repair rate data from OceanIQ was used as a baseline for the forecasts. Forecasted repairs refer only to the number of repairs during a one-year period.

4.2.1. Repair Rate Forecasting Challenges

The rate at which cables will experience faults is challenging to predict. The following data points for individual cables are crucial to providing a more accurate assessment of repair rates by region but were unavailable for this study.

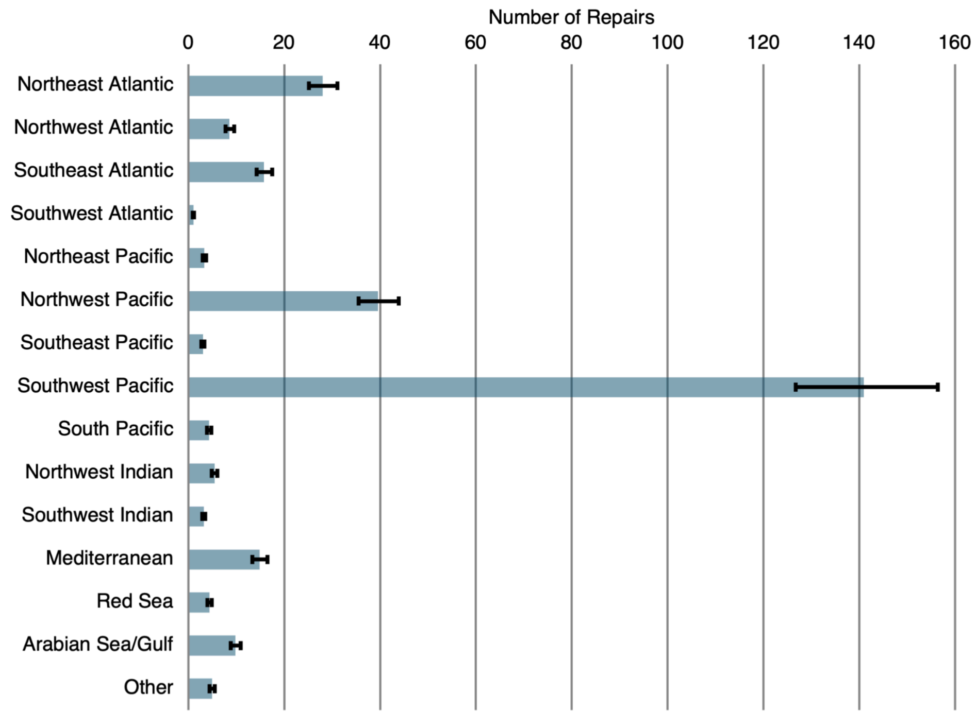
- Historical repair rates
- Water depth
- Burial depth
- Armoring
- Expected date of retirement

The retirement of cables is an especially critical factor for some regions. Some particularly fault-prone cables in Asia are rumored to account for an outsized share of repairs. The retirement of these cables could significantly reduce the fault rate in some regions. The model is unable to factor in this impact due to the lack of cable-specific fault data.

4.2.2. Repair Rate Scenarios

Two alternative scenarios regarding future repair rate evolution were examined due to the inherent uncertainty. In the first scenario, the deceleration of the repair rate was slowed to 2.5% every five years per region (equivalent to an annual change of 0.51%), while in the second, it was accelerated to 7.5% for the same period (equivalent to an annual change of 1.55%). The chart illustrates the deviation in the number of repairs per region from the projected baselines under these two scenarios. As expected, the Southwest Pacific, which is projected to have the highest number of repairs, would experience the most significant impact. Specifically, a 7.5% deceleration would result in 14 fewer repairs in 2040 compared to the baseline, whereas a 2.5% deceleration would lead to an increase of 15 repairs.

Figure 4.25. Scenario Analysis: Repair Rate of -2.5% and -7.5% versus -5% Baseline Forecasted Repairs by Route, 2040



Source: TeleGeography, Infra-Analytics
Notes: Error bars show the impact of 7.5% deceleration in fault rate as a decrease in the number of faults, while a 2.5% deceleration would increase the number of faults.

In closing, the analysis of cable kilometer changes indicates a dynamic period for the submarine cable industry. A significant wave of cable retirements is anticipated, particularly in the late 2020s, but this will be more than offset by a substantial influx of new cable deployments, resulting in a net increase in cable kilometers globally. This growth, however, will be uneven, with regions like the Southwest Pacific, Northwest Pacific, and Northeast Atlantic experiencing the most significant expansion. Despite the overall increase in cable kilometers, the analysis suggests that a decline in the global repair rate per kilometer would prevent substantial increases in cable repairs. Nevertheless, certain regions, notably the Southwest Pacific, are projected to bear a disproportionate share of future repairs. With the anticipated repair requirements established, a review of the global fleet will determine the number of vessels that may be required in the future.

5. FLEET STATISTICS AND FORECAST REQUIREMENTS

This section examines global fleet dynamics and repair vessel requirements, building upon the analysis of cable kilometer growth and repair projections. A review of the current state of the maintenance vessel fleet, including age distribution and operational focus is followed by an evaluation of future needs. The goal is to determine whether the existing fleet can meet future demands and consider the financial and strategic aspects of vessel investment.

5.1. Today's Maintenance Fleet

Currently 62 vessels are actively engaged in the installation and maintenance of undersea telecommunications cables.[72] Numerous Cable Lay Vessels (CLVs) operate in the global market across a range of adjacent offshore industries such as power cables, offshore renewables and the oil and gas industry. Vessels involved in the installation and maintenance of submarine telecoms cables is a small sub-sector of the global CLV market. Many multi-purpose vessels in the global market have the capability to lay telecoms cables, but have no history of or are unlikely to move market focus to the telecoms sector. Conversely, only a limited number of telecom CLVs have experience in adjacent markets.

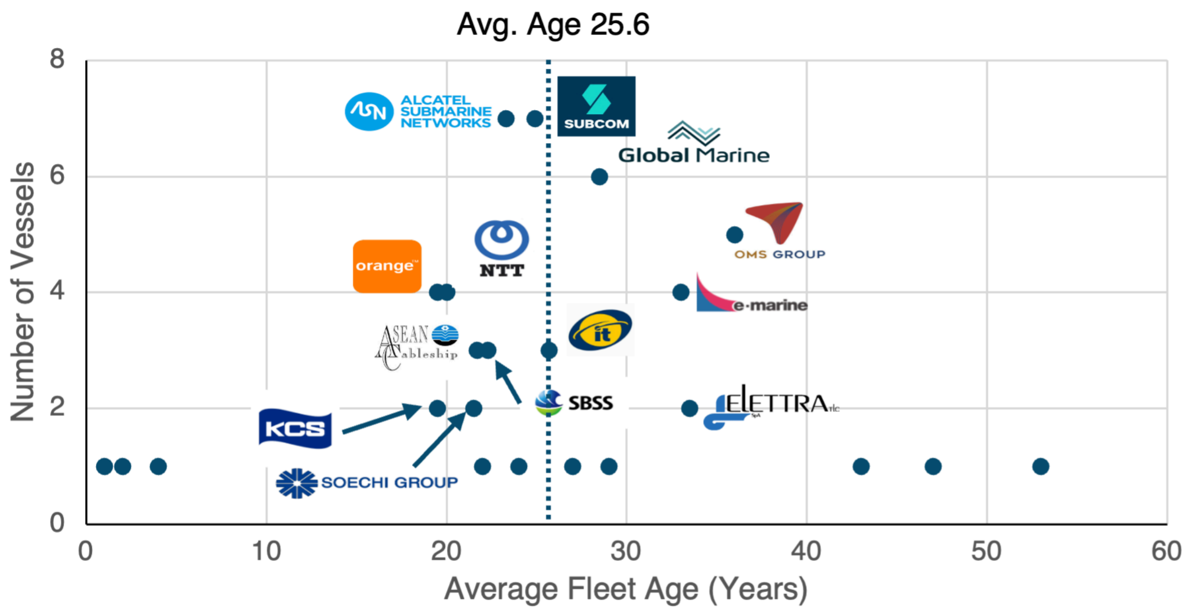
The current global fleet is composed of roughly 60% purpose-built vessels. However, most of these vessels are aging, with approximately 80% having been commissioned more than two decades ago.

5.1.1. Vessels by Owner

The owners with the most cable vessels are Alcatel Submarine Networks, SubCom, Orange Marine and Global Marine. A large number of companies operate only a few vessels.

[72] This number excludes shallow water barges and Russian vessels.

Figure 5.1. Total Vessels by Owner and Average Age, 2025

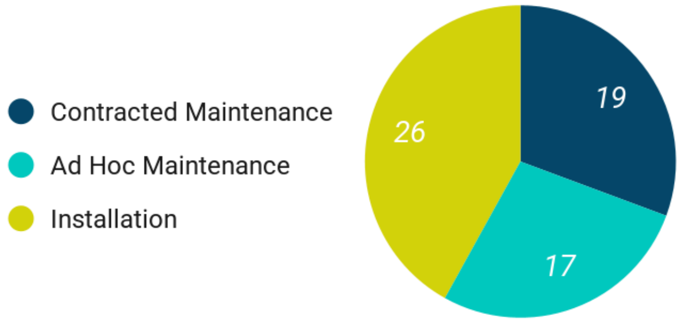


Source: TeleGeography, Infra-Analytics
Notes: Vessel count includes installation, maintenance, and dual-purpose vessels. Owners with only one vessel include Baltic Offshore, BNP, China General Nuclear Power, China Telecom, FibreHome, HMN Tech, LS Marine Solutions, PT Lim, Relacom Finland, and Triasmitra.

5.1.2. Vessels by Function

26 vessels (42%) operate in the cable installation sector. 19 vessels (31%) are contracted to provide dedicated services for maintenance agreements. Not all vessels are contracted on a 12-month year round basis. The remaining 16 vessels (27%) switch between installation and maintenance, with some providing ad-hoc services in the Baltic, Asia-Pacific, and Americas regions.

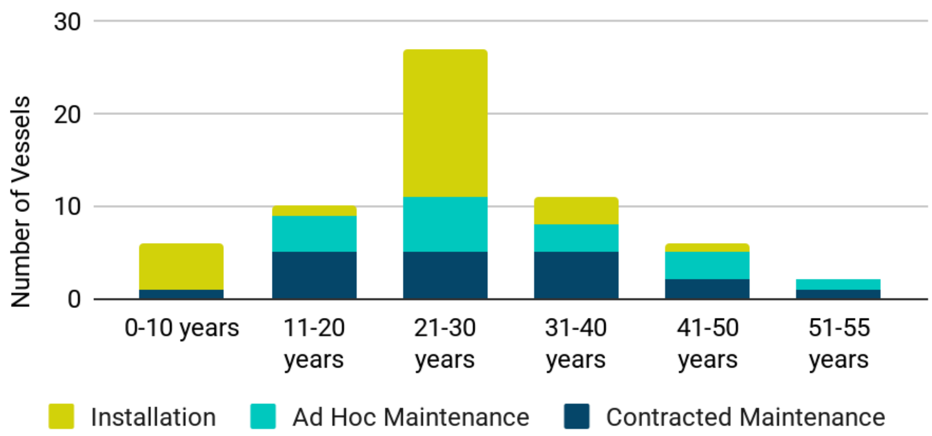
Figure 5.2. Global Fleet by Function, 2025



Source: TeleGeography, Infra-Analytics

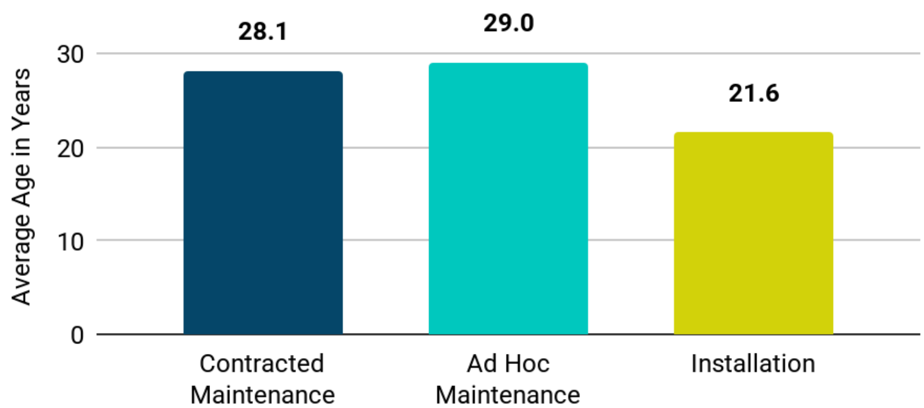
The maintenance fleet is generally older than cable installation vessels, reflecting the trend to repurpose aging vessels from installation to maintenance activities. Additionally, the preference of vessel operators to convert second-hand vessels for maintenance services, rather than investing in purpose-built vessels is arguably a reflection of the investment challenges of this sector. However, converted vessels are usually configured for both installation and maintenance operations.

Figure 5.3. Global Fleet by Age and Function, 2025



Source: TeleGeography, Infra-Analytics

Figure 5.4. Average Vessel Age by Function, 2025

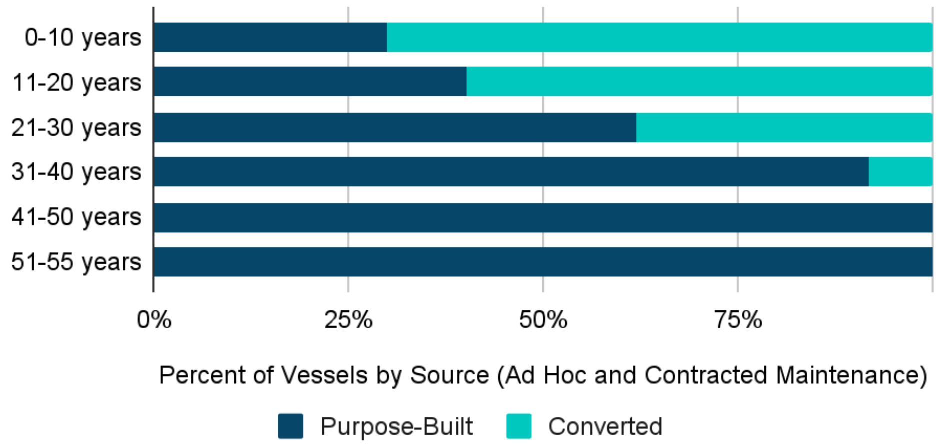


Source: TeleGeography, Infra-Analytics

5.1.3. Vessels by Source

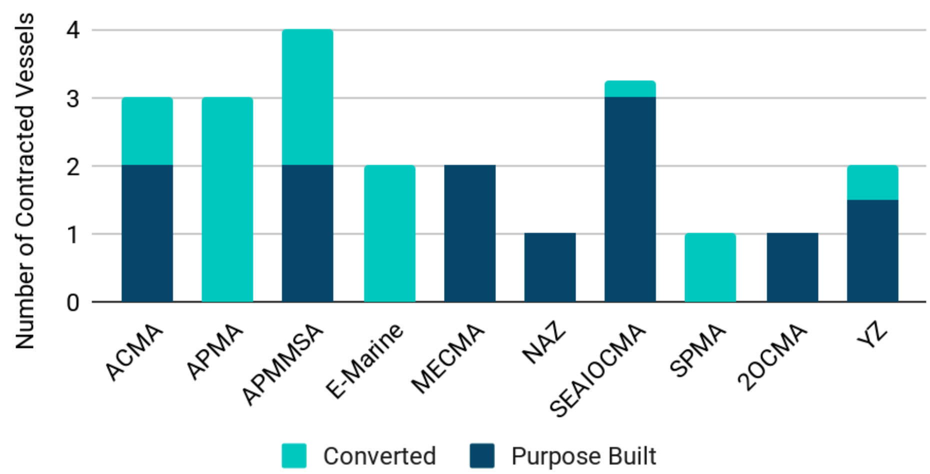
Vessel conversions entered the market in the late 1990s, coinciding with the dotcom era and corresponding substantial rise in cable system investment. Over the last decade, 20 maintenance vessels were introduced, with 70% being conversions. Asian investors financed 80% of these vessels, reflecting the region's economic growth, cable infrastructure development, high fault rates and cabotage restrictions.

Figure 5.5. Percentage of Purpose-Built vs. Converted Maintenance Vessels by Age, 2025



Source: TeleGeography, Infra-Analytics

Figure 5.6. Purpose-Built vs. Converted Vessels by Maintenance Agreement, 2025

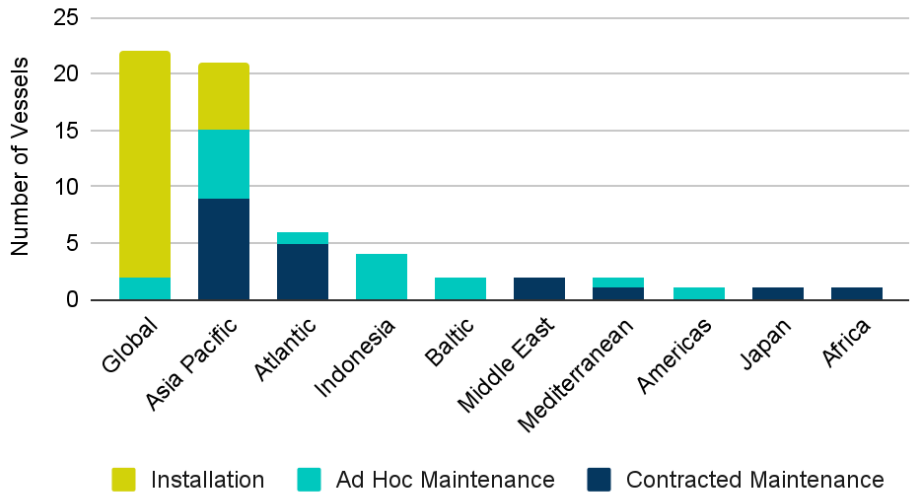


Source: TeleGeography, Infra-Analytics
Note: Vessels only contracted for part of the year are considered partial vessels, based on the number of months they are contracted.

5.1.4. Vessels by Operating Region

Figure 5.7 illustrates the global distribution of vessels, categorized by base port location and operational focus. Asia-Pacific's significant representation is attributed to high repair rates and the presence of numerous smaller regional operators. Notably, Asia-based operators own 53% of the global fleet.

Figure 5.7. Vessel Count by Operating Region and Use, 2025



Source: TeleGeography, Infra-Analytics

5.1.5. Vessel Lifespan

Cable ships have a longer service life than other maritime assets such as bulk carriers or container ships which typically last 20-30 years. The submarine cable fleet includes purpose-built vessels or vessels converted from those produced for the oil and gas industry, such as Platform Supply Vessels (PSV's) or Offshore Support Vessels (OSV's). For the purposes of this study these are referred to as "conversions."

The International Maritime Organization (IMO) regulates Class Surveys for all maritime assets every five years. Intermediate inspections are required every two to three years throughout the vessel's operational life to maintain Classification Certifications. Class Surveys require dry-docking, while intermediate inspections can involve either dry-docking or underwater inspections. As vessels age, maintenance needs escalate due to wear and tear, modernization, and general upkeep to meet Class Certification. The operational expenditure (OPEX) required to retain Class Certification can be substantial and increases as vessels age.

Purpose-built CLVs and conversions are constructed to higher specifications than other ships, due to the nature of offshore construction work. Industry vessels experience less operational time throughout their life because of lengthy periods of downtime, either on standby between repairs or installation projects. In contrast, cargo carriers are in almost constant transit moving between predetermined ports. This difference results in the longer service life of the industry fleet.

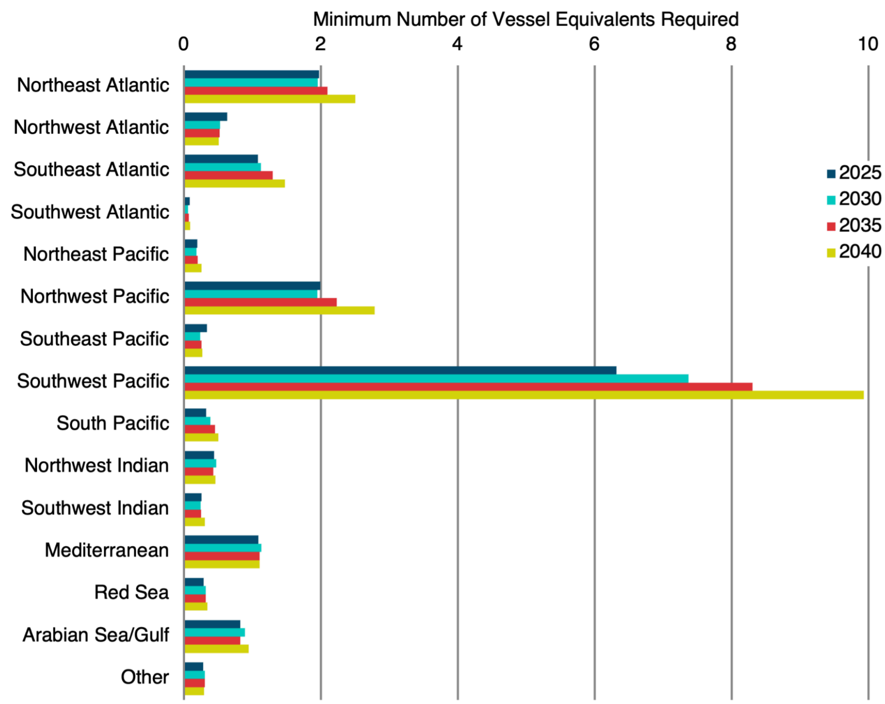
Survey feedback indicates that vessel operators consider the average service life of vessels to be between 35-45 years, with most citing a 40-year service life. This range is supported by M3 Marine, a Singapore-based third-party expert, who suggests that a maximum 35-year service life applies to conversions while purpose built CLVs will have a slightly longer maximum service life of around 40 years. A structured refurbishment and maintenance plan can extend vessel service life. For example, two purpose-built CLVs were recently decommissioned after 41 and 42 years of operations.

Data analysis of the fleet engaged in contracted and ad-hoc maintenance shows that currently six vessels (12%) have surpassed a 40-year service life. Within the next decade, an additional six vessels, representing 26% of the maintenance fleet, are poised to reach the 40-year threshold. Over half of vessel operators and cable owners anticipate the need for new vessels before 2040.

5.2. Vessel Requirement Forecast

Projected future vessel needs are derived from analyzing repair requirements in Section 4.2. Vessel requirements take into account the typical duration of repairs within specific regions and assume a target maximum vessel utilization rate of 60%. This figure was used as it was deemed the maximum level to limit the risk of repair queues forming. To determine overall needs in key geographic areas, the calculated regional vessel requirements are then consolidated based on the home ports of the vessels. Further information regarding the specific methodology employed in this projection can be located in section 9.2.3.

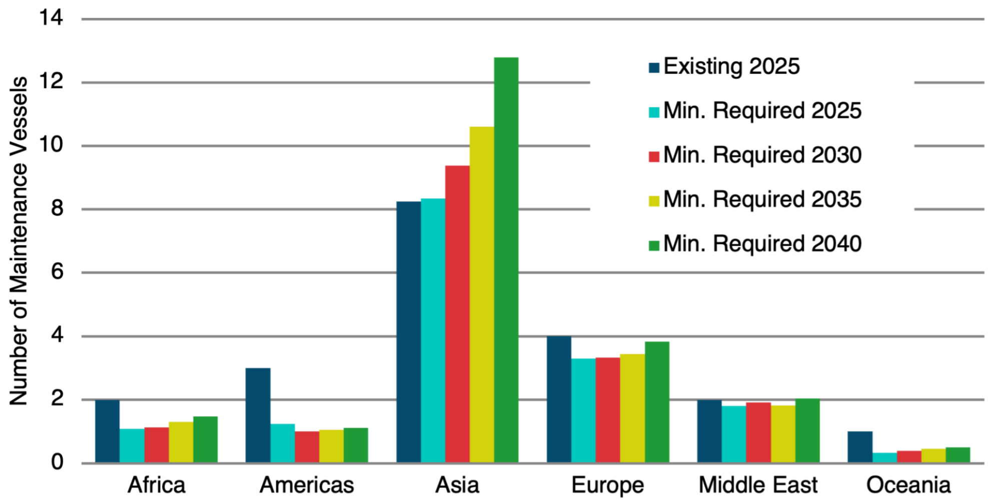
Figure 5.8. Baseline Forecasted Minimum Maintenance Vessel Requirements by Region, 2025-2040



Source: TeleGeography, Infra-Analytics

The figure below shows that the existing vessel count as of 2025 is sufficient in all major regions for the next 15 years with the exception of Asia, where several additional vessels would be needed.

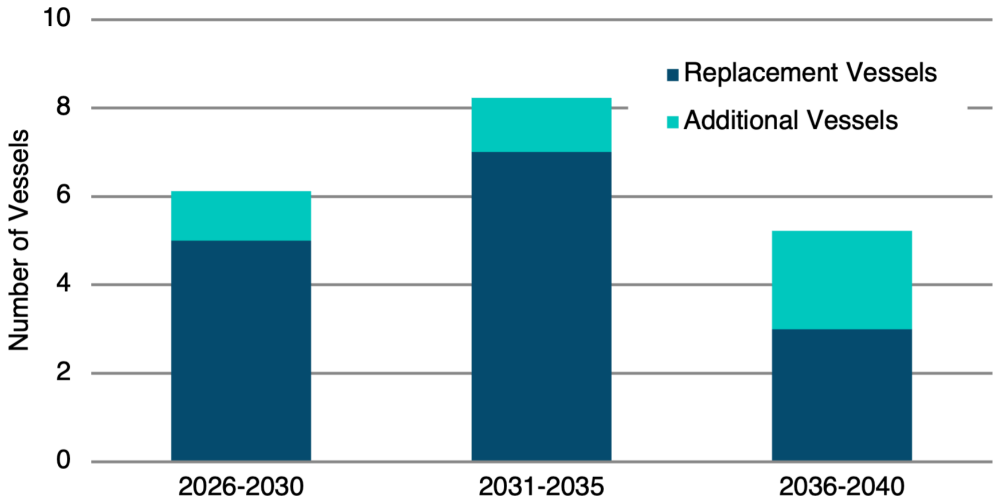
Figure 5.9. Baseline Forecasted Minimum Maintenance Vessel Requirements by Major Region, 2025-2040



Source: TeleGeography, Infra-Analytics
Notes: Existing vessels as of 2025 refers to contracted vessels for each region.

This future requirement for maintenance vessels is not only an issue of meeting incremental repair requirements, it's also about maintaining the existing capabilities. The current fleet, as noted above, is aging and in need of replacement. In the baseline model, we assumed a 40-year lifespan for maintenance vessels. The same lifespan was used for purpose-built and conversions. A total of 15 vessels will need to be replaced within the next 15 years. The vast majority (13) would be needed from 2026-2035.

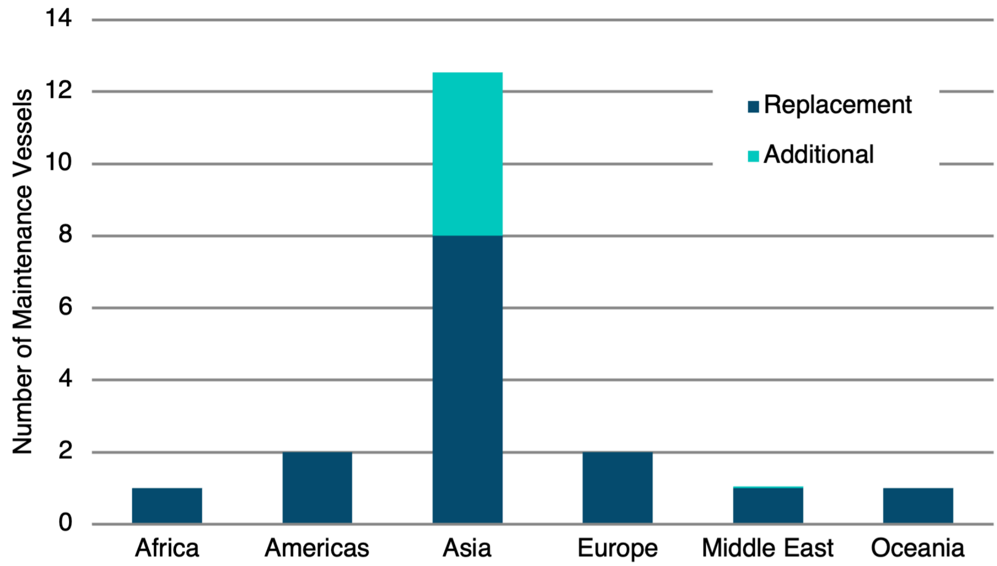
Figure 5.10. Incremental Maintenance Vessel Requirements, 2026-2040



Source: TeleGeography, Infra-Analytics
Notes: Maintenance vessels assumed to have a lifespan of 40 years.

The majority of new vessels will be needed in Asia, where eight replacement vessels will be required by 2040. In addition there's a need for the equivalent of up to five additional vessels in Asia. These forecasts only assume refreshing the existing fleet on a one-to-one basis, while retaining their current home port locations. It's important to consider the utilization rates of the remaining vessels and the distribution of repair vessels (base port location) when deciding whether to replace all retired vessels.

Figure 5.11. New Maintenance Vessel Requirements by Region, 2026-2040



Source: TeleGeography, Infra-Analytics

5.2.1. Scenario Analysis

The requirements for maintenance vessels in this model is based on a large number of variables. Examining how some of the key variables influence the maintenance vessel requirements is useful to discern a potential range of outcomes. The following assessment walks through the impact of key variables at the global level. For views for each of the six major regions, please refer to the Appendix Section B.

5.2.1.1. Cable Lifespan

In the baseline model all repeatered cables were assumed to have a lifespan of 25 years and any cables already in excess of 25 years of life would be retired by 2030. If the lifespan of repeatered cables is extended to 30 years, the impact on vessel requirements is negligible. By 2040 minimum vessel requirements would increase from 21.7 to 22.4.

5.2.1.2. Bandwidth Demand Growth

Varying the baseline demand growth rates forecasted by TeleGeography up or down by 10% has a more pronounced impact on vessel requirements. If demand growth is 10% more rapid than baseline level, then the vessel requirements would reach 26.4 in 2040. A 10% slower growth rate lowers vessel requirement to 18.6 in 2040.

5.2.1.3. Technological Advances in Cable Capacity

The ability for future cables to accommodate increasing levels of capacity is a key feature in determining future cable requirements. If technological advances were to be delayed by two years the impact would boost maintenance vessel requirements. The minimum number of maintenance vessels would increase from the baseline result of 21.7 to 24.1 by 2040.

5.2.1.4. Repair Rate Deceleration

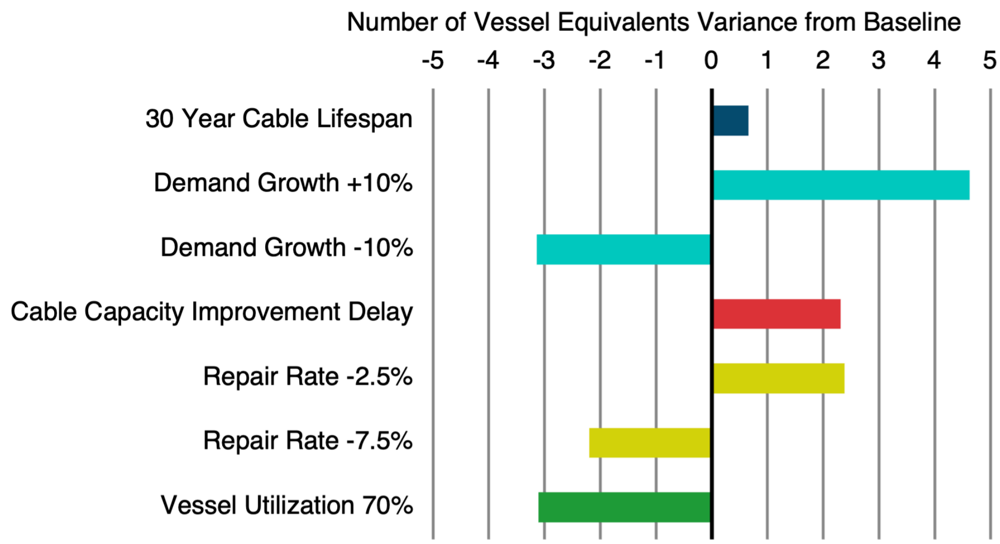
Repair rate deceleration significantly affects maintenance vessel requirements. The baseline approach uses a 5% deceleration (equivalent to an annual deceleration of 1.02%) from the 2020-2024 average fault rate for each region to establish an expected fault rate for each region in 2025, followed by an additional 5% deceleration for each subsequent five-year period until 2040. If a 2.5% deceleration in the repair rate is assumed, vessel requirements would rise to 24.1. Conversely, an increased deceleration rate of 7.5% would lower vessel requirements in 2040 to 19.5.

5.2.1.5. Vessel Utilization Rate

The impact of increasing maximum vessel utilization from 60% to 70% was also examined. This change would mean repair vessels are occupied with increased annual workloads which could potentially increase the risk of repair queues forming. This increase in utilization would reduce the 2040 vessel requirements to 18.6.

A summary of the impact of each scenario on the minimum number of total maintenance vessels required is shown in the figure below.

Figure 5.12. Scenario Analysis: Global Maintenance Vessel Forecasts Variance from 2040 Baseline



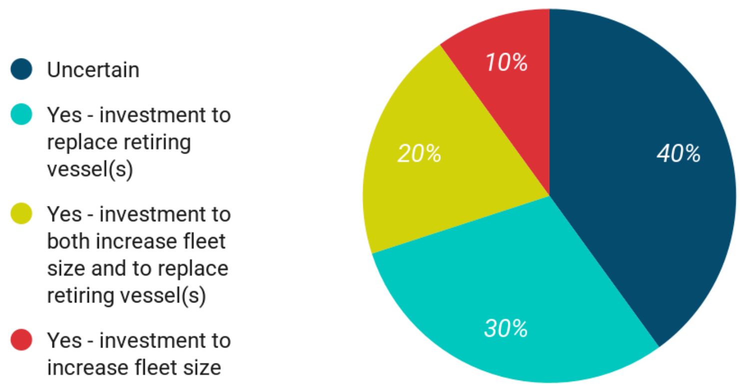
Source: TeleGeography, Infra-Analytics

5.3. Vessel Investment Considerations

Having established the current age and distribution of the existing maintenance fleet in section 4.1 and forecasted vessel requirements by region through 2040 in section 4.2, the factors surrounding vessel investment need to be considered. Given the current fleet maturity and the projected surge in vessel demand, investment decisions regarding purpose-builds, conversions, and vessel operating expenses (OPEX) need to be explored.

A survey of maintenance providers revealed that 60% intend to invest in new vessels within the next five to ten years, primarily for replacement rather than fleet expansion. The other 40% of providers expressed uncertainty about future investments.

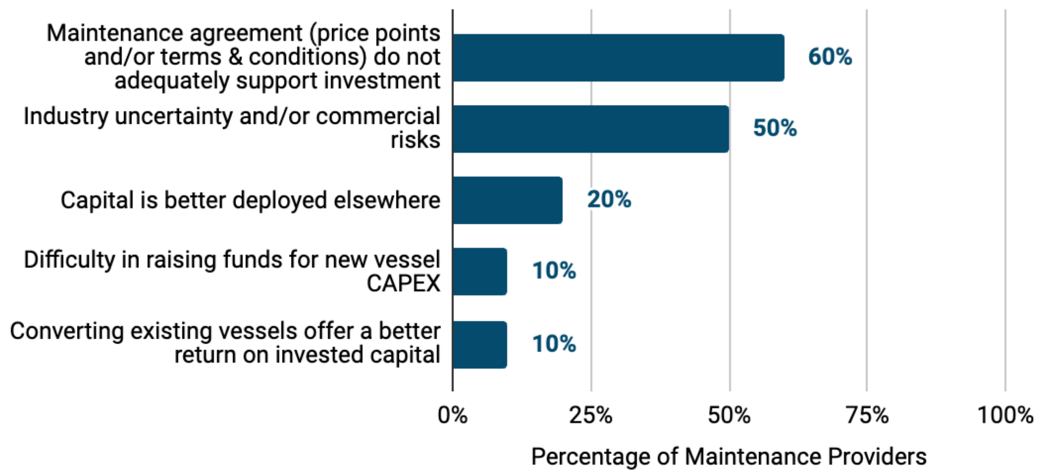
Figure 5.13. Do you plan to invest in further vessels within 5-10 years?



Source: Industry survey of maintenance providers by TeleGeography and Infra-Analytics

Vessel operators were also questioned about which factors are the most persuasive reasons to not invest in new maintenance vessels. Operators cited both maintenance agreement terms and industry uncertainty as the primary reasons. However, none have explicitly ruled out such investments.

Figure 5.14. Which of these are the most persuasive reasons to not invest in new-build maintenance vessels?



Source: Industry survey of maintenance providers by TeleGeography, Infra-Analytics

Factors that influence vessel investment decisions are outlined below. Understanding the trade-offs between purpose-built vessels and conversions, as well as the financial implications of each, is important.

With notable exceptions, for the past two decades, investing in second-hand vessels has generally been preferred over purpose-built ones, especially for maintenance-focused ships. Several factors influence the decision to either commission a purpose-built vessel or convert an existing one. A high-level summary of these considerations is provided below.

Figure 5.15. Purpose-Built vs. Conversion Vessel Comparison

	Purpose-Built	Conversion
CAPEX	Higher CAPEX dependent on shipyard supply-demand	Lower CAPEX dependent on O&G market supply-demand
Design	Opportunity to bespoke design, reduce OPEX costs	May have limited ability to convert with multi-purpose capability
Finance	Greater options available; including off balance sheet finance Typically easy to secure	Less options available Difficult if asset > 15-20 years
Timeframe	Currently ~3-5 years	~1 year
Fixed Costs	Higher due to finance charges	Lower, typically less finance charges
Opex	Lower	Higher (vessel age)
Longevity	Longer service life (40 years)	Service life depends on age/condition at acquisition

Source: TeleGeography, Infra-Analytics

Whether it is a purpose-built vessel or a conversion, incorporating multi-purpose capabilities helps mitigate market certainties by enabling the vessel to address adjacent market sectors, often at higher contract rates. Additionally, having a contracted vessel utilization pipeline, whether through maintenance agreements or installation projects, provides notable benefits for decision-making and financing opportunities.

5.3.1. Purpose-Built Vessels

Capital expenditure (CAPEX) for new-built vessels varies significantly based on design and function (installation and maintenance), and shipyards. CAPEX totals are highly sensitive to steel and propulsion system prices, which together make up about 45% of a purpose- build price.

Investing in a new vessel has several benefits:

- Wider range of finance opportunities (shipyard, ECA, bank or other loans)
- Higher asset collateral value
- Opportunity to reduce fixed costs by fewer on-board crew
- Ability to reduce OPEX costs through efficient propulsion and other systems
- Longer service life
- Bespoke design opportunity, (multi-purpose capabilities)

The economic advantages of purpose-built vessels must be weighed against higher finance charges, increasing fixed costs. Of note, greater fuel efficiency mainly benefits cable owners as fuel/lubricant costs are typically pass-through variable costs in maintenance agreements.

Figure 5.16. Purpose-Built Vessel CAPEX Metrics (USD m)

	Design & Build	Mission Equipment	Total CAPEX (Asian shipyard)
Installation/Multi-Purpose	$110-120	$35	$145-155
Maintenance Vessel	$90-105	$15	$105-120

Source: TeleGeography, Infra-Analytics

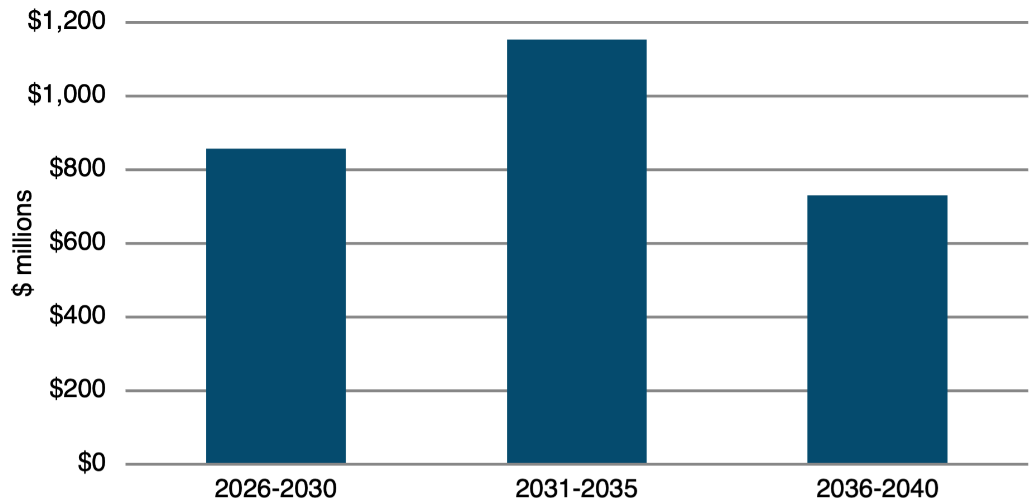
The indicative CAPEX metrics above refer to a mult-purpose CLV capable of transoceanic cable deployments but also serving adjacent markets such as offshore renewables or power cables.[73] A dedicated maintenance vessel will typically be smaller, with less cable-carrying tonnage and mission specific equipment.

European shipyard prices can be 10-20% more expensive although this price differential is slowly closing as shipyards in Turkey and other European locations develop lower cost expertise. Prices are also indicative of shipyard supply-demand dynamics.

Assuming all additional vessel requirements are met with multi-purpose, new-build vessels, the total CAPEX for twenty maintenance vessels required between 2026 and 2040 is an estimated $3.0 billion in current USD. A significant portion of this investment is anticipated to occur between 2026 and 2035, driven by the retirement of a large number of existing maintenance vessels.

[73] M3 Marine Group. Specifications: ~130m length, 24m beam, 6000-7000T cable capacity.

Figure 5.17. Replacement and Additional Maintenance Vessel Investment Requirements, 2026-2040



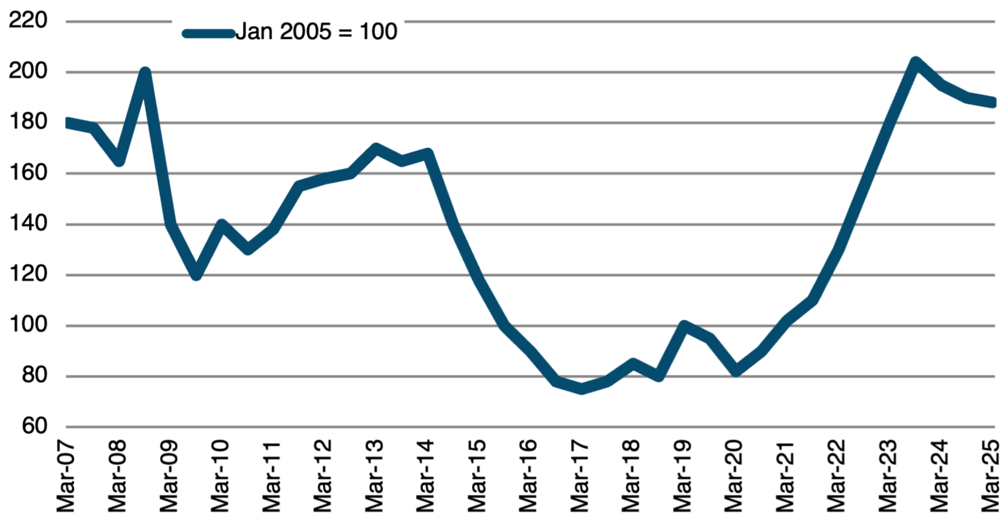
Source: TeleGeography, Infra-Analytics

Notes: Investment assuming multi-purpose vessels only with hybrid installation and maintenance capability.

5.3.2. Vessel Conversions

Selecting a suitable vessel to convert depends on several factors, but age is critical to ensure the investment return balances cost and remaining service life. The availability of second-hand vessels for conversion relies heavily on the supply-demand of the PSV and OSV markets that are associated with the oil and gas and offshore construction industries. When these industries are thriving, suitable vessels become scarce. The current supply-demand dynamics of the OSV market is captured in the following rates index (Figure 5.18).

Figure 5.18. Clarksons Offshore Support Vessel Index, April 2025



Source: Clarksons Research[74]

Clarksons Research Offshore Support Vessel (OSV) Index provides an insight into the current supply-demand for OSV vessels, comparing current index prices from a baseline index of 100 in 2005. Analysis of this data with an independent ship broker, substantiates the current supply-demand limitations to secure a suitable vessel hull to convert. In the past five years, market prices for suitable hulls have quadrupled compared to the previous period (Figure 5.19).

Figure 5.19. Vessel Conversion Scenarios

	Acquisition Date	Acquisition Price ($m)	Age at Acquisition	Conversion + Mission Eqpt ($m)	Total CAPEX ($m)
Vessel A	2019	18	14	20	38
Vessel B	2025	80-105	10-15 years	15-25	95-130

Source: TeleGeography, Infra-Analytics

Figure 5.19 provides a CAPEX guide associated with two conversion scenarios; vessel A an actual acquisition completed in 2019, vessel B representing two suitable target vessels currently available in the OSV market.[75] The assets referenced in Figure 5.19 have the capability to work in a hybrid role; across both cable installation and maintenance sectors. Mission specific equipment costs will vary in accordance to the chosen vessel design and capability (e.g. length, cable carrying capacity). If vessel operators have existing mission equipment inventory, the corresponding CAPEX figures will be lower.

Data indicates that the average age of converted vessels in the global fleet at market entry is 16 years, suggesting a remaining cable working life of 24 years, using a 40-year service life.

[74] Clarksons Research, "Offshore Support Vessel Monthly."
[75] Metrics sourced from M3 Marine Services, an independent ship broker, and an unnamed maintenance provider.

5.3.3. Supply Chain and Finance Considerations

Shipyard supply and demand also significantly affect both CAPEX and delivery timeframes. The present day shipyard demand is high, driving a purpose-build design and build timeframe of 3-5 years. On the other hand, a shipyard conversion timeframe is about a year once a suitable asset is procured. Moreover, recent years have seen lengthy delivery times for specialized cable working equipment (such as cable engines, A-frames, plows, and ROV systems) due to a relatively concentrated supply chain and robust order books.

While CAPEX for converting vessels has been typically less than constructing purpose-built vessels, the current shortage of suitable vessels for conversion has almost equalized investment CAPEX (see Figures 5.15 and 5.17).

Options to finance new-build vessels are greater than options for conversion, despite the typically lower CAPEX requirements. Shipyard finance, Export Credit Agency (ECA) or other traditional debt instruments are easier to secure for a vessel with a longer service life and higher collateral value. In contrast, financing second-hand vessels older than 10-15 years is challenging with less traditional finance options due to the shorter service life and lower collateral valuation.

Investment decisions are also influenced by the higher operating costs associated with second-hand vessels. Although some costs can be capitalized, these need to be factored into the investment case.

Investment in new maintenance vessels will likely be in assets capable of multi-purpose (installation and maintenance) capabilities. For certain vessel operators, this strategy may remain viable as it prolongs the working life of installation vessels and secures low-risk, maintenance revenue streams that are financially appealing, particularly if cable installation activities decline. Conversely, older vessels with substantial cable carrying capacity and higher operational expenses (e.g. fuel) do not represent the most cost-effective solution for maintenance operations.

5.3.4. Fixed & Variable Costs

Vessel fixed costs are a key metric when evaluating maintenance agreement commercial models. Fixed costs are a function of finance charges, depreciation and crew costs, but also need to cover corporate and other SG&A overhead. Other fixed costs include port, agency and other standby fees.

Fixed costs will be higher for purpose-built vessels than conversions due to increased financing costs. Industry experts estimate that annual fixed costs range around $14m-$16m for an older vessel that is either fully, or nearly fully depreciated.

From the vessel operators’ perspective, maintenance standing charges should generate sufficient revenue to cover a vessel’s fixed cost base. Similarly, variable charges, derived from repair operations and other services, should cover actual vessel operating costs. This straightforward, simplistic analysis does not account for other revenue opportunities (e.g. outside work) that contribute to overall revenue mix that can be leveraged to achieve a profitable and equitable maintenance agreement.[76]

[76] The introduction of EU carbon taxes charged against vessels transiting between EU ports will not substantially raise operating costs as taxes are applied against fuel/lubes only.

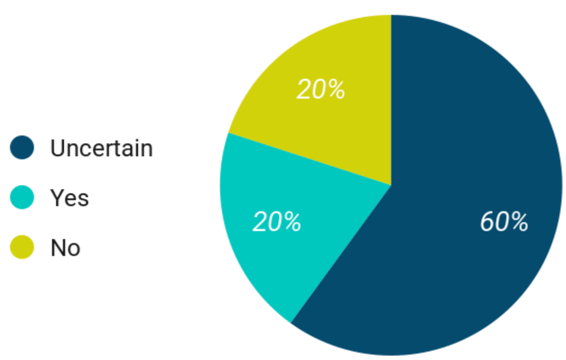
5.3.5. What to Build: Green or Not?

The maritime industry is in a period of flux. With pressure to lower carbon footprints, new EU carbon taxes are underpinning initiatives to adopt 'green' or alternative fuels, or even battery powered solutions. Several alternative fuel solutions are available to lower carbon footprints such as ammonia, hydrogen or biofuels that include methanol. These options do require bigger fuel tanks, therefore may not be as suitable for the smaller cable fleet vessels as larger maritime assets.

For some maritime sectors, alternative fuel options are easier to assess and implement. Cargo vessels, the example used previously, largely maintain set routes where port infrastructure for alternative fuels may already be in place or being actively planned.

The decision on what propulsion system is to be incorporated into a new build vessel can have a substantial impact, as these systems account for roughly 35% of new build CAPEX. Industry experts do not advocate the adoption of alternative fuels for the cableship fleet at this stage particularly when considering a large portion of the fleet operates globally, therefore compatible port infrastructure is a fundamental requirement. In addition, advances in battery technology supports greater fuel efficiency by supplementing the existing diesel-electric propulsion systems used in the existing CLV fleet.

Figure 5.20. Is reducing vessel OPEX by adopting alternative (green) fuels a viable option for new-build vessels?

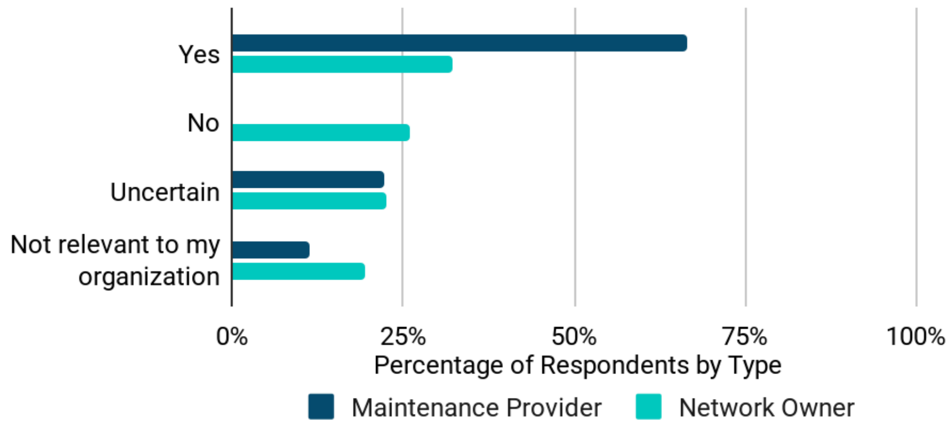


Source: Industry survey of maintenance providers by TeleGeography and Infra-Analytics

The uncertainty in adopting alternative fuels to lower carbon emissions and/or efficiency purposes is reflected by vessel operators in Figure 5.20. On the other hand, 67% of maintenance providers stated that their organization has established Environmental, Social, and Governance (ESG) initiatives that incorporate support for adopting some form of lowering carbon footprints through some form of "green" vessels.[77]

[77] The survey did not identify the alternative fuels or green technology that are available, as this broad subject is outside the direct scope of this study.

Figure 5.21. If your organization has an ESG policy, does it identify or support "green" marine vessels?



Source: Industry survey by TeleGeography and Infra-Analytics

A wait and see approach is wise, according to one vessel operator, suggesting that it's too early to make an informed decision regarding which solution will provide the optimum cost benefit. The other question of concern is whether the customer base will be willing to pay more for "green" marine services to offset any additional CAPEX costs.

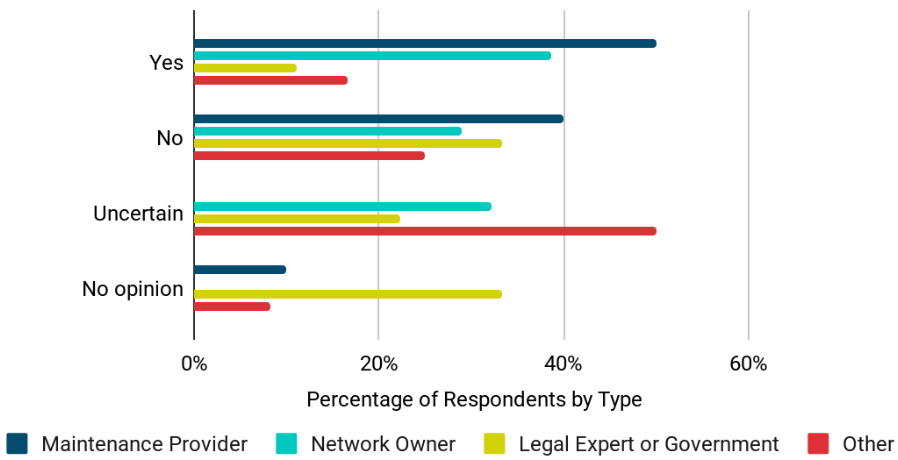
6. STRUCTURAL ANALYSIS

The economic viability and sustainability of the maintenance sector fundamentally depends on the capacity to service the expansion of cable kilometers and increase in cable repairs. Efficient use of capital and vessels creates a cost effective global maintenance footprint and structure. Fleet analysis identifies the maintenance fleet replacement and expansion needs (Figure 5.11). Capital investment relies on sustainable agreement structures and commercial models, and the certainty of investment returns.

This study does not imply that the cost sharing structure is no longer effective to meet the additional 770,000 km requiring maintenance services, nor the 36% increase in repairs anticipated by 2040.

Survey respondents have mixed views on the sustainability of current maintenance structures.

Figure 6.1. Do you believe the current maintenance zone agreements and structure are sustainable?



Source: Industry survey by TeleGeography and Infra-Analytics

This section identifies several interconnected aspects of the maintenance sector that require evaluation to ensure the future sustainability of the sector's capabilities. These aspects include:

- Agreement Structures
- Competitive Structures
- Operational Structures

Any modifications to industry structures must be evaluated within the context of the broader stakeholder macro-environment, which includes:

- Government Interests and Geopolitical Influences
- Corporate Interests
- Resource Expertise

6.1. Agreement Structures

To create value, maintenance agreements should balance customer costs and satisfaction with vendor profitability to ensure quality services conducted by capable assets. This concept includes balancing risk allocation and financial reward.

The economics of the existing agreements rest upon three basic pillars. Cable kilometer quantities, repair numbers and outside work opportunities that balance low vessel utilization rates.

However several aspects of current agreements do not sufficiently support this concept. Re-evaluation is needed to ensure sustainable agreements, commercial models, and service quality levels.

6.1.1. Agreement Terms and Pricing

Market demand and revenues play essential roles to support financing of repair fleet needs. A contracted vessel utilization pipeline provides both, thus extending maintenance agreement terms beyond the standard five-year period. It can also increase asset finance opportunities and support vendor investment decisions. The industry should consider moving to a minimum 10-year term as standard practice.

Likewise, agreement price points support vendor profitability. Consistent pressure to lower prices during agreement renewal negotiations represents a short-term view that discourages vendor investment decisions to replace or expand fleet assets.

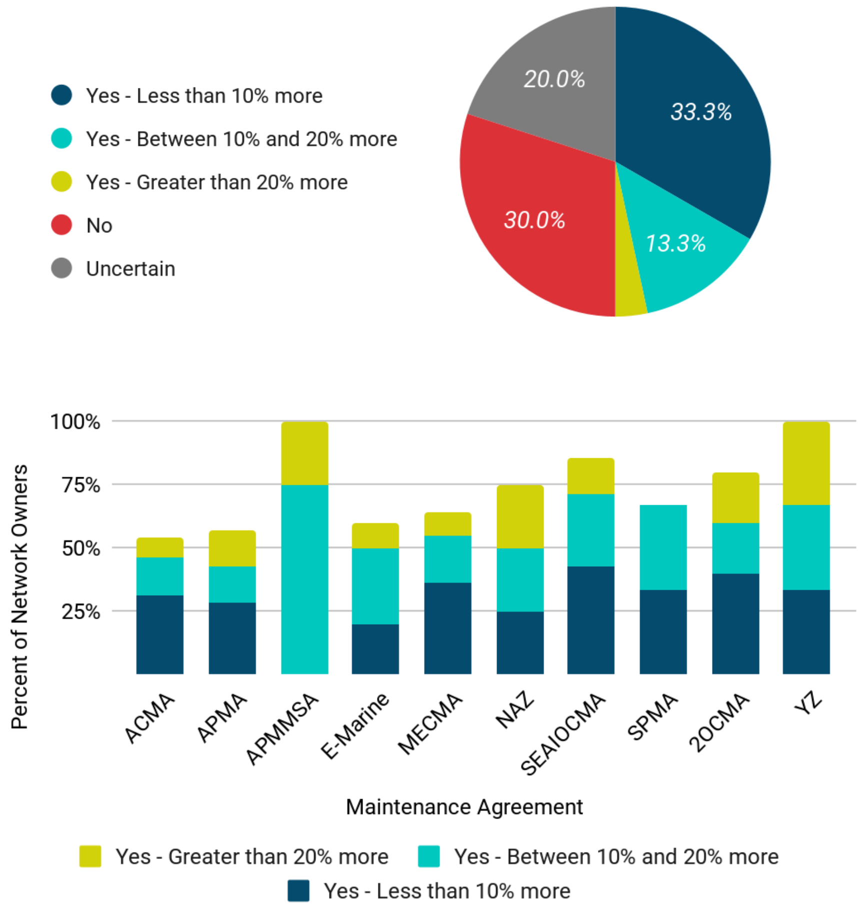
Raising prices (beyond inflationary adjustments) may be challenging, if service levels and vessel capabilities remain the same. Network owners have varying degrees of satisfaction regarding maintenance services, 50% of respondents want lower prices due to the high cost of marine maintenance relative to cable systems' operating budgets. This may infer that they do not consider existing models to be cost effective or reflect the quality of service provided. Other respondents indicate they are willing to pay more for improved service quality.

It is noteworthy that among the survey respondents:

- Only one network owner expressed a desire for shorter agreement terms.
- Over half of network owners and vessel operators indicated investment in new vessels was a change they would like to see.
- 50% of cable owners are willing to pay more to reduce repair queues and/or repair times. While 30% were not willing to pay more and 20% were uncertain.
- 75% of vessel operators would like to see a balanced vessel supply and demand.[78]

[78] One vessel operator stated greater transparency with system investors will allow forward planning.

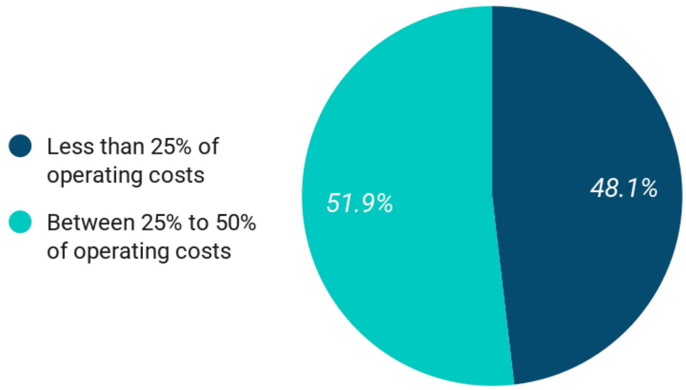
Figure 6.3. Would you be willing to pay more for marine maintenance to reduce repair queues and/or repair times (notwithstanding permit and other delays)?

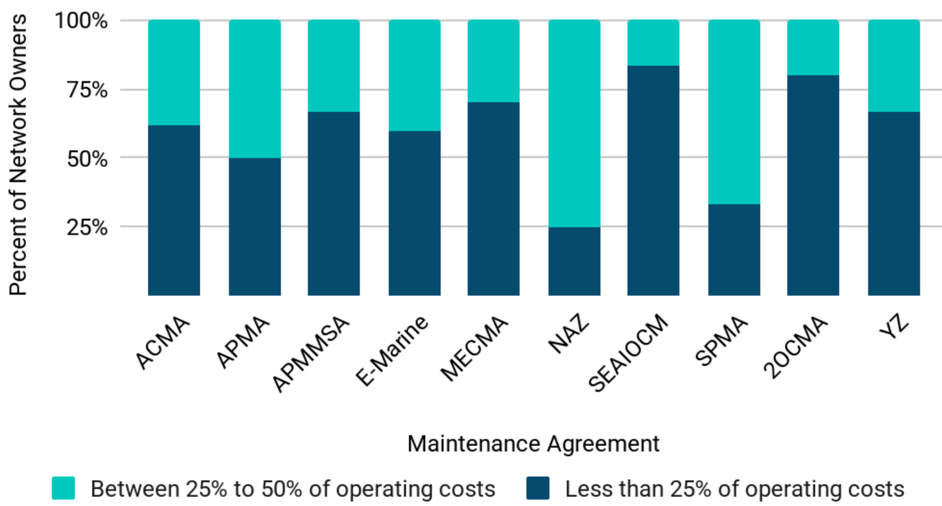


Source: Industry survey by TeleGeography and Infra-Analytics

Operating expenses of each cable vary across agreements, reflecting the underlying economic pillars of commercial models (Figure 6.4).

Figure 6.4. Approximately what percentage of a cable system/network annual OPEX does your organization spend on marine maintenance per year?





Source: Industry survey by TeleGeography and Infra-Analytics
Note: No respondents selected any answer greater than 50%. About half of network owners indicated participation in multiple maintenance agreements.

The data implies that in regions of low vessel utilization, higher annual fixed charges (standing charges) correspond with a higher cable system OPEX. This correlation is further supported by the observation that high repair rates, a consistent feature in Asia, supported by SEAIOCMA and Yokohama Zones (YZ) often result in repair backlogs.[79]

Standing charges directly influence vessel operators' risk profile. Higher standing charges mean a greater portion of fixed annual revenue is secured. Conversely, in regions with lower standing charges and greater vessel utilization, revenue risk increases as less fixed revenue is secured. This balance between risk and return influences vessel operators' pricing, profitability and investment decisions.

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[79] Not all regions are immune to repair backlogs as repair queues are often triggered by a major event, such as an earthquake that can cause multiple faults across multiple cables.

6.1.2. Cable Quantities

Significant reductions in cable km due to decommissioning, or shifts of cable km between competing agreements, undermine the economic fundamentals of maintenance agreements. This affects vessel operators in private agreements, and cable owners in consortium agreements.

Most regions are forecast to see higher (net) cable km growth. However negative growth is forecast in several regions in the near-term future (Figure 4.18). These short-term declines will not have a long-term commercial impact. Overall cable km growth leads to a net increase in kilometers over the 15-year period in all regions except Northwest Atlantic (-6%) and Southeast Pacific (-8%) which show slight decreases.

6.1.3. Depot Services

Depot services provide a synergy with vessel maintenance services. Some agreements integrate depots within the agreement, while others structure depot services under separate agreements.

Separating depot services from repair vessel services will address competitive advantage perceptions in the event that a formal tender process is undertaken during agreement renewal processes. Formal tender processes rarely occur due to several factors including lack of competition and new market entrants, excess vessel capacity and corporate affiliations. Depot services should be considered under separate agreements to mitigate competitive advantage concerns.

Depot services do not need to remain exclusively under the control of vessel operators, especially if third parties with the necessary expertise can provide these services in selected locations, to enhance the global maintenance footprint. A potentially more complex structure involves cable owners providing depot services by either leasing existing facilities for the duration of the agreement or by developing new facilities in locations they deem appropriate.

6.2. Competitive Structures

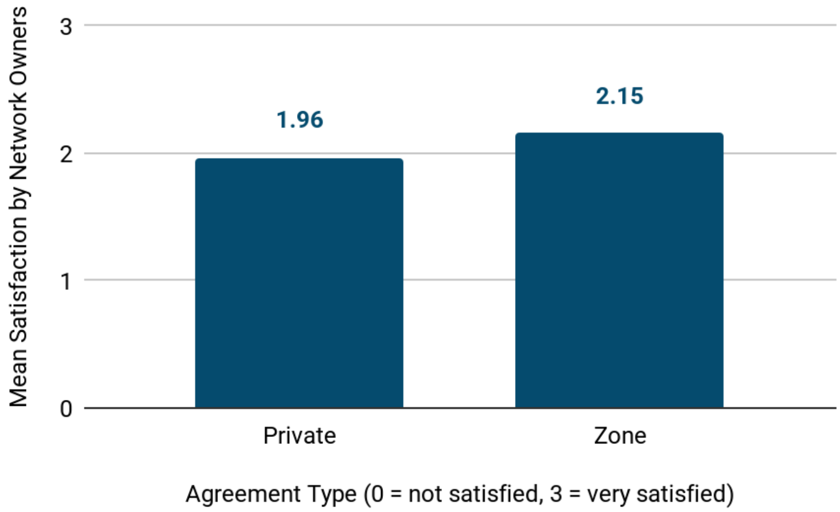
Cable owners generally view competition as beneficial, but not all vessel operators share this sentiment (Section 3.4). Therefore reexamining the current agreement-based competitive structure is valuable, if it leads to better service quality. Aggressive pricing can harm service quality and long-term agreement viability, but healthy competition can enhance innovation, efficiency, service quality and value

The current consortium zone-private agreement competitive structure faces considerable challenges. The methodology for conducting cable repairs is consistent regardless of agreement. There is only one methodology and process to affect cable repairs. There are no significant differences in the performance or quality measures (KPI's DMOQ's) between the agreements that substantiate a clear competitive advantage.

Price based competition for cable kilometers has other disadvantages other than undermining agreement economics. Attracting as many cable km as possible maximizes vessel operators revenue in private agreements, and lowers standing charges for cable owners in consortium models. In either event, if vessel operational capacity is exceeded, service quality suffers.

Introducing additional repair vessels to increase repair service capacity becomes challenging as this has a substantial commercial impact. Comparable network owners satisfaction levels between competing agreements are shown in Figure 6.5.

Figure 6.5. Are you satisfied with your current maintenance services?

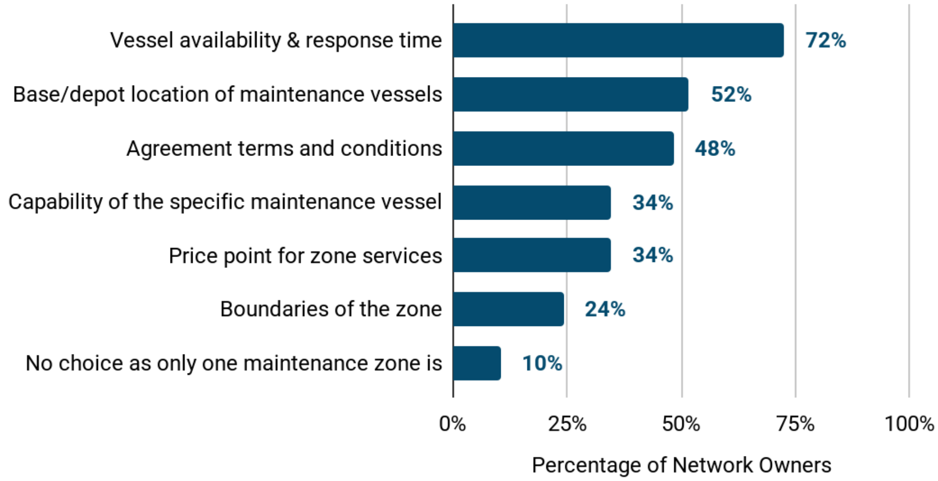


Source: Industry survey by TeleGeography and Infra-Analytics

Agreement-based competition is based upon overlapping agreement boundaries. In regions with low vessel usage, this hinders an efficient use of repair assets. However, regions like the Southwest Pacific with high cable kilometer growth and high repair rates benefit from competition as more vessels from competing agreements boosts vessel availability which is a major influence in agreement choice (see Figure 6.6).

Consolidating competing agreements fails to preserve a competitive environment. An alternative competitive structure necessitates a shift from an agreement-based to an asset-based framework. This focuses competition on service quality rather than risk allocation and can facilitate greater asset efficiency under a consolidation strategy. Service quality depends on asset availability, operator expertise, pricing and base port location. This new structure is more closely aligned with many parameters that are cable owners' priorities (Figure 6.6).

Figure 6.6. What factors most influence your organization's choice between a consortium or a private zone maintenance agreement?



Source: Industry survey by TeleGeography and Infra-Analytics
Notes: Respondents selected up to three responses.

Service providers can compete based on the merit of their assets and service quality. Cable owners pay for the specific capabilities and number of vessels they need. Cable depot ownership may benefit from restructuring as outlined in Section 6.1.3.

Not all regions offer competing agreements. The central and northeast Pacific lack competitive maintenance solutions. Other commercial and operational aspects will also need to be evaluated under a different competition framework.

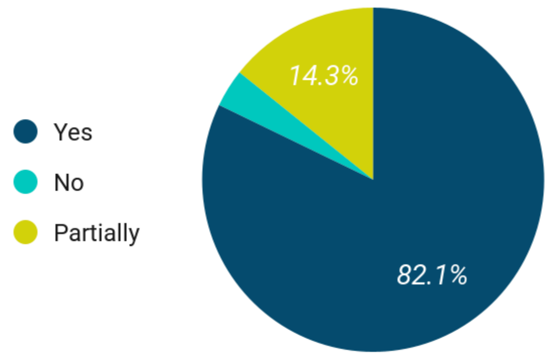
An alternative competition based approach, further developed in Section 7, aims to address the less advantageous characteristics of the current agreement-based competitive structure.

6.3. Operational Structures

6.3.1. Agreement Boundaries

The existing maintenance footprint does not fully encompass all future cable deployment routes. Over 15% of cable owners report that the maintenance boundaries do not fully align with their planned cable investments (Figure 6.7). Several thousand kilometers of cable in the advanced stages of deployment in the southern Indian and Pacific areas will fall outside of existing agreement boundaries.

Figure 6.7. Do current maintenance zone boundaries cover your planned new cables?



Source: Industry survey by TeleGeography and Infra-Analytics

Additionally, cable developments in the Arctic, connecting Asia to Europe, and the Antarctic will also fall outside current agreement boundaries.

A South American domestic cable completed in 2019 that was not located within an agreement boundary required an exemption to join an adjacent maintenance agreement. Although extending agreement boundaries for a single cable has precedent, it may not be a viable solution for all agreements.

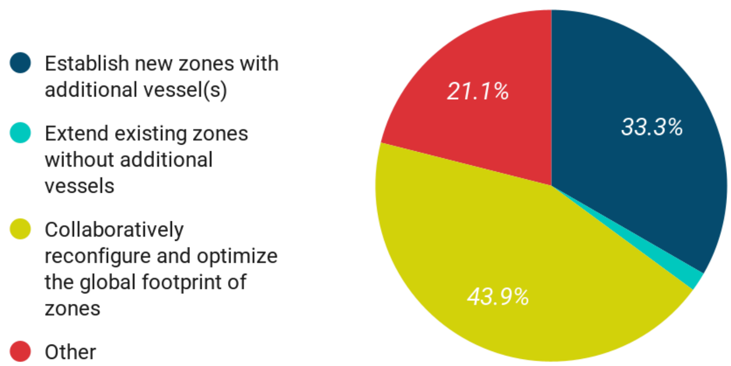
Extending boundaries to cover gaps in the Southern Indian and Pacific Oceans, may be possible but vessel transit times from existing base ports will be extensive under mid-ocean repair scenarios. To adequately address these known footprint gaps a reconfiguration of base ports (e.g. Australia) may be required, and/or an expansion of repair vessels that presents investment and resource challenges.

Both options must consider vessel capabilities due to the harsh weather conditions of the southern oceans. Extending boundaries to add additional cable kilometers has commercial advantages but operational realities must also be considered. Similarly, the capabilities of repair vessels to operate in polar regions is unlikely, if an agreement boundary is to be extended, or a new agreement structured to include cables planned for the Arctic and Antarctic regions. Polar Class repair vessels will be needed for operations in these areas.

According to survey responses, 34% support establishing new zones with additional vessels to expand maintenance coverage. However this solution assumes that the economic conditions and commercial realities support deployment of additional repair vessels, in addition to securing experienced resource expertise.

The large share of survey respondents (44%) prefer a collaborative approach to reconfigure and optimize existing agreement boundaries to address gaps in the current footprint (Figure 6.8).

Figure 6.8. What do you consider to be the best solution to cover gaps in the global maintenance footprint?



Source: Industry survey by TeleGeography and Infra-Analytics

Reconfiguring agreement boundaries will need to consider commercial and operational realities.

6.3.2. Repair Vessel Distribution

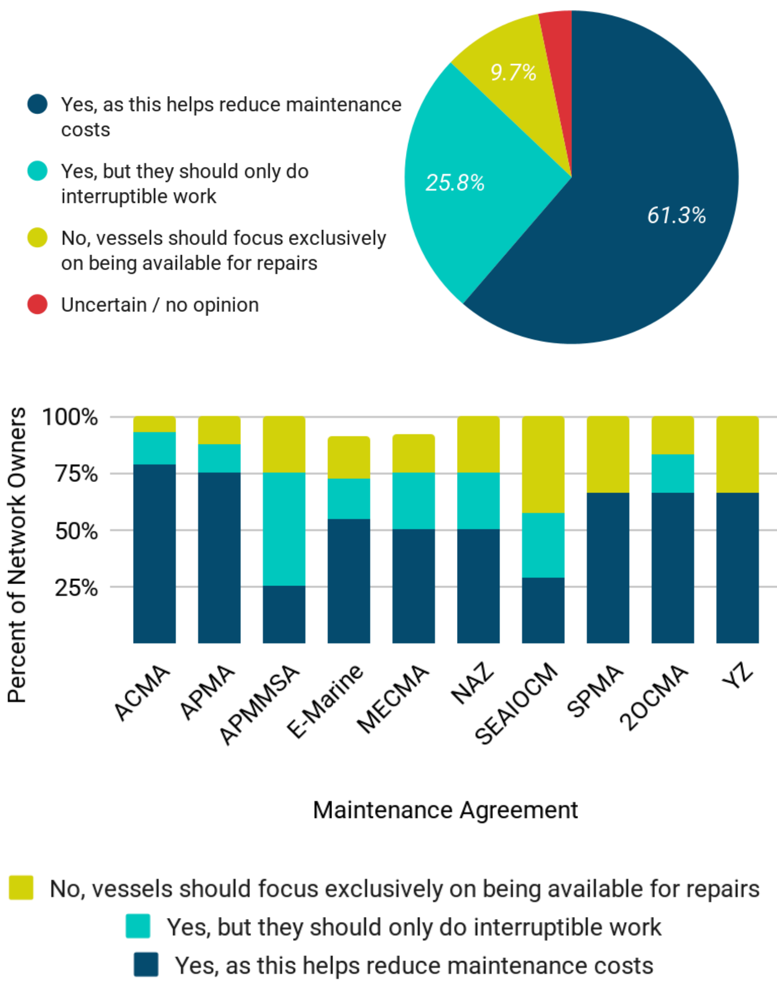
From an asset efficiency perspective, the current distribution and allocation of repair vessels are not optimal relative to the frequency of repairs. Consequently, some regions experience low vessel utilization while others face excess utilization. In essence, the distribution of repair vessels should reflect an optimal use of repair resources.

For instance, data suggests that consolidation of ACMA and APMA will result in excess capacity of one repair vessel that can be returned to the market. The combined fleet of six vessels is excessive based on the optimal efficiency of vessels and projected repair data.

The Northeast and Central Pacific regions, covered by the SPMA agreement and North American agreement (NAZ) are examples. Both have low fault rates and under-utilize the two contracted repair vessels. Consolidating these regions could allow one vessel to be reassigned elsewhere, although extensive vessel transit times to cover the amalgamated boundaries will likely preclude this option. Relocating the remaining base port can mitigate this impact but the prevailing repair locations makes this option unworkable.

These are simplified scenarios, as not all corporate interests are likely to benefit from a consolidation strategy, and other factors influence the distribution of repair vessels. According to the survey, 35% of cable owners support the concept of agreement consolidation when questioned about structural changes.

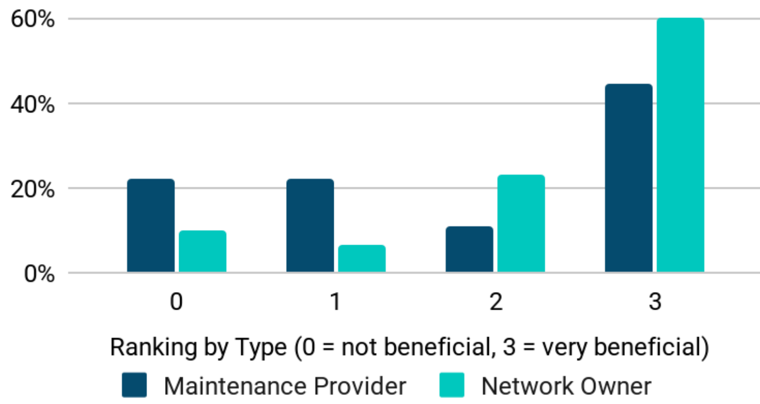
Figure 6.9. Maintenance vessels sometimes take on outside work (like new cable installations), which can be interruptible or non-interruptible in the case of a fault. Should this practice continue?



Source: Industry survey by TeleGeography and Infra-Analytics

Flexibility to undertake outside work can support vessel utilization and profitability, although not all repair vessels possess similar capabilities. Most survey participants support the flexibility provided by outside work, but network owners with cables in the APMMSA and SEAIOCMA agreements (which cover regions with high repair rates) show less preference for outside work provisions, according to survey feedback (see Figure 6.9 above).

Figure 6.10. Would it be beneficial if repairs could be conducted anywhere by any vessel?



Source: Industry survey by TeleGeography and Infra-Analytics

Both vessel operators and cable owners value having complete flexibility regarding vessel distribution and operational activities (see Figure 6.10). This reflects the differing philosophies of each stakeholder. Some cable owners regard payment for vessels as a type of charter arrangement whereas vessel operators broadly see their assets providing a specific service under their complete control. The opportunity to reassess these contrasting philosophies needs to be considered and balanced in a hybrid agreement model.

Consolidating agreements, reconfiguring and expanding boundaries, re-distributing repair vessels and relocating depot facilities, while balancing flexibility, corporate interests, and maintaining competitive elements are all key factors to consider in any restructuring proposition.

Analysis of several potential scenarios are likely to improve the efficacy of maintenance services. These scenarios are not necessarily mutually exclusive. This study aims to identify potential regional alternatives based upon forecast data, that also contemplate stakeholder interests.

6.4. Stakeholder Macro-Environment

6.4.1. Government and Geopolitical Interests

Government interests are broadly underpinned by two clear objectives: Ensuring cable network infrastructure, supply chains and repair capabilities are secure, robust and resilient; and establishing a trusted subsea cable ecosystem that includes the maintenance sector. Both aim to alleviate national security concerns and ensure uninterrupted connectivity in the event of a major cable outage scenario.

Cooperation between the public and private sectors is not without precedent. Recent collaboration and financial support has enabled cable connectivity from island nations to transoceanic cable systems where private investment is not economically feasible.[80] Other support has funded feasibility studies in the Indo-Pacific and South America. Various funding mechanisms have been employed, including Export Credit Agency (ECA) guarantees, direct loans, and development grants from individual governments and multilateral infrastructure development partnerships.[81]

6.4.1.1. Resilient Repair Capabilities

Notwithstanding the urgency to streamline the repair permit processes, government objectives to boost supply chain resilience are best served by financial support of industry investment in maintenance vessels.

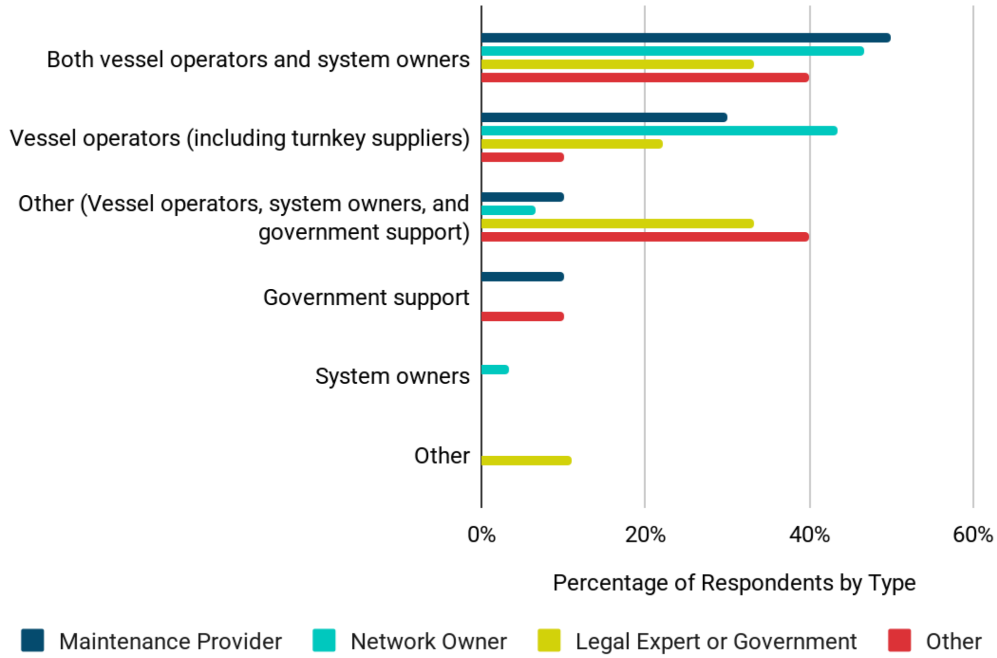
Vessel investment support through grants, loans or loan guarantees will likely come with conditions. The argument for government support may reduce the cost of industry investment, but depending on the level or terms of support, "the industry may have to accept that governments may have a first right of refusal in the unlikely event of a major disruption."[82]

Securing government investment support for fleet expansion and/or replacement could provide several indirect advantages. It might reduce government initiatives to independently procure sovereign repair capacity, thereby retaining this capability under industry control and preventing the fragmentation or disruption of existing maintenance structures. Additionally, financial support could expand the global vessel base to alleviate repair vessel expansion challenges and help enhance an optimum service-quality footprint. Alternatively government support may address vessel supply-demand constraints that are present in cable installation activities.

According to the survey, 61% of participants support vessel co-investment from various industry stakeholders, but less than 17% think governments should directly participate. Only two participants (5%) believe vessel investment should be exclusively government-funded.

[80] Channer, "Improving Public-Private Partnerships on Undersea Cables."
[81] "SUBCO"; "Public Information Summary"; United States Department of State, "The United States Partners with Australia and Japan."
[82] Anonymous, Conversation with an industry expert, February 2025.

Figure 6.11. If new investment to expand, replace, or maintain cable vessels is necessary, who should provide that investment?



Source: Industry survey by TeleGeography and Infra-Analytics

6.4.1.2. Trusted Ecosystem

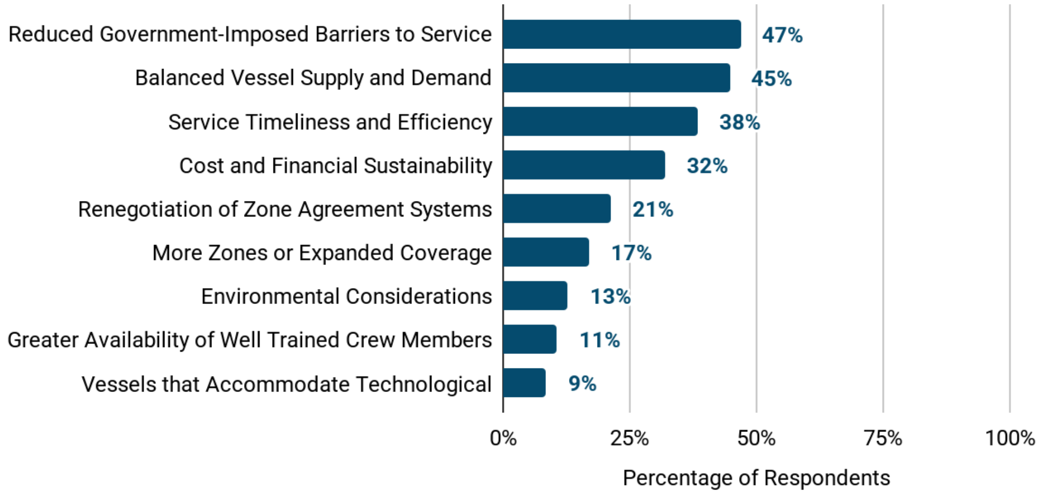
Section 2.4 describes a government regulation scenario that may be invoked as a condition of cable landing licence approvals, or other regulatory and/or security agreements. The scenario outlined may necessitate an increase in repair vessels to ensure that vessel ownership and repair operations comply with the trusted ecosystem concept. It may also fit with some governments' preference to secure sovereign repair capabilities. Either way, this scenario will impact existing agreements in some regions.

U.S.-China tensions may lead to Chinese cable owners choosing to leave the broader subsea cable ecosystem on their own initiative by withdrawing Chinese cables from current agreements and utilizing Chinese-owned maintenance vessels for their own systems. These actions will impact the commercial models of established maintenance agreements. Notably, several Chinese-owned vessels have entered the market in recent years.

As various governments consider sovereign maintenance vessel capability, future policies may impose restrictions on foreign-flagged repair vessels operating within territorial or EEZ waters, similar to existing Indonesian cabotage regulations, though the industry doesn't consider this likely (Section 2.3).

Government interests and the geopolitical environment must be considered in any maintenance agreement restructuring or reconfiguration. These scenarios are unlikely to be welcomed by all industry stakeholders.

Figure 6.12. What are your top three wishes for the future of marine maintenance by 2030?



Source: Industry survey by TeleGeography and Infra-Analytics
Notes: Written responses were grouped into the broad categories above.

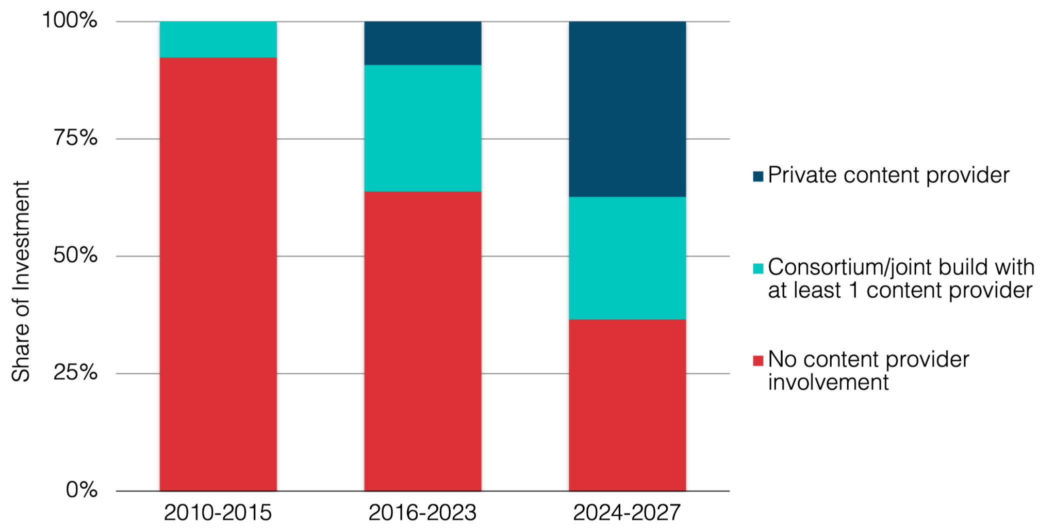
6.4.2. Corporate Interests

A sustainable repair platform provides advantages for both cable owners and vessel operators. The corporate parent-subsidiary affiliations described in Section 3.5 is a pragmatic strategy that has been effective in Asia for over thirty years.

Success has implications. Telecom parent companies support their vessel-operating subsidiaries' investments and use corporate influence to secure their role as service providers. This mutually beneficial system hinges on parent companies maintaining majority voting rights by virtue of their influence as cable system investors.

Over the last decade, content providers have overtaken traditional telecom carriers in cable system investments. They now invest more than all other cable owners combined, causing a decline in the share of investment by carriers. This trend is most evident on trans-Atlantic routes, where private content provider cables account for all new cables entering service from 2024 to 2027.

Figure 6.13. Content Provider Share of Investment in New Submarine Cable Systems, 2010-2027



Source: TeleGeography
Notes: Years refer to cable ready-for-service (RFS) dates. Figure includes both in-service cables and announced cables planned for the near future.

These investment trends are expected to continue, weakening the influence of parent organisations in consortium agreements, as older cables retire and power shifts to content provider investors. This vertically-integrated ecosystem also limits choice and flexibility, raises entry barriers and deters new market entrants.

Over the past decades, few new market entrants have successfully navigated a tenable position in the cable maintenance sector. The barriers to entry are substantial, encompassing not only significant capital investment but also the need for technical expertise and industry relationships.

6.4.3. Resource Expertise

Attracting new talent to the subsea cable industry is a well-known challenge. The obstacles to entering the submarine cable ecosystem extend beyond capital expenditure and technological innovation. Equally significant are the capabilities and expertise of vessel operating personnel that are essential to delivering high-quality maintenance services.

An increase in the number of cable repair vessels necessitates a corresponding increase in experienced offshore crews and specialized expertise, such as cable jointing technicians. Each repair vessel requires two full crews, with additional staffing for contingency purposes. Although outside the scope of this study and forecast modelling, several survey respondents noted this issue as a concern.

7. ALTERNATIVE APPROACHES

This section suggests alternative structures for industry stakeholders to contemplate, with the goal to tackle fleet capital requirements, improve repair vessel efficiency while facilitating healthy competition and readjust risk between cable owners and maintenance providers.

Attempting to provide a single, alternative global structure is impractical, given the significant number of commercial interests and operational complexities involved. Collaboration between industry stakeholders is essential for any alternative maintenance structure to be considered. Alternative approaches are based upon cable kilometer and repairs forecasts and vessel requirements data modelled in Sections 4 and 5.

The alternative structures presented are not necessarily mutually exclusive. Variations of each structure can be considered alongside other structures.

7.1. Retain the Status Quo

The significant challenges in the maintenance sector—vessel capability, an aging fleet, and service quality—can potentially be addressed by existing maintenance providers. However, this would require a collective investment of approximately $3.0 billion (in today's terms) to fund the acquisition of 15 replacement vessels and five additional vessels. This investment is necessary to sustain current service levels and reduce repair delays. Notably, this capital expenditure does not account for vessel replacements or expansions within the cable installation sector.

No maintenance provider has ruled out investment in replacement vessels, or fleet expansion, although many cite pricing and market uncertainty as inhibitors (see Figure 5.14). In the event industry stakeholders are willing to maintain the status quo, that uncertainty will remain. At a minimum, stakeholders should strongly consider longer agreement contract terms, to increase market certainty for maintenance providers. Several agreements will be due for renewal negotiations towards the end of the immediate five-year period. By 2030, five replacement vessels will be required across most regions including Europe, Asia, Africa, Oceania, and the Middle East (Figure 5.12).

Maintaining the status quo has commercial and operational impacts.

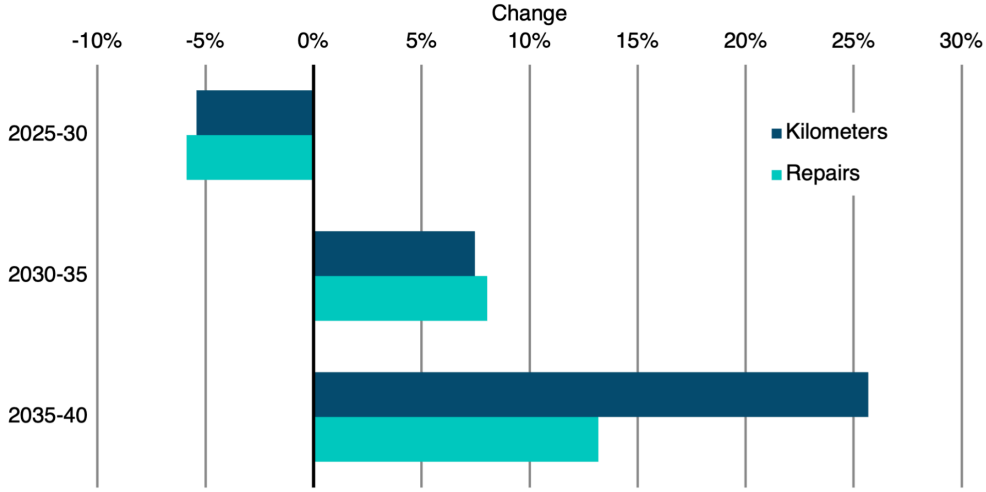
7.1.1. Commercial Impact

Figure 4.18 illustrates that three regions show a negative growth rate of cable kilometers in the immediate five-year period. The Western Atlantic regions show a combined loss of around 35,000 km. To put this loss into context, using a generic $100 per kilometer fixed fee price point, this amounts to an annual loss of $3.5 million that will impact either cable owners or vessel operators. This simplistic equation does not infer such loss will occur in year one, as cable retirements will likely occur over separate years. The Southeast Pacific also has a forecast loss of approximately 10,000 km. Other regions benefit from sustained cable kilometer growth, but will face vessel capacity and operational challenges in areas of high repair rates.

7.1.2. Operational Impact

The frequency of repair queues that primarily form in Southeast Asia will likely rise as cable kilometer growth of 52% and 70% is forecast in the Northwest and Southwest Pacific regions, respectively. This growth totals an additional 295k kilometers of cable that requires maintenance services, in a region which already has a high number of repairs.

Figure 7.1. Northwest and Southwest Pacific Kilometer and Repair Growth, 2025-2040



Source: TeleGeography
Notes: Data reflect the sum of the Northwest and Southwest Pacific regions.

The corresponding number of repairs forecast will jump by 42% to around 170 repairs per year. An additional repair vessel is required within the next five years to maintain current service levels that arguably are already stretched. A further four vessels would be required in the subsequent decade. This doesn't include the eight vessel replacements needed in the forecast period (Figure 5.11).

Maintaining the status quo also won't resolve the estimated 10,000-15,000 km that fall outside existing agreement boundaries, or address any new routes that may be developed. In addition, if individual cable owners choose to extend the life of their cables, the problem of the collective capacity of repair vessels in the Western Pacific will become even more acute in the near-term.

7.1.3. Cable Ownership Transition

Content providers heavily influence future cable system investment, particularly in the Atlantic, Pacific, and other high capacity routes (Figure 6.13). As legacy cable systems owned by telecom operators are slowly decommissioned, voting power within traditional consortium agreements will transition to the largest investor base.

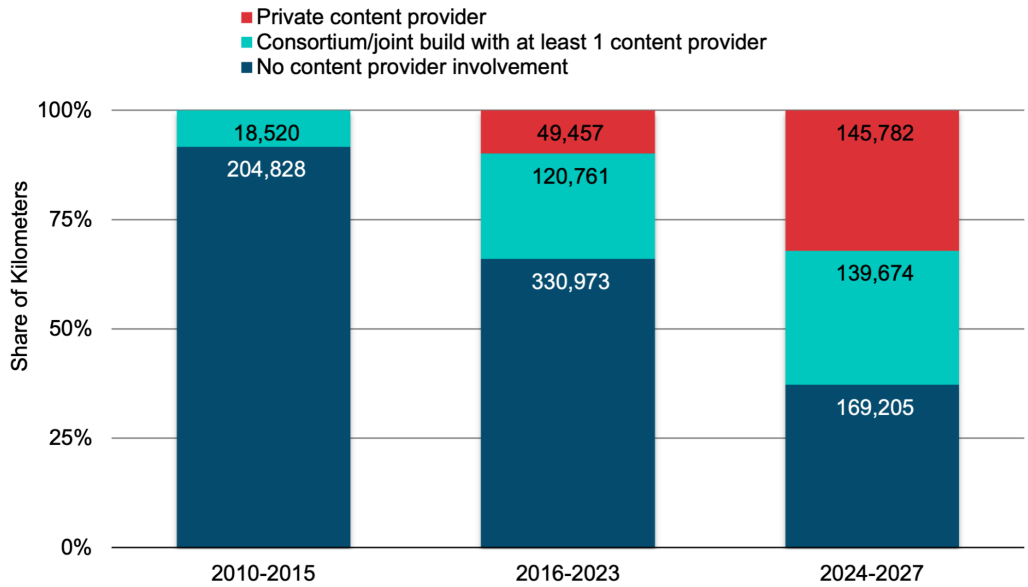
A reasonable conclusion is that the economics and cost-benefit associated with owning and controlling a vast global network, such as those owned by the content providers, could support the opportunity to develop an alternative bespoke maintenance solution. This solution may be completely separate from existing agreements if the content providers believe that this strategy offers a more efficient and cost-effective solution. This proposition is not without precedent.[83] A long-term bespoke agreement will provide adequate market certainty for a vessel operator to raise finance to invest in a few dedicated vessels and give the content provider(s) the flexibility to use these vessels to support maintenance operations and other installation activities. Conceptually, content providers can position these vessels at designated locations that provide the optimum maintenance service based on their own network's fault history. Spare wet-plant can be sorted on all vessels for greater operational flexibility.

This development will also complement some geopolitical interests, if U.S. owned (or allied) maintenance vessels were introduced to maintain the content providers' network. The "trusted ecosystem" concept will be achieved as it will encompass both cable installation and maintenance services (Sections 2.3 and 6.4.1.2). In the event a new market entrant is introduced to facilitate this strategy, they will face the resource and expertise constraints discussed in Section 6.4.3.

Content providers currently own or are part of consortia that will operate approximately 482,000 km of cable by 2027, based on existing and announced systems. Removing this substantial amount of cable from current agreements would create a significant negative economic impact on numerous consortium and private agreements. This scenario is further detailed in the figure below.

[83] In 1999, Global Crossing acquired Cable and Wireless Marine (renamed Global Marine Group). This strategy not only unlocked the vessel supply-demand bottleneck that prevailed at the time, but also facilitated a bespoke, dedicated maintenance solution for Global Crossing's network.

Figure 7.2. Content Providers Share of Global Cable Kilometers, 2010-2027



Source: TeleGeography

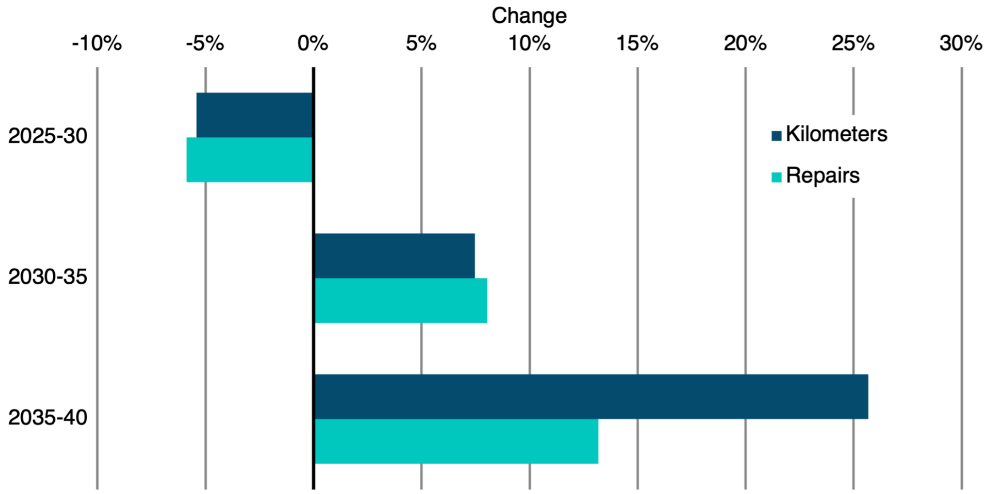
Notes: Ranges refer to year cables entered service. Retired cables excluded.

The authors emphasize that this scenario was not suggested or inferred by any content provider during this study. Considering the looming decommissioning of legacy cable systems owned by telecom operators and the anticipated increase in content provider-funded cables, the long-term economic implications of this scenario warrant consideration.

7.2. Consolidate and Restructure: Atlantic Regions

The Atlantic regions are primarily serviced by two competing maintenance agreements which have extensive overlapping boundaries: the Atlantic Cable Maintenance Agreement (ACMA) and Atlantic Private Maintenance Agreement (APMA). Unlike Southeast Asia, the Atlantic experiences modest growth in cable kilometers, repairs, and vessel utilization. However, negative growth in cable kilometers is expected over the next five years (see Figure below). These combined factors support an alternative maintenance solution for the Atlantic to create a more efficient and cost-effective value proposition. This alternative solution should both optimize the efficiency and improve services by consolidating the existing agreements while also maintaining a competitive component. By reconfiguring both vessels and depots, cost-effectiveness and service would improve. A restructuring of this scale would require a collaborative stakeholder approach and a transition from agreement-based competition to a competitive service-quality perspective.

Figure 7.3. Atlantic Regions Kilometer and Repairs Change, 2025-2040



Source: TeleGeography
Notes: Data are the sum of the Northeast, Northwest, Southeast, and Southwest Atlantic regions.

Data shows that the cable kilometer increase in the Atlantic will reach around 155,000 km (28%) over the 15-year period.[84] The expected decommissioning of many cable systems in the next five years explains the negative growth data (Figure 7.4). Repairs are expected to increase slightly (15%), with 55-60 repairs per year by 2040. Of these, roughly 80% will likely occur in the Northeast and Southeast Atlantic.

7.2.1. Hybrid Commercial Model

Figure 3.2 shows that the varying commercial risk, and operational models of consortium and private agreements appeal to different cable owners. Consequently, merging a consortium and private agreement into a single agreement may not be preferred by all cable owners. However, this approach presents an opportunity to develop a hybrid model that integrates elements of both models that also includes a longer-term agreement. The development of a hybrid model needs extensive collaboration and transparency between cable owners and vessel operators. Forming a management group that represents all cable owners to work with vessel operators will expedite decision-making to draft a Heads of Terms agreement (Term Sheet) that outlines how the hybrid model will work. Ultimately, cable owners will execute separate agreements with vessel operators that may include tailored requirements that should adhere to the Term Sheet. The Term Sheet ought to include:

- The number of vessels required, and base port/depot locations
- Pricing and other commercial terms
- Mechanisms to address cable kilometer increases or decreases

[84] Includes Northeast and Southeast Atlantic, Northwest and Southwest Atlantic and the Southeast Pacific region. Excludes the Mediterranean.

- Outside work provisions
- Revenue sharing mechanisms
- Allocation of liability between counterparties
- Service Performance and Quality Measures
- Provisions for the event of multiple simultaneous repairs
- Collaboration arrangements between vessel operators
- Agreements for depot facilities and services

This list is not comprehensive but outlines a framework for a hybrid commercial model that aims to adjust risk allocation and balance the interests of all parties.

7.2.2. Collaborative Tender Process

Section 6.2 suggests that competition between agreements offers limited benefit beyond price pressures that is arguably not a long-term value proposition. A collaborative tender process will better address stakeholders needs, promoting competition based on service quality and vessel capability.

The management group can oversee and administer the tender process. Tenders will differ in pricing and vessel capability, enabling cable owners to select vessels they consider are fit-for-purpose and pay accordingly.[85]

Agreements with each vessel operator will need to account for base port locations and areas of operation, as this factor influences the operators' commercial risk, revenue composition and profitability (Section 3.2). If required, an annual financial "true up" arrangement may be incorporated, but this should be captured in the Term Sheet for transparency purposes.

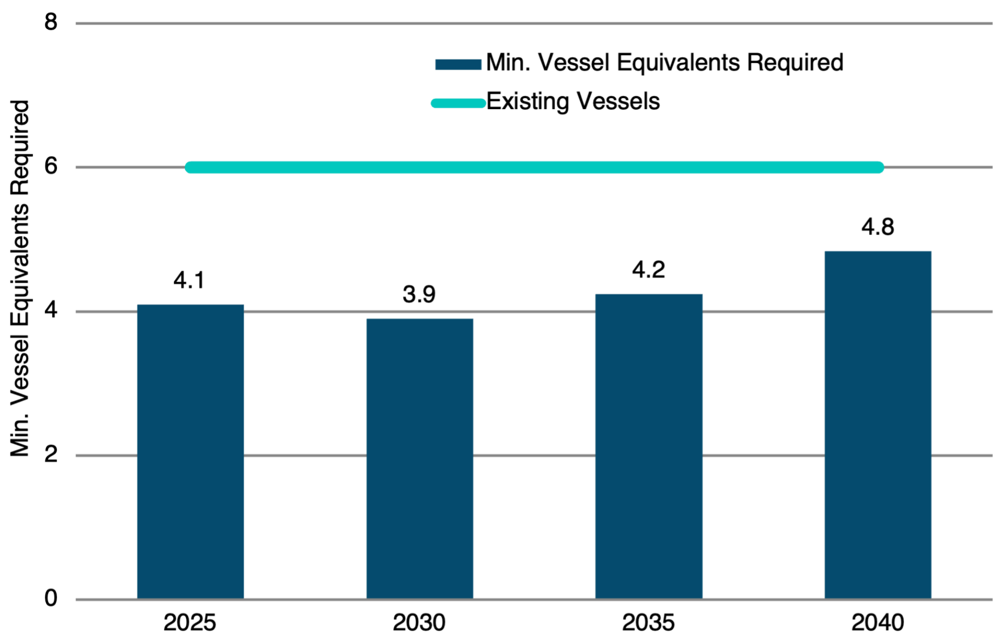
From a vessel operator's perspective, consideration of corporate interests can be reflected in tender proposals. Older vessels with lower fixed costs may reflect lower tender pricing however the capability of these vessels will be adjudicated in the tender process. Similarly, if corporate interests favour long-term maintenance contracts over alternative options, those interests can also be reflected in tender proposals. Notably, some repair vessels that currently service the region have multi-purpose capability and therefore can work in adjacent sectors (like offshore renewables or power cables), opening alternative options and flexibility for vessel owners. A tender process retains a competitive element, but aims to also balance the differing philosophies regarding agreement control between stakeholders.

7.2.3. Vessel Reconfiguration

Vessel utilization rates of the six repair vessels that currently serve the region, range from 25% to 40%. The northeastern Atlantic exhibits the highest rate of vessel utilization.

[85] Vessel design, Remotely Operated Vehicle (ROV), power, and other technical parameters will dictate vessel capability.

Figure 7.5. Atlantic Vessel Requirements, 2025-2040



Source: TeleGeography, Infra-Analytics
Notes: Data are the the total of the Northeast, Northwest, Southeast and Southwest Atlantic regions.

For optimal efficiency, five vessel equivalents are needed over the forecast period. Using this premise, the logical vessel to remove is a vessel based in Curacao, as repair and utilization rates in this area are moderately low, and data suggests one vessel has sufficient repair capacity. Removing a European based vessel is not suggested due to the repair frequency of this area.

Maintaining a vessel in the Cape Verde location is reasonable, though repairs in the southern Atlantic are roughly one-third of total repairs, the average vessel utilization is the lowest, compared to other regions. This region is also supported by the 2OCMA vessel located in Cape Town.

However, retaining all six vessels affords greater flexibility to reconfigure base port locations. Duplicate vessels stationed in Curacao, is not the most efficient use of these assets. Relocating one vessel (and depot) to the west coast of Central or South America, (e.g. Panama) eliminates the time and cost impediments of transiting the Panama Canal. This relocation will enhance services in both the Caribbean and Southeastern Pacific, while enabling an extension of the current boundary to cover a footprint gap in the Southern Ocean.[86]

7.2.4. Depot Reconfiguration

Currently six depot facilities support the Atlantic region, excluding two 'independent' depts in Baltimore and Halifax. Consolidating the two French depot facilities into one will achieve cost-efficiencies. However, retaining two depots in Europe (France and U.K.) maintains the

[86] Transit times from Curacao to Chile (southern boundary of ACMA) range from 11-15 days minimum, complicated by potential for Panama Canal delays.

optimal service footprint. Depot facilities will need to increase space to accommodate the spare plant of the increase in the number of cable systems anticipated.

7.2.5. Challenges

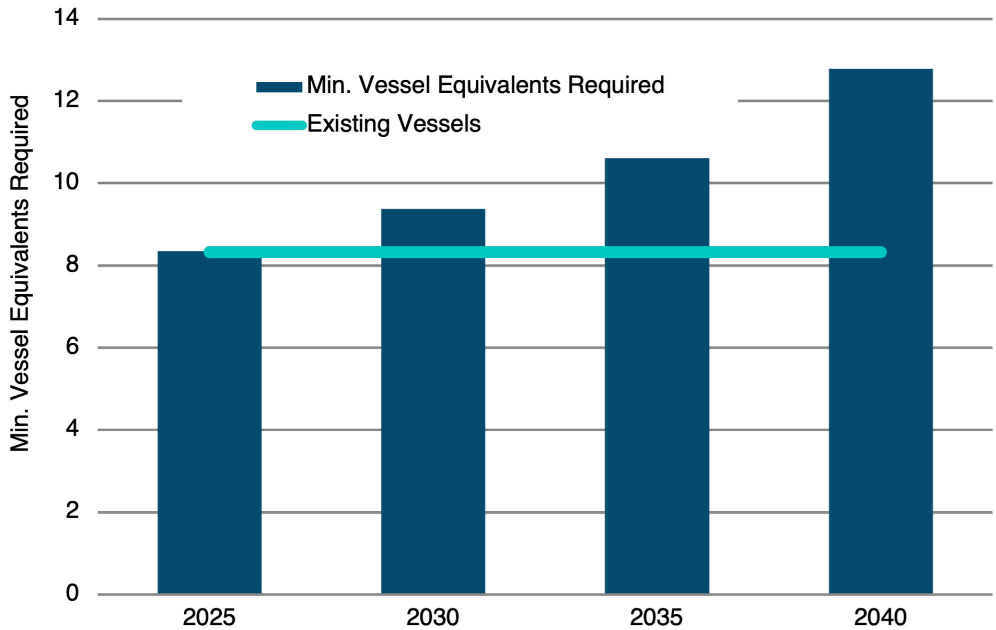
In summary, reducing the number of depots from six to five can lead to cost efficiencies. Eliminating one vessel can enhance efficiency, but retaining all six vessels and relocating one from Curacao to the eastern Pacific improves service quality.

Conflicts arising from competing corporate interests can pose significant challenges in reaching a mutually acceptable outcome. Nevertheless, there are already collaboration arrangements between maintenance providers within the existing Atlantic agreements. Additionally, the relationships between parent company system ownership and vessel-operating subsidiaries are less common in this region compared to Southeast Asia. A successful outcome should serve as a model for other regions with competing agreements, illustrating how cost efficiencies and vessel reconfiguration can improve service levels.

7.2.6. Other Regions: Asia Pacific

The Northwest and Southwest Pacific regions may also benefit from a consolidated agreement structure. Currently served by two consortiums and one private agreement, these areas face the challenges detailed in Section 7.1 and illustrated below (Figure 7.6).

Figure 7.6. Northwest and Southwest Pacific Vessel Requirements, 2025-2040



Source: TeleGeography, Infra-Analytics
Notes: Western Pacific and Indian Ocean requirements are the total of the Northwest, Southwest, and Central Pacific regions.

Currently, eight repair vessels provide maintenance services from various base ports. The disproportionate volume of repairs in Asia results in substantial vessel utilization rates, often surpassing capacity. Forecasts predict a 53% increase in repairs from 2025-2040 in the Northwest and Southwest Pacific regions, necessitating a fleet of 13 vessels to adequately serve the region. Estimated capital investment for additional vessels is around $750 million.

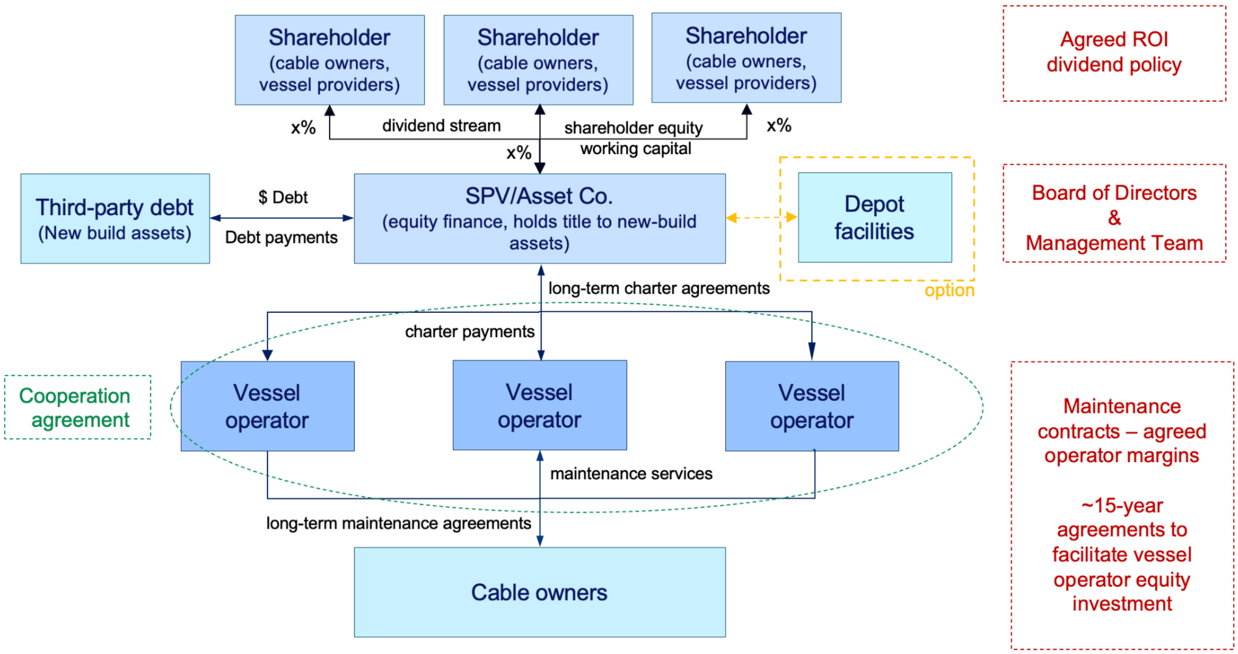
A comprehensive regional analysis will potentially enhance the optimization and expansion of vessel numbers and base port locations. This will ensure improved services to southern areas, including Australia, and address the gap in maintenance cover the Southern Indian and Pacific Oceans.

7.3. Co-Investment Structure

Southeast Asia has maintained a stable maintenance platform primarily by virtue of corporate ties between cable owners and vessel operators, as detailed in Section 3.5. Nevertheless, the region faces substantial investment challenges to replace and expand maintenance vessels.

A co-investment strategy offers a practical solution for addressing the significant vessel investment challenges, bridging gaps in the maintenance footprint and aligning the mutual interests of cable owners and vessel operators within a hybrid agreement model. Figure 7.7 illustrates a possible co-investment structure along with related commercial agreements and revenue flows.

Figure 7.7. Co-Investment Structure



Source: Infra-Analytics

7.3.1. Shareholding Structure

Having a limited number of investors is beneficial to reduce joint venture complexities. It is preferable that cable owner investors have long-term cable development goals to ensure their interests align beyond any legacy cable assets that may be decommissioned in the near or medium-term future.

An appropriate dividend policy can frame a pre-agreed return on investment that meets shareholders' financial benchmarks. A Special Purpose Vehicle (SPV) limits liabilities, though shareholder guarantees might be needed for vessel financing. Employing a suitable dividend policy can ensure a predetermined return on investment that aligns with shareholders' objectives.

7.3.2. Special Purpose Vehicle (SPV).

The SPV will function as an asset holding entity, governed by a Board of Directors, which includes both shareholder representatives and independent non-executive directors. An independent SPV management team will create an autonomous organization that operates without conflicts of interest and ensures ethical corporate governance and transparency. This structure will help ensure that all stakeholder interests are treated equitably.

Shareholder equity can be used to secure debt or other asset-based finance to fund new repair vessels. The SPV will act as the contract counterparty with shipyards and mission-specific equipment vendors. If vessel designs are standardized across all vessels, each vessel's fixed costs and operational capabilities will be comparable.

The SPV will retain title to all assets and structure long-term charter agreements with vessel operators. Charter revenues should be structured to cover debt servicing and dividend distributions to SPV shareholders.

Depot facilities can be owned by the SPV, unlike traditional structures. This separation from vessel operators ensures fair service and prevents perceived competitive advantages.

7.3.3. Hybrid Agreement Model

A hybrid model, as referenced in Section 7.2, could be proposed. This structure will not incorporate a formal tender process for vessel operators; therefore, the Term Sheet concept will govern the commercial and operational framework for vessel operators. Service agreements can be expanded to address the gaps in existing maintenance agreement footprints. Long-term agreements are essential to support the financing of new vessels.

7.3.4. Competition and Performance

This structure lacks a competitive element and does not encourage new market entrants. However, it does align the interests of key stakeholders. Competition has been largely absent under current regional agreements for decades, due to high entry barriers and the lack of alternative repair vessel operators. Vessel operators can be held accountable for service quality and performance using agreed-upon performance measures.

7.3.5. Challenges

In any joint venture structure, shareholder exit provisions for shareholders should be included in agreements. Restrictions on the number of cable owner shareholders can also present issues, as other stakeholders may perceive this investment position as offering beneficial advantages. Independent non-executive Board directors and an independent SPV management structure are proposed to address this concern.

The structure described does not attempt to identify every commercial nuance, tax, legal, or jurisdictional implication, but provides a high-level outline designed to support stakeholder discussions.

7.4. Government Investment Support

Government interests in cable maintenance are covered in Sections 2.2 and 6.4.1. If sovereign repair capability is being considered, a Public Private Partnership (PPP) structure will couple public sector interests with private sector expertise. Cooperation between the public and private sectors has precedent as outlined in Section 6.4.1.

Various partnership structures are possible; however, the conventional PPP structure frequently used for developing fixed infrastructure assets is less often employed for "capability assets," which are likely to include cable maintenance vessels.[87]

[87] Private sector expertise undertakes Design, Build, Finance, Maintain and Operate (DBFOM). Title to the asset is handed to the public sector after a defined period (e.g. 25 years). Examples include roads and railway infrastructure.

A pragmatic partnership approach would utilize public sector grants, loans, or loan guarantees to help fund a vessel, in collaboration with a private sector partner capable of operating the vessel. However, not all governments have private organizations experienced in this specialized industry sector. A multilateral approach may offer a viable solution to fulfil the trusted ecosystem concept and address collective government concerns regarding foreign-owned vessels performing repair activities on critical infrastructure.

Government financial support will likely include conditions intended to benefit the public sector. Where a national private organization with relevant expertise is available, a charter arrangement can offset government financing costs by chartering the vessel to the private sector. Government "step in" rights during a substantial outage event will meet government supply chain resilience goals. This approach can serve as a quasi-insurance policy to safeguard a nation's strategic and economic interests.

ASPI's 2024 report (Section 2.3) highlights the shortage of industry CLVs and concentrated supply chains arguing that this is a strategic asset that the Australian Government should consider. Australia also has a track record in public-private investment partnerships (Section 6.41.) and is an active member of the Quad. Australia's island geography, characterized by an extensive coastline and strategic Indo-Pacific location, is also relatively distant from the base port locations of the nearest repair vessels.

Fiji has a transit time of seven days to the Australian southern coast. Repair vessels from Singapore and the Philippines take seven to nine days to reach Perth on the west coast. Taiwan is located 11 days transit time to the west coast and 13-14 days to the southern coast. Additional time for mobilization, port clearances and transit to cable repair grounds extends these timeframes.[88]

Some of these timeframes are not excessive compared to industry averages and other regions. However, they are particularly significant considering Australia's emerging status as a southern connectivity hub, and the forecast rise in cables connecting to the continent.

The challenge with Australian Government investment support under any structure is the absence of a national private partner with experience in cable installation or maintenance operations. However, collaboration with its QUAD partners could resolve this issue.

Beyond Australia, there are other regions that face prolonged repair vessel transit times that could benefit from public private partnerships to secure sovereign repair capabilities and/or to expand the repair fleet.

Section 2.3 notes that few survey participants welcome government support for funding maintenance vessels.

7.5. Vessel Flexibility

Various alternative frameworks can be devised and evaluated to reconfigure the maintenance footprint, optimize depot locations and repair vessel utilization, with the aim to enhance efficiency and service quality. The study's scope of work cannot encompass the complexities involved in developing all potential alternative structures.

[88] Transit times calculated at 14 knots. This does not include time taken for repairs or permit acquisitions.

As Section 6.2 notes, it is important to understand that there is only one methodology and process for repairing a cable. Therefore, service quality differences are primarily derived from vessel capability, technical expertise and repair response time. Section 6.3.2 and Figure 6.10 indicates that the industry prefers greater flexibility in how maintenance services are configured and operated, so this component needs to be considered under any proposed alternative structure.

Operational flexibility that facilitates repairs to be conducted anywhere by any repair vessel can be enhanced through various approaches. For instance, creating an operating model that pools repair vessels across different regions without the constraints of fixed boundaries can expand the functional use of repair vessels. These repair vessels can provide maintenance services on a “spot market” basis allowing other work to be undertaken, possibly with certain limitations. The commercial complexities of this approach should be addressed collaboratively and captured in a Master Service Agreement (MSA) or similar framework agreement.

Restructuring any framework will require a significant departure from the traditional agreement models and a new paradigm of collaboration among competing entities and all stakeholders to ensure that all interests are balanced and value is created.

7.6. Outlook

The submarine cable maintenance industry faces a period of significant transition, driven by substantial growth in cable kilometers and evolving geopolitical landscapes. While existing models have largely served the sector well, the aging fleet, repair backlogs in high-usage regions, and need for investment in new vessels present formidable challenges. Balancing effective service levels with cost remains a complex equation and the industry must find solutions that incentivize vessel operators to invest in fleet modernization and expansion without disproportionately increasing cable owner expenses. Moreover, the potential for government intervention and the rise of content providers as major investors add further layers of complexity to the future of maintenance agreements and structures.

Looking ahead, the need for flexibility, transparency and adaptability will be paramount. Traditional agreement structures may need to evolve to accommodate diverse stakeholder interests and shifting power dynamics within the industry. Hybrid commercial models, asset-based competition, and collaborative tendering processes could offer viable alternatives to address the limitations of the current status quo. Additionally, strategic decisions regarding vessel investment will be critical, with consideration given to both purpose-built vessels and conversions, as well as the integration of multi-purpose capabilities. The development of ESG initiatives and the consideration of "green" vessel technologies will also play an increasingly important role in shaping the future of the industry.

Addressing gaps in global maintenance coverage, particularly in emerging regions like the Southern Pacific and Indian Ocean, will require innovative solutions. Boundary expansions, the establishment of new zones, or the consolidation of existing agreements could all be considered, but each option comes with its own set of logistical, operational and financial challenges.

It is not feasible to propose that a single global solution will address all operational parameters and all commercial interests of all stakeholders in a single structural transformation. However, the vision to restructure the way the industry approaches our self-insurance model on a global basis should be the ultimate goal that the industry works toward. Ultimately, effective communication, collaboration, and a willingness to explore new approaches will be essential to ensure the sustainability and resilience of the submarine cable maintenance sector amid these future challenges.

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9. APPENDIX A: Methodology

External review was invited at multiple stages to ensure data was accurate, objective, and complete in scope. Feedback was invited for initial versions of survey questions, model design, and written text. Reviewers included executives from telecommunications, marine maintenance, and cable manufacturing companies alongside regulatory experts and members of industry associations.

9.1. Surveys

9.1.1. Industry Survey

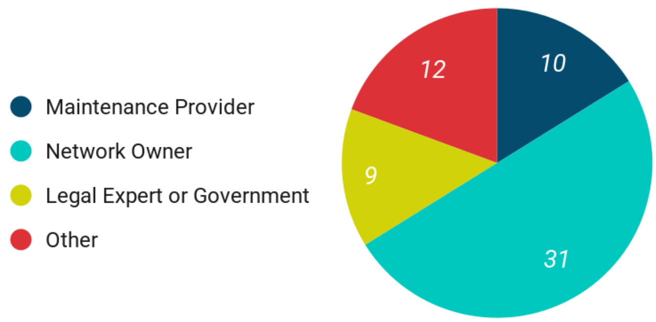
Participants were recruited from across the submarine cable and marine maintenance industries based on the relevance of their organizations and careers. This includes system operators, turnkey suppliers, vessel providers, maintenance zone authorities, cable protection organizations, industry associations, regulatory experts, government representatives, and more.

Invitations to participate were sent via email and the survey was conducted using an English-language Google Form. Respondents were briefed on the study's purpose and assured of their anonymity before agreeing to participate. Participant name and affiliation were also tracked internally to ensure that no one company was over-represented within the sample. Efforts were made to ensure that both global and regional companies were included in the sample.

62 responses, each representing a different company, were received between February and March 2025. Respondent demographics were formalized by asking each participant to identify their primary role within industry. Options included:

- "Maintenance or vessel provider / specialist" **(Maintenance Provider - 16%)**
- "System investor / operator / maintenance authority" **(Network Owner - 50%)**
- "Legal / regulatory / government" **(Legal Expert or Government - 15%)**
- "Consultant / other" **(Other - 19%)**

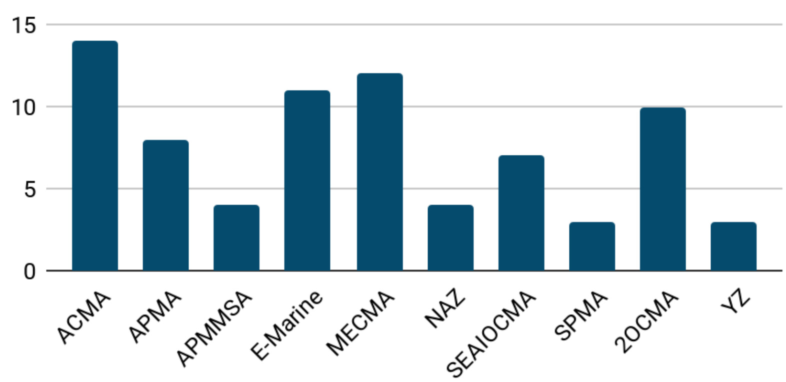
Figure 9.1. Breakdown of Survey Participants by Role



Source: Industry survey by TeleGeography and Infra-Analytics

Responses were received from participants across the globe. The breakdown of geographic interests can be partially represented by the number of network operators who indicated their organization's participation in different marine maintenance agreements. All zones were represented by at least three participants each, and about half of respondents indicated multiple zones.

Figure 9.2. Number of Surveyed Network Owners by Maintenance Agreement



Source: Industry survey by TeleGeography and Infra-Analytics
Note: 50% of respondents indicated participation in multiple maintenance agreements.

In the survey, each group was first asked an identical set of introductory questions. Three groups—Maintenance Providers, Network Owners, and Regulatory Experts—were then also asked a second, demographic-specific series of questions that covered their specialities in more detail. Most questions were multiple choice. Some asked participants to select multiple responses from a list, rank their top three responses from a list, or provide a brief written explanation. Participants were also given the opportunity to provide additional commentary through frequent text blanks.

Results from this survey are included throughout the analysis. Where appropriate, written responses are quoted or summarized to describe perspectives on the industry. Information that may have identified individual respondents has been removed.

9.1.2. Consortium Zone and Private Maintenance Agreement Survey

Some estimates and analysis is based on information collected directly from maintenance providers. This survey was designed to collect quantifiable data and qualitative descriptions related to cable maintenance activities and distributed to all maintenance agreements.

Annual data for 2020 to 2025 (year to date) was requested for the following metrics:

- Total cable kilometers
- Number of repairs completed
- Number of repair vessel operational days
- Number of repairs conduction on cables of various ages: pre-2010, 2011-2015, 2016-2020, 2021-2024
- Number of days of allowable vessel downtime per ship
- Vessel base port locations

Data providers were assured that their information would only be used in aggregate analysis and not reported individually. Data was received from four consortium agreements (ACMA, MECMA, 2OCMA, NAZ) and five private agreements (APMA, APMMSA, SPMA, IT Telecom, Arelion).

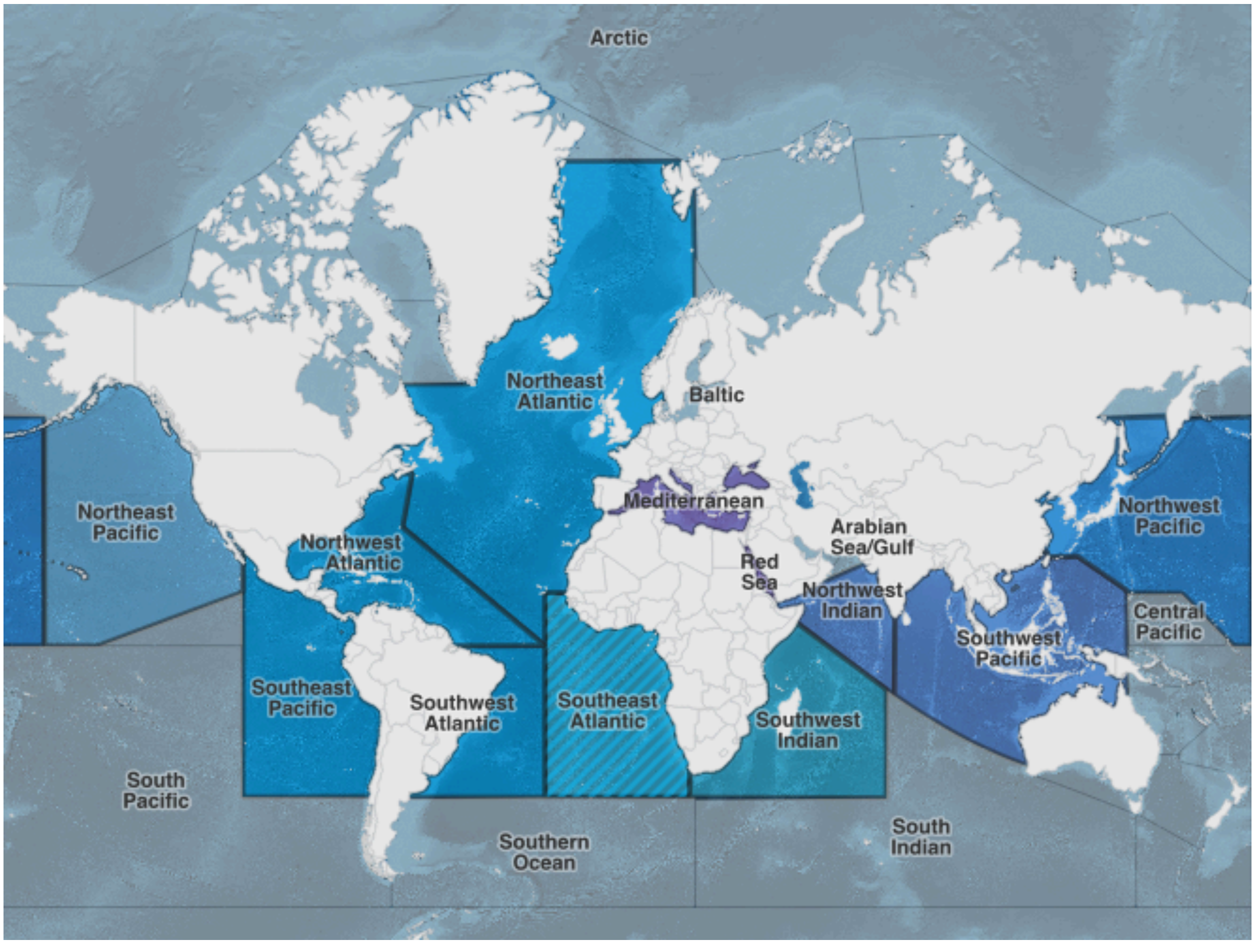
9.2. Models

9.2.1. Cable kilometer forecast

To assess the geographic distribution of future cable kilometers, it is necessary to assess the impact of cable retirements in combination with the introduction of new cables.

The model summarizes the data according to 19 geographic areas. These regions were established to approximate cable maintenance zones. Some areas were disaggregated further to provide more visibility into which parts of zones would see the biggest changes.

Figure 9.3. Cable Kilometer Model Regional Assignments



9.2.1.1. New Cables

To assess the global requirements for new cables by 2030, 2035, and 2040, a 3-pronged approach was employed.

1. **Near-term model.** Many planned cables are expected to enter service by 2030. We included 114 cables in various stages of development. Some cables are actively under deployment, while others do not yet have contracts in force. GIS was used to map the approximate routes of these cables and allocate kilometer counts to the respective regions.

2. **Exhaustion model.** For major cable routes, a capacity exhaustion-based approach was used. These routes account for 72% of global cable kilometers as of 2025.
    - The routes considered in the exhaustion approach include:
        - Trans-Atlantic
        - Trans-Pacific

        - Intra-Asia
        - East South America-U.S.
        - West South America-U.S.
        - Europe-Egypt/Levant
        - Egypt-Middle East
        - Middle East-South Asia
        - Middle East-East Africa
        - South Asia-Southeast Asia
        - Europe-West Africa
        - Oceania-U.S.
    - Demand data
        - TeleGeography's proprietary forecasts of purchased bandwidth for each route was used as a baseline. These estimates were boosted by 5% to model lit capacity requirements.
    - Potential capacity
        - For existing and announced cables (which includes all cables considered in the near-term model described above), the value of potential capacity was based on those reported by network operators. For near-term cables lacking publicly-disclosed potential capacities, estimates were made using similar cables.
    - Exhaustion timing
        - The demand for each route (measured in terms of lit bandwidth) was compared to the supply (measured in terms of the potential capacity for all in-service and near-term planned cables) to assess the point of exhaustion.
    - New cable construction buffer
        - New cables were assumed to be introduced 3 years before route-wide exhaustion would occur.
    - Potential capacity of future cables
        - The maximum capacity of cables on each route was gradually increased over time due to expected advances in cable technology.
            - For the trans-Atlantic route, as an example, we assumed a potential capacity for new cables as follows:
                - 500 Tbps 2025-2029
                - 1.0 Pbps 2030-2032
                - 1.5 Pbps 3033-2035
                - 2.0 Pbps 2036-2038

      - 2.5 Pbps 2039-2040
    - Other routes used potential capacity values that were below these levels.
  - The model makes no assumptions about which technologies would be used to achieve such levels.
  - These assumptions were refined through conversations with cable suppliers. Considerable uncertainty exists about potential cable capacity levels by 2040.

3. **Replacement model.** A significant number of cables cover routes not covered by the exhaustion model approach. For these cables, we assume replacement cables of the same length are deployed the same year each cable reaches the modelled retirement age. While this is unlikely in reality, this approach prevents unusual fluctuations in the annual tallies of cable kilometers per region model results

The sum of these three approaches provides the total new cable kilometers per region by year.

9.2.1.2. Cable Retirements

A baseline lifespan of 25 years was assumed for repeatered cables and 35 years for unrepeatered cables. For cables that are already at or beyond these lifespans as of 2025, it was assumed they would be retired by 2030.

9.2.1.3. Net Cable Kilometers

To determine the future cable kilometers, the baseline number of kilometers per region for 2025 was used as a starting point. New cable kilometers were then added, and retired kilometers were subsequently subtracted. The result of this calculation is the net change in kilometers expected per region.

9.2.2. Cable Fault Forecast

To assess the fault rate per region we used data provided by OceanIQ. This data was the repair rate per 1,000 kilometers for the geographic regions defined for this study.

The assessment of future fault rates by cable was forecasted by applying the average repair rate per 1,000 kilometer from 2020-2024 to get the expected future cable kilometers in service for 2025. The regional fault rates for 2025, 2030, 2035, and 2040 were calculated based on a deceleration of the baseline fault rates. The baseline scenario used 5% deceleration in repairs per kilometer for each region during each five-year period.

To model the future number of repairs, the average repairs per 1,000 km by region were taken and discounted by 5% to establish a 2025 baseline. The regional fault rates for 2030, 2035, and 2040 were calculated based on a 5% deceleration rate for each region during each five-year period (1.02% annual deceleration).

9.2.3. Vessel Requirement Forecast

The total number of new maintenance vessels by region was calculated as follows:

1. **Average Repair Duration:** First, the average repair duration in different regions was determined using data from consortium zones and private maintenance agreements regarding annual repairs and vessel working days from 2020-2024. This established a baseline for average repair duration for each region.

2. **Total Working Days:** Total working days required were then forecasted by multiplying the repair duration for each region by the corresponding number of repairs projected for 2026-2040.

3. **Vessel Utilization Rate:** A utilization rate of 60% was assumed, meaning a vessel is able to engage in work 210 days of the 350 possible maximum working days in a year. These baseline figures were based on interviews with industry experts.

4. **Minimum Vessel Requirement:** The total repair days for each region were divided by the available work days to derive the minimum number of vessels required for each region.

5. **Aggregation into Major Regions:** Vessel requirements from 19 geographic regions were aggregated into broader major regions (Africa, Americas, Asia, Europe, Oceania, Middle East) based on the home port location for each vessel as follows:
    - Africa: Southeast Atlantic
    - Americas: Northwest Atlantic, Northeast Pacific, Southwest Atlantic, Southeast Pacific, Southern Ocean
    - Asia: Northwest Pacific, Southwest Pacific, Central Pacific
    - Europe: Northeast Atlantic, Mediterranean, Arctic, Baltic
    - Middle East: Arabian Sea/Gulf, Northwest Indian, Red Sea, Southwest Indian, South Indian
    - Oceania: South Pacific
6. **Accounting for Vessel Lifespan:** Assuming a 40-year lifespan for maintenance vessels, the model also factored in the replacement of aging vessels. The calculations considered both incremental requirements due to increased repairs and the need to replace vessels reaching end of life.

10. APPENDIX B: Model Results

Figure 10.1. Baseline New Cable Kilometers by Region, 2026-2040

	2026-2030	2031-2035	2036-2040
Northeast Atlantic	73.2	59.9	74.7
Northwest Atlantic	35.5	35.5	38.0
Southeast Atlantic	20.0	30.0	48.2
Southwest Atlantic	8.4	15.0	20.2
Northeast Pacific	48.2	48.2	55.5
Northwest Pacific	72.8	72.0	83.7
Southeast Pacific	10.5	3.9	4.9
Southwest Pacific	127.1	98.2	126.2
Central Pacific	8.2	12.6	2.0
South Pacific	43.6	41.0	25.5
Northwest Indian	26.9	13.2	21.9
Southwest Indian	7.6	20.6	19.9
South Indian	11.8	6.9	0.5
Mediterranean	28.4	16.1	23.8
Red Sea	10.8	10.8	11.1
Arabian Sea/Gulf	8.5	6.6	18.8
Arctic	2.2	1.2	0.0
Baltic	2.6	1.4	0.5
Southern Ocean	9.0	0.0	0.0
Total	**555.3**	**493.1**	**575.4**

Source: TeleGeography, Infra-Analytics

Figure 10.2. Baseline Retired Cable Kilometers by Region, 2026-2040

	2026-2030	2031-2035	2036-2040
Northeast Atlantic	65.4	34.0	17.9
Northwest Atlantic	57.2	29.1	32.6
Southeast Atlantic	11.3	9.0	24.9
Southwest Atlantic	22.5	3.0	3.9
Northeast Pacific	47.4	24.8	0.0
Northwest Pacific	66.8	29.8	7.4
Southeast Pacific	21.3	0.0	1.2
Southwest Pacific	63.2	34.4	20.9
Central Pacific	3.3	5.0	0.1
South Pacific	20.0	15.6	3.1
Northwest Indian	14.2	18.6	9.1
Southwest Indian	7.4	16.4	4.6
South Indian	0.2	0.0	0.5
Mediterranean	20.1	13.1	18.4
Red Sea	5.5	8.6	5.4
Arabian Sea/Gulf	3.6	7.7	10.8
Arctic	0.0	1.2	0.0
Baltic	2.6	1.4	0.5
Southern Ocean	0.0	0.0	0.0
Total	**432.0**	**251.7**	**161.3**

Source: TeleGeography, Infra-Analytics

Figure 10.3. Baseline Net Change in Cable Kilometers by Region, 2025-2040

	2026-2030	2031-2035	2036-2040
Northeast Atlantic	138.6	93.9	92.6
Northwest Atlantic	92.8	64.6	70.6
Southeast Atlantic	31.3	39.0	73.1
Southwest Atlantic	31.0	18.0	24.1
Northeast Pacific	95.7	73.1	55.5
Northwest Pacific	139.6	101.8	91.1
Southeast Pacific	31.8	3.9	6.0
Southwest Pacific	190.4	132.6	147.1
Central Pacific	11.5	17.6	2.1
South Pacific	63.6	56.5	28.6
Northwest Indian	41.1	31.9	31.0
Southwest Indian	15.0	37.1	24.5
South Indian	12.0	6.9	1.1
Mediterranean	48.6	29.2	42.2
Red Sea	16.3	19.4	16.6
Arabian Sea/Gulf	12.1	14.3	29.6
Arctic	2.2	2.3	0.0
Baltic	5.2	2.7	1.0
Southern Ocean	0.0	0.0	0.0
Total	**978.8**	**744.8**	**736.8**

Source: TeleGeography, Infra-Analytics

Figure 10.4. Baseline Cumulative Cable Kilometers by Regions, 2025-2040

	2025	2030	2035	2040
Northeast Atlantic	190	197	223	280
Northwest Atlantic	171.9	150.2	156.5	162
Southeast Atlantic	89	97.8	118.7	142
Southwest Atlantic	60	45.9	57.9	74.1
Northeast Pacific	143.5	144.3	167.7	223.2
Northwest Pacific	196.7	202.8	244.9	321.2
Southeast Pacific	43.2	32.4	36.3	40
Southwest Pacific	279.6	343.5	407.2	512.6
Central Pacific	16.3	21.2	28.8	30.6
South Pacific	87.3	111	136.4	158.8
Northwest Indian	91.8	104.5	99.1	111.9
Southwest Indian	51.5	51.7	55.9	71.1
South Indian	4.9	16.4	23.2	23.2
Mediterranean	89.9	98.2	101.2	106.7
Red Sea	34.8	40.1	42.3	48
Arabian Sea/Gulf	34.8	39.7	38.6	46.7
Arctic	17.1	19.3	19.3	19.3
Baltic	9	9	9	9
Southern Ocean	0	0	0	0
Total	**1,610.9**	**1,725.4**	**1,966.4**	**2,380.6**

Source: TeleGeography, Infra-Analytics

Figure 10.5. Baseline Forecasted Repairs by Region, 2025-2040

	2025	2030	2035	2040
Northeast Atlantic	22.0	22.0	23.0	28.0
Northwest Atlantic	11.0	9.0	9.0	9.0
Southeast Atlantic	12.0	12.0	14.0	16.0
Southwest Atlantic	1.0	1.0	1.0	1.0
Northeast Pacific	2.0	2.0	3.0	3.0
Northwest Pacific	28.0	28.0	32.0	40.0
Southeast Pacific	4.0	3.0	3.0	3.0
Southwest Pacific	90.0	105.0	118.0	141.0
South Pacific	3.0	3.0	4.0	4.0
Northwest Indian	5.0	6.0	5.0	5.0
Southwest Indian	3.0	3.0	3.0	3.0
Mediterranean	15.0	15.0	15.0	15.0
Red Sea	4.0	4.0	4.0	4.0
Other	13.0	14.0	14.0	15.0
Total	**212.0**	**226.0**	**246.0**	**287.0**

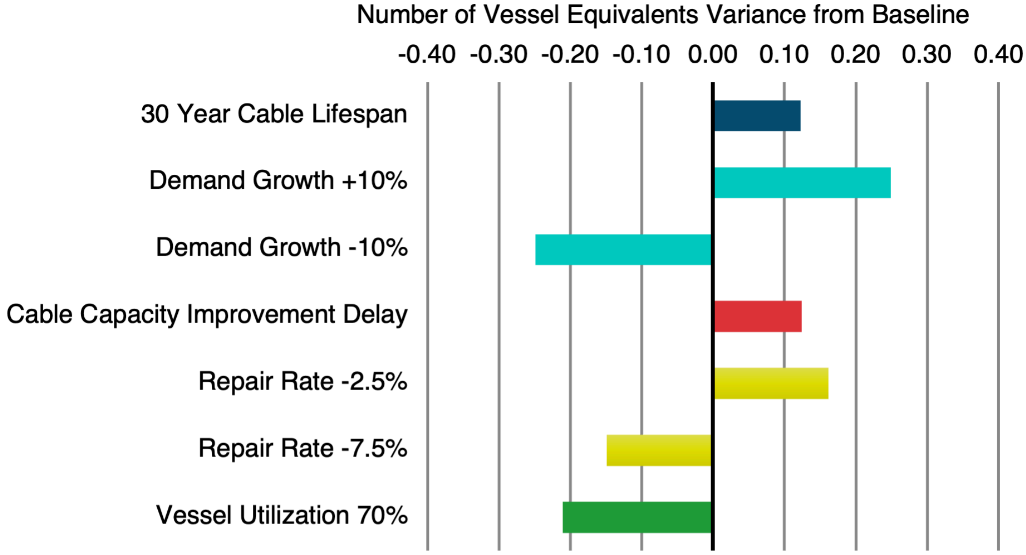
Source: TeleGeography, Infra-Analytics

Figure 10.6. Baseline Minimum Vessel Equivalents by Region, 2025-2040

	2025	2030	2035	2040
Africa	1.1	1.1	1.3	1.5
Americas	1.2	1.0	1.0	1.1
Asia	8.3	9.4	10.6	12.8
Europe	3.3	3.3	3.4	3.8
Middle East	1.8	1.9	1.8	2.0
Oceania	0.3	0.4	0.5	0.5

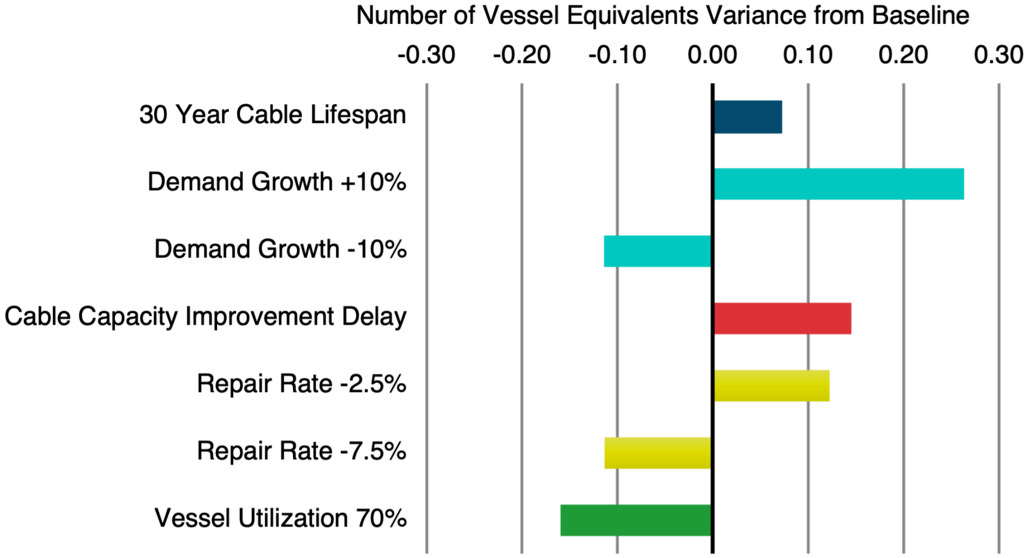
Source: TeleGeography, Infra-Analytics

Figure 10.7. Scenario Analysis Africa Maintenance Vessel Forecasts Variance from 2040 Baseline



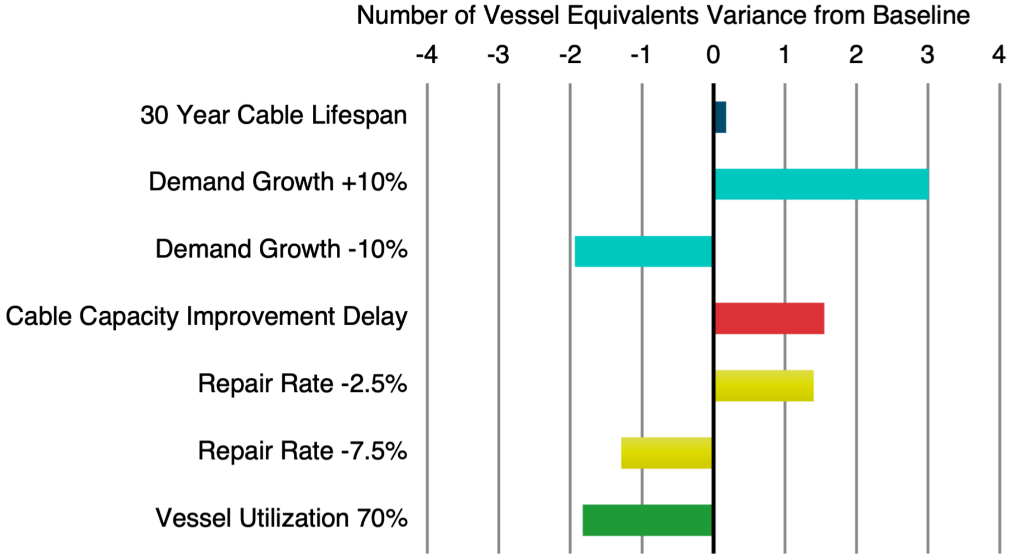
Source: TeleGeography, Infra-Analytics

Figure 10.8. Scenario Analysis: Americas Maintenance Vessel Forecasts Variance from 2040 Baseline



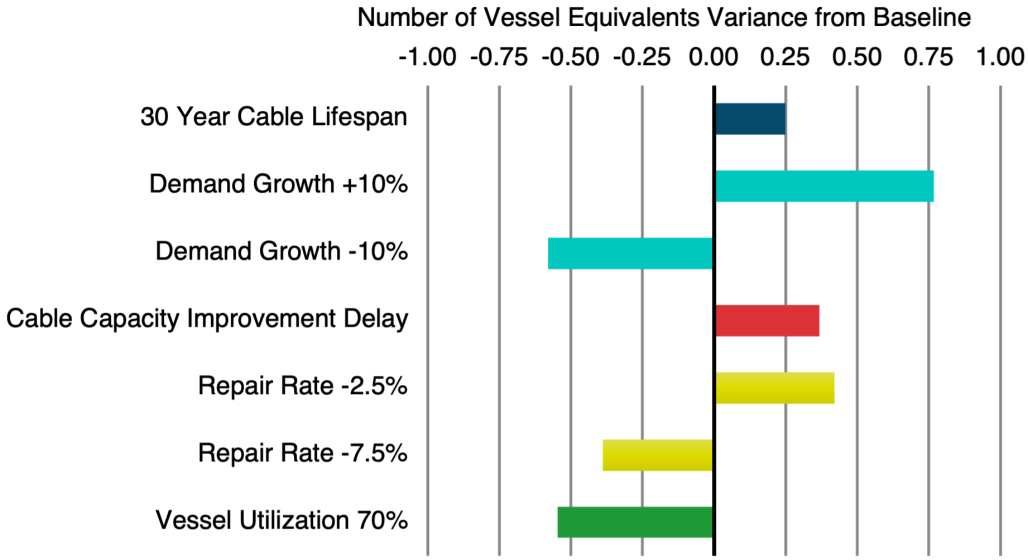
Source: TeleGeography, Infra-Analytics

Figure 10.9. Scenario Analysis: Asia Maintenance Vessel Forecasts Variance from 2040 Baseline



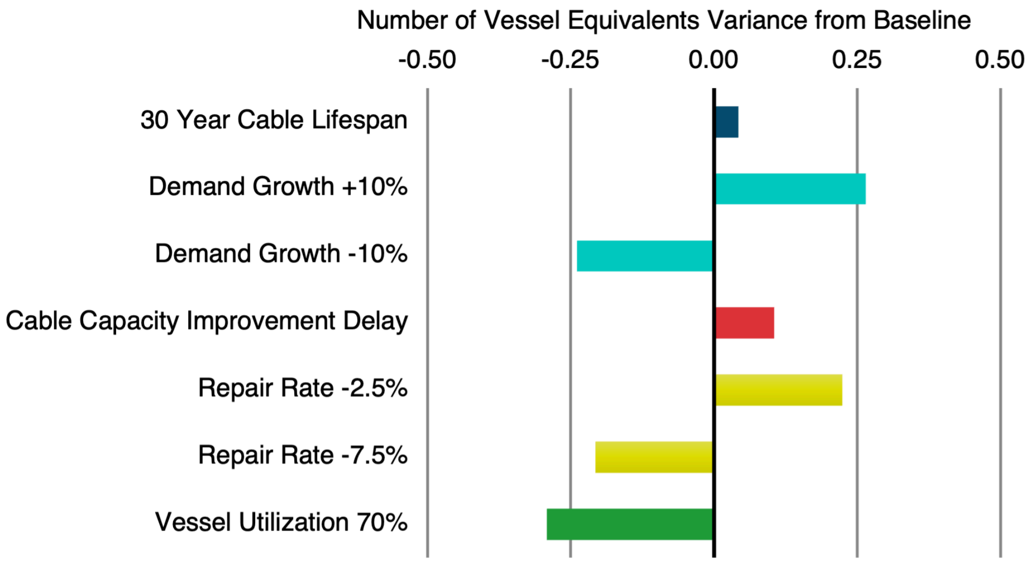
Source: TeleGeography, Infra-Analytics

Figure 10.10. Scenario Analysis: Europe Maintenance Vessel Forecasts Variance from 2040 Baseline



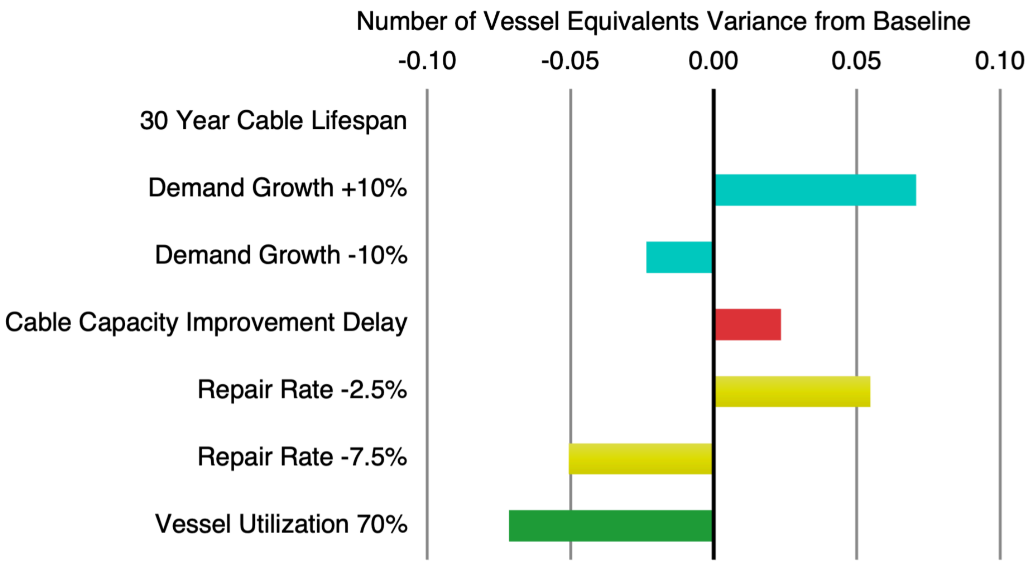
Source: TeleGeography, Infra-Analytics

Figure 10.11. Scenario Analysis: Middle East Maintenance Vessel Forecasts Variance from 2040 Baseline



Source: TeleGeography, Infra-Analytics

Figure 10.12. Scenario Analysis: Oceania Maintenance Vessel Forecasts Variance from 2040 Baseline



Source: TeleGeography, Infra-Analytics

11. APPENDIX C: Cable Installation and Maintenance Vessels

Owner	Vessel Name	Type	Base Port	Age
ASEAN Cableship	ASEAN Explorer	Maintenance	Asia Pacific	23
ASEAN Cableship	ASEAN Restorer	Maintenance	Asia Pacific	31
ASEAN Cableship	ASEAN Challenger	Installation/Maintenance	Asia Pacific	11
ASN	Ile d'Aix	Maintenance	Global	34
ASN	Ile de Batz	Installation	Global	24
ASN	Ile de Brehat	Installation	Global	24
ASN	Ille d'Yeu	Installation	Global	24
ASN	Ille de Molene	Maintenance	Atlantic	19
ASN	Ille D'Ouessant	Maintenance	Atlantic	14
ASN	Ile de Sein	Installation	Global	24
Baltic Offshore	Pleijel	Maintenance	Baltic	53
BNP (Bina Nusantara Perkasa)	CS Nusantara Explorer	Installation/Maintenance	Asia Pacific	29
China General Nuclear Power	Longyin 9	Installation	Asia Pacific	1
China Telecom	Zhong Haike No. 1	Installation	Global	24
E-Marine	CS Maram	Maintenance	Middle East	9
E-Marine	Etisalat	Installation	Global	35
E-Marine	Niwa	Installation	Global	34
E-Marine	Umm Al Anber	Maintenance	Middle East	54
Elettra	Antonia Meucci	Maintenance	Mediterranean	38
Elettra	Teliri	Installation/Maintenance	Mediterranean	29
FibreHome	Fenghua21	Installation	Asia Pacific	4
Global Marine Group	Normand Clipper	Installation	Global	24
Global Marine Group	Cable Retriever	Maintenance	Asia Pacific	28
Global Marine Group	Cable Innovator	Maintenance	Asia Pacific	30
Global Marine Group	CS Recorder	Installation	Global	25
Global Marine Group	Sovereign	Maintenance	Atlantic	34
Global Marine Group	Wave Sentinel	Maintenance	Atlantic	30
HMN Tech	Blue Navigator	Installation	Global	2
IT Telecom	IT Infinity	Installation	Global	17
IT Telecom	IT Integrity	Installation	Global	24
IT Telecom	IT Intrepid	Installation	Americas	36

KCS	KDDI Ocean Link	Maintenance	Asia Pacific	33
KCS	KDDI Cable Infinity	Installation	Asia Pacific	6
LS Marine Solutions	Segero	Installation/Maintenance	Asia Pacific	27
NTT WEM	CS Vega II	Installation/Maintenance	Asia Pacific	17
NTT WEM	Subaru	Installation	Asia Pacific	26
NTT WEM	ORION	Maintenance	Japan	12
NTT WEM	Kizuna	Maintenance	Asia Pacific	25
OMS	Peter Faber	Maintenance	Asia Pacific	43
OMS	Ile de Re	Installation	Asia Pacific	43
OMS	Teneo	Maintenance	Asia Pacific	33
OMS	Lodbrog	Maintenance	Asia Pacific	42
OMS	Cable Vigilance	Maintenance	Atlantic	19
Orange Marine	Léon Thévenin	Maintenance	Africa	42
Orange Marine	Pierre de Fermat	Installation/Maintenance	Atlantic	11
Orange Marine	René Descartes	Installation	Global	23
Orange Marine	Sophie Germain	Installation/Maintenance	Global	2
PT Limin	Limin Venture	Installation/Maintenance	Indonesia	43
Relacom Finland	Telepaatti	Maintenance	Baltic	47
SBSS	Bold Maverick	Installation	Global	24
SBSS	Fu Hai	Installation/Maintenance	Asia Pacific	25
SBSS	Fu Tai	Installation	Asia Pacific	18
Soechi Group	DNeX Pacific Link	Installation/Maintenance	Indonesia	32
Soechi Group	Prima Nusantara X	Installation/Maintenance	Indonesia	11
SubCom	Decisive	Installation	Global	22
SubCom	Dependable	Installation	Global	23
SubCom	Durable	Installation	Global	23
SubCom	Reliance	Installation	Global	24
SubCom	Resolute	Installation	Global	24
SubCom	Responder	Installation	Global	24
SubCom	Global Sentinel	Installation	Global	34
Triasmitra	Former Skandi Sotra - DOF	Installation/Maintenance	Indonesia	22

12. APPENDIX D: Glossary

Bespoke Arrangement: A customized maintenance solution tailored to the specific needs of a cable owner or a particular cable system, often outside of standard zone agreements.

Cabotage: Laws that restrict foreign-flagged vessels from operating within a country's territorial waters or EEZ for certain types of activities, including cable repair in some cases.

Cable Lay Vessel (CLV): A specialized vessel designed for laying and installing subsea cables.

Capital Expenditure (CAPEX): The upfront costs associated with acquiring or building assets, such as new subsea cables or maintenance vessels.

Class Surveys (IMO): Periodic inspections mandated by the International Maritime Organization (IMO) to ensure that vessels meet safety and operational standards.

Consortium Zone Agreement: A collaborative agreement among multiple cable owners to share the costs and resources of maintaining a defined geographic zone of subsea cables. The consortium zone agreements include the following:

- ACMA - Atlantic Cable Maintenance Agreement
- MECMA - Mediterranean Cable Maintenance Agreement
- NAZ - North American Zone
- SEAIOCMA - South East Asian Indian Ocean Maintenance Agreement
- YZ - Yokohama Zone
- 2OCMA - 2 Oceans Owners Cable Maintenance Agreement

Content Providers (OTTs, hyperscalers): Large tech companies that own and invest in cables outside of traditional telecom carriers. The dominant companies in this category are Google, Meta, Amazon, and Microsoft.

Converted Vessel: An existing vessel (originally designed for another purpose, such as offshore support) that has been modified for subsea cable maintenance and repair.

Corporate Bonds: Financial instruments that companies may be required to post as a guarantee during the repair permit acquisition process in certain regions.

ESG Initiatives: Environmental, Social, and Governance initiatives that organizations adopt to operate sustainably and ethically.

Exclusive Economic Zone (EEZ): A maritime zone extending from a country's coast to which the country has special rights regarding the exploration and use of marine resources.

Fault: A damage or break in a subsea cable that disrupts its ability to transmit data.

Intermediate Inspections (IMO): Less comprehensive inspections conducted between Class Surveys to maintain a vessel's classification.

Maintenance Fleet: The collection of vessels and associated resources dedicated to the maintenance and repair of subsea cables.

Maintenance Provider: A company that owns and operates vessels and provides services for the repair and upkeep of subsea cables.

Offshore Support Vessel (OSV): A broad category of vessels that support offshore operations, including those converted for cable maintenance.

Operational Expenditure (OPEX): The ongoing costs associated with operating and maintaining a subsea cable system or a maintenance vessel.

Operations and Maintenance (O&M): The activities and costs associated with the day-to-day operation and upkeep of subsea cable systems.

Platform Supply Vessel (PSV): A type of vessel originally designed to supply offshore oil and gas platforms, some of which have been converted for cable maintenance.

Private Maintenance Agreement: A maintenance agreement between a single cable owner (or a small group) and a maintenance provider for a specific geographic area. The private maintenance agreements include:

- APMA - Atlantic Private Maintenance Agreement
- APMMSA - Asia Pacific Marine Maintenance Service Agreement
- e-Marine
- SPMA - South Pacific Maintenance Agreement

Purpose-Built Vessel: A vessel specifically designed and constructed for the primary purpose of subsea cable maintenance and repair.

Repair Permit: Official authorization from governmental authorities required before a subsea cable repair can be undertaken in a specific jurisdiction.

Repair Rate: The frequency at which repairs occur in subsea cables, often expressed as the number of repairs per kilometer per year.

Repair Timeframe: The duration from the identification of a fault to the completion of its repair.

Repair Vessel Utilization Rate: The percentage of time that a cable repair vessel is actively engaged in repair or maintenance activities.

Repeatered Cable: A subsea cable that includes repeaters (amplifiers) along its length to boost the optical signal, typically used for long-distance cables.

Self-Insurance Model: A unique cost-sharing model in the subsea cable industry where network owners collectively bear the risk and costs of cable maintenance, often through contributions to a shared fund.

Sovereign Repair Capacity: A nation's independent ability to conduct repairs on subsea cables, often involving government-owned or controlled vessels and resources.

System Owner (Cable Owner, Network Owner): The entity that owns and operates a subsea cable system.

Trusted Ecosystem: A secure and reliable environment for subsea cable infrastructure, encompassing supply chains, operations, and maintenance, often with government oversight or involvement to address security concerns.

Unrepeatered Cable: A subsea cable that does not have repeaters, typically used for shorter distances.

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