China's Gray Zone Threats to Trans-Pacific Undersea Cables

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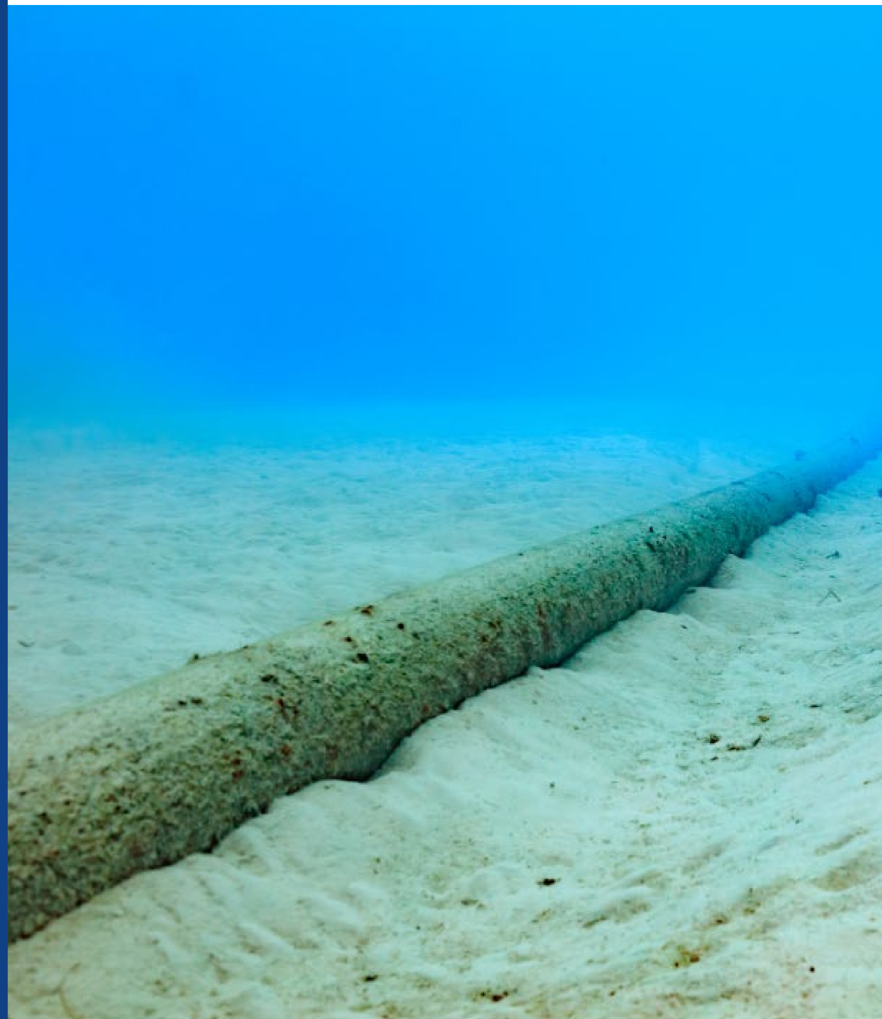

Ishigaki Island Diving - Submarine cable.
Source: Canva Pro Content / by Norimoto from Getty Images.

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Executive Summary

Undersea cables are critical to national security and prosperity, but are also highly vulnerable to disruption. While the vast majority of breakages are accidental or due to natural factors, a series of suspected sabotage incidents has highlighted the ability of hostile actors to weaponize cable sabotage as an effective "gray zone" coercion tactic – whereby attacks can be discreet, non-attributable, and unlikely to escalate above the threshold of conflict. This report seeks to analyze China's strategy and capabilities as they pertain to undersea cables, assess the exposure of U.S. trans-Pacific cable networks to gray zone sabotage, model the impact of cable sabotage on U.S. connectivity with the Indo-Pacific, and make recommendations for bolstering the resilience of U.S. trans-Pacific cable networks. To support this analysis, this paper has created a ***Trans-Pacific Cable Gray Zone Vulnerability Index (GZVI)*** to assess and rank the vulnerability of different U.S. trans-Pacific cable systems to China's gray zone threats. This index is designed as a means to help policymakers understand the risk profile of different cable systems and to aid resource prioritization for monitoring, patrols, and other protective measures. This paper argues that China's rapidly developing capabilities to disrupt undersea cables threaten key U.S. security and economic interests in the region, with "first-island chain" countries especially vulnerable. To meet this challenge, the United States must enhance coordination with allies and partners in the region to strengthen undersea cable protection.

Key findings:

- **China aims to achieve "Command of the Deep Sea":** The undersea domain is becoming of critical importance to China's economic and national security. China's People's Liberation Army (PLA) strategists increasingly reference undersea cables as a vulnerability to be protected, a tool to be exploited for intelligence purposes, and a possible target of an offensive action against adversary infrastructure.

- **China is rapidly building capabilities to disrupt undersea cables:** China is exploiting "military-civil fusion" to develop a range of dual-use technologies to enhance its ability to access and target undersea cables, with both legitimate civilian uses and potential offensive military capabilities. These include China's indigenous operational 10,000-meter-class submersible "Striver" and "swarming" systems of linked uncrewed platforms such as the undersea glider Haiyi. Future technologies under development include "hibernating" cable cutters for pre-deployment on adversary infrastructure.

- **Undersea cable sabotage is consistent with China's "gray-zone warfare":** PLA military strategists highlight that disruption of undersea infrastructure can achieve asymmetric advantages against adversaries, without triggering the political and legal thresholds associated with overt kinetic attack.

- **"First island chain" cables are particularly vulnerable to gray-zone attack:** The confluence of China's extensive maritime claims, shallow waters and dense shipping activity means that cables connecting the United States with Taiwan, Japan and the Philippines are among some of the most vulnerable in the trans-Pacific network. These vulnerabilities affect both existing and new planned cable systems. Continental U.S.

connections to the state of Hawaii and the territory of Guam are also particularly vulnerable, with few redundancy options.

- **Disruption to a single cable could threaten key U.S. trans-Pacific connections:** Disruption to even just a single undersea cable could risk overwhelming current available capacity on direct routings between the United States, Taiwan, Japan, and the Philippines, forcing data onto slower, less direct routes.

- **Simultaneous disruption of multiple cables could overwhelm trans-Pacific capacity:** Scenarios such as an attack on Taiwan or the deliberate targeting of several major cable networks could significantly reduce headroom and even overwhelm trans-Pacific capacity as a whole, forcing communications between the United States and the Indo-Pacific to re-route across the globe.

- **Undersea cable disruption threatens key U.S. economic interests:** Even minor slowdowns in communications latency can have major ramifications for high frequency traders, AI services, and other U.S. economic interests reliant on super-fast connections. More major disruption scenarios would have cascading impacts on the full range of U.S. economic interests in the Indo-Pacific, with tangible impacts likely on internet communications, financial services, and cloud services.

Recommendations:

The United States must act urgently to secure undersea cable networks from gray zone sabotage, which requires bolstering monitoring and protection capabilities:

- The United States must work with its allies in the region to establish common maritime domain awareness platforms, increased cable patrols, joint protocols for incident response, and toughened penalties and exclusion zones near vulnerable areas. This both enables emerging threats to be dealt with quickly and serves as a deterrent against future gray zone aggressors.

- The United States must support allied efforts to bolster cable repair, redundancy, and resilience. The United States, partner countries, and trusted operators must work to replenish global cable repair fleets, which are aging and thinly stretched, and ensure adequate pre-positioning of critical equipment.

- The United States must aim to match China’s ambitions in the undersea domain – which has been a strategic priority for Beijing since at least 2014. Investing in undersea capabilities, both commercial and military, inside and outside of government, is the only way to ensure that the United States can outpace China’s rapidly developing capabilities.

Part 1: China's Undersea Strategy and Capabilities

1.1 Key findings:

- The undersea domain and "Command of the Deep Sea" are viewed as of increasing strategic, economic, and military importance to China's leadership. Within this concept, undersea cables are seen as both a vulnerability for China to protect and an opportunity for information gathering and offensive action.

- China is exploiting "military-civil fusion" to build a range of advanced capabilities with relevance to undersea cables, including accessing undersea cables in the deep sea, seabed awareness and targeting capabilities, and both crewed and uncrewed vehicles with capabilities to monitor, cut, or strike undersea cables.

- Recent patents filed by Chinese companies suggest new capabilities being developed include deep sea robot crawlers, deep sea acoustic sensing, and armor stripping and cable splicing technologies – all of which could have value in planning and executing attacks on adversary undersea cables.

1.2 China's Deep Sea Strategy

Undersea cables (海底光缆 or 海底电缆) are a core component of China's broader deep sea strategy. This section examines China's deep sea strategy, and how the development of both military and industrial capabilities related to undersea cables is seen as critical to its strategic goals, with utility in both conventional and gray zone warfare. This report is scoped primarily to submarine telecommunications cables, because its central concern is the security and continuity of the digital connections linking the United States with its trans-Pacific partners. Subsea power cables, pipelines, and other forms of seabed infrastructure are also strategically important and may be exposed to many of the same access, monitoring, and physical-intervention capabilities examined here. They nevertheless perform different functions and present distinct geographical, regulatory, ownership, and resilience considerations, and are therefore outside the scope of this study. The section also focuses predominantly on sub-threshold disruption and sabotage, rather than espionage. Although the two may rely on overlapping capabilities – including cable access, seabed mapping, maintenance vessels, and control over network infrastructure – espionage raises a separate set of technical and analytical questions concerning covert interception, traffic diversion, equipment compromise, and other counter-intelligence measures.[*] This section begins by analyzing official Chinese policy

[*] Espionage warrants separate investigation because it differs from physical disruption in its objectives, methods, indicators, and mitigation requirements. Whereas sabotage principally seeks to interrupt or degrade connectivity, cable-enabled espionage may involve covert interception, traffic diversion, compromised repeaters or landing-station equipment, exploitation of maintenance access, or the collection of encrypted data for later decryption. Such activity may cause no visible service interruption and therefore requires distinct approaches to technical detection, supply-chain assurance, cryptographic protection, and attribution. The discussion of espionage elsewhere in this report is intended to identify a possible secondary consequence of cable ownership or traffic rerouting, rather than to provide a comprehensive assessment of Chinese cable-related intelligence activity. Concerns have also been raised that advances in cryptographically relevant quantum computing could facilitate a "harvest-now, decrypt-later" strategy. See Bhaw, Divij. *Harvest Now, Decrypt Later: Securing Sea Lines of Communication in the Era of Quantum-Enabled Espionage*. UWA Defence & Security Institute, 2026. https://defenceuwa.com.au/publications/policy-briefs/harvest-now-decrypt-later-securing-sea-lines-of-communication-in-the-era-of-quantum-enabled-espionage-2/.

documents for insights into China's officially declared strategies, and then moves to analyze unofficial Chinese documents (such as academic papers, think tank reports, and patent filings) for a broader sense of China's capabilities and strategy development.

The "deep sea" has been progressively elevated within China's national security and development framework. References to "deep sea security" were first incorporated into China's holistic national security framework (总体国家安全观) in 2014. Since then, successive five-year plans have embedded deep sea exploration and technology within national science and industrial strategies.[1] In 2024, Xi's articulated a "three-step" deep sea strategy—access, exploration, and development（深海进入、深海探测、深海开发). In 2025, "deep sea science and technology" (深海科技) was explicitly elevated in the Government Work Report as a strategic emerging sector, underscoring its perceived relevance to long-term national power.[2] Deep sea capabilities are considered in both official and semi-official narratives as important for the blue economy (蓝色经济), digital economy (数字经济), global scientific governance, and industrial upgrading.[3] In unofficial policy discourses, deep sea capabilities are also cited in reference to resource security (资源安全) and national defense security (国防安全), two frequently cited "security bottom lines" (安全底线).[4] It is also seen as part of broader "digital competition" (数字竞争) with the United States.[5] Annex A includes a table of selected major PRC policy documents related to deep sea strategy and technology development, for further reference.

However, deep sea development in China is driven not only by economic and industrial imperatives. Chinese defense-academic and military-technical literature has also focused extensively on the topic, with a focus on achieving "Command of the Deep Sea" (制深海权).[6] Unlike classical notions of sea control, which are rooted in surface dominance, Chinese strategic thought increasingly recognizes control of the deep sea domain as critical to the effectiveness of surface and air operations.[7] "Command of the Deep Sea" is defined as the ability to enter freely, remain undetected, and shape the deep sea environment over time, often articulated through formulations such as deep sea access capability, deep sea presence, and deep sea sensing.[8] Here, the deep sea is more explicitly interpreted as a battle space. PLA-affiliated analyses describe the deep sea as a sixth operational dimension（第六维空间), characterized by concealment, endurance, and high barriers to attribution, and therefore particularly suited to asymmetric competition.[9] The rationale for achieving "Command of the Deep Sea" is based on the perceived vulnerability of China's underwater domain. Recurrent references to "having seas but no defense, leaving the national gateway open" (“有海无防, 国门洞开”) point to concerns about foreign seabed surveillance, quiet submarines, and the declining effectiveness of traditional anti-submarine warfare in deep-ocean environments.[10]

For China, achieving Command of the Deep Sea is not only relevant during times of overt conflict, but also for sub-threshold or gray zone coercion. Command of the Deep Sea is not focused on permanent occupation or exclusion of adversary undersea assets. Rather, it refers to the capacity to deny adversaries uncontested use of the deep sea, while preserving one's own freedom of maneuver. This approach aligns closely with broader PLA thinking on non-linear warfare and system confrontation (体系对抗), where the objective is not platform destruction but the degradation of adversary operational systems.[11] The importance of gaining strategic advantages in the undersea domain at the sub-threshold level is consistent with Chinese military thought, which frequently emphasizes the importance of shaping conditions before the outbreak of hostilities (战前塑势). In the maritime domain, this logic is institutionalized through the concept of "preparations for maritime military struggle" (海上军事斗争准备), which stresses intelligence dominance, environmental familiarity, and system integration over reactive combat power. On March 7 2024, during the plenary meeting of the delegation of the People's Liberation Army and the People's Armed Police at the Second Session of the 14th National People's Congress, naval delegate Ai Yingchun (艾迎春）put forward opinions and recommendations on advancing the development of maritime situational awareness capabilities. General Secretary Xi Jinping emphasized that it is necessary "to coordinate preparations for maritime military struggle, the safeguarding of maritime rights and interests, and the development of the marine economy, so as to enhance China's capacity to manage and govern the maritime domain."[12] Deep sea capabilities fit squarely within this framework. Long-term seabed mapping, undersea sensing networks, and sustained scientific and commercial presence are repeatedly described as foundational activities that enhance wartime effectiveness without constituting acts of war in themselves.[13]

1.3 Undersea Cables within China's Deep Sea Strategy

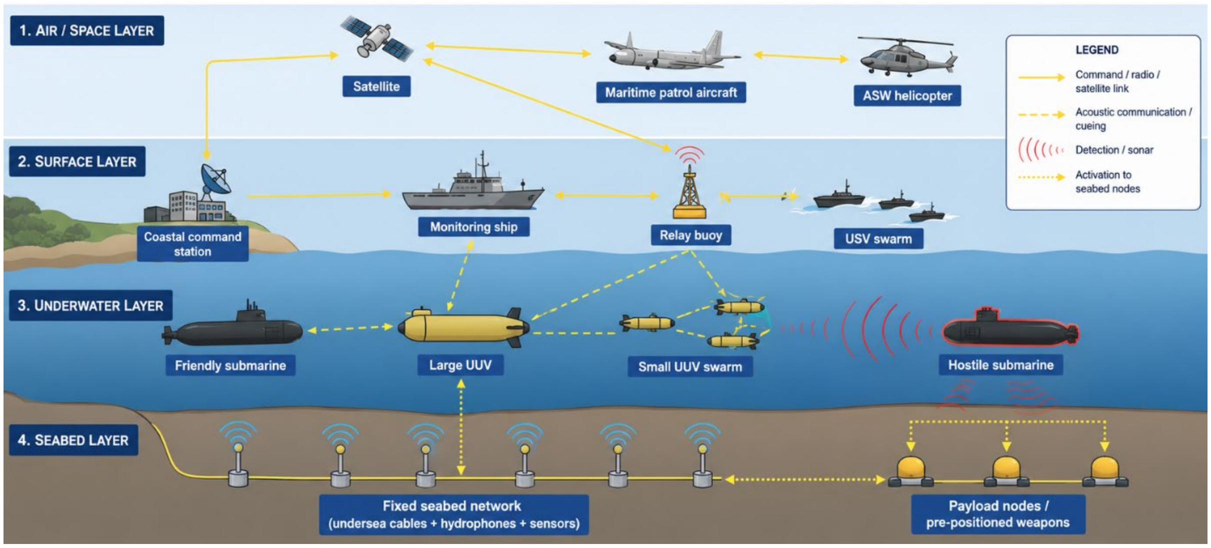
Undersea cables occupy a central position within China's deep sea strategy, where they are characterized as the "central nervous system" (中枢神经) of the global information age[14] and "strategic infrastructure" (战略性基础设施) that underpins economic development, information dominance, and national security.[15] Rather than treating cables as passive assets, Chinese policy discussions frame them as part of a broader deep sea information system (深海信息体系), integrating energy transmission, data flows, sensing networks, and seabed infrastructure into a single, layered architecture.[16] On the one hand, undersea cables are seen as a vulnerability due to their inherent physical fragility and the perceived threat of U.S. technical hegemony.[17] The ability of specialized U.S. platforms, such as the USS Jimmy Carter, to perform covert surveillance on cables is raised as a particular concern.[18] This sense of vulnerability extends to the industrial sphere, where U.S. efforts to exclude Chinese firms from international cable consortia are seen as attempts to isolate China from global data nodes and compromise its information lifeline.[19]

On the other hand, cables are viewed as a strategic opportunity to achieve "Command of the Deep Sea" by transforming the ocean into a "one-way transparent space" (单向透明空间) through their ability to improve situational awareness by hosting sensing capabilities.[20] As such undersea cables form an important part of the "Underwater Great Wall" (水下长城) concept proposed by Chinese policy analysts. In effect, this would be a "multidimensional, layered undersea offensive–defensive system" to secure China's undersea interests, particularly in strategically sensitive theaters such as the South China Sea and the East China Sea.[21] Cables serve as the physical spine for China's Underwater Great Wall, connecting vast arrays of fiber-optic hydrophones and sensors designed to track and target U.S. nuclear submarines in real time.[22]

Undersea cables are also seen as offering an opportunity for offensive action, both above and below the threshold of conflict. The ability to conduct sabotage attacks on undersea cables gives China the ability to effectively hold an adversary's infrastructure hostage as a tool of "asymmetric leverage"[23] in both times of conflict and gray zone coercion. Disruption of seabed infrastructure, such as undersea cables, is repeatedly discussed as a means of achieving asymmetric counterbalance (非对称制衡) against technologically superior adversaries, without triggering the political and legal thresholds associated with overt kinetic attack.[24] Scholars explicitly state that in a conflict, "cutting undersea cables is the most effective way to strike at the opponent's vital points" due to the low military cost and high impact on the enemy's command and intelligence systems.[25]

Undersea cable sabotage operations are consistent with the objectives of strategic pre-positioning and disruption of adversary operational systems within China's "Command of the Deep Sea" concept. Cable sabotage operations not only impose tangible losses on U.S. and allied undersea infrastructure, but also help test China's disruption capabilities and gather important information to prepare for future operations. Such actions could also serve as a deterrent function, reminding the United States and its allies of the vulnerability of undersea cable networks to Chinese interference.

Figure 1: Schematic Diagram of Future Undersea Warfare



Note: Undersea cables play an important role as part of the "fixed seabed network", with the potential to connect vast arrays of hydrophones and sensors.
Source: Author's own graphic based on Hsieh, W. 谢伟, Yang, M. 杨萌, and Gong, J. 龚俊斌, "shui xia gong fang dui kang ti xi ji qi wei lai fa zhan" 水下攻防对抗体系及其未来发展 [Underwater Offensive and Defensive Confrontation Systems and Their Future Development], Engineering Science 中国工程科学 21, no. 6 (2019): 71–79.

1.4 Military-Civil Fusion in the Deep Sea

Ultimately, China's deep sea strategy should neither be considered as exclusively security focused nor as exclusively economically focused. Rather, it is a dual narrative, in which industrial leadership combines with latent security utility in a mutually reinforcing relationship. Deep sea development can aid both economic development and strategic leverage. This complicates external assessments of China's capabilities and intent in the undersea domain and blurs the boundary between scientific activity and strategic preparation.

This dual approach is consistent with China's broader "military-civil fusion" strategy, which has proved highly successful across a range of sectors.[26] The firms listed in Annex B illustrate this process across the deep-sea industrial chain. Their relevance to military–civil fusion does not depend on formal membership in a single program or on whether they are legally classified as military enterprises. It derives from their established roles as defense suppliers, subsidiaries of major defense conglomerates, recipients of state investment, or producers of technologies directly or indirectly applicable to naval operations, underwater surveillance, military communications, and seabed infrastructure. At the upstream level, state-owned material firms such as Western Metal Materials (西部材料), Baoji Titanium (宝钛股份), and Goldsky Titanium (金天钛业) provide the specialized alloys required for deep-sea platforms. Although these materials also support civilian industries such as offshore energy and marine engineering, their capacity to withstand extreme pressure, corrosion, and prolonged underwater deployment makes them strategically important to military platform development. These feed into a second layer of firms focused on underwater information and sensing systems—including China State Shipbuilding Corporation-controlled China Marine Information Electronics (中国海防) and Zhongkehaixun (中科海讯; closely linked with the Institute of Acoustics, China Academy of Science)—which develop sonar, signal processing, and acoustic monitoring capabilities.

These sensing functions are closely tied to the submarine cable sector, where companies such as Zhongtian Technology (中天科技)[†] and Hengtong Optic-Electric (亨通光电) produce and deploy electro-optical cable systems that serve both as communication infrastructure and as potential sensing networks. System integrators, notably HMN Technologies (华海通信) and FiberHome (烽火通信), then bring these components together into large-scale, seabed-based architectures, combining data transmission with persistent monitoring functions.[‡]

Supporting this architecture is a layer of marine engineering and equipment firms that enable installation, maintenance, and operation in high-pressure environments, alongside dual-use defense companies such as Tianhe Defense (天和防务), which translate these enabling technologies into deployable underwater platforms.[§]

Crucially, civilian-led deep sea projects generate enduring "facts on the seabed"—infrastructure, data, technical expertise, and operational familiarity—that can be repurposed under crisis conditions without the need for overt force deployment. This dynamic, sometimes described as a form of "military off-the-shelf" capability, allows China to translate peacetime economic activity into latent strategic advantage.[27]

1.5 Access Capabilities: Reaching, Operating on, and Persisting at Depth

China's expanding portfolio of deep-sea access capabilities can be directly mapped onto the functional requirements of submarine cable operations—ranging from survey and installation to monitoring, maintenance, and potential interference should cables become damaged or need replacing. Although framed within a civilian scientific narrative, the military significance of such capabilities lies in their enabling characteristics. Persistent seabed presence creates conditions for forward undersea basing, pre-positioning of equipment, and the development of covert sustainment concepts for manned and unmanned underwater vehicles. Together, they could be used to pre-position the capabilities to attack undersea cables described in Sections 1.6, 1.7, and 1.8. The ability to conduct such operations undersea—without reliance on continuous surface presence—also complicates detection and interdiction. Notable recent developments in China's deep sea access capabilities include:

[†] Principally an energy and telecommunications company, yet its expertise in optical communications, submarine cables, seabed observation networks, and underwater sensing has also been extended into defense information systems, maritime security, and underwater protection applications. Its significance to military–civil fusion lies precisely in this overlap: the company remains commercially active while serving as an important civilian supplier of technologies relevant to military modernization.

[‡] These companies perform comparable roles across cable manufacture, system integration, marine survey, deployment, maintenance, repeaters, branching units, and seabed observation systems. These activities generate capabilities that are directly relevant to civilian telecommunications, yet also provide the engineering knowledge, seabed access, underwater communications, and persistent sensing functions required for military operations. FiberHome's fixed seabed acoustic arrays are a particularly clear example of the convergence between communications infrastructure and underwater surveillance.

[§] Although formally a civilian-listed company, Tianhe develops AUVs, underwater acoustic sensors, defense electronics, and other technologies applicable to both commercial deep-sea operations and military missions.

Current Capabilities

- **Crewed submersibles:** Notably the Jiaolong (蛟龙号) and Fendouzhe (奋斗者号), the latter being promoted as China's indigenous 10,000-meter-class submersible.[28] Manipulator arms, tooling interfaces, precision positioning, and extended bottom time could aid with cable inspection, handling, and intervention.[29] In a dual-use context, these same features could enable physical access to cable systems for tampering, cutting, or the emplacement of devices.

- **Uncrewed platforms:** National Key R&D projects since 2017 show sustained investment in full-ocean-depth Autonomous Underwater Vehicles (AUVs), work-class Remotely Operated Vehicles (ROVs), hybrid AUV/ROV systems, and specialized seabed vehicles (see Annex C). While such platforms have been originally developed for mining, oil drilling, or geological sampling, the lower visibility, greater persistence, and scalability offered by uncrewed systems make them well suited to covert seabed operations, such as sabotage of undersea cables.[30] Also notable is PLA's HSU-001, a large domestically developed unmanned underwater vehicle (UUV), first publicly displayed in 2019. The indigenous HSU-001 is assessed as being suited to missions such as underwater reconnaissance, and surveys of seabed topography and hydrological conditions – all of which are essential for identifying cable locations, vulnerabilities, and optimal points of intervention, and so could directly assist with cable surveillance and sabotage missions.[31]

In March 2026, China's top maritime institute, Dalian Maritime University, demonstrated China's first ship-centered system for coordinating UAVs, unmanned surface vessels, and underwater robots. Centered on the *Xin Hongzhuan* (新红专), the system used ship–shore communications, aerial relays, and centralized task allocation to support seabed scanning, underwater infrastructure maintenance, and wider-area maritime surveillance. The demonstration indicates a shift from individual unmanned platforms towards integrated, multi-domain operations—an enabling capability that could support coordinated cable survey, monitoring, repair, or, if adapted, interference.[32]

Future Goals and Aspirations

- **Persistent seabed operations:** China is developing a permanently emplaced seabed habitation and experimentation module, which will be capable of operating at depths of approximately 2,000 meters, supporting a six-person crew for missions of up to thirty days.[33] The module will act as a docking and supporting interface for submersibles and remotely operated vehicles, with deployment anticipated in 2030.[34] This will be supported by an associated surface support vessel, with a displacement of approximately 9,380 tons. Together, this enhances China's ability to conduct sustained seabed operations, which could include targeting adversary undersea cable infrastructure.[35]

- **Supporting networks:** The above-mentioned pre-positioned assets will be sustained by a network of distributed undersea energy stations (水下充电站) and deep sea space stations,[36] which provide the high-density power and data relay necessary for long-term "dormancy" and rapid "remote awakening." In the event of a conflict, these nodes can release AUV clusters to conduct strike or surveillance missions against cables.[37]

1.6 Seabed Awareness and Targeting Capabilities

Physical access alone does not confer effective control over undersea infrastructure. Accordingly, Chinese military scholars place heavy emphasis on seabed awareness as the cognitive foundation of deep sea operations. This emphasis is particularly pronounced in literature on undersea domain awareness (水下态势感知), where the deep sea is framed as an information environment that must be rendered legible, predictable, and manageable before staging targeted interventions.

Importantly, for Chinese military scholars, underwater sensing and targeting combine both offensive and defensive capabilities. Such capabilities not only help China protect its own infrastructure, but can also help identify vulnerabilities and aid in targeting adversary infrastructure – including undersea cables. For example, detailed network-topology analysis can reveal high-centrality "hub" landing points or chokepoints where disruption would generate disproportionate systemic effects. Long-term seabed mapping can also identify shallow-water segments, poorly buried cables, or routes crossing geologically unstable terrain, where infrastructure is more exposed and repair times are prolonged. In practice, such vulnerabilities could be exploited through ostensibly accidental means—such as anchor drag in lightly protected areas—or through covert deployment of unmanned systems positioned near critical nodes for rapid activation in a crisis. The difficulty of attribution in the deep sea environment further enhances the utility of such options, as physical damage can be engineered to resemble natural causes or routine maritime incidents. For the United States and its allies, this convergence of environmental monitoring, infrastructure management, and military sensing blurs the boundary between civilian and military awareness. It also complicates attribution: activities justified as scientific observation or environmental protection may simultaneously enhance the ability to map, track, and influence undersea cables.

Key themes and developments in China's development of undersea awareness and targeting capabilities include:

- **Layered awareness architecture:** Military scholars place emphasis on the importance of integrating multiple different sensors into a single networked system, combining environmental data such as salinity, ocean currents, or seafloor data, from fixed seabed observatories, mobile sensor platforms, fiber-optic acoustic sensing, and satellite-supported data relay to create a composite picture.[38] In this architecture, submarine cables occupy a dual role: they are both objects of monitoring and, potentially, sensing conduits themselves. In China's Seabed Observation Networks (海底观测网),[39] subsea cables play a critical enabling role in linking distributed passive sonar arrays across the seabed. Any underwater acoustic signal that enters the coverage envelope of such an array can be detected. By analyzing the sequence in which individual sensors are triggered, together with their respective locations, it is possible to determine the bearing and approximate range of the sound source. This information can then be integrated into a wider maritime situational awareness system and disseminated in near real time to other operational platforms and command-and-control centers. In turn, this enables the cueing and direction of anti-submarine warfare (ASW) assets—such as maritime patrol aircraft or surface vessels—to the designated area, where they can conduct targeted search operations to track and ultimately fix hostile contacts.[40]

- **Environmental monitoring:** Constructing and maintaining cables and other forms of undersea infrastructure require deep knowledge of the seabed environment. Consequently, China has developed technologies, such as the South China Sea Seafloor Observatories and the Three Dragons (manned Jiaolong, unmanned ROV Hailong, and AUV Qianlong), to continuously monitor seabed stability, sediment movement, human activity, and environmental stress over extended periods.[41] While designed to support safe cable routing and maintenance, these same capabilities could also be used to assess vulnerabilities in adversary infrastructure and help target effective attacks.

- **Swarming and unmanned strike missions:** Researchers from the PLA Navy Research Institute have highlighted the importance of coordinating distributed unmanned systems in creating systems to persistently monitor, map, and intervene in undersea environments.[42] The researchers propose a swarming system, whereby AUVs, ROVs, and sensor nodes are deployed from a submarine mothership, and used to conduct forward intelligence, surveillance, reconnaissance, and strike missions.[43] The U.S. Navy regards this approach as an effective means of extending a submarine's "eyes and hands," expanding its operational control radius, and enhancing submarine survivability.[44]

- **Hibernating cable cutting technologies:** China has developed a range of specialized deep sea robotics equipped with cable-cutting capabilities to covertly sabotage enemy communications during a conflict. These include "arresting and catching" robots (抓捕机器人) equipped with "shark-tooth" inspired cable cutters (仿鲨鱼齿形电缆切割器).[45] This specific equipment is designed to sever fiber-optic links in a manner that mimics biological damage, facilitating covert sabotage that is intentionally difficult to attribute.[46] Further, such systems could be deployed as part of "hibernating" undersea systems prepositioned near strategic cable infrastructure.[47]

1.7 Build, Control and Repair Capabilities

Chinese companies remain technically capable and strategically significant in the global undersea cable industry, although their market position has become increasingly uneven. HMN Technologies (华海通信, formerly Huawei Marine Networks) supplied approximately 10 percent of new cable systems built between 2020 and 2024 and an estimated 10 percent of new cable kilometers entering service between 2010 and 2023. Its share of planned cable kilometers through 2026, however, had fallen to approximately 4 percent, reflecting U.S.-led efforts to exclude Chinese suppliers from major U.S.-connected and cross-continental projects. The transfer of the SEA-ME-WE 6 contract from HMN Technologies to the U.S. firm SubCom illustrates how geopolitical and security concerns have constrained Chinese participation in parts of the international market.[48]

This contraction should not be confused with a loss of industrial capability. HMN Technologies and FiberHome (烽火通信) retain the capacity to manage the full lifecycle of international cable projects,[49] including system design, marine survey, equipment integration, installation, maintenance, and capacity upgrades.[50] Chinese suppliers also continue to compete through state-supported financing and lower-cost bids, while retaining a significant presence in Southeast Asia and parts of the wider Global South where governments remain willing to adopt Chinese digital infrastructure. HMN Technologies, for example, continues to participate in regional systems as a supplier, installer, or both, and Chinese bids may be substantially cheaper than alternatives.

A range of other Chinese companies specialize in different stages of the undersea cable supply chain (see Annex B). Their strategic significance therefore lies less in aggregate global market share than in their continuing technical competence, full-chain delivery capacity, and concentrated presence in particular regional markets. Where Chinese firms design, install, operate, or maintain these systems, they retain a degree of access to – and influence over –the physical and informational infrastructure supporting regional connectivity.

At the core of this capability lies repair proficiency, which represents a critical dual-use threshold, and can be used to execute controlled disruption. Technical literature, such as reports from ICCSZ[51], emphasizes that the cutting and re-termination of cables are standard procedures performed under extreme time pressure and difficult marine conditions.[52] Repair processes may include cutting cables to enable retrieval and repair of faulty or damaged cables, before reburial. Consequently, China's refinement of these commercial repair techniques provides a ready-made capability for disrupting undersea infrastructure, applicable to both gray zone provocations and high-intensity conflict scenarios.

In recent years, however, elements of this commercial skill set appear to have been further refined and patented for operations in greater depth and under more demanding pressure conditions. Prominent examples include:

- The reported development in 2025 of a 4,000-meter-class deep sea electric cable cutting device by a research center affiliated with the China State Shipbuilding Corporation, as the China Ship Scientific Research Center's "electric cutting device."[53] Designed with titanium alloy housing, oil-filled pressure compensation systems, and a diamond-coated high-speed grinding wheel, the device is engineered specifically to operate at depths well beyond those typically associated with routine cable burial or armor protection.[54] At such depths, many commercial cables are neither deeply buried nor heavily armored, having long been assumed to be protected by sheer inaccessibility.[55] The ability to conduct precise cutting operations at these "safe-depth" segments represents a qualitative enhancement over standard repair capabilities.[56]

- The refinement of anchor-damage mechanisms into purpose-built, towable cutting devices. Chinese patents describe trawl- or anchor-like systems incorporating internal shearing structures capable of severing heavy armored cables while externally resembling ordinary maritime equipment.[57] Such systems could, in theory, enable long-distance cable damage under the guise of commercial shipping or fishing activity, thereby exploiting the inherent attribution challenges of the undersea domain.[58]

1.8 Developments in Chinese Patents with Relevance for Undersea Cable Disruption

A series of recent patents filed by Chinese universities, companies, and research institutes reveals how China continues to develop a series of commercial undersea cable technologies with dual-use capabilities, including monitoring and disrupting undersea cable networks. Notable patents filed recently include:

- **Deep sea robot crawlers:** a subset of patents explicitly discloses UUVs capable of traveling along submarine cables, with "deep sea cable-crawling robots" representing the highest-risk category. These robots are equipped with self-contained sensor suites and can traverse armored cables while carrying eavesdropping devices, cutting tools, or even seabed drilling equipment.[59]

- **Armor stripping and cable splicing:** China has filed a substantial number of patents relating to submarine cable branching units, electrical switching functions, joint boxes, armor crimping, and in-line splicing.[60] Collectively, these patents suggest the technical capacity to rapidly strip cable armor, manipulate fiber-optic components, re-seal cable sections, and even remotely sever power or communications to specific regions.[61]

- **Cluster seabed mining technologies:** New patents reveal the development of "distributed cluster-type deep sea seabed mineral collection equipment."[62] These systems are built to operate at depths of 4,000 meters or more and are equipped with precision sonar, optical sensing, and manipulator arms capable of gripping, cutting, and lifting hard substrates.[63] They are also built to function together as coordinated "clusters." The same mechanical capabilities used in deep sea mining—such as rotary cutters, hydraulic suction devices, or mechanical grab arms—could be adapted to manipulate, expose, drag, or sever seabed cables, particularly those lying unburied in deep-water segments.[64]

- **Deep sea acoustic sensing:** Patent disclosures also describe an "L-shaped line array" for detecting underwater activity. One part lies along or near the seabed and listens for long-range sounds from ships, submarines, UUVs, and seabed operations. The other extends upwards from the same unit, allowing the system to detect activity higher in the water column. Used together, the two arrays can track underwater vehicles, monitor where cable-laying vessels operate, and help reveal the location and use of seabed infrastructure.[65]

- **Mapping of seabed topography:** Additional patents—including "multi-sensor deep sea pressure cabins based on seabed geodetic control networks" and "autonomous inspection methods and equipment for subsea pipelines based on optical-vision technologies"[66]—enable not only detailed mapping of seabed topography, but also the continuous monitoring of vulnerabilities along subsea pipelines using UUVs.[67]

Part 2: Assessing Risk across Trans-Pacific Networks

2.1 Key findings:

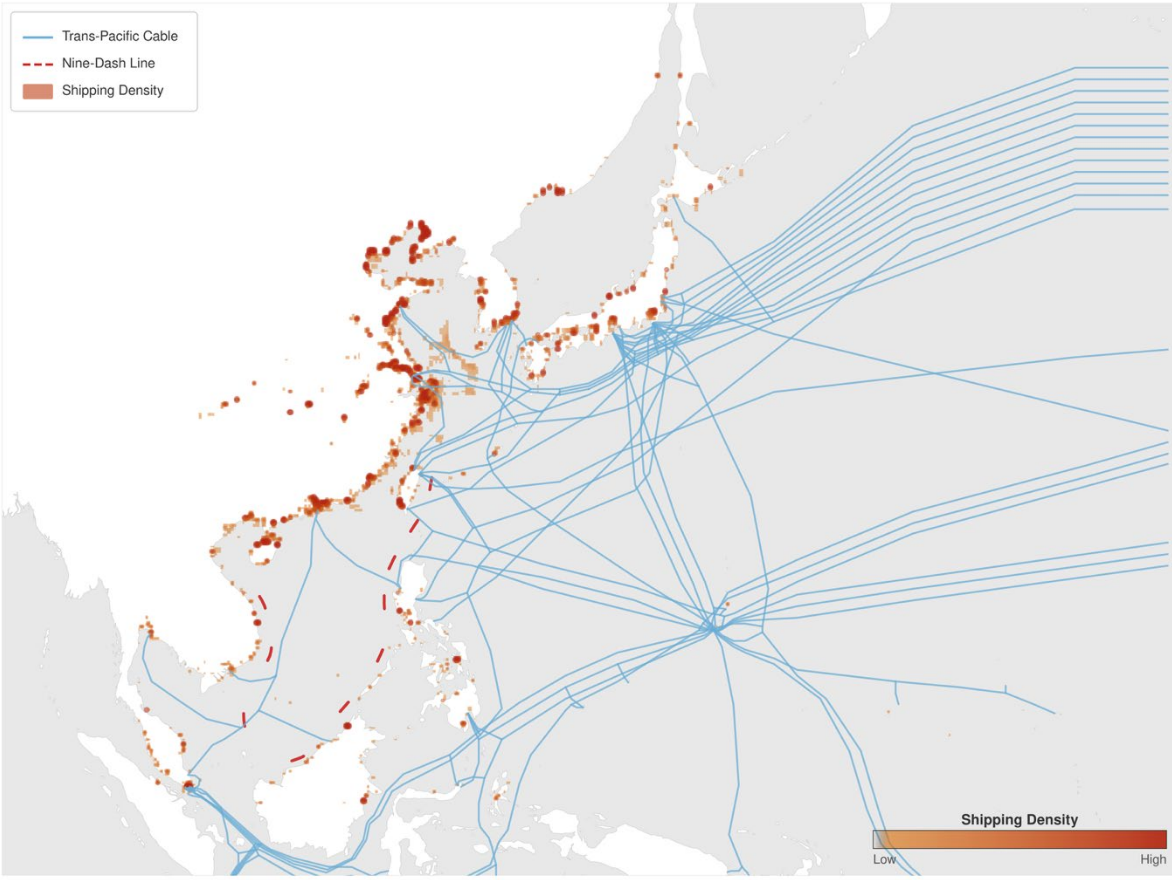
- Cable risk is highest around the first-island chain countries of Taiwan, Japan, and the Philippines. This is due in part to political factors, most notably China's claims over Taiwan, but also because cables connecting these countries with the United States pass through shallow waters with busy shipping lanes, all of which make gray zone sabotage harder to detect and easier to deny.

- New U.S. cable initiatives are particularly vulnerable to gray zone threats. Our model finds four of the top ten most at-risk cables – E2A, TPU, ORCA, and ACC-1 – are still under development, with major ownership stakes from U.S. companies including Google, Meta, and Verizon.

2.2. Methodology: Trans-Pacific Cable Gray Zone Vulnerability Index (GZVI)

Resource prioritization is a significant challenge for policymakers seeking to enhance the protection of undersea cables. Trans-Pacific cable systems stretch for thousands of miles and may have several landing points along their route. Deciding where to place undersea sensors, conduct naval patrols, or focus tracking is critically important for effective monitoring and protection. To aid with these efforts, this paper has created a ***Trans-Pacific Cable Gray Zone Vulnerability Index (GZVI)*** to assess and rank the vulnerability of different cable systems to China's gray zone threats. The scope of the GZVI has been limited to the Indo-Pacific as this is the prime theater of China's gray zone activity, though China has been linked with suspected cable sabotage incidents in the Baltic Sea.[68] Within the Indo-Pacific, the scope of the GZVI has been limited to cables which traverse the Pacific – as opposed to shorter connections within the region – as these intercontinental cables form the main highways of U.S. communications with the region.

Figure 2: Map of selected risk factors taken into account by the GZVI



Note: Trans-Pacific cables are close to both China's maritime claims and areas with high density of shipping.
Source: Author's own analysis

The GZVI takes into account a range of geopolitical factors which may cause a particular segment of cable to be at higher or lower risk of disruption from China's gray zone activities. These factors were determined initially by analysis of existing case studies of suspected undersea cable sabotage linked to China, as compiled by CSRI in a previous report.[69] This analysis found a range of commonalities between suspected sabotage incidents. Notably, in all cases, evidence pointed toward damage caused by commercial or fishing vessels operating in shallow waters, with incidents centered around geopolitical flashpoints around Taiwan or in the Baltic Sea. Prospective risk factors were then presented to a panel of policy and industry experts, who added further risk factors to the list, such as shipping density and the nationality of cable operators and owners. Each risk factor was then assigned an indicator to measure the degree to which the risk factor is relevant to a particular segment of the undersea cable. Scores were then assigned to each indicator, with some indicators broken down into graduated scores (0, 1, 2, and 3) and others as binaries (0 or 3). The authors and the experts then discussed the appropriate ranking of factors in order of importance, which then contributed to the weightings given to different risk factors in the final analysis.

The risk factors determined for inclusion are included below, along with their relevant justifications. A list of the indicators, scores, and weightings for each indicator is included in Annex D.

- **Heavy maritime traffic:** Heavy maritime traffic around cable infrastructure is a relevant risk factor for gray zone sabotage of undersea cables. Firstly, it makes detecting vessels acting suspiciously harder, with vessels having legitimate and ordinary reasons to be near undersea cables in these areas. Secondly, it gives plausible deniability to the attacker, as accidental damage to undersea cables is not uncommon in areas with high levels of maritime traffic. It is particularly notable that publicly reported incidents of suspected cable sabotage operations linked to China have all been conducted by ordinary commercial and fishing vessels, rather than specialist military, coast guard, or other official vessels.[70] The use of commercial vessels further complicates detection and strengthens plausible deniability in areas with heavy maritime traffic. While this risk factor is given a high weighting for the gray zone level of threat considered by this paper, a lower weighting may be applied in a conflict scenario in which deniability and ambiguity are less important for China's objectives, and in which China may use more specialist equipment that can evade detection.

- **Bathymetric profile:** Shallower waters are at higher risk of gray zone coercion due to the ability of ordinary commercial vessels to damage cables in such environments. In particular, trawling and anchoring are thought to account for up to 75 percent of all cable faults globally, including each of the incidents of suspected sabotage linked to China.[71] With the vast majority of such incidents being accidental, this means that prospective gray zone attackers can undertake sabotage in shallower waters while maintaining plausible deniability. While China does have specialist equipment to cut cables in deeper waters, such actions would be more difficult to disguise as accidental sabotage. As with heavy maritime traffic, this risk factor might be considered less important in a conflict or darker gray scenario, in which deniability and ambiguity are less important for China's objectives.

- **Proximity to China's maritime claims (Taiwan):** Taiwan has been the prime target of China's gray zone warfare, with China claiming sovereignty over Taiwan, including its outlying islands, and associated territorial waters. Gray zone operations against Taiwan have included large-scale military drills, frequent encroachments into Taiwan's Air Defense Identification Zone (ADIZ) and 24 nautical mile contiguous zone, information manipulation, and covert political interference.[72] Notably, all of the incidents of suspected cable sabotage by China in the Indo-Pacific have targeted cables with landing points in Taiwan. Cables landing in Taiwan thus have a significantly heightened risk of being targeted as part of broader efforts by China to increase gray zone pressure on Taiwan, and would also be likely to be targeted in a conflict scenario with Taiwan.

- **Proximity to China's maritime claims (EEZ):** Cables passing through China's Exclusive Economic Zone (EEZ) might be considered more vulnerable to gray zone sabotage due to the increased freedom with which China can operate in this area. Sabotage operations could be undertaken with less fear of detection from other countries. While U.S. and allied Freedom of Navigation Operations do transit China's EEZ, such maneuvers are infrequent and easy for China to detect well in advance. This risk factor considers the actual EEZ administered by China, as opposed to its unfounded and extensive territorial and EEZ claims within the nine-dash line, which is considered in a separate risk factor below.

- **Proximity to China's maritime claims (nine-dash line):** China conducts a number of maritime gray zone operations in support of its unfounded territorial and EEZ claims in the South China Sea, demarcated by its "nine-dash line." Such operations include large-scale sand dredging to create artificial islands and military infrastructure, regular patrols near disputed features by Navy and Coast Guard vessels, and a high presence of suspected state-directed "maritime militia" fishing vessels.[73] China's Coast Guard has also employed non-lethal methods against countries disputing China's claims, most notably the Philippines Coast Guard, including water cannons, ramming, and lasers.[74] While so far suspected undersea cable sabotage incidents in the region have centered around Taiwan, sabotage within the nine-dash line would be consistent with China's attempts to enforce its claims through gray zone coercion. For this reason, segments within the nine-dash line and also landing in Taiwan are given a higher risk scoring.

- **Foreign cable ownership:** Cables owned or operated by Chinese companies may be at lower risk of gray zone sabotage. Firstly, because China may wish to avoid unnecessary harm to its own economic interests. Secondly, because, in the event that other cables are damaged, affected data may be re-routed via Chinese operated cables, which in turn may bolster China's ability to conduct espionage against the United States and other targets. Thirdly, because Chinese operated or owned cables may be a good proxy indicator for cables that are most important to China's own communication needs, and so damage to these cables may be avoided. Of the six cases of suspected undersea cable sabotage linked to China between 2021 and 2025, only one case involved a cable with part-Chinese ownership.[**] Consequently, cables that are mostly or entirely operated or owned by non-Chinese companies may be considered as higher risk.

To complete the risk analysis, the authors first compiled a list of U.S. trans-Pacific undersea cables, which number 32, including 8 that are not currently operational but are expected to come into service before 2030. Each cable was then split into segments of 20km (12.4274 miles) in length. A risk score was calculated for each segment, according to the risk indicators and weighting as detailed in Annex D, Table 9. The risk scores of each individual segment were added together, creating a total risk score for the cable as a whole. The simplified ranked results are presented in **Table 1**, with a full table of indicator scores included in Annex D, Table 10.

[**] The cutting of the TPE Cable System in the East China Sea in January 2025, part owned by China Telecom and China Unicom, alongside U.S., Japanese, Korean and Taiwanese owners. See Yeh, Andrew. *Testing the Waters: Securing the UK's Undersea Cables against Grey-Zone Threats*. China Strategic Risks Institute, 2025. https://www.csri.global/research/testing-the-waters.

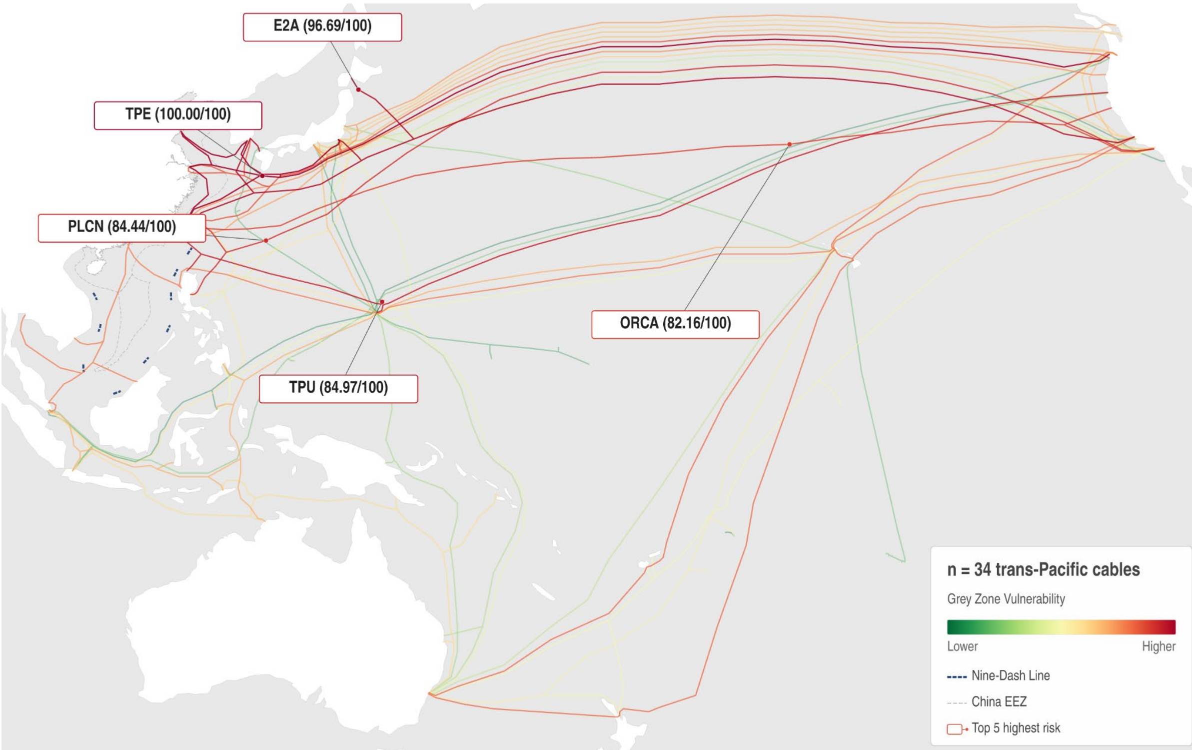
Table 1: Top 10 Highest risk U.S. trans-Pacific cables under the Gray Zone Vulnerability Index with rounded indicator results, full table in Annex D

Rank	Cable Name	Depth Score*	Shipping density Score*	9-Dash Score *	EEZ Score*	Taiwan Landing Point	PRC Ownership	Index
1	Trans-Pacific Express (TPE) Cable System	659	36	0	390	Yes	Partial	**100.0**
2	E2A**	252	3	0	60	Yes	None	**96.7**
3	TPU**	53	0	21	18	Yes	None	**85.0**
4	Pacific Light Cable Network (PLCN)	53	0	0	12	Yes	None	**84.4**
5	ORCA**	56	2	3	9	Yes	None	**82.2**
6	New Cross Pacific (NCP) Cable System	332	30	0	135	Yes	Partial	**74.3**
7	Southern Cross Cable Network (SCCN)	254	0	0	0	No	None	**65.1**
8	Asia-America Gateway (AAG) Cable System	574	15	408	219	No	None	**63.3**
9	FASTER	147	1	0	66	Yes	Partial	**59.6**
10	Asia Connect Cable-1 (ACC-1)**	567	4	0	0.0	No	None	**56.6**

* Scores given are cumulative. This means that each 20km segment (approx 12.4 miles) of cable was assigned a score based on the relevant risk factor, e.g. water depth, and the scores for each segment were added together to give a total score for the cable as a whole. A higher score, such as those in the hundreds, suggests high numbers of segments scored at a high level of risk, while a lower score, such as those in single digits, suggests the vast majority of segments were considered no or low levels of risk. Scores are rounded to the nearest whole number. Full results are available in Annex D, Table 10.

**These cables are not yet operational, with scheduled service before 2030.

Figure 3: Map of Trans-Pacific cable vulnerability score



Note: Cables connecting the United States to Taiwan, Japan, and the Philippines are among the most vulnerable, but risk is not limited to the first-island chain.
Source: Author's own analysis

2.3 Results and analysis: Gray Zone Vulnerability Index

A number of findings stand out from the GZVI. Firstly, **cable risk is highest around the first island chain.** As shown in **Figure 3**, U.S. connections to North-East Asia and the first island chain are particularly vulnerable to China's gray zone coercion, covering the landing points for all of the top five most at-risk cables. This is due to a confluence of political, geographical, and maritime factors which means that Japan, Taiwan, and the Philippines emerge as risk hot spots for U.S. trans-Pacific connections. While this finding may not be unexpected, given China's targeting of these countries, the finding does underline an often overlooked factor in the strategic significance of the first island chain: the first island chain is not just vital to the United States' ability to trade and project military power in the region; it is also vital for U.S. communication security.

Secondly, **new U.S. cable initiatives are highly vulnerable to gray zone threats.** Four of the top ten most at-risk cables—E2A, TPU, ORCA, and ACC-1—are still under development, with expected operational dates ranging between 2026 and 2029. Notably, none of these cable initiatives has any Chinese owners or operators, nor do they connect to China. While this may be beneficial to address concerns that may arise from Chinese ownership – such as enhanced ability to conduct espionage—it does mean that China can target these cables without fearing significant harm to its own interests. On the contrary, three of these cables are part-owned by U.S. companies, with TPU wholly owned by Google, ORCA wholly owned by META, and E2A partly owned by Verizon.

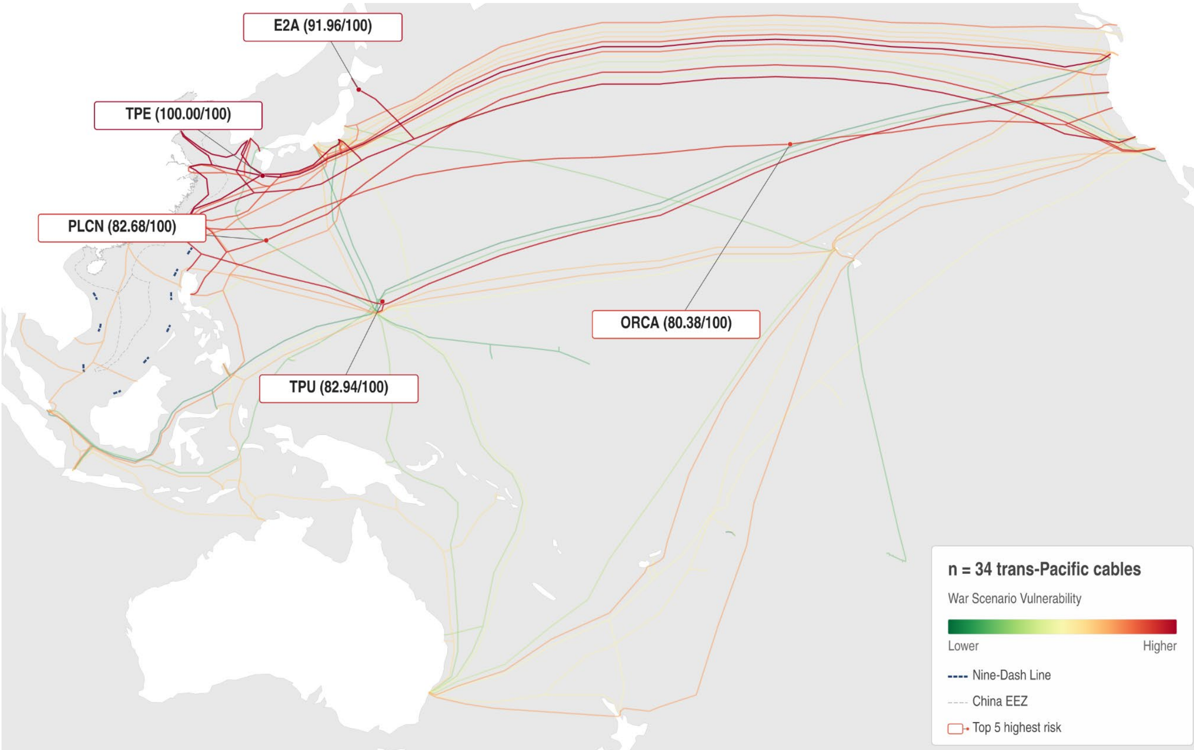
Finally, **cable security must be considered with the full range of Indo-Pacific partners**. Despite the concentration of risk around U.S. connections to North-East Asia, cable risk extends far beyond specific contingencies related to Taiwan and other first island chain countries. Notably, 3 cables without any landing points in Taiwan—SCCN, AAG, and ACC-1—still break into the top 10 most vulnerable cables. These cables connect the United States with many of its most important allies and trade partners in the region. SCCN is a major route linking the United States with Australia, a QUAD, AUKUS, and Five Eyes Partner, as well as New Zealand and Fiji. AAG is an important link to Thailand, a U.S. treaty ally, and together with ACC-1, provides connections to many countries in the economically important ASEAN bloc. The spread of risk means that U.S. cable vulnerability cannot be considered exclusively in relation to China's growing threats against Taiwan, and the United States must be vigilant in protecting its cable networks across the region.

2.4 GZVI Adjustments and Limitations

The GZVI is intended as a tool to help policymakers and cable operators calculate and assess the spread of risk across undersea cable networks. A key limitation of the GZVI is the difficulty of ascertaining the balance of risk factors that may be important to China as it plans its future gray zone attacks. While this report has determined weightings based on the general threat landscape of China's recent gray zone activity, other priorities may take precedence according to different circumstances. The authors recommend that users of the GZVI seek to replicate the methodology with their own weightings according to the threat profiles most relevant to their interests. For example, in a scenario in which China is involved in open conflict with Taiwan, China may consider maintaining ambiguity and plausible deniability is less important – in which case the cover of heavy maritime traffic may be given less weighting. The critical factor may be targeting Taiwan's communications infrastructure, in which case whether a cable has a landing point in Taiwan or not should be given a higher weighting. Equally, should China be willing to deploy its more specialist cable cutting technologies—capable of operating at depth—the weighting given to shallow waters will also be less important. Figure 5 shows an updated heat map for such adjusted weightings in a war scenario with Taiwan, with the full weightings and results in Annex D, Tables 11 and 12.

A further set of limitations is the decisions that China may make in relation to U.S. territories in the region. The authors of the paper were split as to whether cables connecting to Guam and Hawaii would be more or less likely targets of China's gray zone activity. On the one hand, targeting these cables may be an effective signaling mechanism against the United States, causing both embarrassment and economic damage, and questioning the credibility of U.S. power in the region. On the other hand, drawing increased U.S. attention to the region may be considered counterproductive to Beijing, which may prefer that U.S. resources be concentrated away from the region, leaving China to exert its influence.

Figure 4: Adjusted cable vulnerability scores for a 'Taiwan conflict' scenario



Note: Compared to Figure 3, the adjusted weightings see a re-balancing of risk towards cables directly connecting to Taiwan. However, the top four most vulnerable cables remain the same.
Source: Author's own analysis

Part 3: Modeling the Impact of Undersea Cable Disruption on Trans-Pacific Networks

3.1: Key findings:

- Simultaneous disruption to multiple major trans-Pacific cables—in scenarios such as an attack on Taiwan—could overwhelm residual available capacity across the trans-Pacific network as a whole. This would force data to take longer and slower routes, with cascading impacts on financial services, cloud services, and video calls.

- Stand-alone cases of sabotage against individual trans-Pacific cables are unlikely to cause major disruption to the whole trans-Pacific network. However, slowdowns could impact U.S. economic interests reliant on super fast connections, such as high frequency trading and AI services.

- U.S. mainland connections to Hawaii and Guam remain uniquely vulnerable, with disruption to any single key cable increasing risk of congestion and latency issues. Connections with Japan, Taiwan, and the Philippines could also be impacted by even just one cable cut.

- How quickly the trans-Pacific network can recover from major disruption scenarios is dependent on the availability of repair vessels, and/or how quickly operators can upgrade capacity on unaffected cables. Two key concerns thus emerge: the aging fleet of repair vessels, and supply chain constraints on the equipment needed to upgrade the capacity available on existing, unaffected cables.

3.2 Key Challenges: Repair Shortages and Expanding Lit Capacity

Cable networks are designed to operate with significant levels of redundancy – a necessity given the frequency of damage to cables by both natural and human factors. Should a specific cable be unavailable, data can be re-routed to the next fastest available route. Given the 25 cables that cross the Pacific, alternative routings are normally available, and most users are unlikely to notice delays or outages when individual cables are damaged or under maintenance. However, it would be foolish for U.S. and allied policymakers to assume that such redundancy will always be available in a major disruption scenario, or that repair vessels and other repair equipment will be ready and sufficient to address issues quickly.

In the disruption scenarios analyzed in this section, a key question is whether alternative cable routings have sufficient capacity to absorb re-routed data. Before doing so, it is important to note the difference between the theoretical maximum 'design' capacity of a cable, and the currently available 'lit' capacity of a cable.[††] In many of the scenarios analyzed below, lit capacity is overwhelmed but design capacity – if maximized – can still theoretically absorb the impact. A critical question is thus to what extent unused 'dark' fiber pairs can be lit in response to an escalating disruption scenario. How quickly this can take place depends on the ability of cable operators to procure the necessary Submarine Line Terminal Equipment (SLTE) to activate spare fiber pairs. This is particularly challenging given demand for SLTE components globally, with a spike led by both increased demand from the AI sector, and cable operators looking to comply with new U.S. and other requirements for trusted vendors in subsea supply chains.[75] Even for cable operators who manage to procure SLTE equipment, or have such equipment spare, it would still need to be shipped to the landing point, and then undergo an installation process which may take several days. Depending on the resilience and agility of an operator's SLTE supply chain, performing significant upgrades on existing cable capacity may take anywhere between a few days and a few months. This adds a significant degree of uncertainty to the ability of residual capacity to absorb the overspill of multiple cable disruptions.

A further compounding factor is the availability of global cable repair fleets, which are aging and under significant strain. There are only 62 cable vessels globally, of which up to 36 may be used for cable repair and maintenance at any one time.[76] Of these, industry experts estimate that 15 will need to be replaced by 2040.[77] Cable repair times in the Asia-Pacific region are already longer than in North America and the Atlantic regions – averaging about 30 days.[78] A multiple cable break scenario – with aging fleets stretched across the region – could significantly extend this. A further delaying factor is the time taken for cable operators to secure the relevant permits to repair cables, which, due to the international nature of the work, often requires separate processes across multiple jurisdictions. This has proven to be particularly difficult in the South China Sea, where China has demanded that cable repair ships obtain permits to operate on cables in waters subject to its unfounded maritime claims.[79] Consequently, bolstering the ability of cable operators to rapidly access, repair, and upgrade

[††] Available or activated capacity is generally referred to as "lit capacity", as opposed to unused fiber pairs which remain "dark".

cables must be a priority for policymakers.

3.3 Methodology and Limitations: Impact of Cable Disruption on Residual Capacity and Latency

This section of the paper attempts to model the effects of undersea cable disruption scenarios on trans-Pacific networks by looking at two metrics. The first is the impact on residual capacity, or in other words, the bandwidth available on remaining unaffected cables after the disruption scenario has taken place. Here the key question is whether there is sufficient residual capacity on trans-Pacific networks to absorb the re-routed data in the event of disruption. The second metric is the impact on latency. If alternative cable routings are less direct and cover a longer distance, this in turn will affect the time lag (latency) of communications – with data taking longer to arrive when it has to travel over longer distances. The key question here is whether latency increases to the degree that users suffer tangible impacts from slower communications.

To analyze the impact on residual capacity, our model assesses, under a given scenario in which certain cable(s) are disrupted, to what extent the volume of data transmission (demand) will reduce or overwhelm the remaining data transmission capacity (residual capacity) on a given data network. The model considers scenarios covering the impact of both single and multiple cable cuts, in relation to both bilateral connections (such as U.S.-Taiwan) and the U.S. trans-Pacific network (i.e. U.S.-Indo-Pacific) as a whole.

Our model is based primarily on the publicly available data on the published design capacity of the 25 operational trans-Pacific cables, measured in terabytes per second (tb/s). However, this figure should be considered as the maximum theoretical capacity, with most cable operators only activating a portion of the total capacity (referred to as “lit capacity”). Lit capacity data for U.S.-operated cables is published by the U.S. Federal Communications Commission (FCC), which together accounts for approximately 83.5 percent of all trans-Pacific cable capacity.[80] For the remaining cables for which lit capacity data is not available, an estimate is used based on the FCC data. This constitutes a limitation of the model, with the possibility that the actual lit capacity on cables not captured by the FCC data is significantly higher or lower.

Another limitation is that data on demand between particular routes is not available in the public domain. Instead, the model uses insights from industry reports and experts to estimate demand from published design capacity data. A full explanation of the methodology, data sources, and assumptions made is available in Annex E. The findings below consider the impact of cable disruption on residual capacity at peak hours, with higher levels of demand. The full data sets and table of results for all scenarios considered can be found in Annex F.

To analyze the impact on latency, we calculate how much longer it will take for data to travel via alternative cable routings, in the event that the most direct cable routing(s) are not available. It uses a simple path-stretch to time-taken formula, with increases in Return Trip Time (RTT) approximately directly proportional to the increased distance of the route (see Annex G for the full methodology). This model is limited to providing an indicative illustration of different routings. In a real scenario, the exact alternative routes taken may differ according to availability at the time.

3.4 Impact of Single Cable Outages on U.S.-Asia Routings

While single cable outages are not likely to be significant enough to have an impact on overall trans-Pacific capacity, disruption to individual cables could still have a major impact on direct country-to-country routes. Our modeling focuses on cables directly connecting the United States with Taiwan, Japan, and the Philippines. These countries have been chosen on the basis that the first island chain was highlighted as an area of high risk under our GZVI scoring. Table 2 shows the results of our modeling for U.S.-Taiwan connections, with results for other countries available in Annex F, Tables 15, 16, and 17.

- For Taiwan, for three out of the four cases, a single cable cut would overwhelm residual lit capacity between Taiwan and the United States. The only exception to this is disruption to TPE. While a cut to TPE would not overwhelm residual lit capacity, it would reduce headroom to below 20 percent, which is generally the level of headroom with which operators prefer to operate to avoid risks of congestion and resulting slowdown.

- For Japan, any single cable disruption would lead to lit capacity falling below the 20% headroom comfort level to avoid congestion risks. If other cables are upgraded to maximum design capacity, residual capacity should be sufficient to absorb the impact of any one cable cut in all scenarios apart from disruption to JUNO.[‡‡]

- For the Philippines, with only three direct connections to the United States, any one cut could have a significant impact. For two out of three cables, demand would overwhelm residual lit capacity, while in the one other, headroom will be reduced below the 20 percent comfort level.

Table 2: Residual lit capacity vs peak demand in Taiwan-U.S. cable cut scenarios

Route	Cable broken	Residual lit capacity, net (tb/s)	Headroom (%)
Taiwan → U.S.	TPE	16.63	17.37%
	FASTER	-0.55	-0.57%
	NCP	-7.11	-7.43%
	PLCN	-28.13	-29.37%

In scenarios where direct connections between the United States and these countries are overwhelmed or at risk of congestion, data may be forced to reroute onto less direct pathways. For example, if direct U.S.-Taiwan cable routings are not available, data may be forced to re-route via Japan instead. Our model estimates the additional time lag (latency) if data is forced on to these alternative routings. For direct connections between Japan, Taiwan, and the United States, the "next best" alternative routing is between 1.2 and 2.5 times longer, with corresponding increases in latency of between 47.7 milliseconds and 282.1 milliseconds. As analyzed in section 3.7, delays at this level are unlikely to have a tangible impact on most users, but could still impact U.S. firms in the finance and tech sectors. The full results of our latency modeling are available in Annex H, with the results for U.S.-Taiwan connections

[‡‡] As with other cables not operated by U.S. entities, the exact lit capacity of JUNO is not publicly available, and is estimated using the methods described in Annex E.

displayed in Table 3 below.

Table 3: Latency impact on Taiwan-U.S. connections (single cable disruption)						
Route:	**Scenario**	**Cable Path (indicative)**	**Total Path (km)**	**Est. RTT (ms)**	**Change in RTT (ms)**	**Path Stretch**
Taiwan → U.S.	Direct routes available (Baseline)	PLCN	11577	231.5	0.0	1.0
Taiwan → U.S.	Direct routes overwhelmed (Next best alternative)	SJC2 → JUNO	13961	279.2	47.7	1.2

3.5 Impact of Single Cable Outages on U.S. Domestic Routes (Hawaii and Guam)

The impact of a single cable outage is even more pronounced for the U.S. state of Hawaii and the territory of Guam. Guam relies on just two direct connections to the continental United States, as well as an additional two routings via Hawaii. Hawaii has a total of four direct routings to the continental United States. For both Hawaii and Guam, disruption to any one of these cables raises the risk of overwhelming residual capacity in all but one case. If all cables are upgraded to their maximum design capacity, this provides significant redundancy to Hawaii connections, but does little to improve redundancy for Guam—with less than 0.1 percent headroom if one of the two cables is broken. Together this suggests that U.S. domestic connections with Hawaii and Guam are severely vulnerable to high impact disruption. Both upgrades to existing networks and planning new, alternative routes are vital to maintaining the resilience of the U.S. domestic connections in the Pacific. Full results from this analysis can be found in Tables 16 and 17 in Annex F.

3.6 Impact of Multiple Cable Outages on the Entire Trans-Pacific Network

Applying the same methodology, we can model the impact of scenarios in which multiple cables face disruption at the same time. While these scenarios may seem less likely than disruption to an individual cable, it is important to remember that they could result from a confluence of natural factors, accidental damage, and gray zone sabotage. Additionally, simultaneous disruption does not require all cable breakages to occur at exactly the same time. If a series of cables is disrupted over a period of days or weeks, then, depending on the speed and availability of repair capabilities, such multiple cable breakage scenarios could occur.

Our model assesses a number of such scenarios for consideration. Here, the impact is judged not on the individual country to country routings, but on the residual U.S. trans-Pacific network as a whole.

- **High risk cables:** Scenarios A and B model disruption to the top three and top five operational trans-Pacific cables rated as most at risk in the GZVI respectively. Disruption to these cables alone pushes lit capacity close to the 20 percent headroom comfort level in Scenario A, and eliminates it completely in Scenario B. Significant redundancy remains if remaining cables can be upgraded to their maximum design capacity.

- **Taiwan contingency:** Scenario C models the impact on the trans-Pacific network as a whole should all four direct U.S.-Taiwan cable connections be disrupted, as might occur in an escalated gray zone or conflict scenario between China and Taiwan. In this scenario, residual lit capacity is almost entirely eliminated, causing a severe risk of congestion and re-routing with less than 2 percent headroom under peak demand.

- **Targeted disruption for maximum impact:** Scenarios D and E consider the impact of a targeted approach, where China or another gray zone adversary disrupts several larger capacity cables within the same area to cause maximum disruption to the trans-Pacific network as a whole. Disruption to the JUNO and PLCN (Scenario D) would overwhelm residual lit capacity by almost 70 percent. Further disruption to NCP, FASTER, and JUPITER (Scenario E) would not only overwhelm lit capacity, but would also bring residual trans-Pacific capacity under the 20 percent headroom comfort level even in the unlikely event that all other trans-Pacific cables can be rapidly upgraded to their maximum design capacity.

Table 4: Residual capacity headroom (%) under peak demand

Scenario	Cables broken	To lit capacity	To max. design capacity
A: Top 3 Highest risk	TPE; PLCN; NCP	21.96%	73.48%
B: Top 5 Highest risk	TPE; PLCN; NCP; AAG; FASTER	0.00%	66.02%
C: Taiwan Contingency	FASTER; NCP; PLCN; TPE	1.76%	66.62%
D: Top 2 largest	JUNO; PLCN	-69.76%	42.31%
E: Top 5 largest	JUNO; PLCN; NCP; FASTER; JUPITER	-137.12%	19.42%

In these scenarios, the overwhelming of residual lit capacity across the trans-Pacific network as a whole means that data will be forced to re-route along much longer routes. Unlike in the examples examined in Section 3.4, where data could re-route along the next best available trans-Pacific route, in these cases data traveling between the United States and the region will have to take a much more circuitous journey via the Indian Ocean and the Atlantic. This significantly increases the time lag in communications. Our modeling finds that, in such cases, data traveling between the United States on the one end and Taiwan, Japan, and the Philippines on the other will have to take a journey between 2.9 to 5.5 times longer than the most direct routes, with corresponding latency increases of between 716.8 to 909.3 milliseconds. As analyzed in Section 3.7, delays at this level are likely to have a major impact on a broad range of U.S. businesses and other users. The full results of our latency modeling are available in Annex H, with the results for U.S.-Taiwan connections displayed in Table 5 below.

Table 5: Latency impact on Taiwan-U.S. connections (multiple cable disruption)						
Route:	**Scenario**	**Cable Path (indicative)**	**Total Path (km)**	**Est. RTT (ms)**	**Change in RTT (ms)**	**Path Stretch**
Taiwan → U.S.	Direct routes available (Baseline)	PLCN	11577	231.5	0.0	1.0
Taiwan → U.S.	Trans-Pacific routes overwhelmed (Next best alternative)	SJC2 → PEACE Cable → Amitie	57042	1140.8	909.3	4.9

Overall, while the trans-Pacific network as a whole does have significant redundancy, it is not difficult to envisage scenarios in which disruption to multiple cables causes residual capacity issues for the cable as a whole, reducing headroom and risking congestion. Absorbing the impact will be contingent upon the ability to both upgrade the capacity of existing cables and repair broken cables quickly.

3.7 Impact on Key U.S. Economic Interests

The implications of latency increases of the magnitude set out in Section 3.7 will have a tangible impact on internet users, with profound consequences for U.S. financial interests.

- **Financial sector:** Real-time financial applications including high-frequency trading (HFT), payment processing, and algorithmic execution can suffer catastrophic performance degradation from latency increases of less than 1 millisecond (ms), while delays of 100ms can cause payment processors to timeout.[81] HFT, which forms a substantial proportion of U.S. trading in stocks, derivatives, and foreign exchange, is especially sensitive, with some races determined by latency delays at the microsecond level (one thousandth of a millisecond).[82] While traders may set up offices near stock exchanges to win latency races against local competitors, they are dependent on the speed of undersea cables to execute trades between international markets. The Indo-Pacific region is an important part of the U.S. financial sector's international business, with financial services trade with Japan, Singapore, and Taiwan totaling $6.25, 3.39, and 1.47 billion, respectively, in 2024.[83] In particular, the USD-JPY is one of the most actively traded currency pairs globally, with an estimated average daily turnover of about $1.37 trillion in 2024.[84]

- **Video calls and VOIP:** For online video calls or voice calls (Voice over Internet Protocol, VOIP) to feel natural, RTT generally needs to be below 300 ms.[85] Increases above this are likely to cause delays, echoes and "talk over" effect, where conversations become more difficult due to lags and interruptions, with severe issues when RTT is over 800 ms.[86] This means that in all of the multiple cable disruption scenarios considered above, alternative routings would likely cause severe problems for video and voice calls. Aside from causing annoyance to a broad range of internet users, this could also cause complications for everyday business operations for the tens of thousands of

U.S. businesses with subsidiaries, partners, and clients in the Indo-Pacific region. For example, there are thought to be roughly 1,800 U.S. companies based in Japan as of 2019, and over 5,800 in Singapore as of 2025.[87]

- **Cloud, web-based and AI services:** Latency increases also make accessing cloud, web-based and AI services more cumbersome, with communications between local and cloud servers taking longer. Real-time AI services – such as fraud detection and live translation – are particularly sensitive to latency disruption.[88] While quantifying the impact of these changes is challenging, it is worth noting that U.S. tech firms are deeply invested in the Indo-Pacific region. As just one example, Microsoft, Google, and Amazon have collectively opened 5 data centers in Japan and 3 data centers in Taiwan.[89] This establishes Taiwan and Japan as important bases for services provided by U.S. tech firms to the region as a whole, including cloud services and AI services. Transferring data from these centers to their clients in the region will be entirely reliant on undersea cables. Undersea cables are thus vital to the business models of U.S. tech firms operating in the Indo-Pacific, with increases in latency potentially detrimental to the quality and efficiency of service. With 63% of global cloud infrastructure operated by these three U.S. companies alone, there is also the possibility that disruption to connections between U.S. firms' data centers in Taiwan and Japan could also have cascading impacts on the broader network of U.S. firms operating in the region, who may be reliant on these services.[90]

- **De-prioritization of U.S. business interests:** In situations where bandwidth on cables is restricted, operators will be forced to prioritize bandwidth allocation. In the first instance, this will be on the basis of their existing contracts with clients. While U.S. financial institutions, tech companies, and other special interest groups may have existing contracts with operators (or in many cases, own capacity on the cable themselves) granting them guaranteed bandwidth and allocation prioritization, this will not be true for the vast majority of U.S. businesses who will have standard contracts with telecoms providers lacking such protections. Additionally, cable operators may come under pressure or obligation from host governments to prioritize other communications – for example, for national security or government services – over those of U.S. businesses. Together, this means that U.S. policymakers must work with businesses to understand and prepare for such scenarios.

Part 4: Policy Recommendations

Undersea cables are critical to U.S. interests in the Indo-Pacific and yet remain highly vulnerable to a range of geopolitical risks. This paper has outlined the risks that China's gray zone threats might pose to U.S. cable networks in the region. However, this is by no means the only way in which threats could emerge. Such vulnerabilities would be even more heightened in a conflict scenario, in which China could deploy the full range of its military and industrial capabilities. Further, while China's capabilities are in most areas more advanced, the same vulnerabilities could also be exploited by other malign actors such as Russia, North Korea, and Iran. This report puts forward a range of recommendations that can help strengthen undersea cable protection against the full range of these risks.

Bolstering undersea cable monitoring: Monitoring plays a dual role in countering gray zone threats. On the one hand, effective monitoring allows for a more rapid response to emerging threats. On the other hand, it can also serve a deterrent effect, particularly against prospective adversaries who wish to maintain a degree of plausible deniability while operating at the sub-threshold level.

1. **Mandate sensing technologies across cable networks:** Congress should direct the FCC, in coordination with the Department of Homeland Security (DHS), to require the installation of Distributed Acoustic Sensing (DAS) or other sensing technologies capable of detecting vessel movements, tampering and other near activities on undersea cables landing in U.S. territory or connecting U.S. allies, as a condition of cable landing licenses for new projects in high-risk areas. Congress should also authorize and appropriate funding through the National Telecommunications and Information Administration (NTIA) or another suitable body for a grant or cost-share program to retrofit sensors onto existing cables of strategic importance, such as those identified as high risk under the GZVI.

2. **Institutionalize intelligence sharing with cable operators:** Congress should direct the Executive Branch to establish a formal two-way threat-intelligence mechanism between DHS or another suitable agency and trusted cable providers and vendors. The communication channel should be used to share information on suspicious behavior and emerging threats, as well as coordinating rapid response and collecting evidence for criminal or sanctions cases.

3. **Authorize and fund multi-layered maritime domain awareness (MDA) platforms with allies:** Congress should authorize and appropriate funding for the Department of War and the DHS to deploy a combined MDA platform with Indo-Pacific partners including Taiwan, Japan, South Korea, the Philippines, and Australia. This platform should coordinate deployment of monitoring technologies such as Distributed Acoustic Sensing (DAS), satellite imagery, radar, AIS data, and synthetic aperture radar (SAR) across the Indo-Pacific. Data collected should then be synthesized and integrated into the combined MDA platform, creating a shared intelligence picture for participating countries. Congress should require that the platform monitor shipping behavior around undersea cables, as well as shadow fleets and China's "maritime militia."

4. **Increase U.S. and allied patrols in high risk areas:** Through the National Defense Authorization Act (NDAA) and accompanying appropriations, Congress should direct the Secretary of War and the Commandant of the Coast Guard to expand joint naval and coast guard patrols with Japan, Taiwan, the Philippines, Australia, and other partners to stage joint patrols near undersea cables. These should be focused on the first island chain and other high risk areas in the region, as well as cables identified as high risk in the GZVI. Modeled on NATO's Baltic Sentry mission, these should combine both crewed and uncrewed systems, to strengthen deterrence and enhance intelligence sharing, as well as practice coordinated maneuvers.

Strengthening accountability and response: When threats emerge or incidents occur, it is vital that the United States and its allies have the capacity to respond rapidly and effectively.

Additionally, having the necessary policy and legal tools to enforce meaningful accountability is needed to deter future prospective saboteurs.

5. **Bolster Taiwan's counter gray zone capabilities:** Congress should authorize and appropriate Foreign Military Financing (FMF) and direct expedited Foreign Military Sales (FMS) processing for Taiwan to acquire military and dual-use technologies, including MDA technologies, UUVs, ROVs and other systems which can monitor and protect undersea cables within Taiwan's Coast Guard and Navy. Congress should also authorize and fund joint U.S.-Taiwan Coast Guard joint training exercises and exchange of best practices for undersea cable monitoring and protection. While Congress should similarly authorize sales to other regional allies, statutory and report language should explicitly prioritize Taiwan given the acute nature of the threat, and the unwillingness of many other countries to sell arms to Taiwan.

6. **Direct the Executive Branch to negotiate joint protocols on incident response:** Congress should instruct the Secretary of State and the Secretary of War to negotiate, through the QUAD and other regional formats, commonly agreed joint thresholds and protocols allowing for the rapid pursuit, interdiction, and detention of vessels suspected of cable damage. Congress should specify that protocols may include the legitimate use of non-lethal, limited force against non-cooperative or evasive vessels in a manner consistent with the UN Charter. Examples of such measures could include the use of non-consensual boarding, non-lethal disabling technologies (such as entanglement nets or propeller traps) and warning shots. It should also require the Executive to report back on negotiated text. Publicly codifying procedures will both serve as a deterrent and demonstrate that responses are proportionate and consistent.

7. **Direct the establishment and enforcement of protection zones around undersea cables:** Congress should direct the Department of State to engage partners in the Indo-Pacific region, particularly the first island chain countries, to designate and enforce protection zones around high risk areas for undersea cables, including those identified as particularly vulnerable under the GZVI, with activities such as fishing, trawling, or anchoring restricted or prohibited in protections zones. While some countries already have protection zones, such as Australia and New Zealand, these should be reviewed and considered for expansion in light of increased geopolitical risks. Enforcement of such exclusion zones should be incorporated into the joint protocols in Recommendation 6.

8. **Toughen legislation on undersea cable damage:** Congress should amend Title 18 of the U.S. Code to establish or strengthen criminal offenses, civil penalties, and sanctions for damage to undersea cables, covering both culpable neglect and willful sabotage. Congress should additionally direct the Executive Branch to pursue parallel commitments with allies bilaterally and through regional fora. This can take place on both a bilateral level, or through regional forums such as the Pacific Islands Forum, and could also cover other aspects of legislative improvement, such as permitting, exclusion zones, and emergency access for repair ships.

Strengthening repair, redundancy, and resilience: Even with enhanced monitoring and protection, it is still highly possible that adversaries can target undersea cable networks in both gray zone and conflict contingencies. In such situations, governments and operators must have the capability to get systems back up and running as quickly as possible.

9. **Authorize and fund an allied cable-repair fleet:** Congress should authorize and appropriate funding (potentially through a MARAD program or a dedicated regional resilience fund) to co-finance new cable-repair vessels with trusted private operators and allied partners, with a target of at least five additional vessels by 2040 for the Indo-Pacific region.[91] Authorizing language should require that co-financing agreements give the United States and participating partners priority access to cable repair vessels in an emerging crisis.

10. **Stockpile and forward-deploy critical components:** Congress should direct DHS, the Department of War, and the Department of Commerce to assess the preparedness of existing stockpiles of critical components needed for undersea cable repair and upgrading, and to report to Congress whether such stockpiles are sufficient to meet surges in demand for repairs and upgrades in escalated gray zone scenarios. Congress should appropriate funding to forward-deploy Submarine Line Terminal Equipment (SLTE) and other critical components to nodes across the Indo-Pacific, especially around high risk cables identified in the GZVI, enabling rapid upgrades should existing capacity be suddenly restricted.

11. **Expedite "green lane" repairs:** Congress should direct the Department of State, DHS, and the FCC to negotiate standing emergency repair permits with regional allies ("green lane") to bypass bureaucratic delays in Territorial Seas or EEZs and to report annually on the status of these arrangements. A "green lane" arrangement is a standing, pre-negotiated authorization that allows vetted repair vessels operated by trusted parties to enter allied waters and begin work immediately upon notification, rather than applying for clearance each time. Congress should also examine and streamline U.S. domestic permitting processes to set a reciprocal example.

12. **Enhancing protection for cable repair vessels:** Congress should direct the Department of War, the Coast Guard, and the Department of State to establish protocols and dedicate resourcing to enable arranging additional protection for cable repair vessels should they come under harassment from China's official ships or maritime militia during cable repair operations. Authorizing language should permit options including contracted private security or protection from allied coast guards and navies, and appropriate funds accordingly.

13. **Co-finance alternative cable routes:** Congress should authorize the U.S. International Development Finance Corporation, the Export-Import Bank, and other relevant agencies to identify and co-finance alternative cable routings that bypass PRC-controlled landing points and maritime chokepoints, with particular attention to routes through the Arctic or South Pacific. Congress should appropriate dedicated funding for this purpose and require periodic reporting on routes financed and risks diversified.

Fostering U.S. government and industrial capabilities: Undersea cable protection is at risk of falling through the gaps in existing U.S. government structures. Ensuring the right policy prioritization and government organization is essential to advancing U.S. interests in the undersea domain.

14. **Centralize Federal subsea authority:** Congress should enact legislation designating DHS, or another suitable body, as the federal lead for subsea cable security. The body will work in direct coordination with the Coast Guard and the FCC. This lead body should implement a formal National Subsea Cable Strategy that unifies undersea cable development, protection, and resilience under a single resource allocation framework, and should periodically report to relevant congressional committees on implementation.

15. **Mandate a comprehensive "deep sea" strategy:** Congress should direct the Executive Branch, through the Office of Science and Technology Policy, the Department of War, and the Department of Commerce, to develop and submit a national Deep Sea Strategy to counter China's rapid expansion in the undersea domain. This must focus on bolstering R&D in undersea cable development and protection, such as AUVs and deep-sea sensors, while simultaneously incentivizing domestic industrial capacity for seabed resource development. High-tech undersea exploration and security must be treated as a single, integrated front in broader technological competition with China.

16. **Direct sector-specific risk assessment and disruption playbooks:** Congress should direct CISA or another suitable body to conduct a rigorous risk assessment of how serious cable disruption could impact specific sectors of the U.S. government and private industry, from financial clearing to healthcare. Using these findings, Congress should require CISA to work with sector stakeholders to develop cable disruption playbooks – identifying which data flows get priority and establishing internal and external communication strategies to prevent public or market panic during a major outage.

Conclusion

From these recommendations, a number of broader conclusions emerge. First, undersea cables are both more important and more vulnerable than ever before. U.S. economic interests in the Indo-Pacific region—particularly in the financial and tech sectors—are closely tied into the ability to maintain fast and reliable connections across the Pacific. However, China's rapidly advancing capabilities to access and disrupt undersea cables—including in the deep sea—necessitate greater levels of protection. China's willingness to exploit 'gray zone' coercion tactics also presents a key challenge, with U.S. and allied undersea cables at risk even without open conflict being declared. Secondly, this is not a challenge that the United States can face alone. The most vulnerable points in U.S. undersea cable networks are far from the continental United States. The United States must strengthen the ability of its allies in the region to defend against China's gray zone threats. This is particularly true for the first island chain countries of Japan, Taiwan, and the Philippines, where threat and vulnerability are both at their most acute. Only by working with its allies in the Indo-Pacific can the United States secure its prosperity and security for the decades to come. Finally, further work is needed to continue the risk analysis initiated in this report. China's undersea strategy is fast evolving and requires constant monitoring. This report's attempt to build a risk scoring and modeling methodology is innovative but would benefit from further enhancements through access to far more comprehensive and accurate data not available in the public domain. Building a comprehensive picture will require working with both U.S. allies and private sector actors. Doing so is critical to ensuring that protective resources can be concentrated effectively.

Annex A: Key developments in China's deep sea policies

Table 6. Selected Major PRC Policy Documents Related to Deep Sea Strategy and Technology Development

Date	Issuing Authority	Document Title	Key Content
January 2013	State Council	*National Marine Development Twelfth Five-Year Plan*	clarifies tasks for seabed resource exploration and deep sea equipment technology R&D.
February 2016	National People's Congress Standing Committee	*Law of the People's Republic of China on the Exploration and Development of Deep Sea Resources*	Regulates deep sea resource exploration activities; promotes independent innovation in deep sea technologies and international cooperation.
August 2016	State Council	*Thirteenth Five-Year National Science and Technology Innovation Plan*	Lists deep sea exploration as a priority area of science and technology innovation; deploys major deep sea scientific projects; promotes the development of manned submersibles and deep sea resource exploitation equipment.
March 2021	State Council	*Outline of the Fourteenth Five-Year Plan and Long-Range Objectives through 2035*	Treats deep sea exploration as a foundational and core domain for national security and development; identifies deep sea frontier areas as strategic priorities; implements forward-looking and strategic national science and technology projects; strengthens organization and coordination of future industrialization planning; enhances deep sea resource utilization and strategic biological resource surveys and assessments.
December 2021	National Development and Reform Commission; Ministry of Natural Resources	*Fourteenth Five-Year Plan for the Development of the Marine Economy*	promotes industrialization of deep sea oil, gas, and mineral exploitation equipment; supports the construction of deep sea laboratories and scientific research vessels.
August 2024	General Office of the CPC Central Committee; General Office of the State Council	*Opinions on Improving the Market Access System*	Focuses on emerging and future industries such as deep sea, aerospace, and aviation; optimizes the market access environment.
March	State Council	*Government Work*	explicitly lists deep sea technology as a strategic emerging industry, alongside

2025		*Report*	commercial spaceflight and the low-altitude economy.

Annex B: Overview of China’s undersea cable industry

Table 7:

Industry Segment	**Company Name**		**Core Business / Capabilities**	**Nature of Business** [§§]
Materials	西部材料	Western Metal Materials	R&D and production of rare-metal materials, including titanium alloys and layered metal composites; applications in nuclear power, marine engineering, and defense.	Dual-Use
	宝钛股份	Baoji Group	China’s largest titanium and titanium-alloy production base; products used in aerospace and deep sea equipment (e.g. pressure hulls for manned submersibles); full titanium industrial chain.	Dual-Use
	金天钛业	Goldsky Titanium Industry Technology	High-end titanium and titanium-alloy R&D and manufacturing; major domestic base for titanium alloy bars and forged rings; integrated R&D–production system.	Dual-Use
Underwater Information & Defense Systems	中国海防	China Marine Information Electronics Company	Underwater information acquisition, exploration, communications, countermeasures, and navigation systems; business inherited from former defense research institutes (726, 715, 716).	Military
	集智股份	Hangzhou Jizhi Mechatronic	Intelligent underwater acoustic technologies; signal-processing systems and technical support services; cooperation with Zhejiang Laboratory.	Civilian
Underwater Acoustic	中	Zhongkehaixun Digital S&T	Sonar systems, underwater signal-processing platforms, acoustic big-data	Dual-Use

[§§] Military refers to companies whose principal business involves defense systems, military equipment, or direct support to military operations.
Civilian refers to commercially oriented companies whose documented business is primarily civilian.
Dual-Use refers to companies whose technologies, products, or services have established applications in both civilian and military or security contexts. Classification is based on documented business activities rather than corporate ownership.

Detection	科海讯		and simulation systems, unmanned detection systems; system-level integration capability.	
	海兰信	Highlander	Deep sea navigation electronics and smart marine systems; navigation systems, coastal radar surveillance, marine data centers (UDC); extensive domestic and international users.	Dual-Use
	长盈通	Yangtze Optical Electronics	Optical-fiber gyroscope components and specialty optical fibers; applications in inertial navigation and marine monitoring; supports underwater acoustic monitoring and A2/AD-related projects.	Dual-Use
Marine Engineering Equipment	神开股份	Shenkai Petroleum & Chemical Equipment	Petroleum drilling and logging equipment; offshore and deep sea oil and gas engineering; technologies adapted to high-pressure marine environments.	Civilian
	亚星锚链	Asian Star Anchor Chain	Production of marine anchor chains and offshore engineering chains; major exporter and key supplier for large-scale marine anchoring systems.	Civilian
	巨力索具	Juli Sling	High-end deep sea lifting and rigging systems; corrosion-resistant equipment for deep sea platforms and ROV deployment; participant in *Jiaolong* submersible lifting tests.	Civilian
Submarine Cable Manufacturing & Components	中天科技	Zhongtian Technology	Integrated provider of submarine cables, electro-optical composite cables, and marine energy transmission systems; active in deep sea engineering, offshore energy, and subsea infrastructure, combining manufacturing, engineering services, and installation support.	Civilian
	亨通光电	Hengtong Optic-Electric	Full-chain submarine cable systems including fibers, cables, repeaters, branching units, and power-feeding equipment; proven delivery of ultra-long-distance and deep-water cable projects, with expertise in high-reliability, long-life undersea transmission technologies.	Dual-Use
	长	Yangtze Optical	Submarine optical fiber and electro-optical composite cables for deep sea	Dual-Use

	飞光纤	Fiber and Cable	observation, data transmission, and monitoring systems; vertically integrated across R&D, manufacturing, marine engineering, installation, and maintenance, with dedicated cable-laying and support vessels.	
Submarine Cable System Integration & Operations	华海通信	HMN Technologies	Global system integrator providing turnkey submarine cable solutions, including system design, marine survey, manufacturing integration, installation, maintenance, and capacity upgrades; extensive experience in transoceanic cable construction and lifecycle management.	Dual-Use
	烽火通信	FiberHome Technologies	End-to-end submarine communication systems covering optical fiber, submarine cables, repeaters, branching units, and seabed fixed acoustic arrays; strong localization of core components and experience in deep sea communications, sensing networks, and long-term seabed infrastructure deployment.	Dual-Use
Underwater Information, Security and Defense Systems	天和防务	Tianhe Defense	Dual-use undersea systems including 6,000-m-class autonomous underwater vehicles (AUVs), underwater robotics, acoustic sensors, and stealth materials; capabilities span deep sea sensing, unmanned operations, and undersea platform support, with links to defense electronics and communications technologies.	Dual-Use

Source: Adapted from Huayuan Securities 2025.

Annex C: Overview of China's key deep sea research projects

To identify the specific project areas through which China seeks to overcome persistent bottlenecks in deep sea science and technology, this study systematically reviews the Ministry of Science and Technology's National Key Research and Development Programs (National Key R&D Programs) (科技部国家重点研发计划) from 2017 to 2024 (excluding 2020, for which no public data were released), and presents the findings in Table 1.

China's deep sea science and technology research programs are heavily concentrated on deep sea energy and mineral development, which constitutes the largest share of projects (approximately 29%). This is followed by projects focused on deep sea instruments and equipment components, accounting for 19% of the total. In the early stages, research priorities centered on extraction methods for oil, gas, and gas hydrates; however, since 2022, the emphasis has increasingly shifted towards technologies for the extraction of polymetallic nodules, rare earth elements, and sulphide deposits.

Another prominent priority is the indigenization of core components. Although the projects are dispersed across multiple technical domains, each year features a structured and coordinated set of research calls covering the full technology stack—from sensors to basic connectors, winches, and cables. This pattern indicates a deliberate effort to reduce dependence on foreign industrial supply chains and pursue technological decoupling in critical deep sea systems.

Table 8. Overview of China's Deep Sea Science and Technology Research Programs, 2017-2024

Technology Category	**Number of Projects**	**Share**	**Representative Keywords**
Deep Sea Resource Development (Oil & Gas / Gas Hydrates / Minerals)	36	29%	Gas hydrates, sulphides, polymetallic nodules, rotary steering, mining vehicles, slurry transport pumps
Deep Sea Instruments and Equipment Components (Sensors / Materials / Support Systems)	24	19%	Sensors, connectors, umbilical cables, underwater acoustic communications, acoustic release devices, pressure-resistant materials, batteries
Marine Biological Resources and Biomedicine	17	14%	Bioactive molecules, deep sea enzymes, vaccines, cultivation systems, biotoxins, gene banks
Polar Science and Equipment (Icebreakers / Observation)	14	11%	Icebreakers, polar navigation, subglacial lakes, blue-ice drilling, Arctic routes, oil spill response in ice-covered waters
Deep Sea Vehicle Platforms (ROVs / AUVs / Crewed Submersibles / Gliders)	12	10%	Full-ocean-depth submersibles, crewed submersibles, uncrewed submersibles, gliders, transparent pressure hulls
Environmental Monitoring and Ecological Protection	11	9%	Plume monitoring, environmental baselines, ecological restoration, oil spill recovery
Testing, Maintenance, and Standards Development	6	5%	Standardized sea trials, virtual reality (VR), simulation, taxonomy-based management
Frontier and Other Domains (Rescue / Nuclear / Biomimetics)	5	4%	Micro nuclear power, biomimetic systems, deep sea welding, space weather

Source: Compiled by the author.

During the 2017–2019 cycle of China's National Key Research and Development Programs, a total of 42 research projects were solicited. Among these, "vehicle platforms and materials technologies" constituted the largest share (19.0%), followed by "deep sea oil and gas development" (11.9%). This distribution indicates that the core objectives during this period were to enable domestically produced submersibles to operate at depths exceeding 10,000 meters, while simultaneously strengthening deep sea oil and gas extraction capabilities in order to enhance China's energy resilience.

In the 2021–2022 program cycle, 22 research projects were announced. Compared with the previous period, “polar science and equipment” emerged as a newly added priority area, while the relative weight of “deep sea biological resources” increased substantially. These two categories jointly became the most prominent fields, each accounting for 18.2% of the total. At the same time, China intensified efforts to localize the production of key components such as sensors, robotic manipulators, subsea connectors, and acoustic release devices, while expanding research on exploration technologies for natural gas hydrates and deep sea mineral resources.

The 2023–2024 cycle marked a further shift in emphasis, with 49 research projects released in total. “Deep sea mineral resource development” rose to become the single largest category (18.4%), followed by “polar science and equipment” and “deep sea biological resources”. This change suggests that China’s deep sea science and technology agenda has transitioned from a primary focus on equipment development towards deep sea mineral exploration and polar governance. From the 5,000-metre-class “full-system mining area joint trials” launched in 2023 to the 2024 research on predictive methods for the formation of polymetallic nodules and crusts, these developments indicate that deep sea mining activities are increasingly capable of integrating across the industrial supply chain.

Concurrently, research priorities related to polar regions—including icebreaker propulsion systems, stainless-steel materials for heavy icebreaker propellers, emergency response technologies for oil spills in polar waters, and large-diameter blue-ice ice-core drilling technologies in Antarctica—underscore a sustained effort to expand China’s strategic reach and operational capacity in polar environments.

Annex D: Trans-Pacific Gray Zone Vulnerability Index methodology and results

Table 9: Risk factors, indicators and weightings

Risk factor	Rationale	Indicator and Scoring		Weighting
Heavy maritime traffic	Heavy maritime traffic around cable infrastructure makes detecting vessels acting suspiciously harder, with vessels having legitimate and ordinary reasons to be near undersea cables in these areas. Secondly, it gives plausible deniability to the attacker, as accidental damage to undersea cables is not uncommon in areas with high levels of maritime traffic. It is particularly notable that publicly reported incidents of suspected cable sabotage operations linked to China have all been conducted by ordinary commercial and fishing vessels, rather than specialist military, coast guard,	***Shipping density (hrs/km^2)***	***Score***	10%
		Very high (> 500 hrs/km^2)	3	
		High (250 – 500 hrs/km^2)	2	
		Medium (100 – 250 hrs/km^2)	1	

	or other official vessels. The use of commercial vessels further complicates detection and strengthens plausible deniability in areas with heavy maritime traffic. While this risk factor is given a high weighting for the gray zone level of threat considered by this paper, a lower weighting may be applied in a conflict scenario in which deniability and ambiguity are less important for China's objectives, and in which China may use more specialist equipment that can evade detection.	Low (< 100 hrs/km^2)	0	
Bathymetric profile	Shallower waters are at higher risk of gray zone coercion due to the ability of ordinary commercial vessels to damage cables in such environments. In particular, trawling and anchoring are thought to account for up to 75 percent of all cable faults globally, including each of the incidents of suspected sabotage linked to China. With the vast majority of such incidents being accidental, this means that prospective gray zone attackers can undertake sabotage in shallower waters while maintaining plausible deniability. While China does have specialist equipment to cut cables in deeper waters, such actions would be more difficult to disguise as accidental sabotage. As with heavy maritime traffic, this risk factor might be considered less important in a conflict or darker gray scenario, in which deniability and ambiguity are less important for China's objectives.	***Water depth (m)***	***Score***	25%
		Very shallow (<50m)	3	
		Shallow (50 - 1000m):	2	
		Medium (1000 - 2000m)	1	
		Deep (>2000m)	0	
Proximity to China's maritime claims (Taiwan)	Taiwan has been the prime target of China's gray zone warfare, with China claiming sovereignty over Taiwan, including its outlying islands, and associated territorial waters. Gray zone operations against Taiwan have included large-scale military drills, frequent encroachments into Taiwan's Air Defense Identification Zone (ADIZ) and 24 nautical mile contiguous zone, information manipulation, and covert political interference. Notably, all of the incidents of suspected cable sabotage by China in the Indo-Pacific have targeted cables with landing points in Taiwan. Cables landing in Taiwan thus have a significantly heightened	***Cable landing points***	***Score***	10%
		Lands in Taiwan	3	
		Does not land in Taiwan	0	

	risk of being targeted as part of broader efforts by China to increase gray zone pressure on Taiwan, and would also be likely to be targeted in a conflict scenario with Taiwan.			
Proximity to China's maritime claims (EEZ)	Cables passing through China's Exclusive Economic Zone (EEZ) might be considered more vulnerable to gray zone sabotage due to the increased freedom with which China can operate in this area. Sabotage operations could be undertaken with less fear of detection from other countries. While U.S. and allied Freedom of Navigation Operations do transit China's EEZ, such maneuvers are infrequent and easy for China to detect well in advance. This risk factor considers the actual EEZ administered by China, as opposed to its unfounded and extensive territorial and EEZ claims within the nine-dash line, which is considered in a separate risk factor below.	***Cable segment location***	***Score***	10%
		Within China's EEZ	3	
		Outside China's EEZ	0	
Proximity to China's maritime claims (9 dash line)	China conducts a number of maritime gray zone operations in support of its unfounded territorial and EEZ claims in the South China Sea, demarcated by its "nine-dash line." Such operations include large-scale sand dredging to create artificial islands and military infrastructure, regular patrols near disputed features by Navy and Coast Guard vessels, and a high presence of suspected state-directed "maritime militia" fishing vessels. China's Coast Guard has also employed non-lethal methods against countries disputing China's claims, most notably the Philippines Coast Guard, including water cannons, ramming, and lasers. While so far suspected undersea cable sabotage incidents in the region have centered around Taiwan, sabotage within the nine-dash line would be consistent with China's attempts to enforce its claims through gray zone coercion. For this reason, segments within the nine-dash line and also landing in Taiwan are given a higher risk scoring.	***Cable segment location***	***Score***	30%
		Within 9 dash line and landing point in Taiwan	3	
		Within 9 dash line, no landing point in Taiwan	1	
		Outside 9 dash line	0	
Foreign cable	Cables owned or operated by Chinese companies may be at lower risk of gray zone	***Cable operation/owner***	***Scor***	15%

ownership	sabotage. Firstly, because China may wish to avoid unnecessary harm to its own economic interests. Secondly, because, in the event that other cables are damaged, affected data may be re-routed via Chinese operated cables, which in turn may bolster China's ability to conduct espionage against the U.S. and other targets. Thirdly, because Chinese operated or owned cables may be a good proxy indicator for cables that are most important to China's own communication needs, and so damage to these cables may be avoided. Of the six cases of suspected undersea cable sabotage linked to China between 2021 and 2025, only one case involved a cable with part-Chinese ownership. Consequently, cables that are mostly or entirely operated or owned by non-Chinese companies may be considered as higher risk.	***ship***	***e***	
		No PRC owners/operators	3	
		1 PRC owner/operator	2	
		>1 PRC owner/operator	1	
		Fully PRC owned/ operated	0	

Table 10: Index results: All cables with scores

Cable Name	Segments	Depth	Shipping	Ownership	9-Dash	EEZ	Taiwan	Cum. Sum	Normalized
Trans-Pacific Express (TPE) Cable System	775	658.8	35.7	775	0	389.8	2325	1021.0	100.0
E2A	680	252.3	2.7	2040	0	59.8	2040	987.3	96.7
TPU	630	52.9	0.0	1890	20.79	18.3	1890	867.6	85.0
Pacific Light Cable Network (PLCN)	628	52.8	0.0	1884	0	11.9	1884	862.2	84.4
ORCA	610	56.1	1.8	1830	3.05	9.2	1830	838.9	82.2
New Cross Pacific (NCP) Cable System	628	332.2	30.1	628	0	135.0	1884	759.0	74.3

Southern Cross Cable Network (SCCN)	1337	254.0	0	4011	0	0.0	0	665.2	65.1
Asia-America Gateway (AAG) Cable System	975	574.3	14.6	2925	407.55	219.4	0	646.5	63.3
FASTER	538	146.9	1.1	538	0	66.2	1614	608.3	59.6
Topaz*	429	79.8	3.9	1287	0	0.0	1287	599.5	58.7
Asia Connect Cable-1 (ACC-1)	969	566.9	3.9	2907	0	0.0	0	578.2	56.6
Tata TGN-Pacific	1036	150.2	0.0	3108	0	0.0	0	503.8	49.3
Pacific Crossing-1 (PC-1)	982	149.3	3.0	2946	0	0.0	0	479.5	47.0
Hawaiki Nui 1	578	797.1	6.9	1734	0	0.0	0	460.1	45.1
Apricot	285	35.1	0.0	855	0	9.1	855	394.4	38.6
Hawaiki	730	186.9	0	2190	0	0.0	0	375.2	36.8
SEA-U.S.	697	84.3	0.0	2091	0	0.0	0	334.7	32.8
Australia-Japan Cable (AJC)	566	152.3	0.0	1698	0	0.0	0	292.8	28.7
JUNO	483	54.1	0.0	1449	0	0.0	0	230.9	22.6
JUPITER	694	86.1	0.0	1388	0	0.0	0	229.7	22.5
Unity/EAC-Pacific	453	29.9	0.0	1359	0	0.0	0	211.3	20.7
Telstra Endeavour	416	59.9	0	1248	0	0.0	0	202.2	19.8
Japan-Guam-	349	114.1	0	1047	0	0.0	0	185.6	18.2

Australia South (JGA-S)									
PIPE Pacific Cable-1 (PPC-1)	308	89.0	0	924	0	0.0	0	160.9	15.8
Taihei	311	38.9	4.0	933	0	0.0	0	150.1	14.7
Echo	268	7.0	0.0	804	0	0.0	0	122.3	12.0
Honotua	236	29.0	0	708	0	0.0	0	113.5	11.1
Guam Okinawa Kyushu Incheon (GOKI)	176	122.0	10.0	528	0	0.0	0	110.7	10.8
HANTRU1 Cable System	169	17.1	0	507	0	0.0	0	80.3	7.9
Proa	132	35.0	0.0	396	0	0.0	0	68.1	6.7
Japan-Guam-Australia North (JGA-N)	128	39.0	0.0	384	0	0.0	0	67.4	6.6
Bifrost	87	12.0	0.0	261	0	0.0	0	42.2	4.1
Samoa-American Samoa (SAS)	8	8.0	0	24	0	0.0	0	5.6	0.5

* Topaz does not connect directly to the U.S., but instead lands on the Canadian West Coast (Vancouver). However, its proximity to U.S. networks means it could likely play an important role in U.S.-Asia connections, hence it is included in this table.

Table 11: Adjusted weightings: 'Taiwan conflict' scenario

Risk factor	Original Index Weighting	Adjusted 'Taiwan conflict' weighting	Rationale
Heavy maritime traffic	10%	10%	High shipping density may still provide some cover for covert

			operations, but is unlikely to be a significant factor when overt operations are also possible.
Bathymetric profile	25%	20%	Cables in shallower waters still present easier targets. However, the potential for China to deploy deep sea cutting capabilities in more overt actions of sabotage means that the overall significance of this factor is decreased.
Proximity to China's maritime claims (Taiwan)	10%	60%	In the event of war with Taiwan, isolating Taiwan from international communications infrastructure could be a key objective.
PRC claim (9-dash line)	10%	0%	China's claims over the 9-dash line are likely to be of secondary importance in war with Taiwan, reducing the weighting of this factor.
PRC claim (EEZ)	10%	0%	China will be willing and capable of operating with force outside of its EEZ in the event of war with Taiwan, meaning the weighting of this factor is reduced.

Table 12: Adjusted Index Results: 'Taiwan conflict' scenario

Cable Name	Segments	Depth	Shipping	Ownership	9-Dash	EEZ	Taiwan	Cum. Sum
Trans-Pacific Express (TPE) Cable System	775	658.75	35.65	775	0	389.83	2325	1607.815
E2A	680	252.28	2.72	2040	0	59.84	2040	1478.728
TPU	630	52.92	0	1890	20.79	18.27	1890	1333.584
Pacific Light Cable Network (PLCN)	628	52.75	0	1884	0	11.93	1884	1329.35
ORCA	610	56.12	1.83	1830	3.05	9.15	1830	1292.407
New Cross Pacific (NCP) Cable System	628	332.21	30.14	628	0	135.02	1884	1262.656

FASTER	538	146.87	1.08	538	0	66.17	1614	1051.682
Topaz	429	79.79	3.86	1287	0	0	1287	917.244
Apricot	285	35.06	0	855	0	9.12	855	605.512
Southern Cross Cable Network (SCCN)	1337	254.03	0	4011	0	0	0	451.906
Asia-America Gateway (AAG) Cable System	975	574.28	14.63	2925	407.55	219.38	0	408.819
Asia Connect Cable-1 (ACC-1)	969	566.87	3.88	2907	0	0	0	404.462
Tata TGN-Pacific	1036	150.22	0	3108	0	0	0	340.844
Hawaiki Nui 1	578	797.06	6.94	1734	0	0	0	333.506
Pacific Crossing-1 (PC-1)	982	149.26	2.95	2946	0	0	0	324.747
Hawaiki	730	186.88	0	2190	0	0	0	256.376
Southern Cross NEXT	741	154.87	0	2223	0	0	0	253.274
SEA-U.S.	697	84.34	0	2091	0	0	0	225.968
Australia-Japan Cable (AJC)	566	152.25	0	1698	0	0	0	200.25
JUPITER	694	86.06	0	1388	0	0	0	156.012
JUNO	483	54.1	0	1449	0	0	0	155.72
Unity/EAC-Pacific	453	29.9	0	1359	0	0	0	141.88
Telstra Endeavour	416	59.9	0	1248	0	0	0	136.78
Japan-Guam-Australia South (JGA-S)	349	114.12	0	1047	0	0	0	127.524
PIPE Pacific Cable-1 (PPC-1)	308	89.01	0	924	0	0	0	110.202
Taihei	311	38.88	4.04	933	0	0	0	101.48
Echo	268	6.97	0	804	0	0	0	81.794
Honotua	236	29.03	0	708	0	0	0	76.606
Guam Okinawa Kyushu Incheon	176	121.97	10.03	528	0	0	0	78.197

(GOKI)								
HANTRU1 Cable System	169	17.07	0	507	0	0	0	54.114
Proa	132	34.98	0	396	0	0	0	46.596
Japan-Guam-Australia North (JGA-N)	128	39.04	0	384	0	0	0	46.208
Bifrost	87	12.01	0	261	0	0	0	28.502
Samoa-American Samoa (SAS)	8	8	0	24	0	0	0	4

Annex E: Methodology for Residual Capacity Modeling

Publicly available data on the actual lit capacity and demand of individual trans-Pacific undersea cable systems are limited. To address this constraint, all capacity and demand figures in this paper are estimated using multiple sources, including:

1. capacity announcements and disclosures by cable owners;
2. the U.S. Federal Communications Commission (FCC) report released in 2025 (with data as of end-2024);
3. industry data and analysis published by TeleGeography; and
4. consultations with industry experts familiar with undersea cable operations.

Capacity Estimation

Design Capacity

Design capacity refers to the maximum theoretical throughput of a cable system once fully equipped with terminal equipment and spectrum utilization.

We begin by compiling the design capacity of each operational trans-Pacific cable system, as publicly announced by cable owners. Owner-announced capacity figures, however, are reported at different points in time and may reflect future upgrade potential rather than a consistent snapshot. To align these figures to a uniform and up-to-date baseline, we apply a normalization factor derived from a comparison between datasets. Specifically, we compare the aggregate design capacity of trans-Pacific cable systems reported in the FCC's 2025 dataset (data as of end-2024) with the sum of owner-announced capacity figures for the same set of cable systems.

This comparison yields a ratio of approximately 63.8 percent, which is applied uniformly to owner-announced capacity figures to produce a normalized estimate consistent with the end-2024 reporting period:

Design capacity (C_0) = Owner-announced capacity × 63.8%

Lit Capacity

Lit capacity refers to the portion of design capacity that is currently active and is ready to carry traffic.

While the FCC report distinguishes between lit and unlit capacity, detailed breakdowns are available only for capacity held by U.S. entities, which accounts for approximately 83.5% of total trans-Pacific design capacity. Because the lit/unlit breakdown for capacity held by non-U.S. entities is not publicly disclosed, we assume that the same lit-to-total capacity ratio observed for U.S. entities (approximately 51.4%) applies to all trans-Pacific cable systems. Accordingly:

Lit capacity $(C_1) = C_0 \times 51.4\%$

Demand Estimation

Consultations with industry experts indicate that undersea cable operators typically maintain 20–30 percent headroom to ensure resilience, accommodate traffic surges, and manage outages. On this basis, we estimate that peak demand corresponds to approximately 70–80 percent of lit capacity.

To reflect uncertainty in utilization, we construct two demand scenarios:

- **High-stress demand scenario**: higher utilization assumptions
- **Low-stress demand scenario**: lower utilization assumptions

Peak Demand

High-stress peak demand $(D_P^s) = C_1 \times 80\%$

Low-stress peak demand $(D_P^l) = C_1 \times 70\%$

Average Demand

According to TeleGeography, average internet traffic levels in Asia, Oceania, and North America typically range between 55 percent and 65 percent of peak traffic. We apply this range to estimate average demand on trans-Pacific cable systems:

High-stress average demand $(D_A^s) = D_P^s \times 65\% = C_1 \times 80\% \times 65\%$

Low-stress average demand $(D_A^l) = D_P^l \times 55\% = C_1 \times 70\% \times 55\%$

Headroom

To assess the impact of undersea cable disruption, we estimate the headroom of each major route, defined as the residual capacity after fulfilling the demand:

Headroom (H) = Capacity (C) – Demand (D)

Headroom is estimated relative to both lit capacity and design capacity. Headroom relative to lit capacity reflects immediate operational resilience, while headroom relative to design capacity reflects an assumption of rapid capacity activation.

Subsequently, headroom estimation framework is as follows:

	Headroom under peak demand		Headroom under average demand	
	to lit cap.	to design cap.	to lit cap.	to design cap.
High-	$C_1 – D_P^s$	$C_0 – D_P^s$	$C_1 – D_A^s$	$C_0 – D_A^s$

stress				
Low-stress	$C_1 - D_P^l$	$C_0 - D_P^l$	$C_1 - D_A^l$	$C_0 - D_A^l$

Modeling Cable Disruption Scenarios

With these estimated figures, we could then simulate scenarios in which the residual capacity of the route is unable to absorb the lost capacity due to cable disruption:

Capacity of cable(s) affected > Headroom of the route without disruption

Finally, we also simulate the extreme scenario in which the total residual capacity of all trans-Pacific cable systems is unable to absorb the lost capacity due to cable disruption, when part of trans-Pacific data transmission has to be handled through alternative trans-Eurasia and trans-Atlantic routes:

Capacity of cables affected > Headroom of all trans-Pacific cable systems without disruption

Methodological Limitations

- **Limited Cable-Level Capacity Disclosure:** Due to limited public disclosure of cable-level capacity information, including design capacity and lit capacity, the analysis relies on aggregated and generalized data. Capacity estimates for individual cable systems are therefore derived by uniformly applying network-wide assumptions, which may obscure system-specific differences.
- **Assumed Lit/Unlit Allocation for Non-U.S. Capacity:** Detailed lit and unlit capacity data are publicly available only for capacity held by U.S. entities. Because comparable breakdowns for non-U.S. entities are not disclosed, the analysis applies the observed U.S. lit-to-total capacity ratio to all trans-Pacific systems. This simplifying assumption may not fully reflect actual utilization patterns and may modestly affect the precision of the aggregate lit capacity estimates.
- **Indirect Estimation of Demand:** Estimates of demand are inferred from estimated capacity using industry benchmarks rather than derived from direct traffic measurements, introducing uncertainty regarding actual demand levels at the system level.
- **Static Data Snapshot:** The analysis relies primarily on information current as of end-2024, reflecting data availability constraints. One additional trans-Pacific cable system (Bifrost) entered service in 2025 and is included using reference data as of end-2024, which may not fully reflect its current operational characteristics.

Annex F: Data tables for residual capacity modeling

Table 13: Capacity Profile

Route	Cable	Design capacity (Tb/s)		Lit capacity (Tb/s)
		Raw	Weighted (C0)	*(C1)*

Taiwan → U.S.	FASTER	60	38.31	19.70
	NCP	80	51.08	26.27
	PLCN	144	91.94	47.28
	TPE	7.68	4.90	2.52
	Total	**291.68**	**186.22**	**95.77**
Japan → U.S.	FASTER	60	38.31	19.70
	JUNO	360	229.84	118.21
	Jupiter	60	38.31	19.70
	NCP	80	51.08	26.27
	PC-1	8.4	5.36	2.76
	Tata TGN-Pacific	7.68	4.90	2.52
	TPE	7.68	4.90	2.52
	Unity / EAC-Pacific	7.68	4.90	2.52
	Total	**591.44**	**377.61**	**194.20**
Philippines → U.S.	Bifrost	260	166.00	85.37
	Jupiter	60	38.31	19.70
	PLCN	144	91.94	47.28
	Total	**464**	**296.24**	**152.36**
Japan → Guam	AJC	10	6.38	3.28
	GOKI	0.08	0.05	0.03
	JGA-N	24	15.32	7.88
	Tata TGN-Pacific	7.68	4.90	2.52
	Total	**41.76**	**26.66**	**13.71**
Philippines → Guam	AAG	5.2	3.32	1.71
	Bifrost	260	166.00	85.37
	SEA-U.S.	20	12.77	6.57
	Total	**285.2**	**182.09**	**93.65**
Guam → U.S.	Bifrost	260	166.00	85.37
	Echo	260	166.00	85.37
	Total	**520**	**332.00**	**170.74**
Guam → Hawaii	AAG	5.2	3.32	1.71
	SEA-U.S.	20	12.77	6.57
	Total	**25.2**	**16.09**	**8.27**
Hawaii → U.S.	AAG	5.2	3.32	1.71
	Hawaiki	30	19.15	9.85
	SCCN	18	11.49	5.91
	SEA-U.S.	20	12.77	6.57
	Total	**73.2**	**46.74**	**24.04**

Trans-Pacific	JUNO	360	229.84	118.21
	Bifrost	260	166.00	85.37
	Echo	260	166.00	85.37
	PLCN	144	91.94	47.28
	NCP	80	51.08	26.27
	Southern Cross NEXT	72	45.97	23.64
	FASTER	60	38.31	19.70
	JUPITER	60	38.31	19.70
	JGA-S	36	22.98	11.82
	Hawaiki	30	19.15	9.85
	JGA-N	24	15.32	7.88
	SEA-U.S.	20	12.77	6.57
	SCCN	18	11.49	5.91
	PPC-1	12	7.66	3.94
	AJC	10	6.38	3.28
	PC-1	8.4	5.36	2.76
	Tata TGN-Pacific	7.68	4.90	2.52
	TPE	7.68	4.90	2.52
	Unity / EAC-Pacific	7.68	4.90	2.52
	AAG	5.2	3.32	1.71
	Telstra Endeavour	1.28	0.82	0.42
	Honotua	0.3	0.19	0.10
	HANTRU1	0.16	0.10	0.05
	GOKI	0.08	0.05	0.03
	SAS	0.001	0.00	0.00
	Total	**1484.461**	**947.76**	**487.43**

Table 14: Demand Profile

Route	Peak demand (Tb/s)		Average demand (Tb/s)	
	High-stress (DPs)	Low-stress (DPI)	High-stress (DAs)	Low-stress (DAI)
Taiwan → U.S.	76.62	67.04	49.80	36.87
Japan → U.S.	155.36	135.94	100.98	74.77
Philippines → U.S.	121.88	106.65	79.23	58.66
Japan → Guam	10.97	9.60	7.13	5.28
Philippines →	74.92	65.55	48.70	36.05

Guam				
Guam → U.S.	136.60	119.52	88.79	65.74
Guam → Hawaii	6.62	5.79	4.30	3.19
Hawaii → U.S.	19.23	16.82	12.50	9.25
Trans-Pacific	389.94	341.20	253.46	187.66

Table 15: Residual capacity (Headroom, %) under peak demand (high utilization scenario)

Residual capacity (%) under peak demand (high utilization scenario)			
Route	**Cable broken**	**To lit capacity**	**To max. design capacity**
Taiwan → U.S.	FASTER	-0.57%	38.29%
	NCP	-7.43%	31.43%
	PLCN	-29.37%	9.49%
	TPE	17.37%	56.22%
Japan → U.S.	FASTER	9.86%	48.71%
	JUNO	-40.87%	-2.01%
	Jupiter	9.86%	48.71%
	NCP	6.47%	45.33%
	PC-1	18.58%	57.44%
	Tata TGN-Pacific	18.70%	57.56%
	TPE	18.70%	57.56%
	Unity / EAC-Pacific	18.70%	57.56%
Philippines → U.S.	Bifrost	-36.03%	2.82%
	Jupiter	7.07%	45.93%
	PLCN	-11.03%	27.82%

Table 16: Single Cable Disruption (Tb/S), All scenarios

Route	Cable cut	Residual capacity (Tb/s)							
		Under Peak demand				Under average demand			
		High-stress scenario		Low-stress scenario		High-stress scenario		Low-stress scenario	
		to lit cap.	to design cap.	to lit cap.	to design cap.	to lit cap.	to design cap.	to lit cap.	to design cap.
Taiwan → U.S.	FASTER	-0.55	71.30	9.03	80.88	26.27	98.12	39.20	111.04
	NCP	-7.11	58.53	2.46	68.11	19.70	85.35	32.63	98.28
	PLCN	-28.13	17.67	-18.55	27.25	-1.31	44.48	11.62	57.41

	TPE	16.63	104.70	26.21	114.28	43.45	131.52	56.38	144.45
Japan → U.S.	FASTER	19.14	183.94	38.56	203.36	73.52	238.32	99.73	264.53
	JUNO	-79.37	-7.60	-59.95	11.82	-24.99	46.78	1.23	73.00
	Jupiter	19.14	183.94	38.56	203.36	73.52	238.32	99.73	264.53
	NCP	12.57	171.17	31.99	190.59	66.95	225.55	93.17	251.76
	PC-1	36.08	216.88	55.50	236.30	90.46	271.26	116.68	297.48
	Tata TGN-Pacific	36.32	217.34	55.74	236.76	90.69	271.72	116.91	297.94
	TPE	36.32	217.34	55.74	236.76	90.69	271.72	116.91	297.94
	Unity / EAC-Pacific	36.32	217.34	55.74	236.76	90.69	271.72	116.91	297.94
Philippines → U.S.	Bifrost	-54.90	8.36	-39.67	23.60	-12.24	51.02	8.33	71.59
	Jupiter	10.77	136.05	26.01	151.29	53.43	178.71	74.00	199.28
	PLCN	-16.81	82.42	-1.58	97.66	25.85	125.08	46.42	145.65
Guam → U.S.	Bifrost	-51.22	29.40	-34.15	46.48	-3.41	77.21	19.64	100.26
	Echo	-51.22	29.40	-34.15	46.48	-3.41	77.21	19.64	100.26
Hawaii → Continental U.S.	AAG	3.10	24.19	5.50	26.59	9.83	30.92	13.07	34.16
	Hawaiki	-5.04	8.35	-2.64	10.76	1.69	15.08	4.93	18.33
	SCCN	-1.10	16.01	1.30	18.42	5.63	22.74	8.87	25.99
	SEA-U.S.	-1.76	14.74	0.64	17.14	4.97	21.47	8.21	24.71

Table 17: Single Cable Disruption (Headroom, %)

Route	Cable cut	Residual capacity (Headroom, %)							
		Under Peak demand				Under average demand			
		High-stress scenario		Low-stress scenario		High-stress scenario		Low-stress scenario	
		To lit cap.	To design cap.	To lit cap.	To design cap.	To lit cap.	To design cap.	To lit cap.	To design cap.
Taiwan → U.S.	FASTER	-0.57%	38.29%	9.43%	43.43%	27.43%	52.69%	40.93%	59.63%
	NCP	-7.43%	31.43%	2.57%	36.57%	20.57%	45.83%	34.07%	52.77%

	PLCN	-29.37%	9.49%	-19.37%	14.63%	-1.37%	23.89%	12.13%	30.83%
	TPE	17.37%	56.22%	27.37%	61.37%	45.37%	70.62%	58.87%	77.57%
Japan → U.S.	FASTER	9.86%	48.71%	19.86%	53.85%	37.86%	63.11%	51.36%	70.06%
	JUNO	-40.87%	-2.01%	-30.87%	3.13%	-12.87%	12.39%	0.63%	19.33%
	Jupiter	9.86%	48.71%	19.86%	53.85%	37.86%	63.11%	51.36%	70.06%
	NCP	6.47%	45.33%	16.47%	50.47%	34.47%	59.73%	47.97%	66.67%
	PC-1	18.58%	57.44%	28.58%	62.58%	46.58%	71.84%	60.08%	78.78%
	Tata TGN-Pacific	18.70%	57.56%	28.70%	62.70%	46.70%	71.96%	60.20%	78.90%
	TPE	18.70%	57.56%	28.70%	62.70%	46.70%	71.96%	60.20%	78.90%
	Unity / EAC-Pacific	18.70%	57.56%	28.70%	62.70%	46.70%	71.96%	60.20%	78.90%
Philippines → U.S.	Bifrost	-36.03%	2.82%	-26.03%	7.97%	-8.03%	17.22%	5.47%	24.17%
	Jupiter	7.07%	45.93%	17.07%	51.07%	35.07%	60.33%	48.57%	67.27%
	PLCN	-11.03%	27.82%	-1.03%	32.97%	16.97%	42.22%	30.47%	49.17%
Guam → U.S.	Bifrost	-30.00%	0.09	-20.00%	14.00%	-2.00%	23.26%	11.50%	30.20%
	Echo	-30.00%	0.09	-20.00%	14.00%	-2.00%	23.26%	11.50%	30.20%
Hawaii → Continental U.S.	AAG	12.90%	51.75%	22.90%	56.90%	40.90%	66.15%	54.40%	73.10%
	Hawaiki	-20.98%	17.87%	-10.98%	23.02%	7.02%	32.27%	20.52%	39.22%
	SCCN	-4.59%	34.27%	5.41%	39.41%	23.41%	48.67%	36.91%	55.61%

	SEA-U.S.	-7.32%	31.53%	2.68%	36.68%	20.68%	45.93%	34.18%	52.88%

Table 18: Multiple Cable Disruption (Tb/S)

Scenario	Cables cut	Residual headroom under peak demand (Tb/s)				Residual headroom under average demand (Tb/s)			
		High-stress scenario		Low-stress scenario		High-stress scenario		Low-stress scenario	
		to lit cap.	to design cap.	to lit cap.	to design cap.	to lit cap.	to design cap.	to lit cap.	to design cap.
Baseline	/	97.49	557.82	146.23	606.56	233.97	694.30	299.77	760.10
A: Top 3 Highest risk	TPE PLCN NCP	21.41	409.90	70.16	458.65	157.89	546.38	223.70	612.19
B: Top 5 Highest risk	TPE PLCN NCP AAG FASTER	0.00	368.28	48.75	417.02	136.48	504.76	202.29	570.56
C: Taiwan Contingency	FASTER NCP PLCN TPE	1.71	371.60	50.45	420.34	138.19	508.08	203.99	573.88
D: Top 2 largest	JUNO PLCN	-68.00	236.04	-19.26	284.78	68.48	372.52	134.28	438.32
E: Top 5 Largest	JUNO PLCN NCP FASTER JUPITER	-133.68	108.35	-84.93	157.09	2.80	244.83	68.61	310.63

Table 19: Multiple Cable Disruption Residual Capacity (Headroom, %)

Scenario	Cables cut	Residual headroom under peak demand (Tb/s)				Residual headroom under average demand (Tb/s)			
		High-stress scenario		Low-stress scenario		High-stress scenario		Low-stress scenario	
		to lit cap.	to design cap.	to lit cap.	to design cap.	to lit cap.	to design cap.	to lit cap.	to design cap.

A: Top 3 Highest risk	TPE PLCN NCP	21.96%	73.48 %	47.98 %	75.61 %	67.49 %	78.70 %	74.62 %	80.54 %
B: Top 5 Highest risk	TPE PLCN NCP AAG FASTER	0.00%	66.02 %	33.34 %	68.75 %	58.34 %	72.70 %	67.48 %	75.06 %
C: Taiwan Contingency	FASTER NCP PLCN TPE	1.76%	66.62 %	34.50 %	69.30 %	59.06 %	73.18 %	68.05 %	75.50 %
D: Top 2 Largest	JUNO PLCN	-69.76%	42.31 %	-13.17 %	46.95 %	29.27 %	53.65 %	44.79 %	57.67 %
E: Top 5 largest	JUNO PLCN NCP FASTER JUPITER	-137.12 %	19.42 %	-58.08 %	25.90 %	1.20%	35.26 %	22.89 %	40.87 %

Annex G: Latency impact modeling

Methodology: Assessing impact on latency

The analysis begins by calculating the baseline round-trip time (RTT) for selected direct cable routes between the cable's first landing points in the U.S. West Coast and the respective landing points in the selected countries of Taiwan, Japan and the Philippines . For alternative scenarios, it traces plausible indirect detour paths that will offer the best available routings within the limitations of the scenario described.

Using publicly accessible data, each detour path is measured for distance and converted into estimated RTT using a commonly applied conversion factor (approximately 0.01 milliseconds per kilometer of cable for propagation). The formula is thus as follows: **RTT (ms) = Distance (km) / 100**

The results are expressed both as the absolute increase in delay (ΔRTT in milliseconds) and as a path stretch ratio compared to the baseline. This makes clear how much slower communications become under different scenarios.

Limitations:

- Additional "hop" time: Every router or optical repeater the signal passes through adds a tiny bit of "processing latency" (usually measured in microseconds). If a route has dozens of hops, the RTT will be slightly higher than the formula suggests.

- Inefficient cable routings: The publicly available data on cable routings is a simplified version of the actual cable path, which would be less linear and less direct than the simplified version suggests to account for minute changes in seabed and other factors. As such, the actual cable routing will be longer than the routings suggested.

Together these limitations mean that the RTT increases estimated by the methodology are likely to be a conservative estimate, with the potential for delays to be longer than that provided by the model.

Annex H: Data tables for latency impact modeling

Table 20: Impact on latency of indirect trans-Pacific cable routings

Table 5: Impact on latency of indirect trans-Pacific cable routings						
Route:	**Scenario**	**Cable Pathways**	**Total Path (km)**	**Est. RTT (ms)**	**Change in RTT (ms)**	**Path Stretch**
Taiwan → U.S.	Direct routes available (Baseline)	PLCN	11577	231.5	0.0	1.0
Taiwan → U.S.	Direct routes overwhelmed (Next best alternative)	SJC2 → JUNO	13961	279.2	47.7	1.2
Taiwan → U.S.	Trans-Pacific routes overwhelmed (Next best alternative)	SJC2 → PEACE Cable → Amitie	57042	1140.8	909.3	4.9
Japan → U.S.	Direct routes available (Baseline)	JUNO	9585	191.7	0.0	1.0
Japan → U.S.	Direct routes overwhelmed (Next best alternative)	JGA-N → Echo	23690	473.8	282.1	2.5
Japan → U.S.	Trans-Pacific routes overwhelmed (Next best alternative)	ADC → PEACE Cable → Amitie	52846	1056.9	865.2	5.5
Philippines → U.S.	Direct routes available	Bifrost	18758	375.2	0.0	1.0

	(Baseline)					
Philippines → U.S.	Direct routes overwhelmed (Next best alternative)	ADC → JUNO	23273	465.5	90.3	1.2
Philippines → U.S.	Trans-Pacific routes overwhelmed (Next best alternative)	ADC → PEACE Cable → Amitie	54596	1091.9	716.8	2.9

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