MARCH 2021

Securing the Subsea Network

A Primer for Policymakers

AUTHOR

Jonathan E. Hillman

A Report of the CSIS Reconnecting Asia Project

CSIS | CENTER FOR STRATEGIC & INTERNATIONAL STUDIES

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Executive Summary

The United States' position as the world's leading hub in subsea networks, which carry nearly all voice and internet traffic between continents, can no longer be taken for granted. More of the world is coming online, and China is emerging rapidly as a leading subsea cable provider and owner. Reflecting this fast-changing landscape, between 2004 and 2019, the United States went from handling half of all internet traffic to just under a quarter.[1] This four-part guide provides an introduction to these systems for U.S. policymakers, explains major issues, and offers recommendations for advancing U.S. economic and strategic objectives.

The first section explains the essential functions that subsea cables serve, how they are planned, and the most common threats they face. Even as the demand for these systems rises, however, the planning process is becoming more challenging. Data that traverse cables is secured using a multilayer approach that includes physical security, encryption, redundant systems, and real-time monitoring. Security also requires mitigating everyday physical threats such as fishing operations, which are the leading cause of cable faults. The ultimate goal for planning subsea networks is resiliency, which is a function of capacity, redundancy, and diversity.

The second section explains the U.S. economic and strategic interests at stake. Subsea cables strengthen the U.S. economy by supporting high-paying jobs, increasing productivity, and spurring growth. They also help promote development abroad, extend and enhance U.S. soft power, support democratic access to information, and carry government communications. In the face of sudden changes, such as surges in internet traffic during the Covid-19 pandemic, resilient subsea networks keep the U.S. economy functioning.

The third section describes three trends that could point to a diminished role for the United States in global networks. Bandwidth demand is increasing as more of the world comes online and new technologies are adopted. Demand is rising fastest in Asia, where China is emerging as a leading provider and owner of subsea cables. Meanwhile, regulatory challenges and delays are mounting as the United States and other governments bring greater scrutiny to the role of foreign companies in their countries' digital infrastructure. The combination of increasing demand, heightened competition, and rising barriers to action is a recipe for less resilient networks and decreased access to international broadband capacity for Americans.

The final section offers recommendations for protecting U.S. centrality in subsea networks. Policymakers should avoid adopting an overly restrictive posture, which would incentivize cables to land elsewhere, taking data centers and related economic activities with them. The U.S. government can improve the cable planning process by having the FCC create a federal point of contact, which would provide additional clarity on risk assessments and predictability in license applications. Pioneering zero-trust technologies, such as advanced encryption, could allow cables to continue operating in challenging environments. The United States should also improve the foreign environment for cables and seize the opportunity that developing economies present.

The world is not waiting for the United States to address these issues, and global networks are evolving to reflect the interests of other countries. Chinese leader Xi Jinping, for example, has announced a "Digital Silk Road" to position Beijing at the center of global networks. The United States has considerable strengths upon which to draw as it competes in this strategic domain, including cutting-edge technology, world-leading companies, and rule of law. Creating resilient subsea networks is both urgent and achievable.

2

Introduction

Submarine or "subsea" cables have become such an integral part of life that, much like highways and electricity grids, they are often taken for granted. The out-of-sight nature of these systems has also contributed to misperceptions about how they work, as Figure 1 explains. This section provides an overview of the essential functions that subsea cables serve, how they are planned, and the most common threats they face.

The World's Information Super-Highways

Subsea cables are the world's information super-highways, carrying over 95 percent of international data.[2] There are roughly 400 cables functioning worldwide of widely varying quality and capacity.[3] They carry everything from streaming videos and telephone calls to transactions for credit cards, ATMs, and stock exchanges. Thanks to subsea cables, essential services from education to medical assistance can be delivered virtually, expanding access and improving affordability. All these applications depend upon the high-bandwidth connections that subsea cables provide.

The global rise of cloud computing is underpinned by the low-latency, high-capacity connections that subsea cables provide. In the past, companies needed to purchase physical infrastructure and locate it on site to meet their computing needs. The cloud allows businesses of any size to rent those resources and provides the flexibility to scale up as needed, giving them access to computing power that only the largest organizations could access in the past. Accessing those resources requires fast and reliable connections.

The high speed and large capacity of subsea cables allow computing power to be located further away from users. Servers in the United States, for example, can provide computing power to users around the world because of the network transport capabilities that subsea cables provide. Decisions about where to build data centers depend on several factors, especially data privacy and related regulations, but without adequate transport capacity, they must be located closer to users. All else being equal, constraining subsea network capacity to and from the United States would drive data center investments abroad.

Figure 1: Five Myths about Subsea Cables

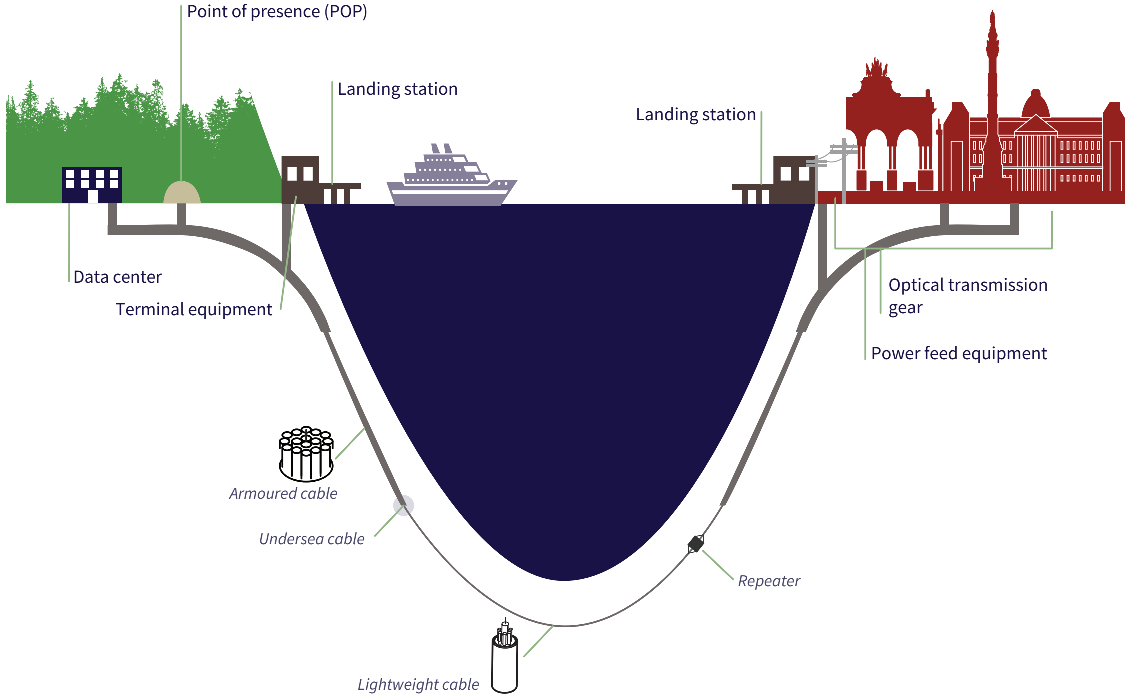
Five Myths About Subsea Cables	
Myth	Satellites carry most data internationally.
Reality	Subsea cables carry over 95 percent of all international data. Although satellites carry much less data internationally, they are often complementary and could expand coverage in the coming years, providing access to rural markets as well as the marine and aviation industries, for example.
Myth	5G networks will make subsea cables less important.
Reality	The arrival of faster wireless networks will actually increase the demand on subsea cables. 5G networks use spectrum that can carry data faster across short distances, often called the "last mile." These networks will link more devices and sensors, driving up the volume of data that needs to move and increasing the demand for the long-distance transit that subsea cables provide.
Myth	Sharks are the biggest threat to subsea cables.
Reality	Fishing and shipping activities are the most common causes of subsea cable faults, responsible for nearly two-thirds of all faults.
Myth	Subsea cables are an outdated technology.
Reality	Today's subsea cables include cutting-edge advances in optics, materials science, and data processing. Cables with capacities of 250TB/s are now being used, roughly equivalent to simultaneously streaming 3.3 million 4K-resolution videos or serving 1.7 million small businesses using typical cloud services. Continued fiber and system innovations will enable even higher capacity per cable going forward.
Myth	Telephone carriers are the primary owners and users of subsea cables.
Reality	In the past decade, content providers such as Google, Facebook, Microsoft, and Amazon have become leading investors in building subsea cables around the world.

Source: TeleGeography; International Cable Protection Committee (ICPC); National Oceanic and Atmospheric Administration (NOAA).

The performance of subsea cables has improved even faster than semiconductors during the last three decades thanks to innovations in key system components (see Figure 2).[4] At the core of today's most advanced cables are multiple pairs of ultra-low-loss glass fiber that carry beams of light over long distances. Each pair functions as a separate conduit for data, and the fibers are encased in protective layers of material. On either end of the cable is terminal equipment, which includes optical transmitters and network management software. Repeaters are positioned along the cable to boost signal strength and to regenerate the signal.

These high-speed, high-capacity connections are unlocking capabilities that were once science fiction. Researchers working in labs around the world share massive data sets and collaborate on vaccine and drug development and research of all types. Businesses of all sizes can tap into computing power as needed, scaling seamlessly to meet spikes in customer demand. High-quality video conferencing connects family and colleagues across continents. These improvements all contribute to rising bandwidth demand, which is expected to almost double every two years for the foreseeable future.[5] Meeting that demand will require building subsea cable systems.

Figure 2: Key Components



Sources: Google; UK Cable Protection Committee; Alcatel-Lucent Submarine Network.

The Cable Planning Process

Moving a cable from concept to operation requires navigating mazes of technical, financial, political, and legal barriers. It is not one maze but several because these global systems usually touch more than one country, each requiring coordination among public and private stakeholders. Even as the demand for these systems rises, the planning process is becoming more challenging.

Cable planners strive to forecast demand, clarify risks, and plan resilient systems. The process usually begins with the private sector taking the initiative. Business considerations drive planning because cables routinely cost hundreds of millions of dollars and are designed to operate for up to 25 years. Recouping these investments requires considering long-term forecasts of likely demand.

After forecasting demand, planners examine all the risks that could impact their systems. These contingencies include climate change and natural disasters, such as earthquakes, which have been responsible for multiple cable faults in the past.[6] Geopolitical risks, such as claims around disputed territory, must also be considered. Planners assess cable paths and scenarios, helping to clarify trade-offs among options, including preventing any adverse environmental impacts from the cables themselves.

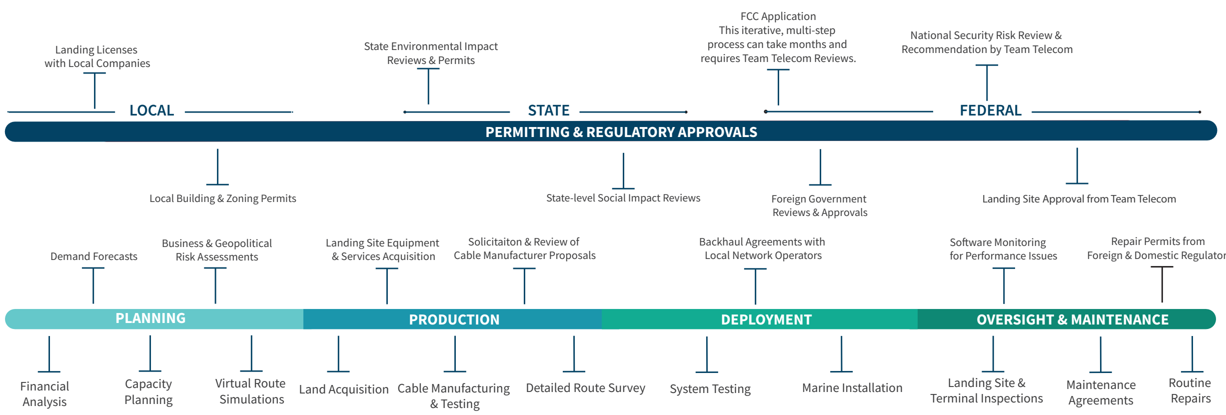
Resiliency is the ultimate goal for subsea networks. It is a function of capacity, redundancy, and diversity. Well-planned networks can adapt to cable faults as well as surges in demand during Cyber Monday, the World Cup, and other events, expected and unexpected. Cable owners often work with their peers to provide back-up services temporarily.

More recently, in response to the Covid-19 pandemic, subsea systems accommodated several major shifts. Offices shifted to remote work, schools shifted to remote learning, and many religious services shifted to livestreaming. More shoppers, whether buying clothing or groceries, placed orders online. Online entertainment, from movies to sports, has surged. As a result of these shifts, internet traffic has risen 25 to 50 percent since November 2019, depending on geographic region, according to International Cable Protection Committee (ICPC) estimates.[7] Subsea networks adapted to these shocks remarkably well.

Given the large upfront investment required, companies often form consortia to share financial and operational risks. Some markets also require partnering with local companies to secure landing licenses. A common approach for consortia is to contractually agree among the participating companies on the design, planning, building, and management of the cable. Representatives from each company participate in various committees that manage the project. Each company's share of the cable and its voting rights are typically proportionate to its investment.

Figure 3: The Cable Planning Process

The process for planning and delivering subsea cables involves a wide range of stakeholders, foreign and domestic, at the federal, state, and local levels. The diagram below illustrates some of the major steps, which are iterative and often overlap in practice.



Source: Author's own analysis based on multiple sources.

For multi-country cables, the most cumbersome part of the process is often permitting and regulatory approval. Cables landing in the United States must receive approvals at the federal, state, and local levels. As of February 2020, 74 subsea cable systems had received licenses from the Federal Communications Commission (FCC).[8] Indicating the rising demand for cable deployments, another 11 applications had been filed by June 2020.[9]

The FCC reviews applications for subsea cables landing in the United States. An interagency group known as "Team Telecom" reviews these applications for national security risks, among other responsibilities that extend beyond subsea cables.. This overall review process has become more protracted over the last decade, due in large part to delays in the Team Telecom component of the process. From 2017 to 2019, Team Telecom review times averaged eight and a half months, and applications requiring these reviews tend to take three to four times longer than those that do not.[10] This puts the United States behind other leading hubs, such as Singapore, where reviews can take two to three months.[11]

An executive order passed in 2020 aims to improve this process, though questions remain about its implementation. The order formalizes Team Telecom to include the Departments of Justice, Homeland

Security, and Defense as the core members, with other agencies such as the Departments of Commerce and State playing supporting roles. It sets limits on the length of reviews, although the government has flexibility in deciding when to "start the clock." Team Telecom was also given a mandate to retroactively review existing FCC licenses.

The FCC application process is iterative. The FCC and Team Telecom can ask companies to provide additional information or to adopt risk mitigation provisions as part of the approval process. These additional risk mitigation steps are typically formalized in a national security agreement (NSA) or letter of assurance (LOA). Common provisions include submitting to inspections of landing sites and terminal equipment. After concluding its review, Team Telecom submits a recommendation to the FCC, which also conducts its own evaluation of commercial factors, such as whether the application will serve a market need.

Additional steps are required at the state and local levels. While specific requirements depend on the localities, generally there are state environmental permits as well as local building and zoning permits. Unless the cable is landing at an established landing station, planners must also acquire land and permits to build the conduits that bring the cable ashore and the facilities that house the terminal equipment.

Beyond the U.S. review process, some version of these steps must be repeated in the other countries the cable touches. The specific steps vary depending on the countries involved but generally require submitting detailed information about the project, addressing any concerns, and paying fees. Even if a cable does not land at a country but passes through its waters, sometimes even beyond its territorial waters, it must receive that country's approval. A cable from Japan to Singapore, depending on the route, might also need approval from Malaysia, Indonesia, the Philippines, and China.[12]

To reduce the time to deployment, cable production and equipment acquisition begins well before all the necessary permits have been formally secured. The project owners will solicit proposals from cable manufacturers. The world's four general contractors are SubCom (United States), NEC (Japan), Alcatel Submarine Networks (France), and HMN (formerly Huawei Marine Networks, based in China). Cables are custom-built for the specific route. Production time depends on the number of fibers and length but typically takes 24 to 36 months, which includes quality control and testing in the factory.[13]

Cable owners must also acquire equipment and services at landing sites. It is increasingly common to terminate cables at neutral interconnection data centers, which allow different companies to co-locate and connect more easily than at carrier-owned sites.[14] As part of the application review process, equipment details and network management system schematics for the control rooms are included in submissions to the regulators. The cable owners must also reach agreements with network operators in landing countries to provide "backhaul," carrying data from the landing site to destinations inland and along the coast.

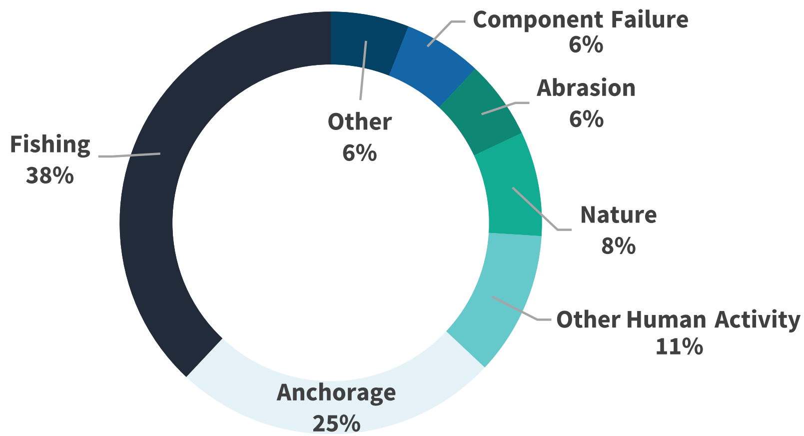
Cable installation begins with a detailed survey of the route. Desktop studies are used to examine route options. After the route is selected, a marine survey reviews the actual route to further identify environmental impacts and reduce exposure to risky areas, including from seismic activity and heavy fishing, for example. With that information in hand, specialized cable laying ships are used to deploy the cable. Divers bring cable ends to shore, where they are connected to ground equipment. Fully installed systems go through another series of tests before being activated.

Functioning cables require regular oversight and maintenance. Network management software detects performance issues, alerting operators so that inspections and maintenance can be performed. There are roughly 45 cable ships in the world, some of which are engaged with laying cables at any given moment, leaving a smaller number available to assist with repairs.[15] To share cable maintenance costs, cable owners often participate in consortia that cover defined geographic zones (and which are distinct from consortia that build and operate any particular cable).

Threats to Cables

Every year, 150 to 200 subsea cable faults occur on average, according to the United Nations.[16] Fishing and shipping activities are the most common cause of faults, responsible for nearly two-thirds of all faults.

Figure 4: Causes of Subsea Cable Faults



Source: Alan Mauldin, "Cable Breakage: When and How Cables Go Down," TeleGeography, May 3, 2017, https://blog.telegeography.com/what-happens-when-submarine-cables-break.

Fishing techniques that touch the sea floor, such as trawl nets and dredges, are especially risky for cables but remain popular in parts of Asia. Anchoring incidents often occur when anchors are inadvertently dropped and dragged along the sea floor. Extreme weather can also drag properly anchored boats into cables.

Cable planners take several steps to minimize these risks. Cables have armor and in some cases are buried when nearer to shore, where most fishing activities take place, to protect against these incidents. Efforts to coordinate with fishing crews, such as the Oregon Fisherman's Cable Committee, can also help avoid accidents. Cable planners also avoid designated areas where ships anchor.

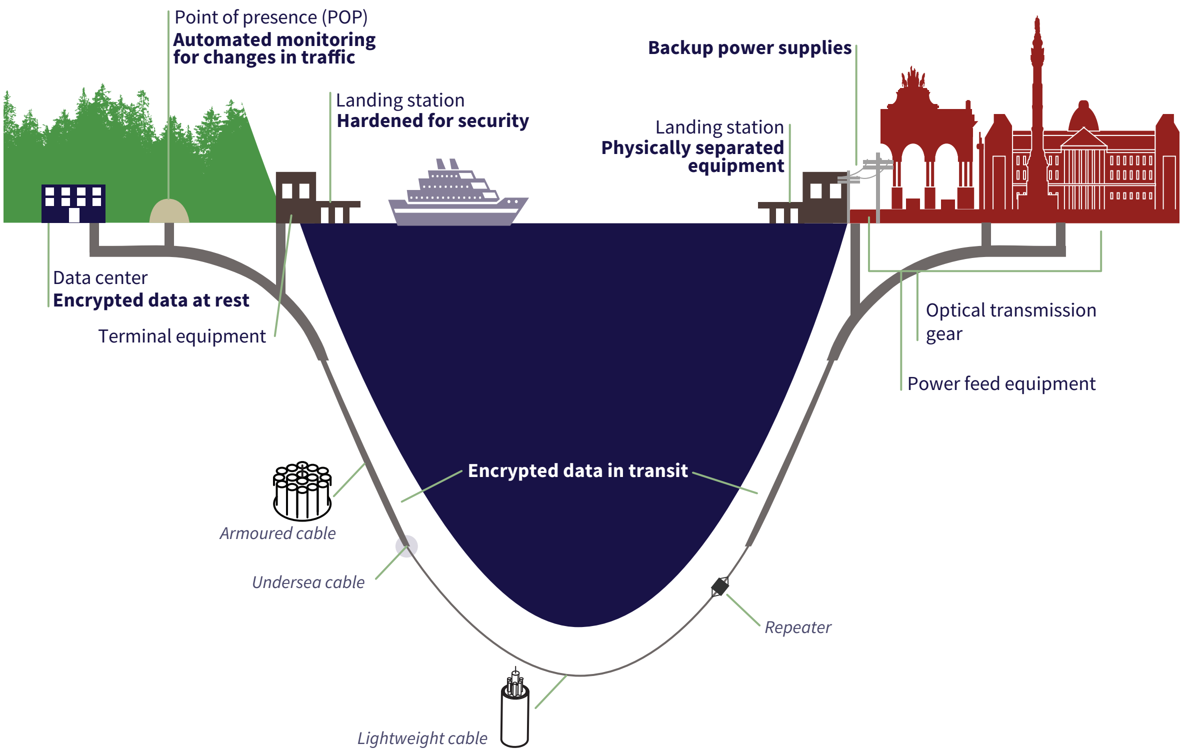
Proactive government efforts can help as well. International treaties dating back to 1884 guarantee unique freedoms to lay, repair, and maintain cables, although national practices vary.

For example, Australia and New Zealand have designated protection zones for cables that restrict fishing and anchoring and impose substantial penalties for cable damage.[17] The United States has neither protection zones nor fines that can effectively serve as a deterrent, as a working group advised the FCC in 2014.[18]

Malicious incidents such as piracy are rare but can have high impacts. In 2017, Vietnam arrested 10 people for cutting 27 miles off one of its two subsea cables.[19] In 2013, Egypt lost 60 percent of its bandwidth after divers cut its main cable to Europe.[20] Although there are no publicly documented examples in recent history, countries cut telegraph cables at the outset of World War I and World War II.

Cable planners also take steps to protect data confidentiality, integrity, and availability with a multilayer approach to security, illustrated in Figure 5. Encrypting data while it is stored and when it is in transit protects data confidentiality. Hardened landing stations, and physically secured equipment within those stations, all provided by trusted vendors, protect data integrity. Incorporating backup power supplies and other redundant components protects data availability. On top of all this, automated monitoring instantly notifies network operators of even minor changes in traffic or physical conditions that might indicate interference.

Figure 5: Multilayer Approach to Cable Security



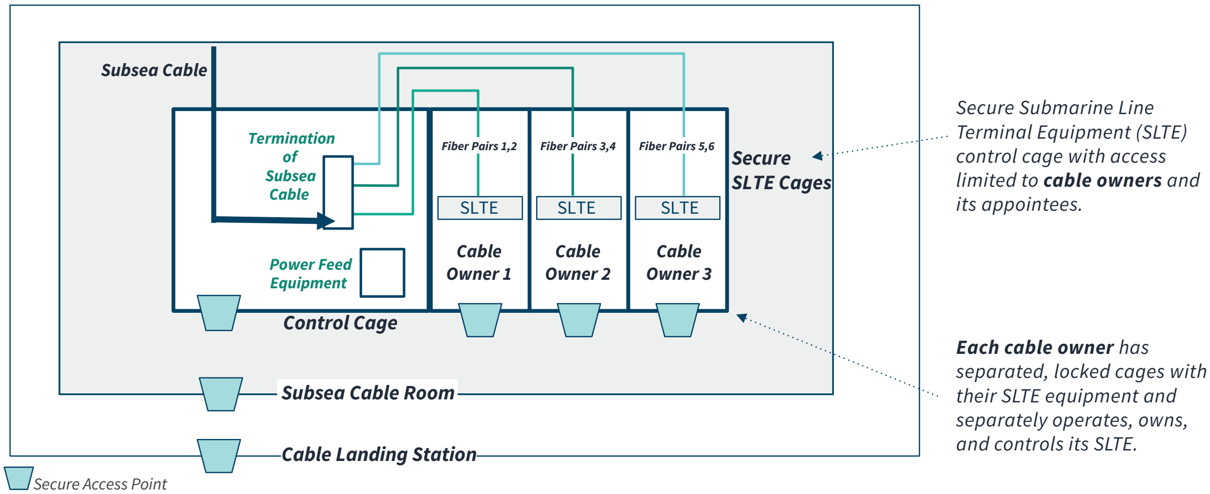
Sources: Google; UK Cable Protection Committee; Alcatel-Lucent Submarine Network.

Risk mitigation begins during the cable's planning phases, when owners decide where to source equipment and who to rely upon for assembly, testing, installation, operation, and maintenance. The companies chosen have access to the most sensitive parts of the system. Compared to terrestrial networks, however, subsea cables have fewer fibers and fewer access points, generally limiting the risk of unauthorized access to each end of the cable.[21]

Landing stations are secured with several measures, illustrated in Figure 6 below. Access to these high-security, physically hardened facilities is restricted and highly compartmentalized. Owners have access to designated cages with separate submarine line terminating equipment (STLE). An additional, separate set of controls restricts access to power feed equipment (PFE).

Figure 6: Landing Station Security Measures

May not represent every cable / cable landing station



Source: Google LLC.

In its national security agreements and letters of assurance, the FCC can require additional security provisions. For example, the FCC can require that network operations centers (NOCs), which provide 24x7 monitoring and support services, are located on U.S. territory and not located in territory where security risks may be greater.

Ownership risks are managed with system architecture as well. In newer shared systems, access is typically limited to specific fiber pairs. Fiber pairs are isolated and can have separate control units, essentially making each fiber pair an independent system. In systems where there is a need to share the fiber pair, newer technology allows secure spectrum sharing, essentially creating a “virtual fiber pair” for each owner. Owning part of the cable’s capacity does not provide physical or virtual access to other parts of the cable.

Encryption is used to protect data in transit and has become even more sophisticated in recent years. Traditional encryption required managing keys and could be inefficient in its use of bandwidth. Newer optical encryption techniques provide security without negatively impacting performance.

In addition to encryption, physical measures and advanced monitoring are used to secure cables at sea. At shallower depths, cables are encased in a protective conduit that runs from the landing station to several miles out at sea. Gaining unauthorized access to cables at greater depths is so technically challenging that little is publicly known about specific methods and which countries have these capabilities.[22] Standing in the way are several challenges: identifying the fiber of interest, copying the data, decrypting it, and evading monitoring systems that detect even minor changes in traffic or physical interference.

As the world has become more dependent on subsea cables in recent years, system operators have increased their security measures. Software provides continuous monitoring to detect irregularities in transmission and alert staff. Some security services even include maritime surveillance with drones and surface vessels.

These threats could evolve in the coming years, but a general hierarchy emerges from the discussion above. Among the malicious threats, cyberattacks are more likely to occur than physical breaches on land or at sea. Accidental physical threats, however, remain by far the largest concern.

These threats also underscore the importance of building resilient networks. Faults can be extremely costly for countries with relatively few subsea connections. In 2017, after a container ship damaged a cable, Somalia was cut off from the internet for three weeks, during which it lost an estimated $10 million a day, a major hit to its $4.5 billion economy that year.[23] For countries with a diverse set of connections, individual faults often go unnoticed by users, as traffic is redirected through other cables. While aiming to prevent cable faults, therefore, U.S. policy should encourage the construction of resilient networks.

3

The Stakes

U.S. Interests

The United States benefits economically and strategically from its position as a global hub in subsea cable networks. This hub status is the result of U.S. innovation, investment, and openness to foreign connections. From the internet boom of the 1990s to the late-2000s, the primary challengers to U.S. companies came from partners and allies. It was, in other words, primarily a commercial competition. China's rise, however, adds a new geopolitical dimension. An effective response must be informed by a careful look at the U.S. interests at stake.

Economic Interests

Subsea cables strengthen the U.S. economy by supporting high-paying jobs, increasing productivity, and spurring growth. Scholars have yet to rigorously measure these benefits for the U.S. economy, but studies of other countries point to gains in GDP and employment.[24]

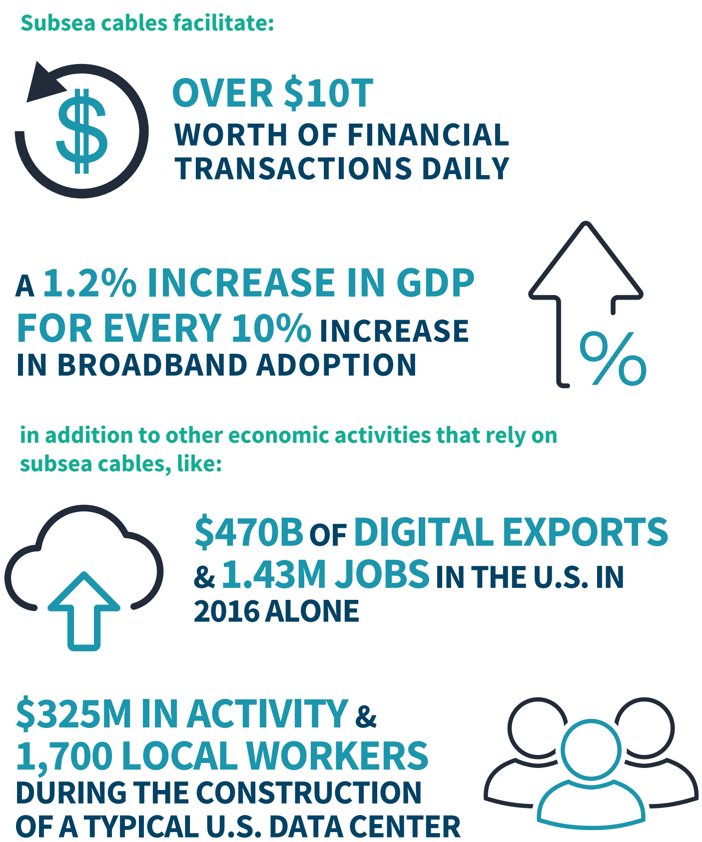
Related studies show that access to high-speed internet increases employment prospects, spurs innovation, and lowers barriers to trade.[25] For high-income countries such as the United States, a 10 percent increase in broadband adoption is associated with a 1.21 percent increase in per capita GDP growth, according to the World Bank.[26] Expanding access requires other steps, of course, especially building out last-mile networks. Subsea cables often benefit users by increasing internet speeds and decreasing costs.

Major U.S. industries would struggle to function without subsea cables. The U.S. financial sector, which is responsible for an estimated 6.5 million U.S. jobs and 7.4 percent of U.S. GDP, relies heavily on subsea cables.[27] "In the financial system, we depend upon reliable telecommunications and it is, therefore, one of our greatest vulnerabilities," Stephen Malphrus, former staff director for management at the U.S. Federal Reserve, once explained.[28] "Whereas if power goes out, we generally have backup generators for critical operations, if you lose telecommunications, the financial system doesn't grind to a halt, it would snap to a halt." These requirements again underscore the importance of building resilient systems.

U.S. exports and the jobs they support rely on subsea cables a well. U.S. exports of information and communications technology (ICT) services, meaning services that are delivered digitally, are increasingly important. In 2016, the most recent year for which data is available, U.S. digital exports totaled nearly $470 billion and supported 1.43 million U.S. jobs, including 161,000 internet sector jobs and an additional 1.3 million in other industries.[29] Underscoring the U.S. strength in this area, digital exports accounted for more than two-thirds of the total U.S. service trade surplus. Without adequate subsea connectivity, these digital products would take longer and cost more to reach their destination, tilting the playing field against U.S. workers and companies and ultimately incentivizing the movement of computing resources abroad.

U.S. businesses of all sizes harness the internet to sell their products. Etsy has 2.5 million active sellers, most of them small businesses based in the United States, and 39.4 million active buyers worldwide.[30] Freelancers can use online marketplaces such as Fiverr to find new customers and clients outside the United States, where more than 95 percent of the world lives. American businesses derive a competitive advantage from the United States' leading position in global networks, which gives them greater visibility and ease of access to foreign markets.

Figure 7: Economic Importance of Subsea Cables



U.S. innovators are at the forefront of several promising developments that could benefit the U.S. economy and rely on global communications. These include, for example, increasing the availability of educational and medical services remotely. U.S. science and research communities also depend on the reliable international bandwidth that subsea cables provide. Whether they are pioneering a vaccine or working on artificial intelligence, these innovators need access to the fast, affordable, reliable connections that subsea cables provide.

The United States has become home to many data centers thanks to subsea cables, which allow data to flow globally and create jobs at home. In the United States, a typical data center employs nearly 1,700 local workers and generates $325 million in economic activity while under construction, according to the U.S. Chamber of Commerce. When operational, each data center supports 157 jobs and generates over $40 million in economic activity every year, including everything from equipment purchases to related services, such as power.[31] Without reliable global connections between the United States and foreign markets, more of these data centers would be built abroad, taking local jobs and economic activity with them.

U.S. companies are also leaders in producing subsea cable technology. In this $23.4 billion industry, U.S. companies are leading manufacturers of advanced ultra-low-loss fiber, cable components, network terminals, and a host of related services, from marine surveys to route planning.[32] Given the technical expertise required, these are typically well-paying jobs. There are an estimated 9,300 subsea cable engineers in the United States, for example, earning average salaries of $114,000.[33] Subsea cables bring together advances in physics, marine technology, and computer science, among other fields, making the industry an important part of the U.S. science, engineering, and technology base.

Strategic Interests

Subsea cables support several U.S. strategic interests as well. While strengthening the U.S. economy, subsea cables also promote development abroad. Recent studies show improvements in employment among several African countries benefiting from the increased connectivity that subsea cables provide.[34] The World Bank estimates that improved internet access and connectivity, in which subsea cables will play a key role, could add 300,000 jobs to Pacific Island economies by 2040.[35]

Subsea cables are also a conduit for U.S. soft power, commonly defined as influence through attraction or persuasion rather than coercion or payment. Movies, video games, education, and media are all sources of soft power that rely on subsea cables.[36] These interactions impact foreign perceptions of U.S. credibility and reputation. Soft power is difficult to measure with precision, but most attempts to do so acknowledge the increasing importance of digital connectivity.[37]

Supporting democratic access to information is another long-standing U.S. foreign policy objective that subsea cables serve. "The American private sector has a direct interest in supporting and amplifying voices that stand for tolerance, openness, and freedom," noted the Trump administration's 2017 *National Security Strategy*.[38] The Obama administration's 2015 *National Security Strategy* called for "supporting technologies that expand access to information, enable freedom of expression, and connect civil society groups in this fight around the world."[39] As the primary conduit for international data, subsea cables are central to these efforts.

The U.S. government relies on subsea cables for diplomatic communications and military operations. It maintains a dedicated network of subsea cables called "black fiber" but still relies on privately-owned infrastructure for 90 to 95 percent of its communications.[40] When three subsea cables between Egypt and Italy were cut in December 2008, U.S. drone flights in Iraq decreased from hundreds to tens a day, underscoring the importance of building resilient networks.[41] As the U.S. military adopts new remote sensing and communications technologies, its demand for bandwidth is likely to grow.

Given the economic and strategic importance of subsea cables, building resilient networks strengthens U.S. security in several ways. In the face of sudden changes, whether natural or manmade, resilient networks keep the U.S. economy functioning, allowing financial transactions to occur and helping businesses of all sizes to reach foreign markets. Resiliency further protects the strategic benefits of subsea cables, allowing them to continue enhancing U.S. soft power, supporting democratic access to information, and facilitating communications for U.S. diplomats and military personnel overseas.

But resiliency must be continuously maintained. As the Covid-19 pandemic has underscored, having sufficient capacity allows the United States and other major economies to accommodate surges in online activity. With more than 70 cables landing on its territory, including multiple cables serving hubs in Europe and Asia, the United States is better positioned to weather natural disruptions than countries with fewer connections. But maintaining these strengths will require planning systems that capitalize on emerging opportunities and adapt to challenges.

4

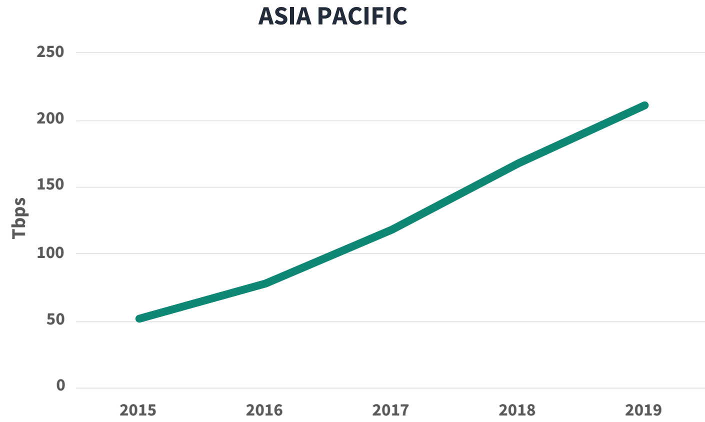
The Future

Three Trends Reshaping Subsea Networks

Subsea networks continue to evolve as new connections are forged among countries, companies, and citizens. Looking ahead, three related trends require attention. First, bandwidth demand is increasing as more of the world comes online and new technologies are adopted. Second, China is emerging as a leading provider and owner of subsea cables. Third, regulatory challenges are mounting as the United States and other governments bring greater scrutiny to the role of foreign companies in their countries' digital infrastructure. These trends could point to a diminished role for the United States in global networks.

The United States remains the world's leading hub for internet traffic, but its centrality in global networks has been declining as more of the world comes online. Half of all internet traffic worldwide flowed through the United States in 2004.[42] Fifteen years later, that share had declined to just under a quarter.[43] Asia has been a powerful driver behind this trend, becoming home to more than half of all internet users in 2018.[44] U.S. companies have responded by seeking additional capacity on routes to Asia, and positioning themselves in other emerging markets, but face regulatory barriers and greater competition from China.

Figure 8: Internet Bandwidth Growth in Asia



Source: International Telecommunication, *Union Measuring Digital Development Facts and Figures 2020* (Geneva: International Telecommunication Union, 2020), 10, https://www.itu.int/en/ITU-D/Statistics/Documents/facts/FactsFigures2020.pdf.

Innovation and technology diffusion will drive demand higher in the coming years. The spread of 5G networks and the industrial applications they support will increase bandwidth needs, especially in advanced economies. In the developing world, investment in network infrastructure and wider adoption of existing technologies will bring more users online. More than a third of countries still lack internet exchange points—the facilities where networks connect—underscoring the potential for growth.[45]

As global bandwidth demand rises, new hubs could emerge in the coming years. Growth in demand has been strongest on links connected to Asia, which grew by 53 percent annually between 2014 and 2018.[46] Between 2015 and 2019, Asia's international bandwidth grew by 42 percent annually. Hong Kong has been a major beneficiary of this growth, ranking sixth globally in international bandwidth in 2019. But trans-Pacific cable planners are looking elsewhere after China imposed a sweeping national security law in June 2020. In the future, routes are more likely to land in Singapore, which is already the leading hub in Asia, as well as Japan, the Philippines, and Indonesia.

Africa's growth potential is massive. The continent is home to 17 percent of the world's population but only one percent of its data center capacity.[47] Between 2015 and 2019, Africa's international bandwidth grew by 45 percent annually, and several subsea cable projects are in the pipeline. Egypt and South Africa are the continent's two leading hubs, hosting 17 and 11 cables, respectively.[48]

In South America, Chile is emerging as a new hub. The country's geography, climate, and business environment are attracting major cloud and content providers. The Chilean government estimates that there were 15 data centers being expanded or newly built in 2019.[49] In July 2020, Chile announced it had selected a Japanese proposal to build a cable to New Zealand and Australia.[50] The decision was a loss for Huawei Marine Networks, which had proposed a route with landing points in China.

Huawei Marine's proposal illustrates a second key trend: China's emergence as a leading provider of subsea cables. What began as a joint venture in 2009 between Huawei and Global Marine, headquartered in the United Kingdom, gradually transformed to include more involvement of Chinese materials and personnel. Over the next decade, Huawei Marine completed over 100 projects, ranging from shorter systems serving a single country to a cable that crosses the South Atlantic. As a result, China went from relying on a foreign partner to having the world's fourth supplier of subsea cables.

In 2020, Hengtong Group, a private company with a history of cooperation with the Chinese military, acquired Huawei Marine Networks and rebranded it "HMN Technologies." Hengtong is China's largest producer of advanced submarine-grade fiber, and it is among the companies currently under investigation by the European Commission for selling at artificially low prices.[51] A press release available only on the Chinese-language version of Hengtong's website notes the company will "offer powerful support for the modernization of our country's national defense" and "advance into the international market."[52]

HMN's flagship project is the Pakistan & East Africa Connecting Europe (PEACE) cable. Slated to become the shortest route between Asia and Africa, the PEACE cable includes landing points in Pakistan, where China recently activated its first direct terrestrial cable, and Djibouti, which hosts China's first overseas military base. The entire proposed route stretches 15,000 kilometers and includes landing points in Kenya and Seychelles as well as a branch connecting to Europe that lands in Marseille, France.[53]

Several major state initiatives support China's push into subsea networks. China's Belt and Road Initiative, announced in 2013, includes a "Digital Silk Road" that aims to increase connectivity between China and more than 130 participating countries. "Made in China 2025," a broad industrial plan introduced in 2015, sets out ambitious targets for China's share of strategic sectors, including capturing 60 percent of the global market for fiber-optic communications equipment.[54] China has backed these efforts with considerable resources, including subsidies and export financing for Chinese companies, investments by China's three main state-owned telecommunications operators, and loans for recipient countries.

China's activities have triggered a response from the U.S. government, part of a broader trend toward governments increasing scrutiny of foreign involvement in digital infrastructure. In July 2020, Team Telecom recommended that the FCC deny a proposed cable connection between the United States and Hong Kong, citing risks stemming from foreign ownership and Chinese control of Hong Kong.[55] Team Telecom is also reviewing existing licenses for subsea cables.

Internationally, the Trump administration encouraged other countries to examine the risks of cables with Chinese investment. In August 2020, the Clean Network was expanded to include a line effort on subsea cables called "Clean Cable."[56] After its announcement, however, few details were offered about the effort. In subsequent months, agreements the United States signed with other countries were primarily focused on 5G. This created confusion about what constituted a "clean" subsea cable, according to industry experts and government officials interviewed for this report.

The U.S. government is also exploring ways to work with partners and allies on projects in third markets. For example, the United States, Japan, and Australia are working together to finance a cable to the Pacific Island nation of Palau.[57] These initial efforts, originally started as part of the Blue Dot Network, could be built upon, as the final section explains.

Other countries have been taking defensive actions as well, and not only against China. The European Commission's call for "digital sovereignty" aims to develop European cloud providers and increase data storage in Europe. India, Indonesia, Vietnam, and other developing and emerging economies are experimenting with data localization requirements. These actions could force U.S. companies to build more data centers abroad, rather than maintaining storage and compute capabilities in the United States and relying on networks to serve foreign markets.

5

Recommendations

The trends described above will challenge U.S. policymakers to strike a balance between restrictive and enabling measures. The following objectives would advance U.S. economic and strategic interests.

1. **Maintain the United States' status as the world's leading hub.** The United States derives significant economic and strategic advantages from its centrality in subsea networks. A highly restrictive approach could undercut these advantages. If the United States were to entirely disconnect cables from untrustworthy locations, all else being equal, traffic would simply find alternative routes to the same destinations through new traffic exchange hubs. The beneficiaries would be countries that are willing to play the role of intermediary. Canada and Mexico could emerge as alternatives in North America. U.S. companies would move data centers to foreign markets, which would reap the economic benefits.

2. **Pioneer zero-trust technologies.** China's emergence as a leading provider of subsea cables will require continued attention domestically and internationally to mitigate risks. Geopolitics will inevitably change during a cable's 25-year lifecycle, and trust between governments can ebb and flow. Given these challenges, the United States should strive for security solutions, such as advanced encryption and advanced intrusion detection, and supporting technologies, such as ultra-low-loss fiber, that enable it to operate more securely in less trustworthy environments. Developing these technologies also presents a commercial opportunity for the United States and its allies, building on their existing strengths in delivering high-quality cable systems.

3. **Create a single federal point of contact for subsea cables.** The FCC should establish a single federal point of contact for other federal, state, and local government agencies and other public and private stakeholders. The existing process is too fragmented and ad hoc. This single point

of contact could also provide information about best practices for risk mitigation, installation, repair, and coordination between public and private stakeholders, such as fishing communities and cable owners. This entity should also conduct a review of existing cable protection laws, including penalties for cable damage, and make recommendations to Congress for updating these laws.

4. **Increase transparency of risk assessments.** The U.S. government should provide additional guidance about how it assesses risks in cable routes. The U.S. State Department's "Clean Network" line of effort on subsea cables did not include many details and raised basic questions. If direct connections to China are the highest-risk routes, for example, are routes to third countries that have their own connections with China a lower risk, and are connections between countries with no direct connections to China the lowest risk? Even if that effort is not continued, more should be done to explain the criteria for assessing risks without sharing sensitive information.

5. **Increase application predictability.** Along with greater transparency, greater predictability would enable U.S. stakeholders to plan systems more effectively. Uncertainty around the status of existing connections and lengthy review timelines for past applications make an already complex process close to impossible. Team Telecom's new procedures, if consistently applied, would be an important step in the right direction. The U.S. government should also issue guidance about alternative hubs in Asia in which it has greater confidence.

6. **Support developing economies.** Rising global demand provides an opportunity for the United States to encourage new routes that support jobs, growth, and innovation at home. To realize those benefits and help meet the needs of developing economies, the U.S. Development Finance Corporation (DFC) and Export-Import Bank should increase their support for digital infrastructure, including subsea cables. For example, some of this support could be used to build branching units into privately-owned cables as they are being planned, making it easier for public or private investors to add branches to underserved markets in the future. Given finite resources and strong common interests, the United States should deepen its existing cooperation with Australia and Japan and expand this cooperation to include other partners and allies.

7. **Improve the foreign environment for cables.** The Executive branch, and the U.S. State Department in particular, should play a more active role in removing obstacles and addressing challenges that cables face abroad. This could include, for example, working with U.S. partners and allies to expedite cable licenses and repairs as well as collaborating on related issues that extend beyond cables, such as addressing data privacy concerns.

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About the Author

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