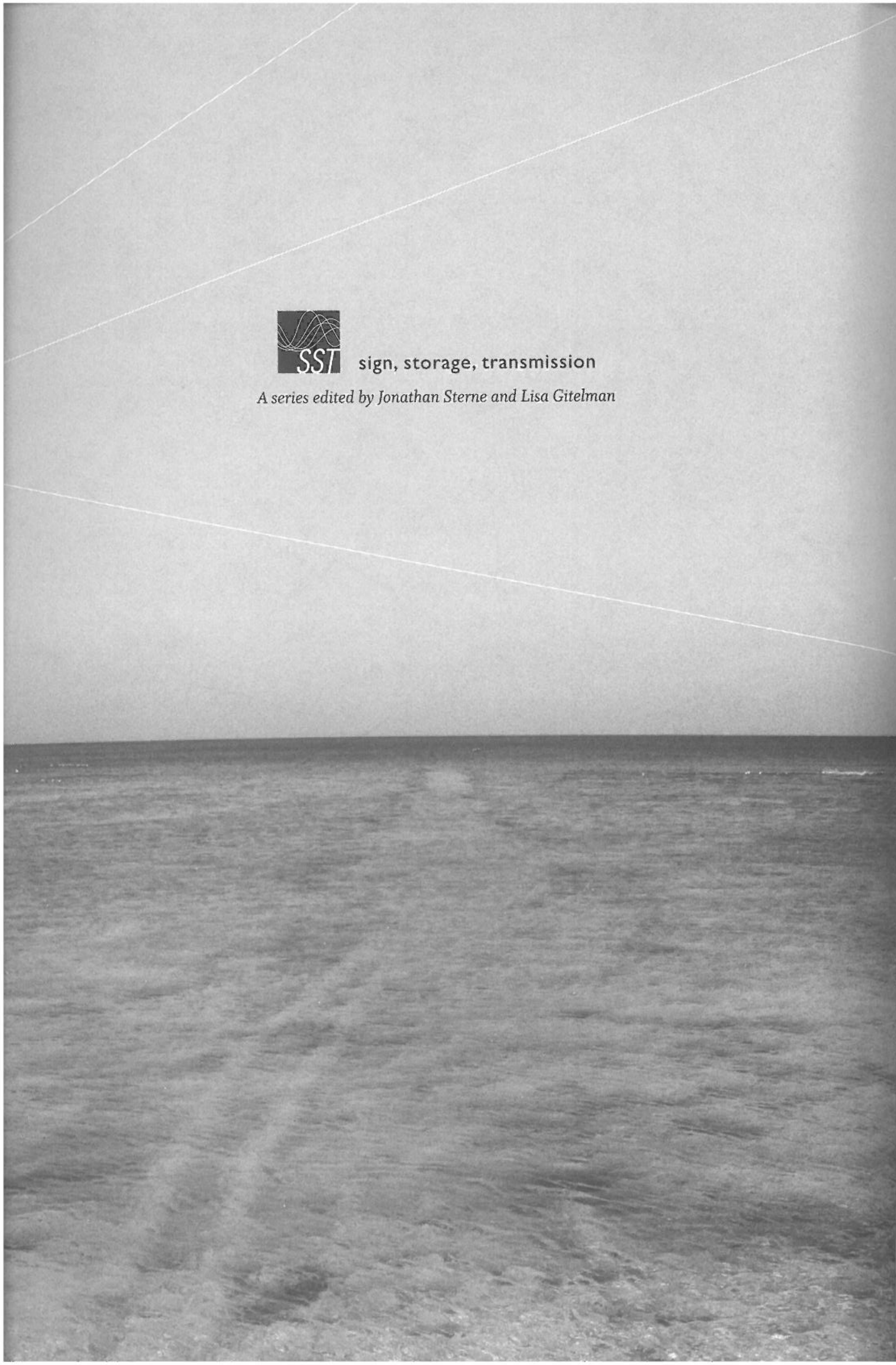

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the undersea network

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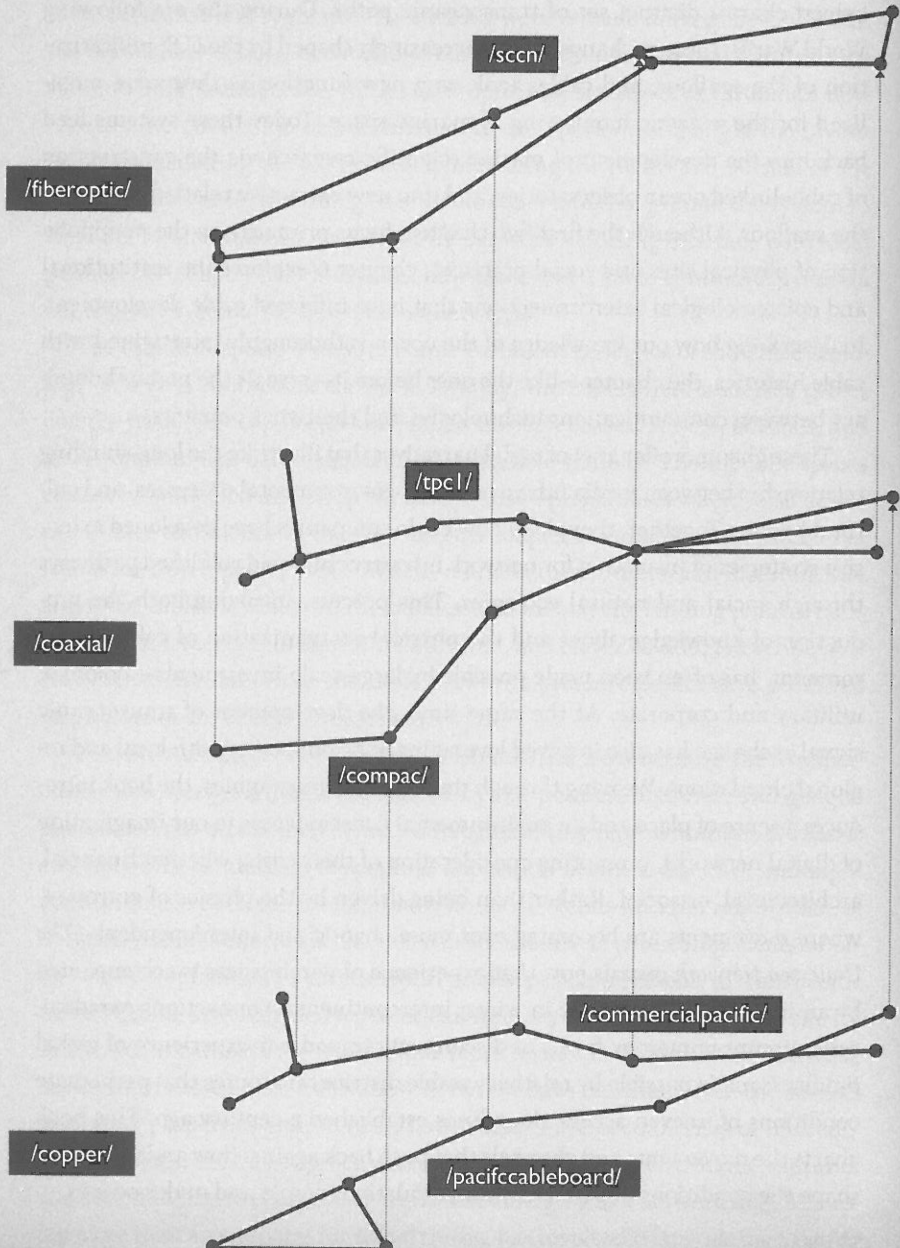


ONE

circuitous routes

From Topology to Topography

At first glance, the Arctic Fibre cable system—the 15,600-kilometer network that would link England and Japan via the Arctic Ocean—makes little sense. With plenty of terrestrial networks spanning North America, why pioneer a circuitous route through one of the least populated areas of the world and an expanse of inhospitable environments, where the cable would be covered by several feet of ice during much of the year? Why spend a projected $640 million to connect Arctic communities with a high-capacity cable when they will likely never use a significant percentage of its capabilities? Given the extensive number of data connections and surplus capacity between London and Tokyo, the cable's two endpoints, why does the world need another cable? Similar questions could be posed to other cable projects seeking to spend millions to link already connected endpoints, from the Hawaiki cable, a proposed system between New Zealand and the United States, to the South Pacific Island Network (SPIN), which was designed to hop from island to island across the Pacific.

One answer to these questions is that these cables offer diversity, a redundant and geographically disparate pathway that would make signal traffic more reliable. If established, these systems (or so their projectors argue) would better insulate our information flows from people, environments, and other forms of interference encountered by networks. Arctic Fibre avoids pressure points on existing routes between Europe and Asia, including the earthquakes of the Luzon Strait, South China Sea, and western Pacific, as well as social and political unrest that make the Suez Canal and Mediterranean particularly turbulent environments. It satisfies a need for routes between Europe, the Middle East, and Asia that skip the United States, an option desired by Asian and Middle Eastern carriers who want to secure their traffic from potential monitoring on U.S. territory. It does not hurt, of course, that Arctic Fibre would also be the quickest route from London to Japan, at 168 milliseconds for a transmission, enabling the company to leverage the market of high-frequency traders who seek to capitalize on the path with the shortest transit time.

The diversity of our global networks, long a concern of telecommunications companies, has recently come to the forefront of policy makers' attention. Prompted in part by a series of very public cable failures, representatives of the telecommunications industry, members of the financial sector, technical experts, and policy agents came together in 2009 at the Reliability of Global Undersea Communications Cable Infrastructure Summit (ROGUCCI) to discuss how to make global network infrastructure more resilient. The summit's participants concluded, among other points, that even though individual systems were highly reliable, on a "global level, the overall interconnectivity of the continents violates a fundamental reliability design principle—avoid single points of failure."[1] Participants pointed out several "geopolitical chokepoints" where cable paths were funneled together and warned that a disaster in one of these areas "could cause catastrophic loss of regional and global connectivity."[2] Our global network, with no overarching body to ensure its robustness, has been constructed in an ad hoc way by companies with a range of different interests, creating an infrastructural reality that runs counter to the common imagination of the global Internet as a distributed mesh, able to easily circumvent any attack in a specific geographic region and route traffic around any disruption.

This chapter argues that in order to understand the geography of signal traffic, we must move beyond network topology, the observation of the geometric or mathematical distribution of nodes and links, to consider network topography, the way that infrastructures are embedded into existing natural and cultural environments. Paying attention to network topography counters several widespread assumptions about the determinants of cable routing. First, there

is a terrestrial assumption: people believe that undersea cables are used only when a terrestrial cable route is not available. Researcher Linda Main argues that since running cables over land is less expensive, "undersea cables have traditionally been used only between continental landmasses, where terrestrial links are not feasible."[3] Cables are assumed to follow the shortest geographic route between continents in order to minimize underwater segments. When cables do not land at the closest terrestrial points between landmasses, their geography is often explained by an urban logic that assumes that cables directly connect the centers of major cities (reflecting a broader focus on the city as the critical unit of analysis for telecommunications infrastructure).[4] A third assumption is that cable routes are driven by demand: they are extended to places where there is a surplus of signals and not enough cables to carry them. This is an anthropocentric and equalizing view of the cablescape: we assume that, like people, cables must be easier to sustain in accessible and central environments and are simply extended to users who lack connection.

This chapter shows that even though terrestrial, urban, or demand-driven logics may at times play a role in determining cable routes, our global infrastructure has been constructed in relation to historically specific social and environmental imaginations. Security, in the broadest sense, has always played a critical role: companies route cables in ways that insulate them from potential interference in their surrounding environments, ranging from natural disasters to anticipated geopolitical friction. Counter to any presumed terrestrial logic, a secure network has most often been an underwater one—territorial politics have made laying routes on land incredibly difficult. Douglas Cunningham of Arctic Fibre argues that the ocean and its ice will serve as a layer of insulation. He commented in one presentation that "60% of cable breaks are from ship anchors and trawls" and observed that "this route will actually be safer than the other routes because we have, on 34% of the length, ice cover for seven months of the year. And that is protection."[5] The deep sea has been the safest zone for a cable because it is farthest from people and subsea engineering is more reliable than terrestrial engineering (components function for decades underwater). The closer a cable gets to shore, the more heavily armored it must be. Although it is true that many cables do connect urban centers (which remain significant endpoints for data flow), landing points are rarely established in the heart of cities. Rural and suburban environments, like the ocean, protect cables from the potential turbulence of human traffic in densely populated areas. The Arctic Fibre cable, though described as going from London to Tokyo, actually lands far outside these cities.

Complete insulation of a cable network is never entirely possible (or profitable). Such insulation would make it impossible for cables to interconnect with the sources of traffic necessary for operation: other undersea cables; domestic fiber-optic systems; and rail, road, and air transport networks. As Stephen Graham and Simon Marvin argue, for this reason new infrastructures are often layered over existing transport and resource systems and rarely develop in isolation.[6] Cables have often been laid to locations where there is already enough capacity as a way of generating competition, stimulating increased signal traffic, and lowering prices. Although many people assume that cable networks are demand driven, advocates of interconnection often make the economic argument that the networks drive demand. Rather than viewing cable laying as a struggle to overcome the ocean or link urban nodes, we might see it as a process of securing routes from turbulent environments and interconnecting them with existing cultural and technological circuits.

Moving from the techniques of the telegraph era, through those of the coaxial period, and to those of today's fiber-optic networks, this chapter describes how investments in cabled environments have shaped the topographies of three generations of transpacific cables and provides a context for the situated geographic analysis of the following chapters. The global telegraph network, constructed in the second half of the nineteenth century, drew support from colonial networks and pioneered the use of the ocean as a layer of insulation. The reinvention of cable technologies after World War II involved negotiations between existing routes of empire, emerging forces of infrastructural decentralization, and a new club system of cable laying (described below). Today, the lines along which the Internet flows evidence a similar push and pull: deregulation and privatization have helped pioneer a new cable geography, which nonetheless is layered into a geopolitical matrix of preexisting colonial and national routes. This genealogy will be familiar to some readers, as historians have analyzed the complex histories of telecommunications systems in detail elsewhere and have well documented the importance of economic and political influences on cable development.[7]

The aim of this chapter—with its focus on security, insulation, and interconnection, especially in the construction of new routes—is to recast our understanding of cable networks to better account for their contingent and material qualities, projecting them as "fragile achievements" that reflect both the ideals of the past and the geographic contours of the earth.[8] I suggest that we view cables not simply as technical systems, but as long-lasting contours in the environment—places where capital, labor, and knowledge have been sunk into the earth's surface, "accumulated imprints" of investment in particular spaces.[9] As a riverbed shapes the flow of water through it, such contours affect—though they do not determine—the direction and force of subsequent circulations. In pursuing the most secure routes, individual cable companies have solidified the network along relatively few lines. As a result, in many places our cable network remains circuitous rather than direct, underwater instead of on land, rural rather than urban, and connects places that are already connected. Perhaps ironically, this tends to perpetuate unequal topographies of global exchange and has left us with a relatively concentrated, semicentralized, and precarious geography that is now proving expensive and difficult—as the case of Arctic Fibre shows—to diversify.

Copper Cable Colonialism

The geography of telegraph routes in the late nineteenth century followed transportation and trade routes, many of which had been pioneered by British colonial investment and served to support existing networks of global business. Cables often landed at the same sites as ships, not only to interconnect with marine transport (the shipping industry was a significant user of cable systems), but also because these sites were often geologically appropriate for both forms of traffic (each required a smooth transition between land and sea). Cables were strewn between ports in the Pacific, from the major hubs of Hong Kong and Singapore to outposts such as Port Darwin. It is no coincidence that Australian cables were brought ashore ten kilometers south of Sydney at Botany Bay, where Captain James Cook claimed the continent for England in 1770 and where the French explorer Jean François de Galaup, comte de Lapérouse, landed in 1788 (figure 1.1).[10] Even at the network's more remote landing points, from Bolinao in the Philippines to Banjoewangi in Indonesia, there was almost always an existing set of colonial infrastructures, however limited, that could support the new stations.

The selection of network routes during this period rarely embodied a completely terrestrial or urban approach. Instead, it represented a balance between the need to interconnect with existing populations and infrastructures and the affordances of an area's natural and social topography. For example, in 1876 the Eastern Telegraph Company laid a trans-Tasman cable from Botany Bay to Nelson, where the company sought to connect with economic trade that was then centralized in New Zealand's South Island. Nelson was neither the closest geographic point to Australia, which was determined to be too remote to support even the cable station, nor a major commercial center—Christchurch was the endpoint for much of this traffic but was deemed too far away. Rather, this route, like many others, was a compromise: Nelson gave the cablemen

FIGURE 1.1. The Botany Bay cable station is adjacent to a monument (far right) honoring the scientist Claude-François-Joseph Receveur, who was part of the first French expedition to the area—a material reminder of the site's many historical landings.

sufficient access to existing infrastructure but did not needlessly waste expensive undersea cable. Landing a cable in Nelson, as was true for other locations such as Botany Bay and San Francisco, entailed laying a longer marine route between landmasses than was absolutely necessary. Although arguments were certainly made about the need to directly connect urban hubs and to minimize undersea routes, it was not uncommon for such statements to be made by individuals with specific commercial interests or geographic pretensions.[11]

More than any single technological justification, security and insulation were important to the negotiation of cable routes. When undersea cables were first laid in the 1850s, the most significant challenge of installation was protecting them from water. Terrestrial wires could remain without physical insulation since air, a nonconductive medium, kept signals from diffusing, but insulation was of paramount importance for an undersea cable. Without it, the signal would easily dissipate into a conductive ocean. In his history of cables, Willoughby Smith dates the origins of undersea cabling not from the successful conduction of signals but from adequate insulation: he considers the 1850 cable from England to France the first pioneer of undersea telegraphy, despite the fact that it conveyed indecipherable messages, because it proved that a circuit of power could be insulated from water.[12] British companies were able to dominate the cable business throughout the late 1800s due not only to their ability to master cable-laying technology and monopolize technical-support infrastructure, but also to their development of an effective form of insulation using gutta-percha, the rubber-like gum from Malaysian trees, and their control over its extraction and distribution.[13]

As the network expanded, aquatic environments once perceived as a threat became the most significant form of cable protection. Counterintuitively, the weakest parts of cable networks were the terrestrial links and coastal segments; in contrast, the deep ocean was the safest zone.[14] Overland cables could become targets during popular revolts, as happened during the Boxer Rebellion in China, when telegraph lines were sabotaged, cutting off communication between local diplomats and the British government. Australia's transcontinental line was often disconnected by Aborigines and the occasional lost cowboy who wandered across the landscape, cutting the line in order to be rescued by cable repairmen. Most natural breaks occurred in shallow coastal waters where tides dragged the cable across rocks. In contrast, very few breaks occurred in the deep ocean, where cables functioned for decades without interruption. To establish political support for the transpacific cables, for example, the argument was made again and again that "in the depths of the Pacific Ocean, the cable would be absolutely safe from interference."[15] In addition to keeping the network safe from perceived physical disruption, running cables through extraterritorial space enabled users to circumvent transit taxes that might have been levied by countries as messages passed through their territory.

Companies began to use the ocean as a layer of insulation to make cables less accessible and visible, thus protecting them from the turbulence of physical, social, and economic conflicts above. Several sites on the Pacific Cable Board's network were initially chosen to minimize undersea segments: the company landed cables at Doubtless Bay instead of Auckland (New Zealand), Southport instead of Sydney (Australia), and Bamfield instead of Port Alberni (Canada) and then linked them via overland lines to populated hubs. However, these terrestrial links soon caused problems. The company worried about the loss of revenue and prestige that could be caused by disruption to New Zealand's "precarious overland route"; the Australian overland line from Southport to Sydney became notoriously unreliable; and the terrestrial line in Canada was often disrupted by winter storms, as well as bush fires and electrical disturbances.[16] The short Canadian segment, not the nearly 4,000-mile-long undersea cable to which it was connected, was referred to as the system's weakest link. Val Hughes recollects: "Getting a message [from Bamfield] to Vancouver often meant sending via Australia and all around the world the other way!"[17] Eventually, more secure undersea cables replaced each of these terrestrial lines.

The global spread of undersea communications networks during this period was led by private companies rather than governments, but it was none-

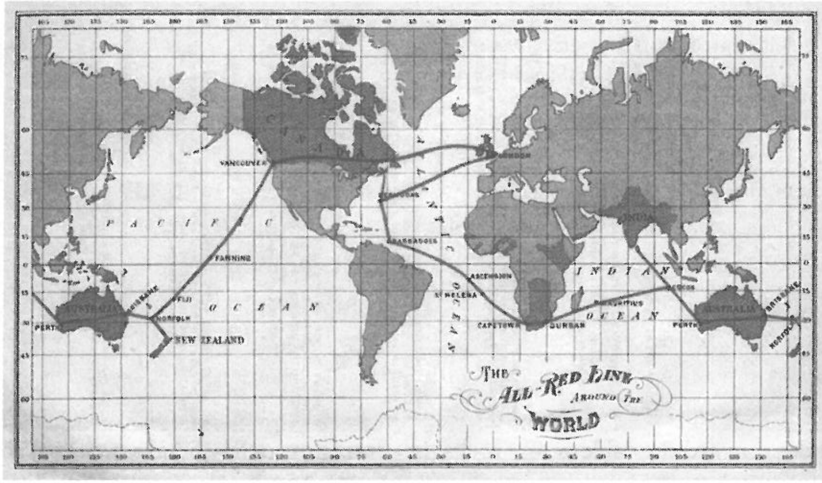


FIGURE 1.2. The All-Red Line, 1902. From George Johnson, *The All Red Line: The Annals and Aims of the Pacific Cable Project* (Ottawa: James Hope and Sons, 1903).

theless framed as a strategy to secure colonial empires. In the latter half of the nineteenth century, the British government supported and subsidized the creation of the All-Red Line, an undersea system composed of strategic cables linking many of the British colonies (some with little commercial value) and landing only on British soil (figure 1.2). Alex Nalbach refers to cables as "the hardware of the new imperialism."[18] Military strategists saw cables as the most efficient and secure mode of communication with the colonies—and, by implication, of control over them—especially during wartime, when enemies might use the geographic dispersion of the empire to their advantage. The invisibility of undersea cables also enabled the extension of these networks (and the perceived control that accompanied them) to places where they might have otherwise been opposed. When there was resistance to the installation of the telegraph in China because it conflicted with customary beliefs (the Chinese government rejected plans to link land telegraph lines to treaty ports), undersea cables were secretly brought ashore in the middle of the night.[19]

In many cases, the effectiveness of undersea cables in actually securing colonies or territorial holdings remained an aspiration rather than a reality. Daniel Headrick writes: "It is tempting to believe that by putting colonies in rapid contact with London, cables gave the Colonial and India offices a tighter reign over their distant subordinates, thus substituting centralized control for the little subimperialisms of the periphery. The evidence, however, points the other way. For information about crises on the frontiers of the empire, London still

depended on the men on the spot, who distorted the facts to suit their own ambitions."[20] Leakage occurred in places where diffusion was not expected, at the point of reception where power was diverted to suit the aims of "men on the spot" (a tactic of short-circuiting power rather than opposing it). Along similar lines, in his discussion of the All-Red Line's connection to New Zealand, James Smithies observes that the cable was economically unproductive and prioritized over other pressing basic infrastructure projects, and rather than creating a simple subservience to British rule, it went "hand in hand" with a growth in colonial nationalism.[21] In the end, the extension of the underwater network, even if did not actually increase control over the sites it covered, indexed the belief that undersea cables could secure economic and political investment. This perception played a key role in justifying networks: for example, the Danish Great Northern Telegraph Company was able to acquire funds for a set of cables connecting parts of Europe and Asia in part because of the desire of Russia and other nations to have a secure communications route that ran independently of British links.

Although security in the broadest sense was certainly important in the nineteenth-century telegraph network, the early global cable network supported a globalized media system, rather than simply a colonial one. As Dwayne Winseck and Robert Pike have shown, it was managed by multinational cartels, and its markets operated with transnational financing: this enabled companies to connect to each other with relative ease.[22] At the beginning of the twentieth century, territorial security became an increasingly important rationale for extending networks—it played a key role in the design of the first two transpacific cables.[23] Prior to this time, cable traffic from Europe to Asia and Australia was routed either by way of Singapore (where the Eastern Telegraph Company had a monopoly) or via a transsiberian line (where the Great Northern Company had a monopoly). This geography kept London and Europe at the center of the cable empire, and companies based in Britain resisted any efforts to develop a transpacific link that would diversify the network and potentially reduce their power.[24] Like the Arctic Fibre project, transpacific cables were not understood to be commercially viable on their own, since at the time there was not much transpacific trade, and they would link territories already connected to the network.

As a result, the first two transpacific systems were justified due to the diversity they offered in comparison with existing routes and the perceived security that the added diversity would bring to the system as a whole, especially if the cable route through the Mediterranean was disrupted. A transpacific link was also seen as a way to break up Eastern Extension's monopoly on the links to New Zealand and Australia and to add a speedier route. As Simone Müeller-Pohl has argued, for this reason crossing the Pacific became tenable only once Britain began to be concerned about imperial security.[25] Sanford Fleming and the Canadian government mobilized arguments about security and helped establish the Pacific Cable Board cable in 1902, setting what would be a foundational route for all north-south transpacific traffic. During this period, creating a secure network meant avoiding sites of potential foreign intervention: the final route—which stretched from Bamfield, Canada, to Fanning Island, Fiji, and Norfolk Island before branching to Southport, Australia, and Doubtless Bay, New Zealand—remained exclusively on imperial territory, even though there were a number of alternatives that offered shorter undersea segments and less expensive installations.[26]

These links were insulated by empire, but this meant that in some places the network lacked sufficient interconnections with local infrastructures. In 1911 the Union Steam Ship Company terminated service to Fanning Island. This threatened the Pacific Cable Board's ability to maintain its cable station, and it began to depend on ships servicing its American competitor, the Commercial Cable Company, and a transportation route through Hawai'i, an island it had avoided landing the cable on for the sake of maintaining the network's imperial cohesion. The New Zealand General Assembly observed that this was quite an "anomalous position," in which the company depended "on the benevolence of a non-British company for maintaining communication with a station which was chosen, in spite of many disadvantages, for the single reason that it fulfilled the condition of being British territory."[27] Even if the network's maintenance and support systems relied on interconnections with foreign networks, they were still seen as secure so long as they remained on imperial territory.

Parallel to the Canadian impetus for the first north-south transpacific link, in the context of growing imperial rivalry, Americans called for a transpacific cable as a "national necessity," initially conceptualizing it as a state project, with "manufacture, laying and operating . . . 'wholly under the control of the United States.'"[28] Similar to the Pacific Cable Board, the U.S. Commercial Pacific cable—which extended from San Francisco to Hawai'i, Midway Island, and Guam before branching to Japan and the Philippines—was not intended to connect sites that were off the grid. Instead, the cable was to help the United States drive demand and exert "commercial and political influence" in the Pacific and was motivated in part by the entrepreneur John Mackay's quest to establish cheaper transpacific communication.[29] In order to interconnect its cable with Asian networks, however, the Commercial Pacific Cable Company

ultimately had to sacrifice three-quarters of its ownership to non-American companies.[30] But as Winseck and Pike note, the company "had no problem claiming to be 'as American as apple pie' when standing before Congress to promote why it should be chosen to lay the first U.S. cable across the Pacific."[31] Again similar to the Canadian cable, the American cable's security was ensured by the extension of the cable through U.S. territory, if not by national ownership of the company.

The transpacific cables, charting new and unprecedented routes across the Pacific, were not easy, quick, or lucrative projects. They mastered the scale of the globe: the Pacific Cable Board line between Bamfield, Canada, and Fanning Island would be the longest undersea cable in the world. They also required new expenditures in infrastructure and the production of environmental knowledge. A new 8,000-ton ship, the *Colonia*, had to be constructed specifically for the Pacific Cable Board line. Surveys of unknown parts of the Pacific were conducted. These efforts were exerted in the interest of interconnecting the new cable with existing networks to generate competition and break monopolies up, and they were motivated by arguments to provide a more secure network via diverse undersea (rather than terrestrial) routes. Conceptualized as the extension of multiple cables to the same endpoint (rather than multiple installations at the endpoints), diversity of routing became a key strategy of insulation for telegraph traffic.[32]

Despite the fact that dominant discourses during this period portrayed water as a threat to telegraphic communication, the resource-intensive, time-consuming, and less economically feasible approach of laying undersea cables was chosen because in many cases it appeared to be the more secure option. However, the approach to securing cables shifted as perceived threats changed: companies moved from a concern about protection from the ocean to a preference for using the ocean's depths as a layer of protection from potential colonial unrest, rival nations, and ships' anchors. As a result, many of the global networks of the late nineteenth century were routed underwater rather than over land.[33] In this context, the transpacific cables, justified on the basis of diversity, positioned Canada and the United States as key centers for traffic and set the stage for the geography of subsequent Pacific communications. Once a secure route had been established, the conservative cable industry was reluctant to forge new paths. Although the expenditures eventually became far greater than the strategic payoff, and the imperial logic and strategic nationalism governing these systems waned, the colonial telegraph network established a set of contours that would affect cabling throughout the next century.[34]

The Coaxial Cold War

In the 1950s analogue coaxial cables were laid under the oceans. The geographies of these new systems evidenced a negotiation between historical contours and emerging forces, including the reconceptualization of security during the Cold War, the nationalization of telecommunications, and the evolution of a club system of construction. Coaxial cables had been first developed in the 1930s, but at that time they could reach only short distances because their signals attenuated after about a hundred miles. In the 1940s the invention of the submersible repeater, a technology that amplified the cable's signal on the bottom of the seafloor, made transoceanic speech transmission possible. Perhaps to forecast the coming of a new era, the first deepwater cable with repeaters was American, laid in 1950 between Florida and Cuba. In 1956 Transatlantic No. 1 (TAT-1) linked Scotland and Newfoundland. These new systems were able to carry not only telephone conversations, but also telegraph messages, telex transmissions, photo telegrams, and even slow-scan television. They required a major shift in technological production: cable ships had to be modified or constructed anew to handle the repeaters; new cable stations had to be created to house terminal equipment; and plastic polythene insulation replaced gutta-percha, which meant that cable companies no longer needed to extract that material from Southeast Asia. This provided an opportunity for the companies to develop both technologically and geographically, and the culture of the Cold War affected their decisions about the new networks' topography.

One of the primary justifications for laying coaxial systems in this period was their perceived security. Undersea cables had been framed as a secure technology after World War I and the later expansion of shortwave radio in the 1920s and 1930s. In comparison to radio, cables were much less vulnerable to interception and remained unaffected by atmospheric conditions and sunspot activity. Therefore, rather than being replaced by radio, cables were deemed a necessary supplement to it. As the naval correspondent of the *Morning Post* reported in the 1920s, "The truth of the matter is that wireless and cable communications supplement one another . . . but the use of the cable, provided that its terminals and intermediate stations are situated on British soil, has one outstanding advantage over wireless—secrecy."[35] Indeed, when the Imperial Wireless and Cable Conference merged wireless and wired networks (forcing the Marconi and Eastern Telegraph Companies together) in 1928, a key argument for keeping the cable networks rather than moving exclusively to wireless was this perceived security. With the advent of wireless, network diversity no longer entailed laying two cables but required the use of multiple transmission technologies. As Herbert Schenck wrote in 1968, "World-wide defense requires world-wide telecommunications. Prudence suggests that these be not concentrated in any one particular mode of transmission."[36] When satellite communication was developed, this only enhanced the perception of cables as secure: they offered insulation for signals that might be easily dispersed or intercepted via the airwaves.

The U.S. military needed secure communications before and during the Cold War, and coaxial cables were seen as giving stability, and presumably secrecy, to international calls. As James Schwoch has observed, "From an American perspective, the interplay of extraterritorialities with global television and electronic information networks was first conceptualized as a security issue. Arguments, positions, rhetoric, and discourse invariably began with an articulation of security concerns."[37] An engineer working during this period recollects that the "security issue" always formed a backdrop for cable projects: "submarine cables always were regarded more secure than satellite circuits. . . . It wasn't spoken about too much, but it was acknowledged."[38] Along many routes, transoceanic telegraph cables were not disconnected until coaxial networks were implemented. Bernard Finn reports that it was well into the satellite era by the time the last significant telegraph cables were removed from service in 1973.[39] Just as coaxial cables did not replace radio (and in many cases additional radio circuits were used to back the cable systems up), neither did satellites later replace the cables. The need for secure routing and diversity via multiple transmission technologies ensured cable's continued presence throughout these periods.[40]

The new geographies of the coaxial network, especially in the United States, reflected the logics of the Cold War and accorded with a dominant strategy of infrastructural decentralization that located stations in remote sites so that they would not be as vulnerable to either nuclear attack or marine traffic.[41] At the end of the telegraph period there had been a general centralization of cable networks around the southern Pacific—a movement reflecting the conceptions of security leading up to and following World War I (cables were perceived as being more secure if they were near urban hubs that would facilitate military protection) as well as transitions in cable technology that made fully staffed cable stations less important.[42] Remote cable stations generally moved closer to cities, where it would be cheaper to hook into existing infrastructure, but they were often located outside the urban hubs.[43] This reorganization set the stage for the coaxial installations: cables could not be in places where there was no infrastructure, so they could not be too far from urban hubs; nor could they be so close that they would be disrupted by other forms of traffic. In the telegraph network, San Francisco had been the Pacific's gateway to the United States; coaxial cable landings were relocated to Manchester (a rural coastal town north of San Francisco) and San Luis Obispo (midway between Los Angeles and San Francisco). In Hawai'i, cables no longer landed centrally in Honolulu but connected O'ahu's less populated west and east coasts.[44] Similar transitions happened in Asia and the South Pacific, as stations at Baler (in the Philippines), Ninomiya (in Japan), and Lauthala Bay (in Fiji) were dislocated from the countries' urban centers. This strategy also served to protect cables from turbulent urban circulations, including nautical traffic that threatened to sever cables, costs of coastal property that made construction and maintenance more difficult, and swelling populations that could inadvertently disrupt cable traffic. Moreover, although in the colonial period, securing one's network entailed routing two cables to the same station, in the Cold War era companies often saw it as establishing a range of diverse landing points and stations.

Telecommunications companies had to balance the drive to decentralize with the traction of existing cable installations. In some places, if failures had not occurred there seemed little reason to relocate. When determining where the Australian terminal station would be located, the management committee for the 1963 Commonwealth Pacific Cable (COMPAC) considered several new sites, including suburban and rural locales. The committee members noted that, given the "premium on space in the city centre," it might be preferable to establish their new station in one of the suburbs.[45] In the end, they decided to route the cable into the existing city hub, in part because of the difficulty of developing a new route: that would entail digging up roads and demolishing buildings to connect the old network with a new landing. When landing facilities, a cable station, and a conduit from the beach already exist, as one engineer observed, "the costs of diversity are quite high."[46] Even if a less central location would have been preferred, the existing gateway had traction: it was appropriately insulated from and connected with the surrounding geography.

Despite the general shift toward decentralized landing points, coaxial cable routes generally followed the same paths as the two original transpacific telegraph cables. Terrestrial routes were avoided even when that meant a longer marine segment: the ocean continued to be used as a means of insulation.[47] The first transpacific coaxial cable, Trans-Pacific Cable 1 (TPC-1), followed the general path of the Commercial Cable Company's cable, moving from California to O'ahu, Midway Island, and Guam before linking to Japan and the Philippines and building on the existing economic, cultural, and technological interconnections with these locations. COMPAC followed the original Pacific Cable Board route, since that had a "low incidence of faults."[48] The builders argued that at "Fanning Island and Fiji the records of the telegraph cable landings

had proved the reliability of the approaches and landings and there was no reason to consider alternatives."[49] This became the industry's standard practice, as the ROGUCCI report directly states: "If an existing route is known to be acceptably reliable from natural or man-made damage then there is a great commercial incentive to lay cables along the same route."[50] Like the earlier transpacific links, many of these cables were laid between countries that already had international voice communication via radio, with the intention of providing diversity of routing to established markets and users.

With the breakup of colonial empires, the focus of securing the cable network shifted from routing via one's territory or colonial holdings to having national control over the processes of building, operating, and maintaining the cable network. Although the British continued to control many of these resources, new players such as the United States and Japan emerged. In the United States AT&T became a major investor in and developer of undersea cable systems. The company created a specialized submarine systems laying group, AT&T-SSI, which had its own fleet of cable ships. Simplex, an American company that had been involved in cable manufacturing since the nineteenth century, invested in the construction of a new facility in 1953 and helped build the American portion of the first transatlantic telephone cable. The U.S. Underseas Cable Corporation was created in 1959 to manage cable projects from inception to completion. These companies also helped facilitate the U.S. military expansion in the Pacific. AT&T's transpacific cable provided circuits for the U.S. Defense Communications System during the Vietnam War. Even though microwave radio links were used for command and control, to obtain reliability "through diversity of route and mode," the military turned to cables.[51] The strengthening of U.S. cable suppliers also facilitated the extension of military-only networks, including both surveillance cables and links between South Vietnam and the Philippines and between Johnston Island and O'ahu, as well as a coastal cable project in Vietnam. As in the case of the All-Red Line, the routing and geographies of these links were often influenced by strategic investments.[52]

Although the Japanese had long been invested in regional telegraph systems, in the coaxial era they too developed a larger-scale network. The Kokusai Denshin Denwa Company (KDD) was formed by the Japanese parliament in 1953 as a monopoly international telecommunications carrier, partnering with the Americans on transpacific and East Asian cable projects.[53] The company subsequently introduced new coaxial cable technologies, invented a new method of burying cables, and built its own cable ship. Nippon Electric Company assisted in cable development, and Ocean Cable Company of Japan supplied cable for a number of these projects. One telecommunications historian argues that in this period "Japan's potentialities to plan, manufacture, construct, maintain, and operate coaxial submarine cable systems [had] been developed to reach the highest technical standard of the world."[54] The national development of a cable industry was a strategy to insulate cables from the potential interference of other nations in their cable construction and operation, since everything could be controlled and accounted for by the incumbent telecommunications company.

During this period, a new model of institutional interconnection, the club or consortium system, displaced the imperial model and eventually introduced a new set of concerns to cable routing. In the club system, cables were no longer designed and operated by a single company (and insulated by empire). Instead, cable construction, engineering, and route design became topics of negotiation on cable committees whose members represented nationally owned or affiliated monopoly telecommunications carriers, whether American, Japanese, British, or French.[55] Committee members first agreed to jointly build a new network. Each company would contribute its expertise and take responsibility for facilitating interactions with its government, developing landing arrangements, and negotiating domestic connections. Although telegraph cables had often been planned and operated by one company, with coaxial systems the duties of maintenance, the costs of construction, and the revenues generated were typically shared more broadly. For example, for COMPAC the participating countries agreed that the cost of £26.3 million would be split among Canada (£8.8 million), the United Kingdom (£8.3 million), Australia (£6.6 million), and New Zealand (£2.6 million).[56] As Richard Collins argues, this evidenced a "supercession of imperial organisational arrangements by national control," one in which self-contained networks moved toward "an integrated global system."[57] "Cooperation was the name of the game in those days," notes Jean Devos, of France's Alcatel Submarine Networks. Through the club structure, "a sense of fraternity and mutual respect developed over the years between all the players."[58]

The terrain to be secured was no longer the country's territory, but the circuits of the cable: each nationally affiliated company would own a percentage of the cable or a specific number of circuits. Typically, companies owned out to the midpoint of a cable (termed a *half circuit*), and the capacity would be allocated before the cable started operation. This structure limited the development of a market for international traffic, since anyone who wanted to provide services using the cable would have to negotiate with multiple owners rather than just one. For example, in the case of the COMPAC cable, AT&T "vigorously" pursued an offer to purchase a 25 percent share in the cable south of Hawai'i, but the "Management Committee considered this proposal ran contrary to the concept of the Commonwealth cable system . . . its acceptance would compromise the Commonwealth nature of the venture and reduce flexibility in control and development."[59] Anyone not in the club could easily be kept out.

Operators would pool their resources to benefit all of the club's participants, yet their interconnection depended on being insulated from competition. The monopolization of international communications by only a few players and the domination of construction by a handful of companies (a club cannot be too big) were critical to this new system. Most often, even when a large number of parties bought into the system, the design and construction of the undersea segment would be handled by one of the large companies.[60] Any country needing access to international networks would have to choose between these suppliers "according to natural areas of political, cultural, economic and financial influence."[61] One engineer described the process this way: "In putting a bid together, if it was for a Cable & Wireless project, I would be foolish to use anybody but Cable & Wireless for our marine installer, because I wouldn't get the work. It was recirculatory money."[62] These trusted alignments and partnerships protected the club's shared investments. As another engineer recalled, club members would be unlikely to work in an environment where "politically you're not familiar with how they do things. There was the security aspect, which was never mentioned too loudly, but it was always in the background, you didn't want to put your cables at a risk. There was not a name for what sort of thing could happen."[63] In brokering interconnections between nations, the club made it more secure for each country to extend circuits into foreign territories.

The result of this new institutional arrangement meant that, even though the practices of cable maintenance and manufacture remained guarded by individual nations, there were now more technological connections between the systems. The club system introduced extensive interconnection agreements to the planning process. Whereas in the colonial era, the British-affiliated cable steered clear of Hawai'i in favor of Fanning Island, under the club system the planners observed that even though Hawai'i was U.S. territory, "a landing there would have substantial advantages from the technical point of view. Moreover, it would provide a junction between the Commonwealth and the American telephone cable systems and yield material financial advantages."[64] This interconnection would also afford diversity of routing, offering a possible backup in case of cable failure, and would be cheaper to maintain.[65] As a result, even though the Commonwealth system would not sell shares to the

United States, it agreed that "there was every advantage in ensuring that the Commonwealth plans and the United States plans were complementary and, as far as practicable, coordinated."[66] In return for the connection at Hawai'i, the U.S. Defense Department received dedicated backup circuits to Canada as well as circuits through Australia.[67] The land on which the station was placed was reportedly given to the Commonwealth in exchange for land in Australia that could house an American military base. However, the landing country retained oversight: in the United States, the Federal Communications Commission stated that the Commonwealth cable must conform "with plans approved by the secretary of the Army" and that it should be shifted (at the expense of the Commonwealth) if the secretary of the Army ever required that.[68]

The geographies of coaxial cables reflected existing route lines, seen as secure because they hadn't had many disruptions, and followed the original investments of telegraph companies. However, companies also had to negotiate the emerging cultural conditions of the Cold War era. Although cables continued to be viewed in terms of security, the companies' understanding of security itself changed, shifting to encompass strategies such as infrastructural decentralization. The nationalization of telecommunications meant that the territory of empire could no longer serve as a layer of insulation. As a result, via the club system, a new set of connections—made at sites such as Hawai'i and Guam—were understood to make the cable network more secure. This enabled countries to extend circuits into other nations without encountering interference (which would be mitigated by the local partner). In addition, by linking to each others' networks, national carriers could achieve a network of circuits with physical redundancy: the TPC systems across the northern Pacific and the COMPAC and South-East Asia Commonwealth Cable (SEACOM) systems across the southern Pacific, even though "owned" out to mid-Pacific by nations on either side, were configured as a loop. Individual carriers (as long as they were part of the club) were able to buy capacity in an entire ring. Routing signals the long way around this ring would still be more reliable than wireless. As in the telegraph period, these transpacific links, made possible by historically specific geographic negotiations, were not always commercially profitable at their inception, did not always connect previously unconnected sites, and did not simply follow the shortest paths between cities. Geoff Parr, a global manager at Australia's largest telecommunications company, recollected that "it didn't really matter if you went a circuitous route," as long as you got to where you were going.[69]

Fiber-Optic Financialization

From the late 1980s to early 1990s, two major shifts—the development of fiber-optic technologies and the process of telecommunications deregulation—significantly changed the culture of cable laying and, as a result, the network's geography. However, the first fiber-optic cables continued to follow the contours of telegraph and coaxial networks, giving the imagined sources of friction and security of those periods—from the debates over territorial security in the colonial era to the spatial decentralization and institutional interconnections of the Cold War era—a residual life in digital communications systems. Fiber-optic systems, which encoded signals in light and sent them down a thread of glass, had been in development since the early 1980s, but given the conservatism of the industry (in which nothing is adopted until it is tried and true), the first international system was not put in place until 1986. Even with this technological advance, the first fiber networks were built according to the consortium model: they were based on standard traffic forecasts, intended to simply increase the capacity available to partner countries, and laid by companies with a long history of cable experience. They reinforced the nodes of the existing telecommunications networks. In 1989 AT&T laid the first transpacific fiber-optic cable, Trans-Pacific Cable 3 (TPC-3), between Cold War–era stations at Makaha, O'ahu; Tanguisson Point, Guam; and Chikura, Japan.[70] PacRim (1993), the first fiber system in the South Pacific, was routed almost exactly along the path of the previous analogue cable, Australia–New Zealand–Canada (ANZCAN) (1984), which had in turn followed the COMPAC route. Terrestrial segments continued to be most dangerous part of the system, to be avoided whenever possible.

As in the coaxial era, telecommunications companies would occasionally consider new paths but ultimately determined that existing routes were more secure. For example, the telecommunications company laying the Australia-Japan Cable in 2001 considered alternative routes to Sydney but determined that they were too difficult. Failed attempts to pioneer new routes demonstrated these risks. When laying JASURAUS in 1997 from Jakarta to Australia, Telstra decided to develop a new landing in Port Hedland, Australia, to connect with a domestic fiber network. To do so, engineers had to design an elaborate trenching scheme to bury the cable fifty kilometers out to sea along a long shallow shelf. After this drawn out and exasperating experience, the company returned to the previous west coast landing in Perth for Southeast Asia–Middle East–Western Europe 3 (SEA-ME-WE 3) in 2000. When routes were altered, this was typically justified in terms of the need to secure a cable from nodes and landing points seen as problematic and to connect it to other networks, including satellite systems.[71] The PacRim system skipped Fiji, which had had several coups, and Norfolk Island, where cables were notoriously difficult to install.

As fiber-optic technologies improved—and data communications networks grew with them—they greatly increased capacity from earlier links: the amount of traffic that new systems could carry increased dramatically every year, and this process helped speed up network development. Although PacRim East had two fiber pairs of 560 megabits per second in 1993 (one telecommunications manager involved in the project recalled wondering "who would want any more than that?"), a mere three years later JASURAUS was completed with five times as much capacity.[72] Throughout, the cost to build systems stayed relatively constant. As a result, many of these early fiber-optic cables reached economic obsolescence before technological obsolescence. The PacRim network was designed to meet demand through 2005 but was full by the end of 1996.[73] The first generation of fiber-optic systems had some of the shortest life spans in cable history. Although the first transpacific telegraph cable lasted over half a century, and the first coaxial cable in the Pacific was in service for thirty-two years, the first fiber link to Hawai'i lasted only fifteen. Builders asked whether there was still a need to engineer to the same set of standards: did they really need a twenty-five-year design life, which put a lot of cost into development, when systems were becoming obsolete within a decade? Although these questions subsided in the late 1990s when new technologies made it possible to transmit more information over existing cables, they had the temporary effect of accelerating network development (helping to generate a cable-laying boom) and causing the industry to question the longevity, and indeed some of the historical foundations, of their systems.[74]

At the same time, deregulation introduced a new alternative to the club system. By the 1980s and 1990s, interconnection agreements and joint ownership had become quite unwieldy. Fourteen companies eventually signed the construction and maintenance agreement for ANZCAN: countries from Papua New Guinea to the Philippines and Fiji were allowed to invest. TPC-3 had seventeen owners, Guam–Philippines–Taiwan (GPT) had twelve, and Hong Kong–Japan–Korea (HJK) had thirteen. As state-owned monopolies were privatized and international telecommunications became subject to competition, the opening up of undersea cable planning intensified. In 1984 the monopoly of AT&T, the world's largest telecommunications provider, was broken up. The Japanese began to deregulate the monopoly of the Nippon Telegraph and Telephone Corporation in 1985.[75] British Telecom and France Telecom were sold to private investors. This created opportunities for both smaller carriers and larger companies to expand and operate international telecommunications in places previously protected by the club's interests.

With the expansion of privatization, many cable projects became speculative money-making ventures that involved calculating market risk, rather than endeavors to meet forecasted demand. Companies that had been "supporters of national industry and public service" became "business-oriented organizations" and moved away from the "open collaboration" and fraternity with fellow companies.[76] The Internet boom made it increasingly difficult to base financing on a traffic forecast, which was "becoming a crystal ball exercise."[77] One entrepreneur in the cable industry remembers his early encounters with the culture of consortium cable work: the consortium had meetings that would go on for days, "almost like formal diplomacy," with highly technical discussions that helped establish the participants' credibility.[78] Increasingly, however, engineers had to articulate and design the system in relation to potential financial gains, and a new group of people in marketing and sales became involved in discussions about cable routing. Without the club's coordination, individual companies took less responsibility for planning a robust global network.

Together, these forces—the quickening pace of cable development, the transitions of deregulation and privatization, and the entry of new players—led to a set of efforts to develop new cable systems that deviated from the club model. The first private cable was the transatlantic cable PTAT-1, which was completed in 1989. Andrew Lipman, the lawyer for the system, recalls that the private model had been pioneered already in satellites, and to some extent, the challenge was a psychological one: the entrepreneurs behind the system had to convince the cable industry that it could be done. Their success sparked a rash of other private cables. The formula spread to the Pacific when North Pacific Cable (NPC) was established to compete with a consortium cable, TPC-3. Developed by companies that were historically foreign to the transpacific cable business (and increasingly including nontelecommunications companies), these newer cables—in part because of the dynamics of capacity—often cost less and carried more than earlier networks, and thus undercut their rates. By 1997 the $1.2 billion Fiber-Optic Link Around the Globe (FLAG) network, backed by over thirty financial institutions, had been laid along a route between Europe and Asia traditionally managed by a consortium. This cable initiated the sponsor's approach, in which a private company organized a project and allowed others—not limited to companies who had financed the network—to buy capacity on it as they needed.[79]

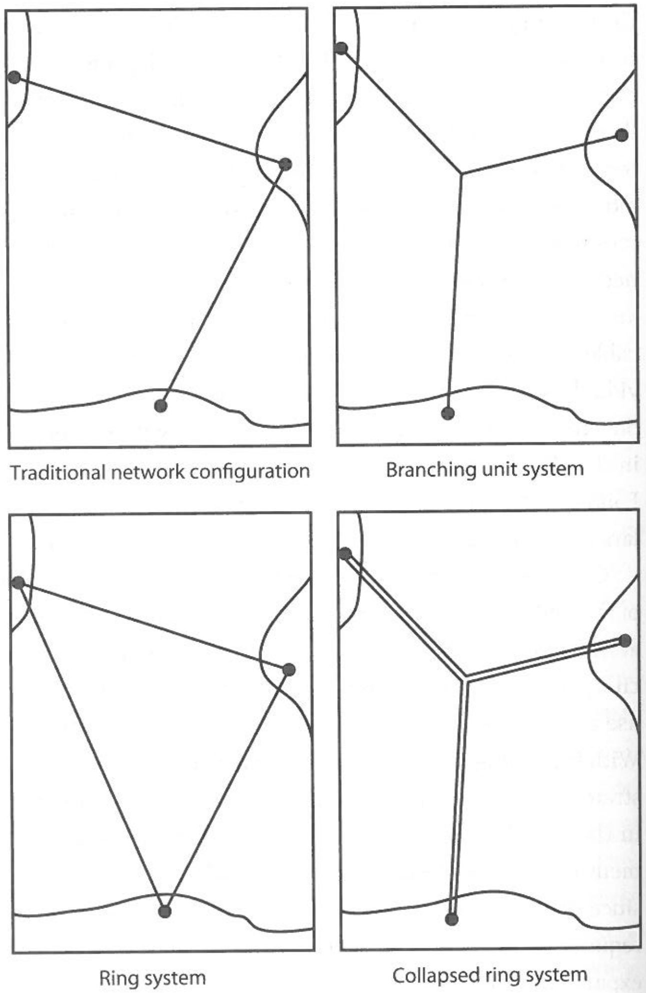
Overall, this process made the distribution of circuits more flexible. The terrain to be guarded in the consortium era—ownership of a circuit—was not the site of contestation. No longer held up by the diverging opinions of numerous committee members, the timetable for private cable projects became shorter to capitalize on the current market: instead of taking five years or longer, cables could be launched and completed in under two years. There was an urgency to this development, since in some cases, if the system was operating by a certain date, precommitted customers would be able to back out.[80] In combination with the new technology, this led to a more risky business environment, although some of these risks shifted from major telecommunications carriers to independent companies and financial institutions.

Deregulation, privatization, speculation about increases in capacity that would be needed by the growing Internet (to be stimulated by high-bandwidth–intensive applications such as videoconferencing), and assumptions about an inherent relationship between telecommunications investment and economic development together drove a global boom in cable laying. Stewart Ash, who worked in cable installation at the time, recollected that "cable manufacturers were building factories all over the place. We had a cable factory in Southampton in the U.K. We had one in Portland, Oregon. We had another one in Australia. People were pushing out 100,000 kilometers of cable a year."[81] The geographic expansion of undersea cables increased at an unprecedented rate.[82] New cable ships were built. The strict national affiliation with cable suppliers was severed, as many companies strove for the best deal and could choose among suppliers from various countries.[83] The invention of the universal joint in the 1980s, an undersea cable technology that enabled the splicing together of different kinds of cables from different companies, further broke down the segmentation of marine services across nations. These shifts, like much of the globalization of the 1990s, shook up—though they did not eliminate—the national entrenchment of postwar cable development. New companies such as Global Crossing, 360Networks, FLAG, Tyco, Level 3, and Singtel/C2C—many of which were based in the United States and had little experience in the industry—entered the cable business and began to compete with older telecommunications companies.[84]

This transition had several significant impacts on the geography of undersea networks. First, the historically complementary relationship between wireless and wired transmissions that had been in place since the development of wireless telegraphy was fundamentally altered. Satellites ceased to be a sufficient backup, and the financial impacts of cable breaks increased.[85] When there was a major outage on PacRim West in the mid-1990s, the network did not have enough satellite capacity to restore its traffic. Brett O'Riley, a telecommunications policy expert in New Zealand, recalls that this was "a wake-up call to the industry" about the imbalance between wired and wireless capacity.[86] This transition was a fundamental shift in network geography that brought the industry back to the telegraph era: cables once again needed cable backups for diversity. Given the increases in how much each system could carry, the content carried by a single new cable might exceed that in all prior systems. Even old cables could not provide backup for the newest links. As a result, companies began to develop ring systems, more extensive than any before, that connected a series of locations so that there were essentially two paths between any given points. These systems embedded diversity in the geography of each cable system and further insulated traffic from any potential instability in individual locations. In 1996 the consortium cable Trans-Pacific Cable 5 (TPC-5) pioneered a ring structure around the Pacific, with two points in Japan and four in the United States, providing instantaneous backup if either leg went down. Following this, four other ring networks, each of which cost over a billion dollars to construct, were built with northern and southern transpacific routes.[87]

Combined with the loss of wireless backups, the technological development of the underwater branching unit, which enabled companies to redirect signals at the bottom of the ocean, pushed the cable industry to develop new transpacific geographies. Previously, to connect any three locations one would have to use a ring structure or choose one location in the network as a central point. With branching units, the cable station was effectively moved underwater: the strategy of insulation—using the ocean to protect communication—developed in the colonial era now enveloped nodes in the network itself. The development of trunk and branch systems made routes more diverse and resilient, since they could not be cut off by a failure at a station in the middle. They also required more planning in the beginning, since the system could not easily be expanded once it had been laid. The Australia-Japan Cable introduced a new mode of diversifying landing points in the Pacific: at each of its landings in Australia, Guam, and Japan, the cable branched into two sections. Since the most dangerous areas of the network were the shore ends, this part—rather than the secure deepwater segments—was duplicated. This network geography inverted the approach of the telegraph era, in which multiple deep-sea cables were laid to the same endpoint; instead, security entailed using one cable with multiple endpoints. At the same time, a collapsed ring structure was developed: following the trunk and branch design, this added diverse technological pathways between points, though they followed the same physical route (figure 1.3). These investments in diversity were conducted at the level of the individual network, without necessarily taking into consideration the stability of the system as a whole.

FIGURE 1.3.
Changes in network design.



Private cables, run by independent companies, also developed a new geography of landing points, since existing telecommunications companies in many places blocked the new networks from terminating at their stations. North Pacific Cable built a new cable station at Pacific City, Oregon, pioneering the landing of cables on the northern Oregon coast. Global Crossing established a new station at Grover Beach, California, for its transpacific and South American cables. Many historical monopolies resisted the change. However, in the end, the new nodes were connected with the old ones, and the boom helped create duplicate routes across the oceans and, ultimately, a more secure network.[88] The drive to diversify and back-up one's networks was strong:

established companies acquired capacity on the new cables to provide backup routes, and in many places new cable companies purchased backup capacity on the older cables. The club system did not disappear, since the historically dominant and nationally affiliated telecommunications companies laid new consortium cables to compete with newcomers.[89]

The Southern Cross Cable Network (SCCN) is exemplary of the era's shifts. By the late 1990s, the PacRim system, the only cable network out of Australia and New Zealand, had filled up. One telecommunications worker claimed that the PacRim consortium "was manipulated by Telstra and AT&T deliberately to keep other players out."[90] He recalled a meeting in Queenstown when representatives of a number of telecommunications companies showed up to discuss how the remaining capacity could be used, only to find that Telstra and AT&T had made a deal before the meeting, allocating all capacity and blocking new players' access to the network. This "created a huge amount of bitterness in the industry," and as a result, a group of New Zealand telecommunications workers began to think about building their own network. Like many of the private systems, SCCN, even though partially owned by the nationally affiliated Telecom New Zealand, was driven by companies that had been shut out of a consortium but needed capacity to participate in the 1990s technology boom.

Simply building a cable to Australia was not a prospect for economic reasons. Even if New Zealand companies could send data to Australia, they would still face the same problem of depending on the PacRim cable (and the former national monopoly, Telstra) to reach the rest of the world. Since north-south links across the Pacific were difficult and expensive to build, New Zealand could not finance a transpacific link based on its users alone, and it could attract little interest from North American, Asian, and European companies. As the company did not have backing or up-front financing from existing telecommunications carriers, it had to devise an economic plan that would convince financial institutions to lend it hundreds of millions of dollars. One of the original cable builders, Charles Jarvie, recalled: "There's got to be a story for the bank. They won't just take your word. They'll say, 'Well, who's giving credit support to this contract? Who's standing behind you?'"[91] No matter how enthusiastic the builders were about the social or economic benefit for New Zealand's industries and emerging Internet users, they were forced to develop a commercially plausible rationale for the system.

Brett O'Riley, who helped to develop the cable network, remembers that "Southern Cross was different, because for the first time we really treated it as a market exercise. This was not industry getting together and saying, 'How do we make this work?' This was sponsors . . . we had a marketing committee. We designed a logo for it. We designed merchandise for it."[92] Even SCCN's name speaks to the shift in cable politics: the Southern Cross is the dominant constellation in the southern hemisphere. The SCCN team wanted a name that was more interesting than the typical engineer-produced name (such as TPC-3) and that would signify that it was a different kind of cable system. Fiona Beck, SCCN's CEO, had a background not in engineering but in finance and strategy, which helped make the cable company aware of the kinds of market-related questions that would be asked of them.

As a result, SCCN's developers conceptualized the network as a transpacific link from the United States to Australia, positioning New Zealand as a stopping point—in effect, using Australia to provide for New Zealand. As one of the builders joked, "The New Zealand way is to say, 'These Australians won't think about us,' that 'we'll have to convince them it's the best idea they've ever had.'"[93] Like many private cable system developers, they sought to move quickly and position SCCN as a more dynamic company, free from the large committees and extended timetable of the "politically based" consortium cables.[94] The network was designed as an Internet-based cable that would be the fastest and most straightforward route to the United States, where most of the Internet servers were. Inspired by FLAG and other independent projects, the Southern Cross team established partnerships with companies in Australia and the United States that had also been left out of major cable consortia. They were ultimately successful in getting funding (the network cost $1.5 billion), and the system went live on November 15, 2000. As using its own transpacific cables became less feasible—PacRim became economically obsolete and the Australia-Japan Cable proved to be a truly circuitous route to the United States—Telstra, which had initially blocked New Zealand's attempts to get capacity, ended up becoming one of Southern Cross's largest customers.[95]

Because of its oppositional relationship with the major telecommunications companies, SCCN established a new geography of cable landings that included setting up new landing zones, stations, and local agreements. New stations were constructed in Australia at Alexandria and Brookvale (separate from, but close enough to Telstra's Sydney stations), in Hawai'i at Kahe Point (just down the shore from AT&T's station) and in California at Morro Bay (near the existing AT&T station at San Luis Obispo). The Southern Cross stations were open access, and new companies were allowed to connect their cables with them. Although PacRim had skipped Fiji because it was a problematic node, Southern Cross stopped there, accepting the Fijian telecommunications company as a partner in the project. Landings at New Zealand and Fiji, because the partner organizations there were descendants of Cold War–era public telecommunications companies, were in the sites that had been established in the 1960s. In addition, SCCN was planned as an elaborate ring system, another form of differentiation that gave customers diversity and protection. The network's geography—like that of many networks of the period—evidenced a compromise between the need to connect with existing nodes and the spatial pulls of the new cultural environment.

Just as SCCN was being put in the water, the cable market collapsed as a result of the excess capacity offered by the numerous cable systems laid in the late 1990s. The timing of Southern Cross was perfect, as its builders recollect, poised on the crest of the cable boom. Barney Warf explains that, due to the cable boom, between 1988 and 2003 the number of voice paths across the Pacific increased from 1,800 to 1.87 billion, and at the end of this period, fiber-optic cables had 94.4 percent of the world's transmission capacity (compared to only 16 percent in 1988).[96] Corresponding to this, the price of transmission dropped drastically, sometimes by as much as 90 percent.[97] One cable engineer explains:

> Banks decided you could have as much money as you want, as long as you wrote in the back of your cigarette packet "dot com" or "submarine cable." They would say, "How many millions do you want?" You had this stupid situation where five or six people wanted to build a cable across the Atlantic, and they all guaranteed that they were going to get 100 percent of the traffic that would be going on those cables. Of course, what happened was that when the five were built, they all got 20 percent each and they all went bust.[98]

Many companies could not recoup the hundreds of millions of dollars expended to lay these networks.[99] 360Networks, Global Crossing, FLAG, Level 3, and WorldCom all went bankrupt between 2001 and 2002; some were acquired for cents on the dollar. In total, the market fell from over $10 billion per year to only a few hundred million after 2002, and control shifted to South Asian operators: some of the largest owners of undersea cable networks are now in India (Reliance Globalcom and Tata Communications).[100]

Through the cable bust and the financial cuts of privatization, companies lost a significant part of their labor force, and with it, these workers' knowledge and experience. By 2001 Alcatel had reduced its workforce in undersea networks by 48 percent and closed its U.S. plant in Portland and an Australian one in Port Botany.[101] In the period 1991–95, AT&T cut 123,000 jobs, 30 percent of its labor force.[102] Years later, as the industry began to rebuild itself, knowledge about the way to do many things had been lost. Stewart Ash described the situation: "Over the last 160 years a lot of mistakes have been [made], and people have learned from them. The best companies have secured that knowledge in written documentation, procedures, etc. Others have maintained the knowledge in the heads of the experts that they had in the organization. In the bust, a lot of that experience walked out the door."[103] He observed that with its regeneration since around 2005, the cable industry now lacks experience. "History is valuable because the experience informs the way forward," he says. "Mistakes made before shouldn't be made again. Unfortunately, if you tend to lose expertise, the same mistakes repeat themselves." After the bust, some things have gone back to normal: the consortium system made a significant comeback, and there are even some hybrids that have aspects of both consortium and private cables. However, people in the cable industry fear that failing to learn from the past will result in a less stable and secure network in the long run.

Diversity: Three Guys and a PowerPoint

At the turn of the twenty-first century, a number of frictional forces—along with the cable bust—challenged the industry, tempering its exaggerated claims to easily move through time and space. Nautical traffic was reaching new heights, with the intensification of fishing and shipping in coastal waters. Cables were regularly endangered by ships at pressure points such as the Strait of Malacca, between Indonesia and Malaysia. Although in the consortium model national boundaries were rarely crossed by foreign companies, which typically "respected each other's sovereignty" and let each national partner negotiate its own landings with its respective national authorities, with the new geography charted by private companies, a single company often had to negotiate landings in many nations where they were unfamiliar with established practices.[104] Conflicts occurred at landing zones as the multitude of private cables, whose entry was no longer mediated by a nationally affiliated company, crossed paths and overlaid one another. Although it had been common practice to lay new systems along existing routes, especially in areas that had a low level of faults, in the era of quickly paced competition, companies extended cables into more risky areas and put less preparation into securing routes, which led to an increase in faults.

Following the cable bust, a set of high-profile breaks drew attention to the limitations of existing routes. In December 2006 the Hengchun earthquake off the coast of Taiwan, a key destination for Asian traffic, triggered underwater landslides that caused nine breaks in seven different cables, significantly

decreasing Internet connectivity and the quality of phone calls.[105] The repairs took seven weeks and required the use of cable ships from around the world.[106] This stopped Internet traffic, which in turn prompted articles in the media and brought a broader recognition of the significance of undersea networks. One cable station manager recalls this as the point when Internet cables first became visible to the public, since "people don't tend to worry about things until they're personally affected."[107] In 2008 a series of cable cuts occurred just north of Alexandria, Egypt, a pressure point in Europe-Asia traffic. Haiti's 2010 earthquake disrupted a cable station and the country's underwater connection. The following year, the Japanese tsunami broke several cables. Repairing such systems quickly can be difficult given the scarcity and wide dispersion of capable repair ships, which are allocated to specific zones of coverage and not always located close to a problem. Cable owners might be able to call in a ship from another zone (especially in the event of several breaks), but at times they have to wait for weeks until a ship is available.[108] Additional delays can be caused by weather or the need to acquire permits before making repairs in some nations' waters. After the Japanese tsunami, cable repair ships would not go in local waters for fear of radiation contamination.

Concerns about deliberate attacks and a new "asymmetric terrorist threat" escalated in the era after 9/11, especially given the widespread dependence on these systems.[109] Cables are now considered *critical infrastructure*, a term that not only means they are critical to a nation's economic, financial, and social stability but also makes them increasingly subject to regulation.[110] One cable operator notes that "to a certain degree, all telecommunications infrastructure has been subject to aggression since day one"—the industry has always had to deal with people digging up cables, but today speculation about potential terrorism abounds and rumors circulate about the hiring of pirates to cut cables.[111] In many places, especially in the United States, security measures have been increased to control cable operations more tightly. A group of actors and agencies, collectively known as "Team Telecom," review applications for new telecommunications developments and clear cable projects landing in the United States, and this group has made it increasingly difficult to land a cable on American soil.[112] A manager for a recent cable project told me that it took his company six hundred days to get one particular approval.[113] A cable builder reports that to land a cable segment in the United States, he would have to set up a network operations center in the country as well as a point at which "one person can push a big red button to turn the system off."[114] These requirements make many builders nervous, but they do not have many alternative routes to access the Internet. As one cable builder quips, when laying cable across the Pacific, the United States is still the place to go, since no one has yet figured out the "challenge of how to deal with the Mexicans."[115]

Together these forms of friction—whether inadvertent disruption, natural disaster, or fear of attacks—have drawn attention to the lack of robustness in the cable system, even in spite of the ring networks built during the boom, and have created an impetus in both the public and private sectors to develop more diverse routes. Telecommunications companies have put pressure on governments to address potential sources of friction, stimulating a set of conversations among companies, governments, and regulators (such as ROGUCCI, described at the outset of this chapter) about potential policy developments. This has also motivated a renewed emphasis on security in the geography of route design. The Asia-America Gateway, which began operations in 2009, was developed in response to the Taiwan earthquake: its promoters' main pitch was that it would increase the reliability of traffic between Southeast Asia and the United States by avoiding Taiwan and Japan. Projects such as Arctic Fibre, the SPIN system, and the BRICS cable (which establishes a southern route between South America, South Africa, India, and China while avoiding Europe and the United States) have proposed innovative routes that diverge from the historical contours of cable networks. These developments exemplify Stephen Graham and Nigel Thrift's observation that "disconnection produces learning, adaptation and improvisation" and thus disruptions are often constitutive of new approaches to infrastructural development.[116] However, as the ROGUCCI report observes, cable companies are for the most part content to work "within the current paradigm of incremental improvement based on lessons learned from historical outages": widespread catastrophes have to occur before action is taken to protect the network.[117] Without these catastrophes, potential funders are hesitant to finance improvement projects.

A recent attempt by Pacific Fibre to lay a new transpacific system illustrates the difficulties networks have in developing new geographies, as well as the continuing importance of the state and the rhetoric of security in justifying alternate routes. Since 2001 Southern Cross has been the only cable system linking New Zealand to the rest of the world, a situation that parallels the network geography of the early telegraph era: one company monopolizes the country's international communications infrastructure, meaning that the nation depends on a single system.[118] In 2010 Pacific Fibre announced plans to extend a transpacific system serving Australia that would use New Zealand as an intermediary node.[119] Pacific Fibre was a private company, but it was nevertheless touted as something for the nation to be proud of, the "brainchild of some of New Zealand's brightest entrepreneurs and technology businessmen," and a heroic monopoly buster that would create competition and lower prices for everyone.[120]

From the outset, however, the builders knew that they faced not simply an engineering challenge, but also one of raising funding—a feat other systems had attempted without success.[121] Although Southern Cross was commercially motivated—in part by a lack of capacity—with the upgrades made possible by new technologies, it still had more than enough capacity for the country. Pacific Fibre faced an economic rather than a technological bottleneck. Given that it would be attempting to connect users who already had connections, Pacific Fibre and its supporters used arguments about the need for diversity and information security. The head of InternetNZ, the organization in charge of the country's Internet governance, argued that "the most important thing to us is that another cable would provide a divergent pathway."[122] If Southern Cross were to be disrupted, InternetNZ claimed that it would jeopardize the nation's functioning, especially as most Internet content originates offshore and users' access to basic services is dependent on international links. One telecommunications expert ruminated that if there were a severe disruption at the cable stations, the country's Internet connections could be down for months and "as a twenty-first-century economy, you just can't afford to take that risk."[123] The risk is twofold: not only would there be the economic cost of lost traffic and cable repair, but the country would also suffer a blow to its reputation and could lose its ability to attract technology jobs. "It's a hard thing to talk about," the expert told me, "because you don't want to alarm people about it. And you don't want to alert people to the danger that exists." Mobilizing these fears nonetheless remains integral to any project to develop diverse routes.

Although the ostensible intent of Pacific Fibre was to diversify the cable routes, the historical geography of cable laying presented the company with a number of difficulties. It would be much cheaper and easier to extend a new cable to old landing points. Landing inside existing cable protection zones would make the company's network more secure from other forms of traffic in the ocean, yet this would give the cable network less diversity. It would be difficult to set up new protection zones—this could involve costly and time-consuming fights with fishermen. One cable entrepreneur told me how he responded when the Australian government expressed interest in routing the cable to Melbourne instead of Sydney for diversity (adding extra length and millions of dollars to the network's expense): "The only way it's going to work is if you pay for it. Send check, I'll build. Haven't heard too much since then."[124] The company could not fully diversify the route unless another commercial interest or a government was willing to pay for it, and without an actual disruption to look back to, companies hesitated to put up the money. "When did we last have a terrorist attack here?" the entrepreneur asked me rhetorically. "Never. Who the hell's interested in New Zealand? How could you justify anything here?"[125] Anthony Briscoe of Telecom New Zealand suggests that the resistance to fund infrastructure is a global issue: "As soon as you say 'Internet' now, people think, 'I get it, free.' Yet someone has to make that infrastructure investment."[126]

In addition, to differentiate itself from Southern Cross and to build a case that it would make money, Pacific Fibre sought to plan a low-latency cable—one that would offer a more direct route and less temporal delay. Having the shortest cable route has become more important with the development of the Internet. Microseconds make a difference to groups of users—for example, in banking or gaming—who benefit from real-time interactions. High-frequency traders on global stock markets use computational algorithms to take advantage of the slight changes in price in different locations and to secure trades at slightly quicker rates; companies that have a more direct connection can exploit this for profit. It has been estimated that just a few milliseconds can result in a difference of $20 million in a single month.[127] Once a high-frequency trading company buys capacity on the line, the other traders must do the same to keep up. Even though such low-latency users tend not to purchase a lot of capacity and by themselves cannot sustain an entire network, they are an integral market for new cable projects.

If Pacific Fibre landed its cable in Los Angeles, it could pitch itself as the quickest route to the United States (ironically, Southern Cross mobilized this same argument to get customers to switch to their cable from the Australia-Japan Cable). John Humphrey, part of the original project team, recalls the moment he realized this potential advantage. One night on Google Earth, he drew a straight line between Australia and Los Angeles and was surprised by how close the line was to New Zealand. He suddenly saw that by building from Australia to New Zealand to the United States, his team would have a cable that was quite a bit shorter than Southern Cross, which took more time going up through Hawai'i.[128] The cable's proponents suggested that a lower-latency cable could stimulate a range of new industries, such as making New Zealand a site for data centers.[129] However, this pitch for a low-latency cable—an "express route"—would entail further consolidating the routes at existing locations in the southern hemisphere, landing at Sydney and Auckland as well as Los Angeles. The desire to connect directly to these cities conflicts with the desire to construct a physically diverse network.

Another approach to differentiating the network is to make it simple. Although Southern Cross has many landing points and a complex pricing structure, Pacific Fibre could include only a few points, minimizing potential disruptions and making it easier for customers to purchase capacity. However, the logical conclusion of this argument—made to help finance the network—would be to continue connecting places that were already connected, missing the opportunity to link to locations that are off the grid. The network's potential routes were very close to small Pacific Islands with little infrastructure, such as Samoa, Tonga, Wallis and Futuna, Kiribati, Tuvalu, and Niue. Humphrey described the situation this way:

> We're sitting in the United Nations. I said, "Oh, by the way, we could also land in Kiribati," and they went, "How?" I said, "Well, actually I'm going to have to steer the cable around it. We could pick up those side things, but you see then it gets to be a question of economics because I have investors looking for a return, and if I complicate the system too much or I start putting them more at risk, potential risk—don't know whether it's real or not. Every time you introduce something else that can go wrong you're raising the risk. They may never fail, but one could. Perception is reality."[130]

The landing might not actually include extra risk, but making the network more complicated increases the perceived risk and negates the initial pitch of simplicity—historically established routes are by default perceived as more secure.[131] Moreover, the additional links would make the system cost more: governments in the Pacific Islands would have to pay millions for a spur to be put into their country and to develop local infrastructure with which the cable could connect. If they cannot secure the financing and permitting quickly, within the "aggressive timetable" of the cable project, the cable will not stop there.[132]

Creating an innovative network structure thus introduces a new geography, a set of new things that could fail, which—in the competitive market that has emerged since the 1990s—can deter investment and experimentation. This is especially true in countries that are perceived as politically unstable. One prospective cable builder speculated that during a moment of political conflict, developing nations might hold the cable hostage. He told me about one conversation he had with government officials: "They got a bit offended when I told them this. I just said, 'Your army could take it over,' and they said, 'Well, we don't have an army.' 'I see. Okay, your police.' 'Police?' I said, 'Okay, who in this country has got guns? Someone's got guns. Someone with guns could take it over.' They said, 'Yeah, you're right. Someone could.'"[133] Although this is an unlikely prospect, in the speculative discourse of cable building, perception is reality, as Humphrey noted. These arguments make a difference to private cable builders, who must convince potential customers to sign on and banks to finance the network.

As is the case with many other infrastructures, private cable companies that seek to build an undersea network must build an imagined world around the cable project, using narratives of connection to generate confidence in the proposed network. Charles Jarvie, head of technology and operations for Telecom New Zealand, puts it this way: "It is kind of fake it 'til you can make it sort of an exercise," since anyone can tweet, blog, and spread news about a planned project via social media.[134] Another cable builder recalls: "Your investors are looking at you, going, 'Okay, maybe it is worth it,' and your customers are going, 'Maybe these guys aren't just three guys and a PowerPoint. Maybe they've actually got something.'"[135] Companies have to move past the "perception hurdle," scale "the credibility curve," and transform their work from a mere story "to go real."[136] In this environment, new routes bring uncertainties and expenses, even when diversity and security is a selling point. As the ROGUCCI report notes, "Investors tend to prefer the relative *low risk* option of placing cables along certain existing routes (whose safety is known)."[137] Even if security is a potential selling point for an individual cable system, few companies will invest in a new route to increase the security of the overall undersea network.

In the case of Pacific Fibre, raising hundreds of millions of dollars was a huge challenge, and eventually, the company announced that it had failed to garner enough funding. As one telecommunications head describes the efforts: "There's a story. You're tugging the emotional heartstrings and it sounds good, but ultimately it doesn't get to be funded unless you can convince people that they can stand behind it."[138] Another New Zealand telecommunications worker summarized his perception of what had happened: "[The cable layers] had this little belief that, 'Oh, if every man, woman and child in New Zealand would pay fifty dollars each, they could have as much broadband as they want!' Every man, woman and child in New Zealand is saying, 'Well, I don't want to pay fifty bucks.' Because they think, 'You should actually put it up for free. The government should provide it or someone else should provide it.'"[139] Despite the fact that most people I encountered in the industry agreed that New Zealand could use a second cable (even Pacific Fibre's competitors expressed hope that it would succeed), the arguments for diversity, lower latency, and simplicity—which at many points contradicted one another—were not sufficient to convince investors, governments, or the public to pay for the route.

Pacific Fibre, like Arctic Fibre, sought to avoid geopolitical chokepoints and

add physical diversity, creating a more robust and reliable global network as envisioned by the ROGUCCI report. A month after Pacific Fibre announced that it would no longer pursue the project, a new competitor, Hawaiki Cable, revealed its blueprint for a cable between Hawai'i, New Zealand, and Australia.[140] Even imagined cables and failed networks leave a residual impact in the contours of the economic and political landscape—from conversations with lenders to environmental impact studies—that can be picked up later. In addition, the actors who have a say in routing, if not the routes themselves, continue to diversify. Some new networks have shareholders that are also large users of capacity and therefore have a greater say in cable development. Internet companies such as Google have also begun to venture into cable activity.

On the whole, however, there remains a fundamental conservatism in the cable industry that dates back to the telegraph era, and many of the companies remain aligned with, though not beholden to, national governments. One can see this quite clearly in the emergence of Huawei Marine, a Chinese cable supply company that was launched in 2008 to compete with American and French cable suppliers. After Huawei Marine signed a contract to build Hibernia Atlantic's Global Financial Network Project Express from New York to London, along one of the most heavily trafficked routes in the world, the U.S. House Intelligence Committee released a report warning of the risks of using a Chinese supplier and suggesting that their equipment could be used to tap content.[141] Hibernia Networks subsequently halted its work on the cable system and shifted to a U.S. vendor, TE SubCom.[142] The historical emphasis on the security of individual systems and the dependence on established technologies, routes, and players has made undersea cable one of the most reliable communications technologies in the world, yet at the same time it has kept the cable network's geography one of the most static in the history of communications.[143]

Fixing the Cablescape

Chronicling the development of undersea cable paths across the Pacific, from the early transpacific telegraph lines to the latest fiber-optic systems, this chapter has demonstrated how colonial investment, Cold War circulations, and trends in deregulation have shaped the contours of transoceanic cable routes. It has shown that a focus on network topography—the ways that systems become embedded in their surrounding environments—illuminates the dynamics of such historical developments and reveals how Internet infrastructure, as a material set of technologies and practices, has been affected by territorial struggles. In spite of the technological biases that govern existing conceptions of network infrastructure, cable deployment has always been a social as well as a technological process, one that involves negotiating the insulation of one's network and its connection with other systems. The space where our data flows is neither weightless nor easily accessible; instead, it costs large sums of money and often connects places that are already connected (at least under the current economic model). Rather than simply taking a terrestrial route or a straight path between major urban hubs, cables tend to follow routes that are already established.

Throughout history, security has been especially important, yet what is seen as secure has varied over time. In the colonial period, companies used the ocean as a kind of insulation to protect cables from shipping, fishing, and national interventions. Securing traffic entailed extending it through territory that one controlled; the network was diversified by routing multiple cables to the same endpoint. Urban hubs have been variously seen as a source of danger (because they bring potential disruptions) and, in the period immediately after World War I, as a source of protection. In the 1950s cables were made secure by separating systems from urban centers. Because cables often follow existing contours, many of these investments in security remain residual in contemporary network routes.

As the case of Pacific Fibre shows, in the tried and true environment of undersea cabling, it takes a major investment to break free from existing route lines. Although the initial private investment of the 1990s diversified routes, ultimately when private companies—each responsible for its own infrastructure and shareholders—are in charge of network building, there is no one to take a cohesive, systemwide view. As the ROGUCCI report acknowledges, "Investment to ensure the resilience at *a global level* is outside the scope of those building this increasingly critical international infrastructure," and without a reliable cable network, "public welfare is endangered, economic stability is at risk, other critical sectors are exposed, and nation-state security is threatened."[144] This is especially pressing as our networks, which once used wireless transmission as a backup, now need cables to back up other cables. New cables will continue to follow the old routes until governments or other organizations are willing to spend the money it takes to develop new pathways of exchange: global network diversity is a problem that cannot be fixed by market forces alone. Indeed, we can find a historical analogue in the first transpacific cable network, which was also motivated by a need to diversify the network but was not assumed to be profitable by itself. As a result, it was driven by state interest and support. Looking back to this history, we might ask: Who is invested in having a robust global network today? Who will pay for it? What rationales

will be compelling enough to convince companies to buy in? At what cultural and historical moments will these rationales become important? As much of our content moves to cloud-based systems, which make us more dependent on a cable network that is always functioning, can we continue to assume that our networks will never fail? And if we accept that we do not have a robust global system, might we instead develop responsible media practices for a precarious infrastructure?