The Worst Possible Day
U.S. Telecommunications and Huawei

By Thomas Donahue

As a global power, the United States must be able to sustain military forces and project power anywhere in the world, even in the face of resistance from a sophisticated adversary with the ability to infiltrate or disrupt telecommunications and other critical infrastructure within the United States, in space, under the ocean, and in other regions of the world. Policy must consider the worst possible day, not the routine day.[1]

The emergence of the Chinese company Huawei as a leading provider of integrated telecommunications systems is seen as such a security threat that the U.S. Government (USG) has sought to raise barriers to the use of the company's technology in U.S. infrastructure, and even threatened long-standing intelligence sharing arrangements with the nation's closest allies who choose to use less expensive Chinese technology.[2]

While arguably helpful in the short term, the USG must confront the basic problem of whether an acceptable alternative must be based in the United States, and whether the U.S. Government should support even a foreign champion with foreign, trade, and industrial policies to promote a viable global competitor to Huawei. As was done in the wake of initial successes by the Soviet space program, the United States should consider whether its strategic role as a global power requires increased government investment in research, industrial capacity, and programs with specific objectives comparable in scale to the U.S. space program of the 1960s.[3]

This article considers how the United States fell into this dilemma, how the government has assisted infrastructure development in the past, and options for how the USG—in partnership with allies and the private sector—might be able to promote competition in the global market place with a view toward enhancing the resilience of national security communications and critical infrastructure.

Opening Gambit

Telecommunications is both a homeland security and a national security issue because the entire economy depends on a shared, interoperable infrastructure, and because many national security communications ride on top of commercial infrastructure both in the United States and abroad.[4] Nonetheless, the United States generally considers free market solutions as more effective and agile, particularly when it comes to consumer products, even when that means foreign companies dominate a technology market. Even when the government is involved in the creation of a technology, privatization is the preferred outcome, as occurred with the

Thomas Donahue is a former Senior Director for Cyber Operations on the U.S. National Security Council Staff.

internet.[5] The business of integrated telecommunications equipment, however, is not a "consumer" issue; it is about systems used by critical infrastructure. In addition, the business of integrated telecommunications equipment is not a "free marketplace" in the usual consumer sense because the multi-decade timelines for investing in national infrastructures inevitably create cyclic demands as carriers seek to recover their capital expenditure investments and manage financing of these procurements.[6]

The United States, in the wake of a major economic downturn in 2001–02, made "free market" decisions by allowing U.S. industry to succumb to global market forces even as China's companies, Huawei and ZTE, began to emerge in global markets. Now the United States finds itself struggling to control a national security issue without the usual means to compete, namely its own industry.

Despite U.S. efforts to create a more diverse market of telecommunications service providers, the trend for equipment manufacturing has been toward reconsolidation to achieve economies of scale.[7] Market consolidation during the past 15 years has reduced the global telecommunications equipment integrator market to primarily Finland's Nokia, Sweden's Ericsson, China's Huawei and ZTE, and South Korea's Samsung (all but Huawei are publicly traded).[8] The United States now mostly depends on Nokia and Ericsson, with a smattering of Huawei deployments in low-density rural areas (the Rural Wireless Association in December 2018 told the FCC that 25 percent of its members use Huawei equipment).[9] Nokia and Ericsson in recent years have been financially shaky, with debt bonds emerging from junk bond status in 2017 only to lowest-grade investment status in 2018 and 2019, and both companies have suffered negative net income most quarters since the beginning of 2017.[10] Nokia suffered a significant downturn in the stock market after announcing that it would not meet its original growth targets in 2020 and would not be paying dividends in order to help fund development costs.[11]

According to industry market research, Huawei's global market share (including China) for service provider equipment is now greater than that of Ericsson and Nokia combined.[12] As of 2016, Huawei reportedly supplied more than half of the 537 "fourth generation" (4G) mobile networks globally and 59 of the 90 4.5G networks, an intermediate step before 5G.[13] European providers use Nokia and Ericsson equipment but increasingly have turned to Huawei for better prices and "advanced" capabilities that are ready to deploy.[14] The Dutch telecommunications carrier in April 2019 cited a 60 percent price advantage when choosing Huawei.[15] More than half of Huawei's 5G contracts as of July 2019 were in Europe.[16]

This proliferation of Chinese technology is further enabled by Chinese telecommunications service providers working together with other Chinese industries and cities to develop 5G applications within China and offering to build 5G infrastructure for other countries as part of the broader investment Beijing offers under its Belt and Road Initiative.[17] As part of this overall effort, Huawei seeks to dominate the application of 5G for the "Internet of Things"—used in infrastructure and manufacturing—through technology development and the setting of international standards.[18]

Can't We Just Keep Huawei Out of the United States?

U.S. concerns with Chinese telecommunications companies—especially the more successful Huawei—are not new. The USG for years has sought to limit the proliferation of telecommunications equipment manufactured by China's Huawei largely on the grounds that Huawei enables espionage for China's security services.[19] The U.S. Congress released a report on the threat posed by Chinese telecommunications manufactured equipment in 2012.[20] Reports in 2019 from British and U.S. cybersecurity

experts have cited a high degree of risk from a large number of security vulnerabilities well in excess of current industry norms.[21] The African Union in May 2019 renewed its partnerships with Huawei on a range of technologies, from broadband and cloud computing to 5G and artificial intelligence, despite accusations in the media that China used Huawei equipment during a period of five years to steal data from the Union's headquarters in Addis Ababa (construction of which was funded by Beijing).[22]

President Trump in May 2019 issued an Executive Order on supply chains and ordered the placement of non-U.S. affiliates of Huawei on the Commerce Department's Entity List.[23] In addition, Section 889 of the *Fiscal Year 2019 National Defense Authorization Act* began to take effect in August 2019. This bill prohibits federal agencies from using "covered" entities or their subsidiaries and affiliates, including Huawei and ZTE.[24] The bill prohibits federal contracts with companies that use covered entities as of August 2020. The actual impact of these recent policies will not be fully determined until rules and regulations are put in place; however, such impacts may be blunted significantly as part of a broader trade agreement.[25] Other proposed bills call for promoting the development of 5G industry and for ensuring the security of 5G and future mobile telecommunications systems and infrastructure within the United States.[26]

The exclusion policy has the potential to prevent further Chinese deployments within the United States but does not solve the longer-term problem of ensuring trusted communications infrastructure on a global basis for the United States or the proper functioning of other foreign critical infrastructure depended on by the U.S. military and other U.S. interests overseas.[27] Even for domestic infrastructure, the exclusion policy would not protect U.S. interests in the event that the Nordic companies continue to run into financial difficulties despite positive outlooks for growth in 5G sales.[28]

Most discussion of the Huawei issue centers around "espionage;" however, the greater concern is actually availability, given that encryption and authentication technology can be used to protect confidentiality and integrity of communications. Every critical infrastructure system in the United States, including that of the USG, depends on commercial telecommunications infrastructure.[29] On the worst possible day in a conflict with a peer adversary, the United States may not be able to count on the survivability of communication satellites, and satellites do not provide sufficient data rates for the full scope of information-based warfare strategies regardless.[30] Even surviving fiber links would be subject to disruption if the communications must pass through equipment provided by vendors from hostile countries, notably Huawei and ZTE. For example, Huawei completely dominates the telecommunications infrastructure in Iraq that the USG and its military presence depend on.[31]

Current policy depends on convincing other countries to use more expensive European equipment with capabilities reportedly lagging Huawei features by a year or more.[32] U.S. policy also potentially has the effect of asking other countries to rip out existing investments in Huawei equipment prior to installing new 5G equipment, which in the case of Europe would cost more than $60 billion, according to some estimates,[33] although others suggest it would cost much less.[34] Within the United States, small rural carriers would face existential financial hardships transitioning away from Huawei.[35] This policy impact could be mitigated in part with equipment that will be available by the end of 2019 to bridge the gap between old Huawei and new western equipment.[36] To counter future transition problems, telecommunications service providers, in part through the Open Radio Access (O RAN) Alliance, are promoting the global use of interoperable standards that would allow the service providers to avoid vendor lock-in for future generations.[37]

Some countries are seeking mitigation of the threat by limiting Huawei to the "edge" of their networks and excluding Huawei from the "core;" however, telecommunications companies and U.S. Government officials have noted that, with 5G, the distinction between the edge and the core largely disappears, suggesting this approach would not satisfy U.S. security concerns.[38] The British experience with inspections of Huawei equipment highlights the challenge of guaranteeing security through inspection as another means of mitigation.[39] A nation might seek to adopt a "zero trust" model for 5G; however, industry experience in developing "trusted computing" suggests that hardware as the "root of trust" has a degree of privilege that cannot be controlled against an untrusted supplier.[40] Meanwhile, Huawei is seeking to improve its code review process to mitigate concerns raised by the British reports.[41]

Some argue that U.S. policy should solve the global problem by "killing" Huawei through the cut-off from western supply chains; however, this view ignores the likelihood that Beijing would step in to assist its national champion even more so than it has already.[42] China to date has always fallen short of the information technology state of the art and thus succumbed to the market imperative to use better western components; however, bifurcation of the global market would alter this dynamic decisively.[43] The founder and chief executive of Huawei, Ren Zhengfei, prior to the G20 summit in June 2019 said;

> *The U.S. is helping us in a great way by giving us these difficulties. If we aren't allowed to use U.S. components, we are very confident in our ability to use components made in China and other countries.*[44]

In response to U.S. policy and concern for their Chinese markets, Ericsson and Nokia reportedly are planning how they might need to bifurcate organizations and supply chains to remain in both western and Chinese markets, with potentially significant costs on top of already weak financial positions.[45]

According to Triolo and Allison of the Eurasia Group, in their paper on "The Geopolitics of 5G";

> *The United States and China also are competing to develop innovative technology applications that will run on top of deployed 5G networks. The United States has an advantage in terms of innovation capacity, but China will benefit from its head start building out its domestic 5G ecosystem and as Chinese companies then compete for market share abroad.*[46]

Triolo and Allison note that, "The push for a China-free 5G alternative is likely to delay 5G deployment where backup suppliers are forced to invest in new manufacturing capacity and human capital, further cementing China's first-mover advantage." They also note that;

> *A bifurcated 5G ecosystem would increase the risk that the global technology ecosystem would give way to two separate, politically divided technology spheres of influence. Such a split could result in some interoperability issues or lower economies of scale and higher transaction costs.*[47]

Potential Damage to the U.S. Semiconductor Industry

Meanwhile, the semiconductor industry and other high-technology industries in the United States have expressed concern about the collateral effects of the Huawei policy resulting from market "uncertainty" and the potential loss of Chinese markets, which in some cases account for a significant fraction of their revenue (for example, Qualcomm, Micron Technology, Qorvo, Broadcom, and Texas Instruments each earn more than 40 percent of their revenues from China; Intel and Nvidia get

more than 20 percent from China). Huawei depends particularly on U.S. optical and analog components from companies such as NeoPhotonics (49 percent of revenue from Huawei alone), Lumentum (18 percent), Inphi (14 percent), Qorvo (13 percent), II-VI (9 percent), and Finisar (8 percent).

Because U.S. economic policies have so strongly favored globalization, key capabilities in the high-technology sector during the past 30 years have moved overseas to a significant degree. At first this primarily involved assembly of electronic components; however, the most complex manufacturing—including for advanced printed circuit boards and semiconductors and their associated supply chains—increasingly are centered outside the United States. U.S. industry has focused on maintaining ownership of intellectual property through the design process but often depends on companies such as the Taiwan Semiconductor Manufacturing Company (TSMC) to make products.

How Did We Get to This Point?

The lack of a U.S. industrial base for integrated telecommunications equipment manufacturing that could compete with Huawei and the European firms for the global deployment of 5G systems is the direct result of a "perfect storm" of regulatory, technology, and economic shifts at the end of the 1990s. As detailed in the extensive study published in 2011 by Lazonick and March, the primary U.S. company, Lucent Technologies, ultimately failed because it made short-term financial decisions without a long-term vision for technology and global market development.[48] In particular:

- The USG breakup of the Bell System in 1984 led by 1996 to the spinoff of Western Electric manufacturing and the world renown Bell Laboratories. The new company, Lucent, was intended to serve as a neutral provider to all of the emerging U.S. service providers. Canada's Nortel had spun off from the Bell System in 1949 as a result of an earlier anti-trust suit.[49]
- Telecommunications markets benefited from the boom times of the late 1990s and early 2000s but were then crushed in the wake of a general downturn in western economies in 2001–02.
- Lucent had an incumbent advantage with legacy technologies but failed to make the pivot to internet services and applications, in part because it sought to develop its own protocols rather than use the broadly accepted Internet Protocol.
- Lucent with the help of Bell Labs, along with Canada's Nortel, made great progress in optical network technology; however, the technology was deployed far faster than anyone was prepared to use it, leading to a collapse in demand after 2000 for Lucent, Nortel, and the submarine cable business. Lucent spun off its optical cable division to Furukawa Electric in 2001. Global demand for optical networks did not recover for more than a decade.[50]
- Lucent contributed to the early expansion of mobile networks with arguably superior technology for 3G networks, such as CDMA, but failed to capture markets in Europe and Asia that used other technology such as GSM.
- Lucent in 2000 spun off its profitable microelectronics division after forcing the division to compete for Lucent business with third-party providers.
- Lucent in 2000 also spun off its "slower growing" enterprise network division, leaving the company without an ability to compete when this market segment grew faster than the general telecommunications market after the 2001–02 economic downturn.

This toxic mix led to consolidation of the integrated equipment manufacturing firms in the West

The Chinese company Huawei is establishing a dominant position in the global 5G marketplace despite concerns over security and its ties to the Chinese government. (Furicpic.pw)

even as Huawei and ZTE emerged in global markets after the worst of the downturn, building on top of rapidly modernizing and expanding infrastructure in China.[51] The UK's Marconi went through a complicated series of mergers and divestments, with the telecommunications group eventually ending up in 2005 as part of Sweden's Ericsson.[52] Ericsson in 2010 absorbed what was left of Nortel after that company collapsed into bankruptcy in 2009.[53] Finland's Nokia absorbed Motorola Solutions in 2011, and then the communications group of Germany's Siemens in 2013. Meanwhile, in 2006 France's Alcatel absorbed Lucent; however, even this new firm could not thrive and was absorbed by Nokia in 2016.[54] The only other major player to arise during this period has been South Korea's Samsung, which so far has little overall market share in telecommunications equipment but seeks to build on its mobile phone and semiconductor reputations and South Korea's investment in broadband networks.[55]

Government's Longstanding Role in Promoting Critical Infrastructure

History provides a guide for how the government could help reset the playing field with the goal of creating stronger competition against China's heavily supported national telecommunications champion. Consensus on the government's role in infrastructure development did not emerge immediately and will remain a matter of discussion in terms of when such interventions are appropriate. Discussions in the early days of the nation primarily centered on toll roads and canals that were deemed vital to commerce and military mobility for the growing nation. Competition for commercial traffic led to fights among the States until the 1824 Supreme Court decision in *Gibbons v. Ogden* ruled that the commerce clause of the U.S. Constitution granted power to regulate interstate commerce to the U.S. Congress, overriding any decisions by the States.[56] From that point forward, the U.S. Government acted more decisively.

- The U.S. Army Corps of Engineers took on a direct role in the planning, building, and management of national waterways once the U.S. Congress passed the General Survey Act of 1824.[57]
- The USG provided companies with financing and land rights for the building of the Transcontinental Railroad during the 1860s (the companies eventually paid off the loans).[58]
- During the Depression of the 1930s, the Roosevelt Administration led the effort to build dams and the national power grid to accelerate the spread of electric power.[59] [60]

The government has been involved in projects that created new infrastructure and involved long periods of investment, including for communications.

- In 1956, the Eisenhower Administration worked with the U.S. Congress to begin building the nation's Interstate Highway system of almost 50,000 miles, largely funded by the U.S. Government.[61]
- Starting in the late 1960s, the USG-funded research and development for packet-switched networks that by 1995 evolved into the commercial internet.[62] USG interest initially was to create communications that would be resilient in the event of wartime destruction of key telecommunication nodes; however, the interest pivoted to the creation of new commercial services that had been piloted inside government-funded networks.

In other cases, the government sought to create private sector capabilities that required a large investment boost to get started.

- During the 1960s, the USG under President Kennedy funded a large-scale expansion of the nation's space industry through the Apollo program.[63] In 2019 dollars, NASA spent more than $250 billion between 1960 and 1973 to put a man on the moon—creating a major impetus for communications, electronics, and computer development.[64] At its peak, the NASA budget represented more than 4 percent of the federal budget.[65]
- The international satellite communications company IntelSat, with a constellation of about 50 geostationary satellites, in the early 1960s was created by a multinational government consortium and then fully privatized by 2001.[66] InMarSat, with about a dozen geostationary satellites, has had a similar history, beginning in the late 1970s as an intergovernmental organization and transitioning to privatized operations in 1998.[67]

The government has used a combination of loans, investment, subsidies, taxes, fees, and procurement to save U.S. industry from imminent

collapse, to stimulate innovation, or to stimulate the economy as a whole.

- Since 1958 the Defense Advanced Research Projects Agency (DARPA) has funded the development of emerging technologies for military applications, most famously the networking technology that underlies the internet.[68] In the late 1980s DARPA provided matching funds for SEMATECH, an industry consortium that managed grants for semiconductor manufacturing research.[69]
- The U.S. Congress in early 1980 granted Chrysler $1.5 billion in loan guarantees to help the number three automaker recover from bankruptcy.[70] Chrysler paid off the loans in 1982.[71]
- The Department of Defense (DOD) in 2000 used procurement funds to help the Iridium satellite phone business stay afloat and remained a major customer as the infrastructure went through bankruptcy, sale, and then regeneration, because the constellation provided a unique global communications capability.[72]
- DOD in 2005 used $50 million of Title III Defense Production Act funds to restore manufacturing capabilities of high-purity Beryllium metal that had been mothballed five years earlier because of declining demand and liability for health hazards to workers.[73]
- The USG exercised a major role in preserving industry and infrastructure during times of economic difficulties, most dramatically in the wake of the 2008 financial crisis, when the U.S. Treasury and the Federal Reserve intervened on an unprecedented scale to save financial institutions and automakers on the brink of collapse resulting from bad loans. The U.S. Congress authorized the spending of up to $750 billion under the Troubled Assets Recovery Program (TARP), primarily through loans and stock purchases. Assistance to the insurance company AIG alone amounted to $182 billion. The government at one point owned 92 percent of AIG stock but over time sold all of the stock, resulting in a net gain of about $22 billion for taxpayers.[74]
- The 2009 *American Recovery and Reinvestment Act* made extensive use of tax incentives for individuals and companies, but also set aside procurement funds, all intended as a short-term economic stimulus.[75] Of almost $800 billion, only about $100 billion was specified for infrastructure, and less than a third of that went to building infrastructure (including about $7 billion for broadband internet)—illustrating the challenges for the USG to influence infrastructure either quickly or without a specified objective.[76]

The rise of the defense industrial base after World War II, which helped create "Silicon Valley," is the best example of a long-term government investment for national security purposes.[77] This capacity was nurtured throughout the Cold War with massive, long-term investments through Defense Department procurements in combination with USG capabilities and facilities. By the year 2000, however, Defense Department policies sought to control costs through commercial-off-the-shelf products and an international supply chain.[78] Policy guidance continues to be "buy, not make."[79]

Options for the Nation

Given the shortfalls of a "just say no" policy, the United States will need to compete in the telecommunications equipment integration sector, both in terms of products and trade strategy. The U.S. Government typically seeks to use procurement for federal networks and research and development investment as the primary levers for influencing high technology. U.S. industry already leads in

component and subsystem technologies (notably in optics); however, that advantage has not overcome the boom and bust cycles of the equipment integration market. Thus, a new element will be required that will involve some combination of direct investment, subsidies, loans, and tax incentives as has been done for other industries, either for national security purposes or to preserve national economic or industrial capabilities. In addition, the USG could include preferred telecommunications equipment manufacturers (no matter where they are from) in U.S. trade, defense, and foreign policy packages that the United States seeks to implement with other nations that are upgrading their telecommunications infrastructure.

Similar ideas have been raised before, including by this author and by James Lewis of the Center for Strategic and International Studies.[80] Lewis cited three options: build networks from insecure components, build a national champion, or subsidize European producers. According to Lewis, the Obama Administration considered funding a national champion using the *Defense Production Act*, "but it could at most allocate 1 percent of what China spent. The discussion of how to respond to the telecom problem made it as far as a Deputies Committee meeting, but none of the major information technology companies wanted to reenter this field. Though a few medium-size companies could have been candidates for investment, the administration ultimately decided to rely on Google and Silicon Valley to innovate our way out of the problem without the need for the government to spend anything."

The U.S. Defense Science Board's June 2019 report on "Defense Applications of 5G Network Technology" notes that "the lack of a U.S. integrator and Radio Access Network vendor industrial base" creates challenges. The report recommends that the Department of Defense "should provide seed funding for western industrial base alternatives of key system components, e.g., Radio Access Networks."[81]

The scale of investment required—as can be seen from the size of the European companies—would require the U.S. Congress to appropriate additional funds, even if implemented under existing authorities, such as Title III of the *Defense Production Act* (annual appropriations typically range only in the 10s to 100s of millions of dollars).[82] Ericsson and Nokia each employ about 100,000 or more workers (although not just for telecommunications integrated equipment manufacturing), and each as of 2018 had net equities in the range of $10-20 billion and net assets in the range of $25–45 billion.[83] Nokia spent $16.6 billion acquiring Alcatel–Lucent in 2016.[84]

Maintaining leadership requires huge research investments. Huawei is participating comprehensively in the international standards process and makes large investments in research and development, now increasing to $15–20 billion per year from levels of $13–15 billion in 2017–18.[85] European firms lag significantly. Nokia has increased investment in research and development to about 20 percent of its revenue or roughly $5 billion per year after a significant decline during 2013–15.[86] In addition, the European Investment Bank in August 2018 provided a $583 million five-year loan to Nokia in 2018, and Canada in January 2019 provided Nokia with a $40 million research grant.[87] Ericsson in 2017 increased investments to at least 15 percent of its revenue—a bit more than $4 billion per year—despite concurrent net income losses.[88]

The major U.S. telecommunications service providers with operations in the United States and abroad would need to be included at least in the planning process for such an investment policy given that they would be the ultimate customers for most of the equipment, have expertise on the markets and systems and, most likely, would serve as the final systems integrators and operators during implementation and deployment. Indeed, the service providers could be provided incentives

to participate directly in the investment strategy; however, they are also burdened with high levels of debt from capital expenditures.[89] Other operators of critical infrastructure (financial systems, electric power, oil and gas distribution, transportation, etc.) also might benefit by participating in the planning and investments.

The following three options are not mutually exclusive.

Option 1: Champion the European and South Korean Companies

U.S. telecommunications infrastructure already depends on Ericsson and Nokia (and to a much lesser degree on Samsung[90]), each of which have a significant economic presence through their U.S. subsidiaries. As noted previously, these companies include some of the residual capabilities that once belonged to now-defunct U.S. integrated telecommunications equipment companies. The USG, perhaps working primarily through the U.S. subsidiaries, might be able support these companies with stock investments, tax policies, debt guarantees, loans, and procurements, particularly to stabilize their finances and to boost their research and development investments that lag significantly behind those of Huawei. Both companies have undergone significant adjustments in management and business portfolios to stabilize their financial situation while investing for future growth. Both companies expect global demand to grow as most countries seek to take advantage of the benefits of 5G. In the unlikely event that the two Nordic companies merged to gain economies of scale relative to Huawei (despite potential EU, Chinese, and U.S. anti-monopoly concerns and challenges merging product lines), the USG could support the new merged entity in the same way.

> *As a sign of the Samsung's commitment to diversifying its product line, press reports in July 2019 indicated that Samsung plans to invest more than $100 billion over the next 10 years to gain prominence in global chip processors.*[91] *Samsung, however, in November 2019 announced the closure of its US-based research lab for mobile phone chips after failing to win market share from Qualcomm from external customers.*[92]

Option 2: U.S. Entities Acquire Either or Both European Companies

If the United States needs to have a home-based champion for 5G and beyond, the fastest approach might involve working with the private sector to acquire a controlling interest in parts of one of the existing European companies, possibly using authorities under the Defense Production Act Title III or else with a separate Congressional authorization. Nokia Networks would be the primary division of interest from Nokia along with Bell Labs, and Business Area Networks would be the key division within Ericsson.[93] Samsung's 5G segment may not be a good target for acquisition because it has much less market share and is part of a growth strategy for the otherwise very large vertically integrated South Korean conglomerate.[94]

- The USG could use past models of loan guarantees, tax incentives, and direct investment. Either of these companies would benefit from significant U.S.-based investment and more innovative and agile management to help them stabilize their finances and close the gap in research and development that these companies have with Huawei.
- Both companies have significant presence in the United States and recently have sought to expand their U.S. research and production. For example, Ericsson plans to open a fully automated factory for advanced antenna systems in the United States by 2020 and previously set up a design center in Texas for

5G-related application specific integrated circuits (ASICs).[95] Nokia is expanding its operations in Texas, and operates the original Bell Labs facilities in New Jersey.[96]

- These companies, however, are major contributors to the economies of their home countries, suggesting a major acquisition might be resisted by those governments and the European Union.
- For example, Nokia owns Alcatel Submarine (undersea cables) that competes with the U.S. company now known as Subcom, as well as the optical networking capabilities of Alcatel–Lucent, and is likely to be seen by the Europeans (particularly Paris) as an asset that needs to remain European.[97] Meanwhile, Ericsson is not a major player in optical networks and depends more on microwave for backhaul communications.[98]
- In addition, these companies have facets unrelated to integrated telecommunications equipment manufacturing that are, in part, artifacts of prior mergers and acquisitions. Culling out the equipment manufacturing alone, however, might leave behind unsustainable business organizations. Also, as Lucent experienced, the equipment manufacturing by itself may not be sustainable through demand cycles.[99] These companies also have existing business arrangements and obligations, in some cases with China, that may create complications for U.S. trade policy.[100]

Option 3: Create a U.S.-Based Consortium

The USG could seek to create business conditions through a combination of procurement, investment, and financing to bring together the robust, diverse capabilities of existing U.S. private sector capabilities and patent rights that foreign integrated telecommunications equipment manufacturers already depend on under an integrated corporate management. Private equity could supplement USG funds, leading over time to an eventual reduction in the share of government investment while maintaining U.S. financial guarantees and trade support in the background.

Over time, this "consortium" could be led by a "prime" company comparable to the big integration companies that dominate U.S. defense contracting. Such an entity could add or even subtract "sub-prime" capabilities as needed in accordance with changes in technology, fluctuating demand, and maturation of national infrastructures. Again, the USG could use combinations of past strategies to drive the formation of this consortium, with the ultimate goal of leaving the private sector in control.

- Rather than be treated as direct competitors, Nokia and Ericsson could contribute subsystems (particularly for radio access networks)—as might other companies from trusted international partners, notably the Five Eyes, Germany, France, Japan, and South Korea.
- Such an approach could in effect create a single, trusted U.S.-based, international consortium with the financial backing of the USG for use by U.S. allies and any nation that would trust such an alliance more than Chinese providers.
- Success would depend on a competitive pricing strategy in combination with U.S. and allied incentives to participate. Such a consortium also would benefit from strong relationships with the U.S. and allied defense departments and ministries.

A Bottom Line Comparison of Options

Each option involves positive and negative tradeoffs. All of them face potential resistance from overseas, including the Nordic countries, the EU (especially

France), and possibly China. The resistance could be regulatory or through the WTO.

- **Support to an existing foreign firm** would involve the least commitment from either the USG or private sector; however, this option offers the least influence or certainty of a useful result.
- **Buying one of the two Nordic firms** would be easier than creating a new corporate entity and the fastest way back into the telecommunications equipment integration business but would require greater investment than simply supporting a firm with its current ownership. The United States would not have as much leverage on the outcome as would occur with the purchase of both firms.
- **Creating a new consortium** would be the hardest to implement in terms of creating product lines, gaining market share, and licensing patents but would offer the greatest control of the outcome and thus the best opportunity to invest for longer-term technologies. As a result, this option potentially would require the greatest investment but also has the potential for the greatest return in terms of U.S. jobs and stimulating the U.S. high-technology sector.

Economic success of the strategy would depend on international trust of the equipment provider. In some parts of the world, U.S. ownership would provide comfort; however, in other parts of the world even some friendly countries might prefer "neutral" European products, a potentially useful outcome if the U.S. policy goals include not undermining a viable European competitor. In any case, western entities will need to persuade potential customers that the reliability and quality of products combined with transparent security policies is an attractive feature in comparison to what is offered by Chinese alternatives.

The final implementation of 5G will represent more than an upgrade to 4G technology components; the new systems over many years will evolve to a fundamentally different architecture and drive massive changes in the infrastructures and businesses that will benefit from 5G.[101] With this longer perspective in mind, the best U.S. strategy might involve a combination of the options. In the near-term, the United States needs to "get in the game," perhaps through options 1 or 2, to avoid surrendering future incumbent advantages to China and to gain experience in working with the new systems. For the long run, however, the United States as a second step might need to focus on the broader U.S. high-technology industry with Option 3 to drive innovation and to be in the best position for future generations.

The deployment of 5G technology across all of the infrastructure will take at least 10 years; however, discussion of 6G technology has already begun. In November 2018 a Chinese official claimed that the Ministry of Information and Industry Technology had already begun work on 6G with a view toward initial commercial deployments as early as 2030.[102] Finland's Oulu University's 6Genesis Project seeks to develop communication networks with bandwidths over 1 terabit per second with a grant of more than $250 million.[103] As the Finnish researchers note, 6G will build on 5G infrastructure and applications, and thus any investment in 6G will need to build on a prior investment in 5G.

Find a USG Champion

Justification for the amount of resources needed to reboot the nation's supply chain for integrated telecommunications systems would need to be framed in terms of ongoing U.S. strategies for resilient global command and control systems for national security and for maintaining control of critical infrastructure functions under the most stressful circumstances of a war with a peer adversary, such as Russia or China. This level of demand is a unique national-level governmental requirement and thus must be met at least in part by the USG. The measure of success would be determined by whether U.S. defense and

critical infrastructure planners could demonstrate greater resilience against the full spectrum of threats. The U.S. military already is seeking to improve the resilience of critical systems, including for nuclear command, control and communications (NC3).[104]

The biggest player within the USG, and the most likely center point for a successful effort, would have to be Department of Defense. This is the only department with the global reach and mission requirements, technical depth, procurement and large-scale integration experience, budgetary capacity, and existing authorities to handle such a large project. The Office of the Secretary of Defense would need to work with the Joint Chiefs of Staff to incorporate military strategic requirements and with the Department of Homeland Security and other government agencies that work with private sector critical infrastructure.

Conclusion: Resiliency Strategy Must Determine the Way Forward

As noted by West Point authors Borghard and Lonergan, the United States needs to examine its policies toward the next generation of telecommunications in the context of strategic requirements for resilient global command and control of U.S. military forces and other U.S. interests, to include how the U.S. military depends on commercial communications.[105] This discussion must consider the worst possible day, not the routine day. The challenge is primarily one of availability on that worst day, not espionage. These requirements abroad and for critical infrastructure at home are uniquely the purview of government, and thus the government must step up and make the strategic investment in what is essentially the central nervous system of the nation. An effort of this magnitude will require a unified approach across the Executive Branch and broad bipartisan support from the U.S. Congress.

Trade policy alone, particularly one given to broader compromise, will not allow the United States to define how other nations choose to implement infrastructure that U.S. national security communications may need to pass through. The United States needs a unified vision of how to compete in terms of technology and close deals for U.S. advantage. As with the defense industrial base, the USG in the long run should seek to have the private sector operate any new manufacturing capability and thus would need to work in partnership with the industries that best understand the technology and customer needs. The USG would need to stand behind industry efforts to gain deals with other nations—just as it has for other vital industries with national security implications, notably aviation.

The USG, as it has with most national security efforts abroad, would need assistance from traditional national security allies and countries located at what already are or should be key communications junctures.[106] For example, new pathways might be needed that are less vulnerable to disruption as compared to the ones now passing where they are vulnerable to adversary disruption, through areas of dense commercial activities, or in regions of longstanding conflicts.[107] As has been done for some military systems, the United States would need to work with trusted nations that can provide useful technology and manufacturing capacity, in part to gain their support for a new player in the integrated telecommunications market place.

It will not be enough for the private sector with government support just to create a company to manufacture and integrate telecommunications systems. The USG, in partnership with the private sector, will need to consider how it will remain competitive over the long term.

- This may require financial support to help industry get through demand lulls, including if demand lags expectations, as occurred from 2000 to 2010, because of slower than expected implementation of applications elsewhere in U.S. infrastructure and businesses.

- In addition, a long-term strategy would require reinvigoration of investment in the hardware elements all across the U.S. high-technology sector that have either moved to Asia or been too long dependent on investments made years ago.[108] A telecommunications equipment integrator based in the United States would provide an anchor for investment in all of the component technologies and their associated supply chains, including future generations of semiconductors. The success of innovation in the U.S. high technology sector will depend on preserving homeland-based manufacturing and supply chain ecosystems.

Key challenges going forward include mobilizing the USG to act and then drawing in the right elements of the private sector as investors or participants in product development. Then the real work would begin with developing a product line that can compete in terms of the best combination of technology, pricing, and financing. Additional incentives from U.S. and allied governments might be needed to overcome incumbent advantages or to walk back some past infrastructure decisions in key, strategic locations.[109]

This will be a "long march" (as China's President Xi would say). But better to start now than repeat this conversation in 10 years. PRISM

Notes

[1] Wikipedia "Anti-satellite weapon," available at <https://en.wikipedia.org/wiki/Anti-satellite_weapon>; Garrett Hinck, "Evaluating the RU.S.sian Threat to Undersea Cables," Lawfare, March 5, 2018, available at <https://www.lawfareblog.com/evaluating-rU.S.sian-threat-undersea-cables>.

[2] Emma Vickers, "The 70-Year Spy Alliance the U.S. Says It May Cut Off," Bloomberg Businessweek, June 30, 2019, available at <https://www.bloomberg.com/news/articles/2019-06-30/the-70-year-spy-alliance-the-u-s-says-it-may-cut-off-quicktake>.

[3] Thomas Oliphant, "Inside Kennedy's Quest to put America on the Moon," review of *American Moonshot: John F. Kennedy and the Great Space Race*, by Douglas Brinkley, *The Washington Post*, April 4, 2019, available at <https://www.washingtonpost.com/outlook/inside-kennedys-quest-to-put-america-on-the-moon/2019/04/04/6bd26cac-499c-11e9-93d0-64dbcf38ba41_story.html>.

[4] National Research Council, "Renewing U.S. Telecommunications Research, Chapter 1:The Importance of Telecommunications and Telecommunications Research," The National Academies Press, available at <https://www.nap.edu/read/11711/chapter/3#10>.

[5] Peter Lewis, "U.S. Begins Privatizing Internet's Operations," *The New York Times*, October 24, 1994, available at <https://www.nytimes.com/1994/10/24/bU.S.iness/U.S.-begins-privatizing-internet-s-operations.html>.

[6] Sean Buckley, "Telco Capex: AT&T, Verizon Remain Kings, While CenturyLink, Frontier and Windstream Adjust Integration, Cost-containment Plans," April 11, 2018, available at <https://www.fiercetelecom.com/telecom/telco-capex-at-t-verizon-remain-kings-while-centurylink-frontier-and-windstream-adjU.S.t>;Antonio Cosma and Ugur Bitiren, "Increasing Focus on Working Caapital in the Telecoms Industry," Connectivity Busiiness, July 2018, available at <https://www.ca-cib.com/sites/default/files/2018-07/Connectivity-BU.S.iness-Telecoms-IndU.S.try.pdf>.

[7] Quexor Group, "10 years of Consolidation in Wireless: The Rise of Verizon, AT&T, T-Mobile and Sprint," *Fierce Wireless*, 2015, available at <http://assets.fiercemarkets.net/public/mdano/amis/wireless-consolidation1.jpg>; Harry McCracken, "A Brief History of the Rise and Fall of Telephone Competition in the U.S., 1982-2011, Technologizer, March 20, 2011, available at <https://www.technologizer.com/2011/03/20/att-buys-t-mobile/>; Roger Cheng and Marguerite Reardon, "The T-Mobile-Sprint Deal May Close Soon: Here's What you Need to Nnow," C-Net, July 5, 2019, available at <https://www.cnet.com/news/t-mobile-sprint-deal-may-close-soon-heres-what-you-need-to-know/>.

[8] William Lazonick and Edward March, "The Rise and Demise of Lucent Technologies," 2011, available at <http://thebhc.org/sites/default/files/lazonickandmarch.pdf>; Brian Fung, "How China's Huawei Took the Lead over U.S. Companies in 5G Technology, *The Washington Post*, April 10, 2019, available at <https://www.washingtonpost.com/technology/2019/04/10/U.S.-spat-with-huawei-explained/?utm_term=.079c8eb7d3c8>; Stratfor, "The U.S., China and Others Race to Develop 5G Mobile Networks," April 3, 2018, available at <https://worldview.stratfor.com/

article/U.S.-china-and-others-race-develop-5g-mobile-networks>.

[9] Martha DeGrasse, "Ericsson Widens Lead over Nokia in U.S. Equipment Markets: Analysts," Fierce Wireless, May 11, 2018, available at <https://www.fiercewireless.com/5g/u-s-5g-helping-ericsson-gain-ground-huawei>; FCC WC Docket No. 18–89, "Protecting Against National Security Threats To the Communications Supply Chain Through FCC Programs," December 7, 2018, available at <https://ecfsapi.fcc.gov/file/12080817518045/FY%202019%20NDAA%20Reply%20Comments%20-%20FINAL.pdf>.

[10] Moody's Investors Service, "Rating Action: Moody's changes the outlook on Nokia's ratings to negative," February 8, 2019, available at <https://www.moodys.com/research/Moodys-changes-the-outlook-on-Nokias-ratings-to-negative--PR_394891>; Moody's Investors Service, "Rating Action: Moody's changes the outlook on Ericsson's ratings to negative," July 18, 2018, available at <https://www.ericsson.com/assets/local/investors/documents/bondholder-information/rating/moodys/moodys_180718.pdf>; Parmy Olson, "With Huawei on Defensive, Ericsson and Nokia Fight Each Other for Edge," *The Wall Street Journal*, May 29,2019, available at <https://www.wsj.com/articles/with-huawei-on-defensive-ericsson-and-nokia-fight-each-other-for-edge-11559122200?ns=prod/accounts-wsj>.

[11] Richard Milne, "Nokia shares plunge on 5G outlook in US and China," *Financial Times*, 24 October 2019, available at https://www.ft.com/content/1fff9178-f62c-11e9-9ef3-eca8fc8f2d65

[12] Stefan Pongratz, "Key Takeaways—Worldwide Telecom Equipment Market 2018," Dell'Oro Group, March 4, 2019, available at <https://www.delloro.com/telecom-equipment-market-2018-2/>.

[13] Eric Auchard and Sijia Jiang, "China's Huawei set to lead global charge to 5G networks," *Reuters*, February 23, 2018, available at <https://www.reuters.com/article/U.S.-telecoms-5g-china/chinas-huawei-set-to-lead-global-charge-to-5g-networks-idU.S.KCN1G70MV>.

[14] Stu Woo, "Huawei Rivals Nokia and Ericsson Struggle to Capitalize on U.S. Scrutiny," *The Wall Street Journal*, December 31, 2018, available at <https://www.wsj.com/articles/huawei-rivals-nokia-and-ericsson-struggle-to-capitalize-on-u-s-scrutiny-11546252247>.

[15] Ellen Nakashima, "U.S. Pushes Hard for a Ban on Huawei in Europe, but the Firm's 5G prices are nearly Irresistible," *The Washington Post*, May 28, 2019, available at <https://www.washingtonpost.com/world/national-security/for-huawei-the-5g-play-is-in-europe--and-the-U.S.-is-pU.S.hing-hard-for-a-ban-there/2019/05/28/582a8ff6-78d4-11e9-b7ae-390de4259661_story.html>.

[16] Li Tao, "Nearly 60 percent of Huawei's 50 5G contracts are from Europe," *South China Morning Post*, July 19, 2019, available at <https://www.scmp.com/tech/big-tech/article/3019248/nearly-60-huaweis-50-5g-contracts-are-europe>.

[17] Jeff Pao, "Chinese Telecoms Unveil their 5G Strategies," Asia Times, June 28, 2019, available at <https://www.asiatimes.com/2019/06/article/chinese-telecoms-unveil-their-5g-strategies/>; Frank Chen, "A look at Shenzhen and Huawei's 'Smart City' Project," *Asia Times*, July 11, 2019, available at <https://www.asiatimes.com/2019/07/article/a-look-at-shenzhen-and-huaweis-smart-city-project/>; Darlie Yiu, "Shanghai to be 'Intelligent Manufacturing' Hub," *Asia Times*, June 25, 2019, available at <https://www.asiatimes.com/2019/06/article/shanghai-to-be-intelligent-manufacturing-hub/>; Jeff Pao, "China Unicom to Build 5G Networks on Belt and Road," *Asia Times*, June 25, 2019, available at <https://www.asiatimes.com/2019/06/article/china-unicom-to-build-5g-networks-on-belt-and-road/>.

[18] Yuan Yang, James Kynge, Sue-Lin Wong, and Nian Liu, "Huawei Founder Predicts Internet of Things is Next U.S. Battle," *Financial Times*, July 3, 2019, available at <https://www.ft.com/content/716181ce-9bd8-11e9-9c06-a4640c9feebb>.

[19] Raymond Zhong, "'Prospective Threat' of Chinese Spying JU.S.tifies Huawei Ban, U.S. Says," *The New York Times*, July 5, 2019, available at <https://www.nytimes.com/2019/07/05/technology/huawei-lawsuit-U.S.-government.html>; Cassell Bryan-Low et al., "Hobbling Huawei: Inside the U.S. War on China's Tech Giant," *Reuters*, May 21, 2019, available at <https://www.reuters.com/investigates/special-report/huawei-U.S.a-campaign/>.

[20] Jim Wolf, "U.S. Lawmakers Seek to Block China Huawei, ZTE U.S. Inroads," Reuters, October 7, 2012, available at <https://www.reuters.com/article/U.S.-U.S.a-china-huawei-zte/u-s-lawmakers-seek-to-block-china-huawei-zte-u-s-inroads-idU.S.BRE8960NH20121008>.

[21] British Cabinet Office, "Huawei Cyber Security Evaluation Centre Oversight Board: Annual Report 2018," July 19, 2018, available at <https://www.gov.uk/government/publications/huawei-cyber-security-evaluation-centre-oversight-board-annual-report-2018>; Davey Winder, "GCHQ Director Says 'Shoddy' Huawei Security Engineering Belongs in the Year 2000," *Forbes*, April 8, 2019, available at <https://www.forbes.com/sites/daveywinder/2019/04/08/gchq-director-says-shoddy-huawei-security-engineering-belongs-in-the-year-2000/#4f0d1deeafe6>; Finite State, "Supply Chain Assessment: Huawei Technologies Co.,

Ltd.," June 2019, available at <https://finitestate.io/wp-content/uploads/2019/06/Finite-State-SCA1-Final.pdf>.

[22] Salem Solomon, "After Allegations of Spying, African Union Renews Huawei Alliance," VOA, June 6, 2019, available at <https://www.voanews.com/africa/after-allegations-spying-african-union-renews-huawei-alliance>; John Aglionby, Emily Feng, and Yuan Yang, "African Union Accuses China of hacking headquarter," *Financial Times*, January 29, 2018, available at <https://www.ft.com/content/c26a9214-04f2-11e8-9650-9c0ad2d7c5b5>.

[23] White House, "Executive Order on Securing the Information and Communications Technology and Services Supply Chain," May 15, 2019, available at <https://www.whitehoU.S.e.gov/presidential-actions/executive-order-securing-information-communications-technology-services-supply-chain/>; Bureau of Industry and Security, Commerce, "Addition of Entities to the Entity List," 84 Fed. Reg. 22961, May 21, 2019, available at <https://www.federalregister.gov/documents/2019/05/21/2019-10616/addition-of-entities-to-the-entity-list>.

[24] John S. McCain National Defense Authorization Act for Fiscal Year 2019, Pub. L. No. 115-874, Section 889, 115th Cong. (2018), available at <https://www.congress.gov/115/bills/hr5515/BILLS-115hr5515enr.pdf>.

[25] David Phelan, "Trump Surprises G20 With Huawei Concession: U.S. Companies Can Sell To Huawei," *Forbes*, June 29, 2019, available at <https://www.forbes.com/sites/davidphelan/2019/06/29/trump-surprises-g20-with-huawei-concession-u-s-companies-can-sell-to-huawei/#7f520a11e212>; Kiran Stacey, "U.S. Announces Significant Relaxation of Huawei Ban," *Financial Times*, July 9, 2019, available at <https://www.ft.com/content/301d6d9c-a2a7-11e9-974c-ad1c6ab5efd1>.

[26] United States 5G Leadership Act of 2019, S. 1625 (introduced), 116th Cong. (2019), available at <https://www.govtrack.U.S./congress/bills/116/s1625/text>; Secure 5G and Beyond Act of 2019, S.893, 116th Cong. (2019), available at <https://www.govtrack.U.S./congress/bills/116/s893/text>.

[27] David Vine, "U.S. Military Bases Abroad, 2015," Base Nation, 2015, available at <https://www.basenation.U.S./maps.html>.

[28] Markets Insider, "Ericsson (Telefon AB L.M. Ericsson) (B) Outperform," June 18, 2019, available at <https://markets.bU.S.inessinsider.com/analysts-opinions/ericsson-telefon-ab-l-m-ericsson-b-outperform-675287<; Market Beat, "NYSE:NOK-Nokia Oyj Stock Price, News, & Analysis," viewed July 17, 2019, available at <https://www.marketbeat.com/stocks/NYSE/NOK/>; Seeking Alpha, "Ericsson, Nokia to benefit from 5G cycle BofAML," May 22, 2019, available at <https://seekingalpha.com/news/3466082-ericsson-nokia-benefit-5g-cycle-bofaml>.

[29] "Telecommunications: Addressing Potential Security Risks of Foreign-Manufactured Equipment" GAO-13-652T (Statement of Mark L. Goldstein, Director Physical Infrastructure Issues Government Accountability Office, May 21, 2013), available at <https://www.gao.gov/assets/660/654763.pdf>; "Information Technology: Major Federal Networks That Support Homeland Security Functions," GAO-04-35 (A GAO Report to Congressional Requesters, September 2004), available at <https://www.gao.gov/new.items/d04375.pdf>; Department of Defense, "Department of Defense Information Network (DODIN) Transport," Instruction 8010.01, September 10, 2018, available at <https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/801001p.pdf?ver=2018-09-10-082254-477>.

[30] Sandra Erwin, "Air Force Gen. Pawlikowski: Military Satellites will be Smaller, More Mobile," *Space News*, May 15, 2018, available at <https://spacenews.com/air-force-gen-pawlikowski-military-satellites-will-be-smaller-more-mobile/>; Michael Matis, "The Protection of Undersea Cables: A Global Security Threat" (master's thesis, U.S. Army War College, 2012), available at <https://apps.dtic.mil/dtic/tr/fulltext/u2/a561426.pdf>.

[31] Shaun Waterman, "Chinese Firm 'Owns' Telephone System in Iraq," *Washington Times*, February 21, 2011, available at <https://www.washingtontimes.com/news/2011/feb/21/chinese-telecom-end-ties-U.S.-high-tech-start-/>.

[32] Stu Woo, "Huawei Rivals Nokia and Ericsson Struggle to Capitalize on U.S. Scrutiny," The Wall Street Journal, December 31, 2018, available at <https://www.wsj.com/articles/huawei-rivals-nokia-and-ericsson-struggle-to-capitalize-on-u-s-scrutiny-11546252247?ns=prod/accounts-wsj>; Newley Purnell et al. "U.S. Campaign Against Huawei Runs Aground in an Exploding Tech Market," *The Wall Street Journal*, February 21, 2019, available at <https://www.wsj.com/articles/india-a-pivotal-internet-market-isnt-buying-u-s-campaign-against-huawei-11550762080>; Niharika Mandhana, "In Global Tech Battle, a Balky U.S. Ally Chooses China," The Wall Street Journal, July 15, 2019, available at <https://www.wsj.com/articles/in-global-tech-battle-the-philippines-has-chosen-sides-not-the-u-s-11563205891>.

[33] Asia Times staff, "Banning Huawei 'Would Cost EU Operators $62m [sic]'," *Asia Times*, June 9, 2019, available at<https://www.asiatimes.com/2019/06/article/banning-huawei-would-cost-eu-operators-62m/>.

[34] Strand Consult, "The real cost to rip and replace

of Chinese equipment in telecom networks," September 2019, Copenhagen, available at http://www.strandconsult.dk/sw8402.asp; also described by Roslyn Layton, "To Rip and Replace Huawei in EU Mobile Networks Costs About $7 per Subscriber," *Forbes*, 23 September 2019, available at https://www.forbes.com/sites/roslynlayton/2019/09/23/to-rip-and-replace-huawei-in-eu-mobile-networks-costs-about-7-per-subscriber/#20093a981c8f

[35] FCC "Protecting Against National Security Threats To the Communications Supply Chain Through FCC Programs," WC Docket No. 18-89, December 7, 2018, available at <https://ecfsapi.fcc.gov/file/12080817518045/FY%202019%20NDAA%20Reply%20Comments%20-%20FINAL.pdf>.

[36] Harri Holma, "Nokia 5G Radio: Simple to Deploy on Top of Another Vendor's 4G," Nokia, March 26, 2019, available at <https://www.nokia.com/blog/nokia-5g-radio-simple-deploy-top-another-vendors-4g/>.

[37] Matt Kapko, "AT&T Aims to 'Break the Vendor and Technology Lock-In'," SDX Central, April 5, 2019, available at <https://www.sdxcentral.com/articles/news/att-aims-to-break-the-vendor-and-technology-lock-in/2019/04/>; Corinne Reichert, "Verizon: Multi-vendor Interoperability Key for 5G," ZDNet, June 27, 2017, available at <https://www.zdnet.com/article/verizon-multi-vendor-interoperability-key-for-5g/>; O-RAN Alliance, "Operator Defined Next General RAN Architecture and Interfaces," viewed July 23, 2019, available at <https://www.fiercewireless.com/wireless/o-ran-aims-to-eliminate-vendor-lock-at-radio-access-network>; Kathy Cacciatore, "The Interoperability Challenge in Telecom and NFV Environments: A Tutorial," SuperU.S.er, April 20, 2017, available at <https://superU.S.er.openstack.org/articles/interoperability-telecom-nfv-tutorial/>.

[38] Kiran Stacey, "UK's Approach to Huawei is Flawed, Warns Ericsson's U.S. Boss," *Financial Times*, June 23, 2019, available at <https://www.ft.com/content/a91825e2-8e17-11e9-a24d-b42f641eca37>;and Nakashima, May 28, 2019.

[39] British Cabinet Office, "Huawei Cyber Security Evaluation Centre Oversight Board: Annual Report 2018," July 19, 2018, available at <https://www.gov.uk/government/publications/huawei-cyber-security-evaluation-centre-oversight-board-annual-report-2018>; Davey Winder, "GCHQ Director Says 'Shoddy' Huawei Security Engineering Belongs in the Year 2000," *Forbes*, April 8, 2019, available at <https://www.forbes.com/sites/daveywinder/2019/04/08/gchq-director-says-shoddy-huawei-security-engineering-belongs-in-the-year-2000/#4f0d1deeafe6>.

[40] Palo Alto Networks, "What is a Zero Trust Architecture," viewed July 17, 2019, available at <https://www.paloaltonetworks.com/cyberpedia/what-is-a-zero-trU.S.t-architecture<; Trusted Computing Group, "Where Trust Begins," viewed July 17, 2019, available at <https://trU.S.tedcomputinggroup.org/wp-content/uploads/INFOGRAPHIC-TCG-PR-Works-FINAL.pdf>.

[41] Jeff Pao, "Huawei Ensures Cyber Security with a Huge Transformation," *Asia Times*, July 22, 2019, available at <https://www.asiatimes.com/2019/07/article/huawei-ensures-cyber-security-with-a-huge-transformation/?_=1981968>.

[42] Jun Mai, "Bannon Says Killing Huawei More Important than Trade Deal with China," *South China Morning Post* (reprinted by Politico), 22 May 2019, available at https://www.politico.com/story/2019/05/22/steve-bannon-huawei-trade-china-1464607; Louise Lucas et al., "Can Huawei survive U.S. blacklisting?", *Financial Times*, May 16, 2019, available at <https://www.ft.com/content/21727292-7796-11e9-bbad-7c18c0ea0201<; Fareed Zakaria, "The Blacklisting of Huawei Might be China's Sputnik Moment," *The Washington Post*, May 23, 2019, available at <https://www.washingtonpost.com/opinions/global-opinions/the-blacklisting-of-huawei-might-be-chinas-sputnik-moment/2019/05/23/9352fc66-7d99-11e9-a5b3-34f3edf1351e_story.html?hpid&utm_term=.ee87fea2f279>.

[43] Yoko Kubota and Dan Strumpf, "American Threat to Huawei's Chip Maker Shows Chinese Tech Isn't Self-Sufficient," *The Wall Street Journal*, June 2, 2019, available at<https://www.wsj.com/articles/huaweis-main-chip-maker-faces-long-term-risks-from-u-s-ban-11559467846>; Yingzhi Yang and Li Tao, "Inside Huawei's Secretive Plans to Develop an Operating System to Rival Google's Android," South China Morning Post, June 11, 2019, available at <https://www.scmp.com/tech/big-tech/article/3013813/inside-huaweis-secretive-plans-develop-operating-system-rival-googles>; Li Tao, "Huawei Keeps Market Guessing Whether New Honor Smart Displays will run on its own Hongmeng OS," *South China Morning Post*, July 16, 2019, available at <https://www.scmp.com/tech/enterprises/article/3018680/huawei-keeps-market-guessing-whether-new-honor-smart-displays-will>.

[44] James Kynge et al. "Huawei: still Fighting for Survival Despite Trump Truce," *Financial Times*, July 3, 2019, available at <https://www.ft.com/content/a6db14d8-9993-11e9-9573-ee5cbb98ed36>.

[45] Anna Isaac, "Nokia and Ericsson Plan Emergency Break-up over Trade War and Security Fears," *The Telegraph*, June 8, 2019, available at <https://www.telegraph.co.uk/bU.S.iness/2019/06/08/exclU.S.ive-nokia-andericsson-plan-emergency-break-up-trade-war/>.

[46] Paul Triolo and Kevin Allison, "The Geopolitics of 5G," Eurasia Group, November 15, 2018, available at <https://www.eurasiagroup.net/live-post/the-geopolitics-of-5g>.

[47] Ibid.

[48] William Lazonick and Edward March, "The Rise and Demise of Lucent Technologies," 2011, available at <http://thebhc.org/sites/default/files/lazonickandmarch.pdf>.

[49] Wikipedia, "Nortel," viewed July 17, 2019, available at <https://en.wikipedia.org/wiki/Nortel>.

[50] G.P. Agrawal, "Optical Communication: Its History and Recent Progress," in *Optics in Our Time: Its History and Our Progress*, ed. M. Al-Amri et al., (Cham, Switzerland: Springer Nature, 2016), 177-199, available at <https://link.springer.com/chapter/10.1007/978-3-319-31903-2_8>.

[51] Keith Johnson and Elias Groll, "The Improbable Rise of Huawei," Foreign Policy, April 3, 2019, available at < https://foreignpolicy.com/2019/04/03/the-improbable-rise-of-huawei-5g-global-network-china/>.

[52] Wikipedia, "Marconi Communications," viewed July 17, 2019, available at <https://en.wikipedia.org/wiki/Marconi_Communications>.

[53] Wikipedia, "Nortel," viewed July 17, 2019, available at <https://en.wikipedia.org/wiki/Nortel>.

[54] Trefis Team, "Nokia's $16.6 Billion Acquisition of Alcatel-Lucent Explained," Forbes, April 16, 2015, available at <https://www.forbes.com/sites/greatspeculations/2015/04/16/nokias-16-6-billion-acquisition-of-alcatel-lucent-explained/#58334cc2605c>.

[55] Cho Mu-Hyun, "Samsung and 5G: Will this time be different?", ZDNet, February 1, 2019, available at <https://www.zdnet.com/article/samsung-and-5g-will-this-time-be-different/>; Kenichi Yamada, "Samsung Earmarks $22bn for Nurturing New Fields," *Nikkei Asian Review*, August 8, 2018, available at <https://asia.nikkei.com/Asia300/Samsung-earmarks-22bn-for-nurturing-new-fields2>.

[56] Wikipedia, "History of Turnpikes and Canals in the United States," viewed July 17, 2019, available at <https://en.wikipedia.org/wiki/History_of_turnpikes_and_canals_in_the_United_States>.

[57] Wikipedia, "United States Army Corps of Engineers," viewed July 17, 2019, available at < https://en.wikipedia.org/wiki/United_States_Army_Corps_of_Engineers>.

[58] Maury Klein, "Financing the Transcontinental Railroad," Gilder Lehrman Institute of American History, viewed July 17, 2019, available at <https://ap.gilderlehrman.org/essays/financing-transcontinental-railroad>.

[59] David Billington et. al, "The History of Large Federal Dams: Planning, Design, and Construction in the Era of Big Dams," Bureau of Reclamation/Interior, 2005, available at <https://www.U.S.br.gov/history/HistoryofLargeDams/LargeFederalDams.pdf>.

[60] Wikipedia, "Rural Electrification Act," viewed July 17, 2019, available at <https://en.wikipedia.org/wiki/Rural_Electrification_Act>.

[61] Federal Highway Administration, "History of the Interstate Highway System," June 27, 2017, available at <https://www.fhwa.dot.gov/interstate/history.cfm>; Wikipedia, "Interstate Highway System," viewed July 17, 2019, available at <https://en.wikipedia.org/wiki/Interstate_Highway_System>.

[62] Kim Ann Zimmermann and Jesse Emspak, "Internet History Timeline: ARPAnet to the World Wide Web," Live Science, June 27, 2017, available at <https://www.livescience.com/20727-internet-history.html>.

[63] Douglas Brinkley, review of American Moonshot, 2019; Greg Ip, "The Moonshot Mind-Set Once Came from the Government No Longer," *The Wall Street Journal*, July 14, 2019, available at <https://www.wsj.com/articles/the-moonshot-mind-set-once-came-from-the-government-no-longer-11563152820?mod=hp_lead_pos5>.

[64] The Planetary Society, "How much did the Apollo program cost?", viewed July 17, 2019, available at <http://www.planetary.org/get-involved/be-a-space-advocate/become-an-expert/cost-of-apollo-program.html >.

[65] Henry Mance and Yuichiro Kanematsu, "Why NASA's next Moon Mission Can't be an Apollo Retread," *Financial Times*, July 5, 2019, available at <https://www.ft.com/content/5adc069a-9d27-11e9-b8ce-8b459ed04726>.

[66] Wikipedia, "Intelsat," viewed July 17, 2019, available at <https://en.wikipedia.org/wiki/Intelsat>.

[67] Wikipedia, "Inmarsat," viewed July 17, 2019, available at<https://en.wikipedia.org/wiki/Inmarsat>.

[68] Defense Advanced Research Projects Agency, "About DARPA," viewed July 25, 2019, available at <https://www.darpa.mil/about-U.S./about-darpa>.

[69] Robert D. Hof, "Lessons from Sematech," *MIT Technology Review*, July 25, 2011, available at <https://www.technologyreview.com/s/424786/lessons-from-sematech/>.

[70] Chrysler Corporation Loan Guarantee Act of 1979, P.L. 96-185, 96th Cong. (1980), available at <https://www.congress.gov/bill/96th-congress/hoU.S.e-bill/5860>.

[71] J.M. Bickley, "Chrysler Corporation Loan Guarantee Act of 1979: Background, Provisions, and Cost," R.40005, (Washington, D.C.: Congressional Research Service, 2008), available at <http://digitalcommons.ilr.cornell.edu/key_workplace/569>.

[72] Wikipedia, "Iridium Communications," viewed

July 17, 2019, available at <https://en.wikipedia.org/wiki/Iridium_Communications>.

[73] Secretary of Defense, "Determination Under Section 303 (a)(5) of the Defense Production Act for High Purity Beryllium Metal Production Program," October 12, 2005, available at <https://www.esd.whs.mil/Portals/54/Documents/FOID/Reading%20Room/Other/Determination_of_the_Defense_Production%20Act_for_High_Purity_Beryllium_Metal_Production_Program.pdf>.

[74] Federal Reserve Bank of St. Louis, "Financial Crisis Timeline, 2007-2009," viewed on July 17, 2019, available at<https://www.stlouisfed.org/financial-crisis/full-timeline>; Department of the Treasury, "Investment in American International Group," available at <https://www.treasury.gov/initiatives/financial-stability/TARP-Programs/aig/Pages/default.aspx>.

[75] "American Recovery and Reinvestment Act of 2009," P.L. 111-5, 111th Congress (2009), available at https://www.congress.gov/bill/111th-congress/hoU.S.e-bill/1/text

[76] Farhana Hossain et al., "The Stimulus Plan: How to Spend $787 Billion," *The New York Times*, January 5, 2017, available at <https://www.nytimes.com/interactive/projects/44th_president/stimulU.S.>; Wayne Duggan, "What Happened to All the 'Shovel-Ready' Infrastructure Projects From the 2009 Stimulus Bill?", Benzinga, February 13, 2017, available at <https://www.benzinga.com/general/education/17/02/9036944/what-happened-to-all-the-shovel-ready-infrastructure-projects-from-t>.

[77] Steve Blank, "The Secret History of Silicon Valley," Stanford University, Computer History Museum Lecture, November 20, 2008, available at <https://www.youtube.com/watch?v=ZTC_RxWN_xo>.

[78] Office of the Secretary of Defense, Memo on Acquisition Policy for Commercial Products, July 14, 2000, available at <https://www.acq.osd.mil/dpap/docs/cotsreport.pdf>.

[79] Adam Stone, "To improve Military Networks, the Army Looks to Commercial Solutions," C4ISRNET, August 3, 2018, available at <https://www.c4isrnet.com/special-reports/military-it-modernization/2018/08/03/to-improve-military-networks-the-army-looks-to-commercial-solutions/>.

[80] Thomas Donahue, "Strategy Needed to Protect National Sovereignty of U.S. Telecommunications Backbone," *Military Cyber Affairs*, Vol. 3, Issue 2 (February 2018), available at<https://scholarcommons.U.S.f.edu/mca/vol3/iss2/4>; James Andrew Lewis, "Telecom and National Security," Center for Strategic & International Studies, March 18, 2018, available at <https://www.csis.org/analysis/telecom-and-national-security>.

[81] Defense Science Board, "Defense Applications of 5G Network Technology," Department of Defense, June 24, 2019, available at <https://www.acq.osd.mil/dsb/reports/2010s/5G_Executive_Summary_2019.pdf>.

[82] "The Defense Production Act of 1950: History, Authorities, and Considerations for Congress," R.43767 (Washington, D.C.: Congressional Research Service, 2018), available at <https://www.everycrsreport.com/reports/R43767.html>.

[83] Nokia Corporation, "Financial Report for Q4 and Full Year 2018," January 31, 2019, available at <https://www.nokia.com/about-U.S./news/releases/2019/01/31/nokia-corporation-financial-report-for-q4-and-full-year-2018/>; Ericsson, "Fourth Quarter and Full-year Report 2018," January 25, 2019, available at <https://www.ericsson.com/assets/local/investors/documents/financial-reports-and-filings/interim-reports-archive/2018/12month18-en.pdf>.

[84] Trefis Team, "Nokia's $16.6 Billion Acquisition of Alcatel-Lucent Explained," Forbes, April 16, 2015, available at <https://www.forbes.com/sites/greatspeculations/2015/04/16/nokias-16-6-billion-acquisition-of-alcatel-lucent-explained/#58334cc2605c>.

[85] Sijia Jiang, "China's Huawei to raise annual R&D budget to at least $15 billion," *Reuters*, July 26, 2018, available at <https://www.reuters.com/article/U.S.-huawei-r-d/chinas-huawei-to-raise-annual-rd-budget-to-at-least-15-billion-idU.S.KBN1KG169>; Habeeb Onawole, "Huawei join Samsung, Alphabet in Top 5 R&D investors for 2018," Gizmo China, January 2, 2019, available at <https://www.gizmochina.com/2019/01/02/huawei-join-samsung-alphabet-in-top-5-rd-investors-for-2018/>.

[86] Ruchi Gupta, "What Does Nokia Spend on Research and Development?", Market Realist, December 10, 2018, available at <https://marketrealist.com/2018/12/what-does-nokia-spend-on-research-and-development/>; Statista, "Nokia's Expenditure on Research and Development Since 1999," July 29, 2019, available at <https://www.statista.com/statistics/267821/nokias-expenditure-on-research-and-development-since-1999/>.

[87] Rochelle Toplensky and Alex Barker, "European Investment Bank: the EU's hidden giant," *The Financial Times*, July 15, 2019, available at <https://www.ft.com/content/940b71f2-a3c2-11e9-a282-2df48f366f7d>; Nokia, "Nokia lands EUR 500 million EU Financing for 5G research," August 27, 2018, available at <https://www.nokia.com/about-U.S./news/releases/2018/08/27/nokia-lands-eur-500-million-eu-financing-for-5g-research/>; Chris Kelly, "Canada to sign $40m 5G R&D deal with Nokia," Total Telecom, January 25, 2019, available at <https://www.totaltele.com/502006/

Canada-to-sign-40m-5G-RD-deal-with-Nokia>.

[88] Iain Morris, "Huawei Dwarfs Ericsson, Nokia on R&D Spend in 2017," Light Reading, April 3, 2018, available at < https://www.lightreading.com/artificial-intelligence-machine-learning/huawei-dwarfs-ericsson-nokia-on-randd-spend-in-2017/d/d-id/741944>; S. O'Dea, "Ericsson's Expenditure on Research and Development Worldwide from 2011 to 2018," Statista, May 6, 2019, available at <https://www.statista.com/statistics/566320/ericsson-research-and-development-expenses-worldwide/>; Corinne Reichert, "Ericsson Plans Continued 5G R&D as Net Loss Reduces to 700m SEK," ZDNet, April 20, 2018, available at <https://www.zdnet.com/article/ericsson-plans-continued-5g-r-d-as-net-loss-reduces-to-700m-sek/>.

[89] Jon Brodkin, "AT&T, facing $158 billion debt, to sell Puerto Rico network for $2 billion," Ars Technica, 9 October 2019, available at https://arstechnica.com/information-technology/2019/10/att-facing-158-billion-debt-to-sell-puerto-rico-network-for-2-billion/

[90] Mike Dano, "Huawei's Share of the Global Telecom Market Keeps Growing," Light Reading, 29 August 2019, available at https://www.lightreading.com/market-research/huaweis-share-of-the-global-telecom-market-keeps-growing/d/d-id/753768

[91] Edward White, "Inside Samsung's $116bn plan to overtake chip rivals," *Financial Times*, 22 July 2019, available at https://www.ft.com/content/85ebfa62-a2f8-11e9-a282-2df48f366f7d

[92] Song Jung-a, "Samsung closes US chip R&D unit," *Financial Times*, 5 November 2019, available at https://www.ft.com/content/8c773768-ffa3-11e9-b7bc-f3fa4e77dd47

[93] Wikipedia, "Nokia," viewed July 18, 2019, available at <https://en.wikipedia.org/wiki/Nokia>; Wikipedia, "Ericsson", viewed July 18, 2019, available at <https://en.wikipedia.org/wiki/Ericsson>.

[94] Samsung, "5G Core Vision," 2019, available at https://image-us.samsung.com/SamsungUS/samsungbusiness/pdfs/5G_Core_Vision_Technical_Whitepaper.pdf

[95] "Ericsson Extends Global Supply Chain With Company's First Smart Factory in the U.S.," PRNewswire, June 26, 2019, available at <https://www.prnewswire.com/news-releases/ericsson-extends-global-supply-chain-with-companys-first-smart-factory-in-the-U.S.-300875136.html>; "Ericsson Increasing U.S. Investments To Support Accelerated 5G Deployments," Ericcson.com, August 10, 2018, available at <https://www.ericsson.com/en/press-releases/2018/8/ericsson-increasing-U.S.-investments-to-support-accelerated-5g-deployments>.

[96] Brian Womack, "Nokia's North Texas operations helping build T-Mobile's 5G network," Dallas Business Journal, July 30, 2018, available at <https://www.bizjournals.com/dallas/news/2018/07/30/nokias-north-texas-operations-helping-build-t.html>.

[97] Subcom, "Our Capabilities," viewed July 18, 2019, available at <https://www.subcom.com/>.

[98] "UbiquitoU.S. 5G Transport," Erricsson.com, viewed on July 18, 2019, available at <https://www.ericsson.com/en/networks/offerings/transport/5g-ready-transport>.

[99] William Lazonick and Edward March, "The Rise and Demise of Lucent Technologies,"*Business and Economic History On-line*, Vol. 9 (2011), available at <http://thebhc.org/sites/default/files/lazonickandmarch.pdf>.

[100] Nokia, "Nokia and Xiaomi sign Business Cooperation and Patent Agreements," July 5, 2017, available at <https://www.nokia.com/about-U.S./news/releases/2017/07/05/nokia-and-xiaomi-sign-bU.S.iness-cooperation-and-patent-agreements/>.

[101] *5G System Design: Architectural and Functional Considerations and Long-Term Research*, ed. Patrick Marsch et al. (United Kingdom: John Wiley & Sons Ltd., 2018), available at <https://onlinelibrary.wiley.com/doi/book/10.1002/9781119425144>.

[102] Steve McCaskill, "China Looking to Launch 6G by 2030," Techradar.pro, November 19, 2018, available at <https://www.techradar.com/news/china-looking-to-launch-6g-by-2030>.

[103] Matti Latva-aho, "Radio Access Networking Challenges Towards 2030" (Powerpoint Presentation, Oulu University, Finland, October 2018), available at <https://www.itu.int/en/ITU-T/Workshops-and-Seminars/201810/Documents/Matt_Latva-aho_Presentation.pdf>; "Discover How 6G will Change our Lives," University of Oulu, July 2019, available at <https://www.oulu.fi/6gflagship/>.

[104] Secretary of the Air Force, "Nuclear Command, Control and Communications," U.S. Air Force Instruction 13-550, April 16, 2019, <available at https://static.e-publishing.af.mil/production/1/af_a10/publication/afi13-550/afi13-550.pdf>.

[105] Erica D. Borghard and Shawn W. Lonergan, "The Overlooked Military Implications of the 5G Debate," Council on Foreign Relations, April 15, 2019, available at <https://www.cfr.org/blog/overlooked-military-implications-5g-debate>; U.S. Air Force Space Command, "Defense Satellite Communications System," March 22, 2017, available at <https://www.afspc.af.mil/About-U.S./Fact-Sheets/Display/Article/1012656/defense-satellite-communications-system/>; U.S. Air Force Space Command, "Advanced Extremely High Frequency System," March 22, 2017, available at <https://www.afspc.

af.mil/About-U.S./Fact-Sheets/Display/Article/249024/advanced-extremely-high-frequency-system/>; U.S. Air Force Space Command, "Wideband Global SATCOM Satellite," March 22, 2017, available at <https://www.afspc.af.mil/About-U.S./Fact-Sheets/Display/Article/249020/wideband-global-satcom-satellite/>; U.S. Air Force Space Command, "Global Broadcast Service," March 22, 2017, available at <https://www.afspc.af.mil/About-U.S./Fact-Sheets/Display/Article/249021/global-broadcast-service/>; DM Chan, "Can commercial satellites cut U.S. defense costs?", Asia Times, July 15, 2019, available at <https://www.asiatimes.com/2019/07/article/can-commercial-satellites-cut-U.S.-defense-costs/>; Peter Barker, "The Challenge of Defending Subsea Cables," The Maritime Executive, March 20, 2018, available at <https://www.maritime-executive.com/editorials/the-challenge-of-defending-subsea-cables>.

[106] TeleGeography, "Submarine Cable Map," June 28, 2019, available at <https://www.submarinecablemap.com/#/>.

[107] "David E. Sanger and Eric Schmitt, "Russian Ships Near Data Cables Are Too Close for U.S. Comfort," *The New York Times*, October 25, 2015, available at <https://www.nytimes.com/2015/10/26/world/europe/rU.S.sian-presence-near-undersea-cables-concerns-U.S..html>; Department of Homeland Security Analyst Exchange Program, "Threats to Undersea Cable Communications," Office of the Director of National Intelligence, September 28, 2017, available at <https://www.dni.gov/files/PE/Documents/1---2017-AEP-Threats-to-Undersea-Cable-Communications.pdf>.

[108] Slava Solonitsyn, "Why U.S. Hardware Startups will Start Moving to China," Ruvento Ventures, March 19, 2017, available at <http://www.ruvento.com/news/2017/4/21/why-U.S.-hardware-startups-will-start-moving-to-china-1>; Richard Florida, "America is Losing Its Edge for Startups," City Lab, October 9, 2018, available at <https://www.citylab.com/life/2018/10/america-losing-its-edge-startups/572323/>.

[109] Zhou Xin, "Xi Jinping calls for 'New Long March in Dramatic Sign that China is Preparing for Protracted Trade War," South China Morning Post, May 21, 2019, available at <https://www.scmp.com/economy/china-economy/article/3011186/xi-jinping-calls-new-long-march-dramatic-sign-china-preparing>.

Editor's note:

References below were inadvertently omitted from this article. Additional sources for the first paragraph of the section titled "Potential Damage to the U.S. Semiconductor Industry" on pages 18–19 should include the following:

Jeanne Whalen, Reed Albergotti and David J. Lynch, "US tech firms push Trump to allow sales to Huawei, set up White House meeting next week," Washington Post, 19 July 2019, available at https://beta.washingtonpost.com/business/2019/07/19/us-tech-companies-push-trump-allow-some-sales-huawei;

Dan Strumpf, Yoko Kubota and Wenxin Fan, "Silicon Valley Will Feel Sting of Export Restrictions Against Huawei," Wall Street Journal, 16 May 2019, available at https://www.wsj.com/articles/silicon-valley-will-feel-sting-of-export-restrictions-against-huawei-11558021918;

Puja Tayal, "What Chip Ban Means to Huawei and US Chip Suppliers," Market Realist, 20 May 2019, available at https://marketrealist.com/2019/05/what-chip-ban-means-to-huawei-and-us-chip-suppliers/;

Bob Pisani, "Semiconductors are killing it—thanks to China," CNBC, 3 April 2019, available at https://www.cnbc.com/2019/04/03/semiconductors-are-killing-it-thanks-to-china.html;

Ian King, Mark Bergen and Ben Brody, "Top US Tech Companies Begin to Cut Off Vital Huawei Supplies," Bloomberg, 19 May 2019, available at https://www.bloomberg.com/news/articles/2019-05-19/google-to-end-some-huawei-business-ties-after-trump-crackdown