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How to Bridge the Rural Broadband Gap Once and For All

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Nearly one in five rural Americans still lack access to broadband Internet service. Federal subsidies could bridge that gap if they are carefully targeted through a reverse-auction program that leverages economies of scale by encouraging large providers to participate.

KEY TAKEAWAYS

- A large, one-time injection of federal capital can succeed in bridging the rural broadband divide if it is reasonably targeted and allocated through a reverse-auction program that serves as a transition away from the FCC's Universal Service Fund.
- The current FCC program is funded through regressive fees levied on a shrinking base of telecommunications services. Roughly half of its rural support goes to small, inefficient firms for piecemeal investments. This system is unsustainable.
- Subsidies should be awarded through auctions that encourage companies of all sizes to participate—particularly those with large economies of scale, so they can efficiently extend broadband service into previously uneconomical areas.
- These procurement-style auctions should award support for unserved locations using new FCC maps that show precisely where and what type of infrastructure is already available.
- Policymakers must recognize the cost trade-offs of brand-new, ultra-fast networks: The goal should not be "future proofing," but the broadest-possible coverage of networks that support reasonable expectations of future application demand.
- Policymakers also should combine subsidies with other efforts to remove barriers to deployment, including streamlining the pole attachments process and ensuring pole replacement fees are shared fairly between all beneficiaries.

INTRODUCTION

Despite years of effort and tens of billions of dollars in subsidies, the United States still faces a stubborn rural-urban broadband gap. It is time for something new. As part of either an overall infrastructure investment package or dedicated rural broadband legislation, Congress should seize the opportunity to make a large, one-time investment in upgrading rural broadband infrastructure. A big injection of capital, if carefully targeted and allocated through reverse auctions, could help expand the footprint of existing networks and fund new deployments in areas previously uneconomical to serve, thereby bridging the rural-urban digital divide.

A large one-time appropriation would also help to transition away from the Federal Communications Commission's (FCC's) outdated Universal Service Fund (USF) for high-cost areas. The USF, which is paid for through an ever-rising, regressive fee on telecommunications services, is unsustainable in its current form. Path dependencies in the system have channeled billions of dollars of USF money into small, inefficient firms that make only meager upgrades in exchange for those large subsidies and a guaranteed return—nearly 10 percent—on their investment.[1] While no one should begrudge a small company trying to provide broadband to its surrounding community, this is a wildly inefficient way to connect high-cost portions of the country.

A revamped high-cost support program would go a long way toward eliminating the broadband access gap and ensuring virtually everyone has robust broadband sufficient to participate in the digital economy for the foreseeable future.

Subsidies should instead be awarded through auctions, designed to encourage broad participation by companies of all size, particularly companies with large economies of scale (and lower production costs) that can efficiently broaden their reach into previously uneconomical areas. The move should be away from the USF's model of continual, ongoing support and the arcane red tape of its Eligible Telecommunications Carrier (ETC) system. At the very least, an infrastructure subsidy program should have a strong preference for projects that would not require ongoing support after the initial subsidized cost of network infrastructure deployment. A revamped high-cost support program would go a long way toward eliminating the broadband access gap and ensuring virtually everyone has robust broadband sufficient to participate in the digital economy for the foreseeable future.

In summary, to set the new broadband program up for long-term success, high-cost support should leverage existing FCC efforts to improve mapping in critical areas, provide a large one-time infusion of capital expenditure funds allocated through reverse auctions, apply reasonable standards for allocating funding (rather than gold plating in the name of "future-proofing"), and make other infrastructure and pole access reforms that will help subsidized investment go further. The Information Technology and Innovation Foundation (ITIF) believes that any broadband infrastructure package should be guided by the following key principles:

- It should rely on procurement-style auctions to determine which entities receive subsidies, and base potential received support on revenue in order to avoid small companies with little experience receiving outsized awards.

- To connect the most locations with a limited amount of funding, subsidies should first be focused on genuinely unserved locations before being used to upgrade speeds beyond 25/3 Mbps. To reach universal coverage with robust service, the last remaining locations will be the most-costly to serve, with broadband satellite service almost surely proving to be the most cost effective.
- Support should be made available for both fixed and mobile broadband. Fixed support should be technologically neutral and designed to achieve specific, reasonable performance goals, allowing for different access technologies, including fixed wireless (but not satellite).
- Policymakers must recognize the cost trade-offs of brand-new, ultra-fast networks. The goal should not be "future-proofing," but the broadest possible coverage of networks capable of supporting reasonable expectations of future application demand, which is lower than some advocates claim.[2]
- Ideally, subsidies would target areas that only require up-front capital support, rather than fund ongoing support for operating expenses. Carefully structured one-time subsidies would be more effective at reaching a targeted improvement in rural network performance than piecemeal advances over a longer period. They also serve as a market-based mechanism for identifying which areas should rely on upgraded satellite broadband services rather than fixed terrestrial service.
- Policymakers should combine subsidies with other efforts to remove barriers to deployment, including making fees to access rights of way cost-based and competitively neutral. Efforts to streamline pole attachments and ensure pole replacement fees are shared fairly between all beneficiaries could considerably lower deployment costs.
- Targeted subsidies should also be paired with tax incentives in the form of first-year expensing of broadband capital expenditures.

By embodying these principals and applying the knowledge gained from previous programs, policymakers have an opportunity to build a robust program to meaningfully and expeditiously close the rural-urban divide. It is time to get this done.

THE HISTORY OF UNIVERSAL SERVICE PROVIDES LESSONS FOR THE FUTURE

Universal service has been a touchstone of communications policy for over a century. Historically, the wide deployment of telephone service was facilitated by the formation of the old AT&T monopoly.[3] Early competition between independent, non-interconnected telephone networks saw different networks scramble for broad regional coverage. The famous 1913 "Kingsbury Commitment" allowed the Bell system to operate free from antitrust enforcement as long as it interconnected with independent firms, agreed to regulatory oversight, and worked to achieve universal service. Theodore Vail, AT&T's president for over 15 years near the beginning of the 20th century, coined what would become the mantra of the Bell system for decades: "One System—One Policy—Universal Service." The 1921 Willis-Graham Act effectively established AT&T as a natural monopoly, stating that "there is nothing to be gained by local competition in the telephone industry."[4]

Efforts continued through the 20th century to drive broad coverage of the telephone network. As a monopoly service, the Bell system was able to cross-subsidize, using revenues from high-return services in urban areas (including business service and long-distance) to support high-cost deployment and low-margin services. This system started to break down after the 1996 Telecommunications Act, which supported the creation of a more-competitive environment, something that was ultimately achieved through technological innovation. To achieve universal broadband, we cannot rely on the old, implicit cross-subsidies of the Bell system. Instead, explicit subsidies must be used to solve this market failure.

Network Access Technologies

There are a variety of existing network access technologies, each with its own advantages and disadvantages. A rough understanding of existing deployments, the performance capabilities of different technologies, and the possible build-out of new technology is useful for navigating rural broadband policy.

Digital Subscriber Line (DSL)

DSL offerings rely on the network built for telephone services. One of the main advantages of this access technology is its large existing footprint of available infrastructure. Over a century of efforts to achieve universal telephone availability means the underlying infrastructure DSL uses is the most broadly deployed. However, the network was originally designed for voice conversations and has a difficult time transmitting a large amount of data, particularly over longer distances. A host of different standards, such as asymmetric DSL (ADSL), vectored DSL (VDSL), and G.fast—which is able to achieve gigabit speeds, at least over a short distance—are able to leverage the legacy copper network. These flavors of DSL are broadly available and provide high performance in more-densely populated areas. But in rural America, where loop lengths are particularly long, its performance drops off and becomes quite slow.[5] Today, fiber is incrementally built deeper into the network in order to achieve faster speeds, with the legacy copper telephone network providing service to the last distance to the home.

Hybrid Fiber-Coaxial (HFC)

HFC is the technology of the cable industry. Originally built out to provide video service, the development of Data Over Cable Service Interface Specifications (DOCSIS) allowed for broadband. Municipal and state-level franchise agreements gave video providers access to city rights of way in exchange for broad build-outs (and additional regulations), meaning cable networks were already broadly deployed in this TV-loving country by the time broadband came along. Cable networks generally offer higher performance with faster speeds than DSL, and can be upgraded at relatively little cost. Like DSL, cable today is a mix of fiber and coaxial cable—with fiber pushed out ever closer to homes in order to increase performance. Industry estimates claim that about 90 percent of U.S. households have access to a cable network.

Fiber Optic Cable

Fiber optic cables rely on lasers reflecting through thin tubes of glass and are used for the highest throughput parts of the Internet. The long-distance transit lines that carry large amounts

of information are all fiber. Fiber was developed relatively recently and does not have a widespread last-mile deployment such as DSL or HFC. However, for new builds, it offers the highest performance over long distance, is highly upgradeable, and has relatively low operating costs. Choosing from among the various flavors of fiber network—fiber-to-the-node, fiber-to-the-cabinet, fiber-to-the-basement, and fiber-to-the-home—depends on how close it runs to the subscriber's home, with each exhibiting different top-end performance and cost levels to deploy. Fiber-to-the-home gets a lot of attention from broadband advocates, as it is the latest and greatest technology with more throughput than will likely ever be needed. But it is also generally the most expensive to deploy.

Fixed Wireless

Wireless Internet Service Providers (WISPs) offer Internet service with a fixed wireless link for the last several hundred or thousand feet to the end user. Wireless can offer a very cost-effective means to extend a network and be particularly useful in rural areas with challenging terrain.

Satellite

Satellite networks have historically offered a backstop broadband service, available virtually everywhere, but with some performance and cost limitations. Traditional satellite services rely on large satellites in geosynchronous orbit. At an orbit of around 22,000 miles from earth's surface, satellites orbit at the same speed the Earth rotates, making the service much easier to manage. This is a long distance for an Internet signal to travel over the air, however, and the service struggles with high latency or delay as information has to travel up to space and back down as users browse the web. Recent efforts to use Low Earth Orbit (LEO) satellites are generating considerable excitement, as positioning them closer to the ground offers higher performance with significantly less delay. Importantly, the broad coverage area of satellites makes for a completely different architecture than terrestrial service, meaning the geographic-specific subsidy system may not be the most effective way to support rural satellite access. Subsidies directly to end users to purchase service, up-front customer-premises equipment, or both would likely be more effective than providing capital to satellite providers to cover specific geographies.

Mobile

While mobile technology such as 4G LTE and upcoming 5G provide access to the Internet, capacity limitations restrict its use as a home broadband replacement. This is changing, however, with many wireless carriers beginning to offer home broadband, similar to the fixed service offered by WISPs. As the wide coverage of mobile networks also offers important economic benefits outside of the home, an effort to seriously extend and upgrade networks in rural America should include support for mobile technologies alongside connectivity to the home.

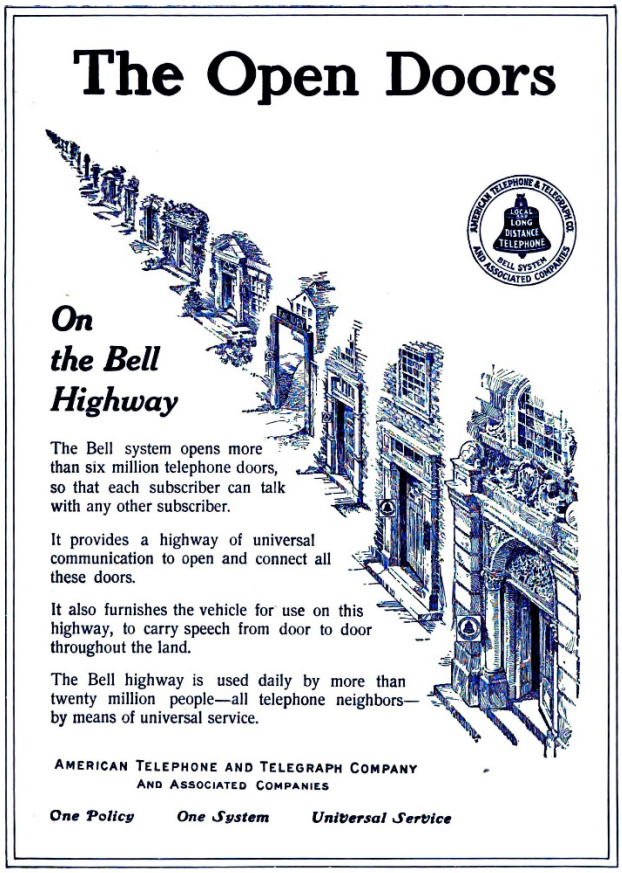
Today, unconnected areas lacking high-speed broadband infrastructure skew heavily toward rural and tribal lands. According to the FCC's Broadband Deployment Report, "22.3% of Americans in rural areas and 27.7% of Americans in Tribal lands lack coverage from fixed terrestrial 25/3 Mbps broadband, as compared to only 1.5% of Americans in urban areas."[6] While the divide between rural and urban areas continues to shrink, government support is needed to help providers close the gap. The positive spillover effects associated with ensuring everyone is online

are innumerable, and it is evident that a government intervention is warranted in order to better connect society.

When considering future plans to better bridge the divide, U.S. Congress, the FCC, and the National Telecommunications and Information Administration (NTIA) should leverage lessons learned from historical and existing programs to build a roadmap for connecting rural America. History paints a clear picture of what works and what does not, such as the successes and challenges associated with the USF, the newest Rural Digital Opportunity Fund (RDOF), the Rural Utilities Service (RUS) Programs, and even the Broadband Technology Opportunities Program (BTOP). Each of these programs presents an opportunity to learn from the past in order to build a stronger, more resilient, and efficient broadband program aimed at connecting rural America.

House Resolution Two from the 116th U.S. Congress—the Moving Forward Act—provides a likely template the current Congress might consider when working to accelerate broadband deployment with an infusion of capital.[7] However, several changes should be made to the bill before moving forward. For example, given the relatively little benefit of extremely fast speeds, there is little reason to prioritize fiber networks or reserve auction money for fiber-only networks.[8] Fiber is often cost effective when building a new network, and likely would do well at a reverse auction. But Congress should not presume what technology is best for every area, and instead rely on the auction mechanism and expert assessments of trade-offs to cost-effectively select the appropriate access technology for any given location.

Figure 1: 1912 Bell System advertisement promoting universal service[1]



The Moving Forward Act also wrongly requires symmetry in upload and download speeds for networks. Actual use of networks is not symmetrical, and likely never will be. In fact, download traffic is larger than upload traffic by more than an order of magnitude (even during widespread video conferencing under COVID-19 social distancing). Requiring symmetrical speeds would be very costly and limit the number of additional locations that could be connected for a given price.

At the same time, it is expected that the use of upstream bandwidth is likely to grow at a faster rate than downstream.[9] It would be reasonable to raise expectations around upload speeds from the current standard for USF support (3 Mbps), but only modest changes would be necessary to enable any anticipated applications.

Dramatically larger upload speeds are useful for alleviating users' impatience in backing up data or uploading large files (something that is usually done in the background while the person is working on other things), and live streaming very high-resolution and high-frame-rate video (something few current video-conferencing participants do). Policymakers should aim to achieve a broader build-out that ultimately brings more people online with robust broadband, rather than connect fewer people just so they can stream marginally higher-resolution video.

Policymakers must also consider how to reconcile slow-moving support with dynamic new entrants in broadband networks, particularly LEO satellites. Given the architectural differences between these services, it may be necessary to reconsider how subsidies are provided for satellite users. It is reasonable to expect the last, most-costly-to-serve locations to rely on these new-and-improved satellite services. But up-front capital expenditure (CapEx) is not the right approach for funding satellites with an existing global footprint of services. Instead, low-income rural users relying on satellite broadband should be offered vouchers for initial customer-premises equipment and ongoing support.

GOVERNMENT SHOULD ENSURE AVAILABILITY OF ROBUST BROADBAND FOR THE VAST MAJORITY OF CITIZENS

There are considerable benefits to society when virtually all of its members are online. Sufficiently robust broadband is increasingly viewed as a necessity for a thriving community; it is a critical tool for participation in the digital economy and society. As a general matter, private competition drives continually improving service and high levels of investment, and provides strong incentives for dynamic innovation. However, as population density falls off, the return on investment for building or upgrading networks drops precipitously. Costs are higher and revenues are lower than in higher-income urban areas. After a certain level of density, this dynamic enters a classic market failure: Competitive private networks simply do not have the incentive to build where there is no return. There is thus widespread support for government action to address areas wherein the economics do not work for the nonsubsidized provision of broadband.

There Are Strong Economic Benefits to Increased Connectivity

Broadband access is indisputably associated with what economists call "positive externalities"—those spillover benefits to society and the economy that cannot be captured by the firms supplying a particular good or service. Connectivity helps to increase employment opportunities and industry growth through a wide array of mechanisms, connecting unemployed individuals with prospective jobs and allowing for remote work. One study finds that those searching for a job "were 4 percentage points more likely to be employed [within] one month" if they had broadband, versus job seekers without connectivity.[10] Another study notes that organizations are able to save money by leveraging part-time remote workers, thereby increasing profits by 21 percent.[11] Increased connectivity would even help to improve local economies in smaller towns and cities, as roughly 66 percent of those surveyed indicated they would move outside of urbans areas if they had the opportunity to work remotely.[12]

Broadband's positive benefits are of course not limited to employment. Internet connectivity opens the door to a whole host of health care opportunities, facilitating low-cost care and more-regular communication with doctors. Broadband can help ensure patients administer medication

correctly, provide for monitoring of complex conditions, and even facilitate remote psychiatry services.[13]

Innovation is noticeable in the agricultural sector as well, wherein broadband "enables next-generation farming capabilities, such as self-driving tractors and combines, greater data collection and utilization, predictive maintenance, and more."[14] Leveraging broadband, the agricultural sector (which often powers the economy in rural areas) is able to increase efficiency, productivity, and even conservation, such as through soil moisture sensors that "can reduce water use while increasing harvests," and supply-chain sensors that manage the delivery of products.[15] There are even start-up companies that help farmers leverage their data with artificial intelligence and other technologies—but this requires farmers to be connected.[16]

Improved efficiency through broadband in agriculture and other traded sectors is an effective means to boost U.S. international competitiveness. Recent quantitative analysis from Katherine LoPiccalo in the FCC's Office of Economics and Analytics shows a correlation between broader connectivity of baseline speeds (25/3 Mbps) and notable crop yield improvements.[17] Broad connectivity—both mobile and fixed—even of modest speeds, continues to be more effective in improving economic outcomes than narrower deployments of super-fast networks.[18]

Nonsubsidized Providers Cannot Solve This Problem Alone

Unfortunately, the enormous benefits associated with connectivity cannot be realized by relying on nonsubsidized providers. Due to the economics of density, it is relatively easy for providers to recoup the cost of building networks in highly populated areas, but it is quite difficult to earn sufficient profits to justify deploying high-speed broadband in rural areas. This is made even harder by average rural-area household incomes being lower than urban, thereby reducing take-up rates. Adoption also tends to be lower on average in rural areas due to an overall lack of interest in the service.[19]

Firms in competition face several options when it comes to investing in broadband. A limited capital budget will generally see providers investing wherever the return on capital is highest. Broadband capital costs, such as cabling and equipment, coupled with labor for deployment or upgrading of existing infrastructure, must be recovered over time. Providers rely on estimates of the number of subscribers they will gain in a given geographic area if they provide service at a certain level. Once this infrastructure is deployed, it is only useful for providing broadband service—it cannot easily be repurposed to another use. Broadband providers also have ongoing operating expenses, which are higher in rural areas. However, these expenses are relatively small compared with the up-front cost of getting the infrastructure in place.

When contemplating a network deployment, operators often consider the number of customers per mile of fiber. In rural builds, that metric is inverted: The number of miles of fiber per customer, illustrating the radical difference in cost structure between rural and urban markets.[20] Without the ability to recover initial investment, broadband providers lack both the incentive and the means to deploy new networks as well as upgrade existing ones in sparsely populated areas (see figure 2 for the disparity of coverage across different areas). As a result, some rural areas are left with aging technology that is not able to provide adequate performance.

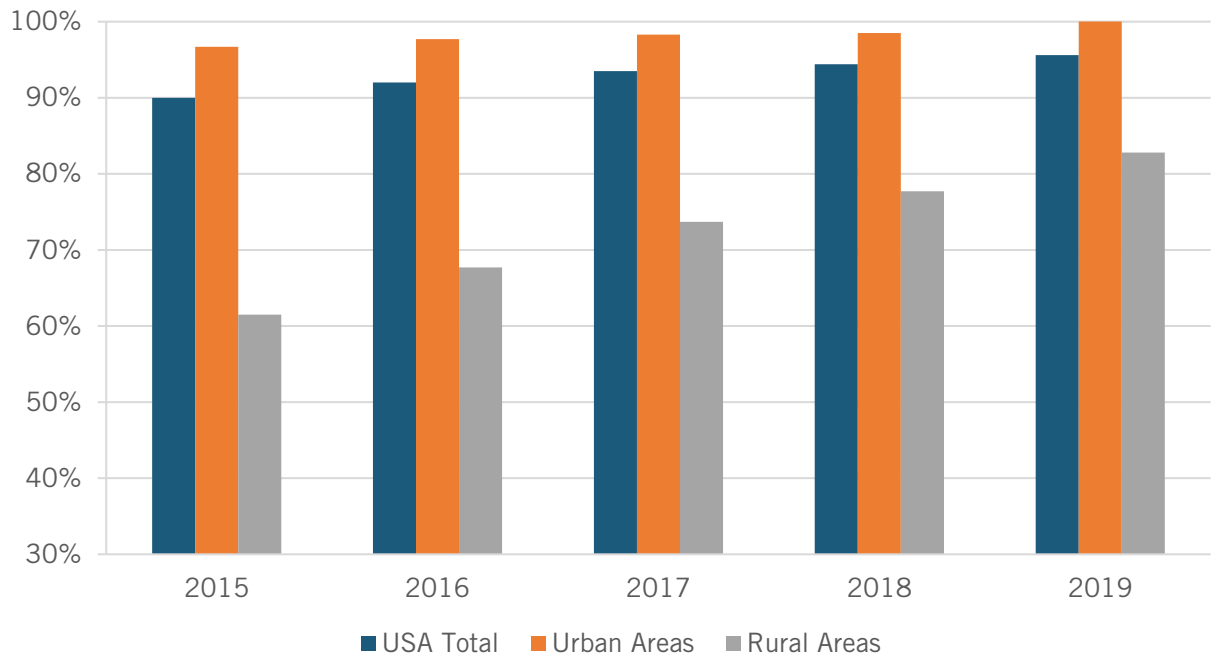
It is clear that the benefits of being able to organize our society under the assumption that all have access to the Internet justify targeted government investment. A government intervention

would help to overcome the initial capital-expenditure hurdle that makes broadband deployment prohibitively expensive.[21] Moreover, by better connecting rural areas, subsidized networks would encourage movement to towns and generate an infusion of economic activity in many previously struggling areas. The result of connectivity would allow for both a population diffusion toward more rural areas while simultaneously better unifying those areas with the opportunities traditionally only available in population-dense locations.

EXISTING AND PAST PROGRAMS HAVE FAILED TO CONNECT RURAL AMERICA

Several programs across multiple agencies and departments subsidize connectivity across America. Programs managed by the FCC, NTIA, and the U.S. Department of Agriculture (USDA) work to bridge the digital divide. While the programs try to avoid duplicative efforts by restricting overlapping loans across other federally funded programs, each program has its own standards, which leads to a lack of uniformity across rural areas. Customers' federally supported broadband options are then subject to the discretion of which federal institution oversees their broadband provider.[22] A brief review of the key programs offers lessons that should be incorporated into any future effort to fund connectivity.

Figure 2: FCC broadband population coverage at 25/3 Mbps estimates[23]



The Evolution and Challenges of the Universal Service Fund

The history of the USF helps to explain why it's currently sitting on shaky ground. The USF is housed within the FCC and administered by the Universal Service Administrative Company (USAC). Initiated by the Communications Act of 1934, the USF originally focused on ensuring telephone services to all Americans regardless of location.[24] The program evolved to include broadband after the passage of the Telecommunications Act of 1996.[25]

The USF has a roughly $8 billion budget annually, distributed across the Lifeline Program, the E-Rate program, Rural Health Care, and the High-Cost Fund, with the High-Cost Fund (for rural

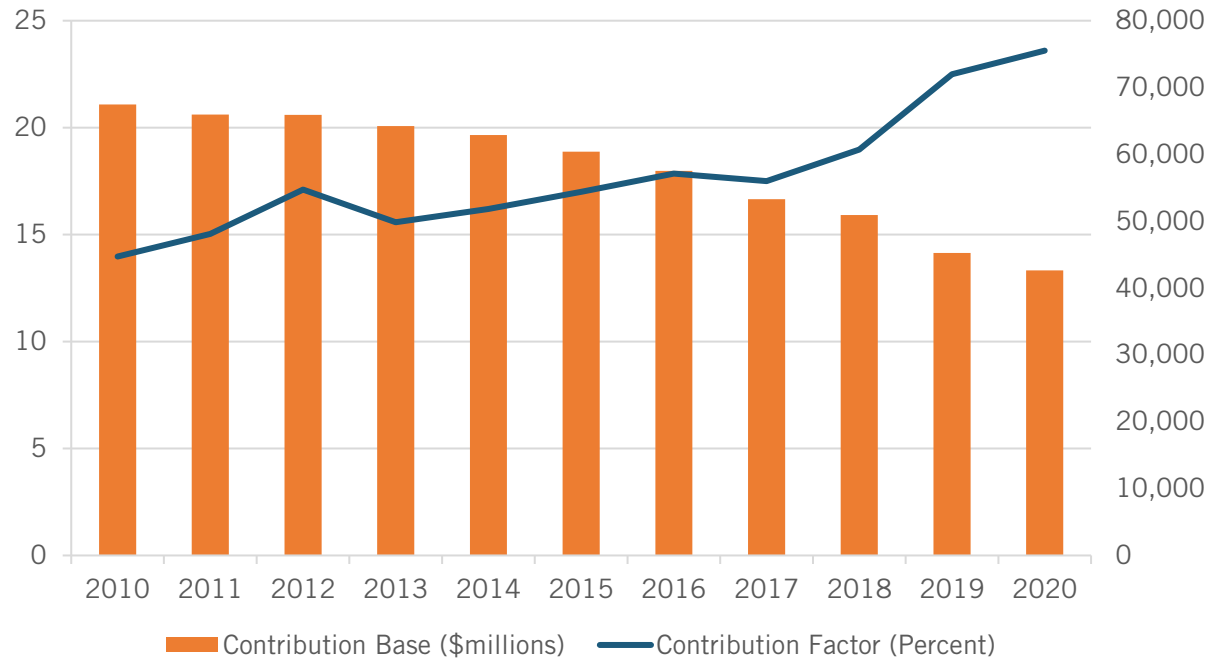
areas) spending the majority of the funding at roughly $4.5 billion per year.[26] The High-Cost Fund expanded to support broadband with its transition into the Connect America Fund (CAF) in 2011–2012 in an effort to refine processes and procedures for distributing funds and to support broadband in addition to voice services.[27]

A prominent challenge with the USF is its financing. The money for the fund is collected through a fee on telecommunications services. This fee is set as the percentage (known as the contribution factor) of telecommunications interstate end-user revenues (known as the contribution base). The factor is adjusted each quarter depending on what percentage of telecom provider revenues are needed to meet the USF budget (and other unrelated government services).[28] At present, the contribution rate for the first quarter of 2021 is 31.8 percent.[29]

This contribution mechanism has several challenges. First, it is regressive, with the same rate ultimately flowing through to all consumers regardless of income. A fee on communications services does not make sound economic sense: The goal of the program is to promote universal and affordable communications tools, but it does so by taxing communications tools. The old distinctions and the cross-subsidy theory underpinning the system do not hold under a new regime of intermodal competition, broad interconnection of IP-based networks, and increasing decentralization of communication applications.

Importantly, the contribution base of telecommunications services is shrinking. More and more communications services are flowing over the top, relying on diverse applications that are available over the web. While this trend has enabled tremendous innovation in communications tools, policymakers must reckon with its impact on the traditional source of funding for USF. For this dwindling base of legally taxable services, the rate at which they are taxed in order to meet the budget of the USF program is steadily increasing. The trend is not sustainable long-term.

Figure 3: Universal service contribution base and factor[30]



This problem is not new—just politically difficult to solve—as these challenges were identified and discussed over a decade ago.[31] What is worse, the shrinking of the contribution base (and in turn increase in the contribution factor) has dramatically accelerated in recent years—a trend that is likely to worsen, as companies and individuals have grown to favor video-chat applications such as Zoom, Teams, and BlueJeans during the pandemic. As a result, the USF program is not on sustainable ground as the program's contribution base continues to shrink. As Wall Street analyst and former FCC official Blair Levin put it, "[F]unding for universal service is in a death spiral."[32]

Theoretically, the program could expand the tax base, which at present is based on "an assessment [of telecommunication providers'] interstate and internation[al] end-user revenues."[33] Some propose to expand the base to include broadband—which the program is now asked to support. But again, a regressive tax on everyone's broadband for some to does not seem like the best way to promote broadband—especially when the explicit goal of another USF program, Lifeline, is to ensure broadband is affordable for all Americans. While a full discussion of contribution reform is surely needed, any changes to the contribution base will inevitably prove controversial. ITIF supports any effort to ensure the important government programs funded by USF—particularly support for low-income Americans to afford broadband—not only can be achieved, but also strive to be realistic. Instead of counting on a rickety old program largely designed for the era of voice services, Congress should seize the opportunity to fund a large capital investment to upgrade our rural broadband infrastructure through appropriated funds.

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Some early efforts to support broadband through the USF—prior to reverse auctions—could have been improved upon in retrospect. At risk of over-simplifying, USF funding for high-cost networks is broken up into two different types of subsidies depending on the type of company providing service in exchange. First, there is the support for smaller carriers—often referred to as "rate-of-return carriers"—which the FCC reimburses for invested capital on an ongoing basis. Second is what is known as "price cap carriers," which are larger, established companies offered support based on FCC estimates of costs to build networks of a certain performance for a given geographic area. These companies are regulated through price controls, as prices in subsidized areas are required to be roughly equivalent to those in urban areas, even though the cost of providing service is much higher.

Both of these models could be improved upon in a new effort to connect rural America. Mandating support of smaller rate-of-return carriers is an inefficient way to achieve universal coverage. The incentives of continual payments encourage marginal upgrades based on government dictates, rather than networks consumers favor. Small carriers necessarily duplicate all of the back-office and administrative work and cannot purchase equipment or contract for services at scale. The rate-of-return model is difficult to police and requires detailed oversight to determine which investments are considered appropriate to include in the base for the guaranteed return.

At the same time, the initial CAF right of first refusal offered to price cap carriers, in retrospect, looks quite modest. At the time, the FCC was only aiming to achieve 10/1 Mbps service. Areas already subsidized to achieve this speed are now open to new subsidies under the higher 25/3 threshold. An auction mechanism is much more likely to see a one-time upgrade that puts us on a path of permanently closing the access divide.

During the Obama administration, the FCC tested the use of a reverse auction under CAF through the Rural Broadband Experiment.[34] Following the results of the Experiment, the FCC adopted a reverse-auction procedure for Phase II of the CAF.[35] After CAF Phase II, in August 2019, the FCC began developing processes and procedures for the next round of broadband funding to be delivered through the RDOF.[36] As analyst Joseph Gillan put it in his assessment of these market-based allocation of subsidies, the "CAF II Auction demonstrates that competitive bidding systems are more efficient at extending broadband to rural areas than systems with predetermined outcomes."[37]

Lessons From Rural Digital Opportunity Fund

Composed of two separate phases, the RDOF is the most recent effort in a series of funding initiatives aimed at bridging the rural divide. Using a reverse-auction format, its Phase I pitted bidders against each other to see which would offer to connect unserved census blocks (based on Form 477 data) with robust networks at the lowest cost.[38] While the FCC originally allocated $16 billion for the auction, the bidding total ended short, at just over $9 billion.[39] The unspent funding will now roll over into the Phase II auction, which will include a total of over $11 billion to support partially served census blocks and any areas missed by the Phase I auction.[40]

During the Phase I auction, 180 bidders participated in hopes of gaining support to serve up to 5.2 million locations.[41] Of the winners, three have been initially awarded over $1 billion, with Elon Musk's SpaceX securing a fourth-place finish with over $885 million.[42]

The results of the auction represent a new success for LEO satellites as a competitor for traditional broadband networks. Fixed wireless providers were also successful, accounting for six of the top ten award winners. With both satellite and fixed wireless walking away from Phase I with substantial gains, the auction points to a potential turning point in traditional broadband delivery, processes, and infrastructure, which have historically been dominated by large telecommunications providers. The RDOF's funding streams to new broadband opportunities may help rural areas overcome legacy infrastructure issues.

Limited detail is required up-front during the auction process, and it is not initially clear whether each winning bidder's technology will actually be able to deliver on its promises. Without requiring detailed information (provided during the long-form process), winning bidders may have bitten off more than they can chew.[43] In particular, some fixed wireless providers have claimed to be able to provide gigabit speeds, when the realization of such speeds consistently is simply unrealistic.

Another notable result from the initial RDOF winners is the strong showing by gigabit-performance networks. While the program aims to remain technology neutral, the Phase I auction rightly featured a weighting system to give an advantage to bidders that could offer higher-performance networks. In effect, this meant penalties to those unable to provide very high-speed

networks.[44] As a result, "nearly all RDOF auction winners (99.7%) have committed to deploying service at speeds of at least 100/20 Mbps, with 85% getting gigabit broadband."[45]

Figure 4: RDOF performance weighting[46]

Performance Tier	Speed	Monthly Usage Allowance	Weight (Penalty)
Minimum	≥ 25/3 Mbps	≥ 250 gigabytes (GB) or U.S. average (whichever is higher)	50
Baseline	≥ 50/5 Mbps	≥ 250 GB or U.S. average (whichever is higher)	35
Above Baseline	≥ 100/20 Mbps	≥ 2 terabytes (TB)	20
Gigabit	≥ 1 Gbps/500 Mbps	≥ 2 TB	0
Latency	**Requirement**		**Weight (Penalty)**
Low	≤ 100 ms		0
High	≤ 750 ms & Median Opinion Score ≥ 4		40

While higher-speed broadband is general preferred, higher speeds often come with a trade-off in terms of cost, as they require deploying additional new infrastructure rather than simple upgrades or extension of fiber. There are a few possible explanations for the strong showing of gigabit services: It is possible that the cost trade-off of deploying fiber is not as high as previously thought. Put another way, the cost savings of incremental upgrades may not be sufficient to remain competitive. Phase I of the RDOF is focused on completely unserved census blocks, so it is likely that these areas require completely new deployments, in which case fiber often makes the best sense. For future subsidized deployments, there will be much more focus on locations wrongly considered served under previous data. These areas are necessarily near existing deployments, meaning incremental upgrades or extensions of existing access networks will likely be more cost competitive.

It is also possible that the RDOF weighting is inappropriately tilted toward higher speeds. Again, economic evidence indicates that the important benefits come from having broad adoption at any speed, rather than considerably higher speed. The most taxing applications in terms of bandwidth are generally very high resolution, high frame-rate video—lower speeds are unlikely to lock subsidy beneficiaries out of transformative applications. Policymakers should consider a more gradual weighting system that does not penalize speeds below one gigabit as harshly as did Phase I of the RDOF.

Another very possible explanation is that bidders embellished the speeds they would be able to achieve in order to stay competitive in the auction. Bidders, especially those claiming to achieve gigabit performance over fixed wireless, may struggle to provide such speeds consistently to the designated census blocks. The large number of new entrants with limited experience in the telecommunications space is a real concern.[47] Without built-in experience and economies of scale enjoyed by established firms, new entrants may find projects more difficult than

anticipated. The results of the RDOF demonstrate the clear need to leverage an expert agency when evaluating the viability of projected bids.

These concerns are shared by the over 100 members of Congress who called upon "the FCC to validate that each provider in fact has the technical, financial, managerial, operational skills, capabilities, and resources to deliver the services that they have pledged for every American they plan to serve."[48]

Even for those "experienced" bidders that were successful in Phase I, several have a history of financial trouble and the inability to deliver as promised. Frontier and Lumen Technologies recently disclosed that they may be behind on commitments made during the last high-cost auction: the CAF Phase II.[49] Meanwhile, LTD, the RDOF's largest Phase I winner with over $1 billion, "defaulted in a previous [FCC] auction."[50] It remains to be seen whether these winners will be able to fulfill their obligations during this second go-around, or if the FCC will continue with this support; but policymakers should consider building-in guardrails limiting participation of either untested companies or those that have failed to live up to previous high-cost support obligations. The FCC should also avoid giving support that would require dramatically increasing the size and operations of any particular winner.

In designing any future program, policymakers should use a reverse auction, which has been shown to find those willing to build networks at a much lower cost than legacy support mechanisms. However, the specifics of the auction process should be scrutinized to ensure the appropriate conditions are in place to enable successful execution of deployment funding. While the RDOF has shown that procurement auctions significantly reduce the cost of deploying high-performance broadband, policymakers should ensure that small companies are not expected to dramatically scale up their operations or overstate achievable performance.

The success of gigabit-tier networks in the RDOF strongly indicates that there is no reason for specific set-asides for particular technologies, such as those contemplated by the Moving Forward Act. Either the auction mechanisms allow for market participants, rather than Congress, to evaluate what is realistic for a given geographic area, or the set-aside funding for gigabit-tier networks risks being gamed with bidders' rosy engineering estimates of achievable performance.

Rather than selectively approving grants or guaranteed loans for companies that know how to navigate the process, a new infusion of capital to upgrade rural broadband must be allocated through an auction process.

Rural Utilities Service Programs

USDA also administers broadband programs aimed at bridging the digital divide. The RUS programs present another opportunity to compile key insights for the development of a new broadband deployment strategy aimed at closing the digital divide. RUS includes a telecommunications program that historically faced challenges in funding effective projects. Reporter Tony Romm explained in a detailed *Politico* report that "sometimes, RUS funded high-speed Internet in well-wired population centers. Sometimes, it chose not to make any loans at all. Sometimes, RUS broadband projects stumbled, or failed for want of proper management; loans went delinquent and some borrowers defaulted."[51] In fact, a U.S. Government

Accountability Office (GAO) report from 2014 finds more than two-fifths of loans were rescinded or defaulted.[52] Anecdotally, USDA loans are often repaid with USF money.

Overbuilding, a historical problem in the broadband industry, occurred within the RUS programs as well. A sizeable portion of its grants don't end up supporting unserved rural areas, and can instead get funneled into cherry-picking arbitrageurs that overbuild lower-cost, higher-return areas that are already served.[53] For example, the Rural Broadband Access Loan and Loan Guarantee (also known as the Farm Bill Broadband Loan) only requires "15% of the households in the proposed funded service area[]" to be unserved, and allows for funding in areas with two existing providers.[54] Such overbuilding is not an efficient use of subsidies. And while the ReConnect Rural Broadband Program does not allow for overbuilding where another loan participant exists (subject to the Secretary of Agriculture's discretion), it leaves open the possibility for overbuilding in areas where privately funded providers currently operate, opening the door to cross-subsidization.[55] One RUS official once told ITIF that the reason subsidies end up funding overbuilding is because "this is where the money is."

Rather than selectively approving grants or guaranteed loans for companies that know how to navigate the process, a new infusion of capital to upgrade rural broadband must be allocated through an auction process.

Broadband Technology Opportunities Program

A third entity, NTIA, has managed a broadband deployment program as well. NTIA's BTOP was meant to "bridge the technological divide; create jobs; and improve education, health care, and public safety in communities across the country."[56] Initiated by the American Recovery and Reinvestment Act of 2009, the program delivered $4 billion of grant funding in over 200 projects, 2 of which are currently active.[57] While BTOP sought to initiate projects not already funded through other programs such as the USF and the USDA's Broadband Initiatives Program, BTOP grants were an effort to find shovel-ready projects as a stimulus.[58] "Rather than use a competitive auction … more than 1,800 providers submitted applications for awards, in what an economist might call a 'beauty pageant.'"[59]

After the recent experience from the Rural Digital Opportunity Fund and several successful iterations of awarding money from reverse auctions, policymakers could do better when developing future programs to help bridge the divide.

A recent report from the Technology Policy Institute nicely highlights the possible positive outcomes had NTIA used a reverse auction.[60] The report finds "a reverse auction might have yielded double the output with the same subsidy budget."[61] Not only would the program have benefitted from a different funding structure, but the grant-awarding process remained obscure and demonstrated the need to ensure the involvement of expert advisors to determine the feasibility of proposed projects.[62] After the recent experience from the RDOF and several successful iterations of awarding money from reverse auctions, policymakers could do better when developing future programs to help bridge the divide.

A ROADMAP TO CONNECT RURAL AMERICA ONCE AND FOR ALL

The experiences learned from programs administered across the FCC, USDA, and NTIA provide ample evidence to help build a robust broadband deployment program aimed at bridging the rural-urban divide. Such a program would involve four key steps.

Step One: Get the Maps Right

If a significant amount of money is going to be spent on broadband, precisely where and what type of infrastructure is already available will have to be determined up-front. Like so many other policy issues, there are real trade-offs when it comes to broadband-availability maps. Highly accurate broadband maps are expensive and time-consuming, and quickly become obsolete. The current maps face a number of challenges—though they are often overstated.

Tremendous ink has been spilled over the granularity of which areas count as "served." The former FCC data-collection process would count an entire census block as served if at least one addressable location within that block were served. However, as the Trump administration's NTIA comments pointed out, only "2 percent of Census blocks … exceed two square miles in land area."[63] Census blocks are a fairly granular measurement, and for many purposes, low-cost, rough-and-ready data is sufficient. However, if Congress is to allocate tens of billions of dollars to improving broadband infrastructure, high-quality maps should be expected—and could help inform a successful auction design. Certainly, this granularity previously resulted in some overcounting of areas served, and hopefully a new, large allocation of funding for rural broadband will address these previously mis-counted areas.

In any event, Congress has now both required and funded new mapping efforts by the FCC. The FCC in turn has adopted new procedures for collecting data, and is in the process of generating more-accurate maps of broadband availability.[64] All that remains is for the FCC to implement their new mapping process, which should hopefully be done quickly. Moreover, a robust challenge process should certainly be a component of any auction to ensure that subsidies do not inappropriately go to overbuilding already-served locations. A challenge process could reduce the need for perfect maps, instead relying on well-informed and incented parties to keep each other honest as to service claims.

Policymakers should consider step one of the rural broadband roadmap more or less done and focus on actually funding infrastructure legislation, with a significant amount of money dedicated to broadband.

Step Two: Large CapEx Infusion Awarded by Auction

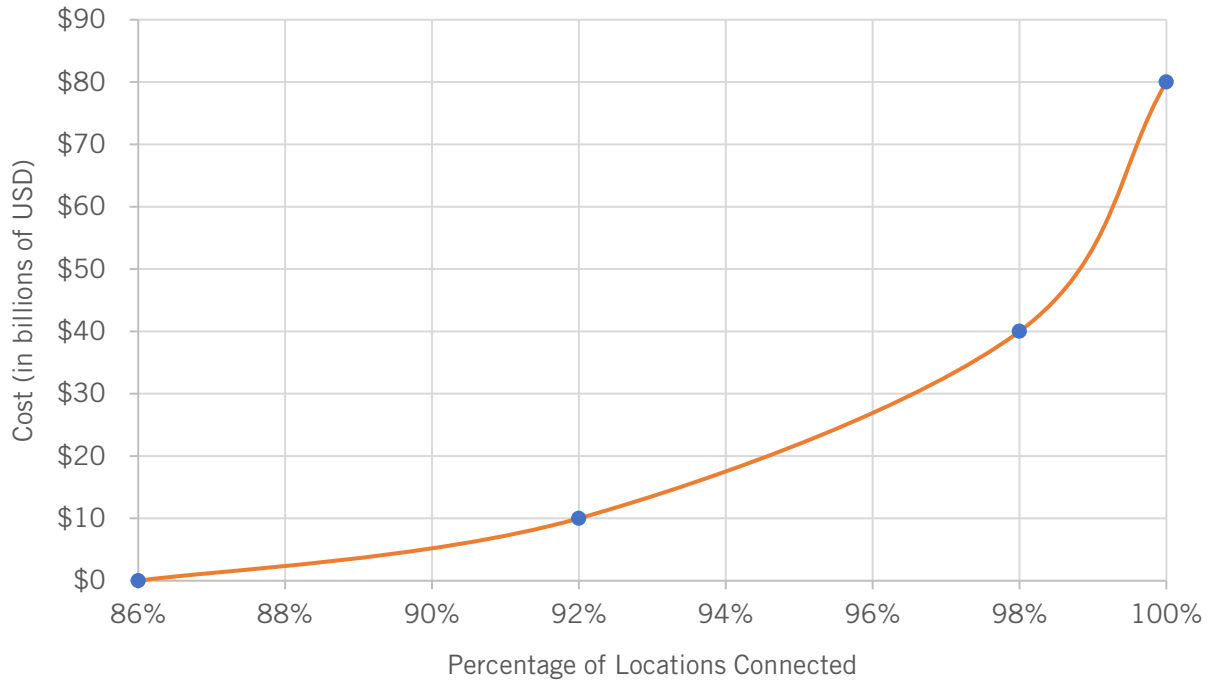
A one-time, large-scale infrastructure upgrade for rural broadband would go a long way toward closing the digital divide. As Blair Levin and Carol Mattey have convincingly argued, "Congress should consider setting aside some portion of a new infrastructure fund … for a one-time rural broadband acceleration fund."[65] A one-time, CapEx-focused fund would help reduce both the initial infrastructure hurdle and the burden on USF and the strained contribution mechanism, thereby allowing a future program for high-cost areas to taper off support for rate-of-return carriers and lessen support for operational expenditures.

The amount of funding required for a large infusion for capital expenditures depends on what level of connectivity is considered sufficient. For instance, a lot depends on what level of connectivity policymakers want to reach, as costs balloon to unreasonable levels as the target

approaches 100 percent. Various proposals have called for amounts ranging from $20 billion to $150 billion. While the specific amount will ultimately be decided by the political process, ITIF believes the appropriate amount to significantly upgrade rural networks is in the $40 billion range.[66]

An influential report from the waning days of the Obama administration estimates that it would take $40 billion to achieve 98 percent coverage with high-speed, easily upgradable networks, and another $40 billion to achieve 100 percent coverage. ITIF recommends maximizing the value of the infusion by focusing on 98 percent connectivity via terrestrial broadband. The remaining 2 percent could rely on new satellite services, which are dramatically improving with new LEO satellite services. Also, these estimates are based on of the FCC's CAF Phase II models, which overestimate the cost of providing service compared with what can be achieved via auction.

Figure 5: Estimated cumulative investment needed to increase high-speed broadband coverage[67]



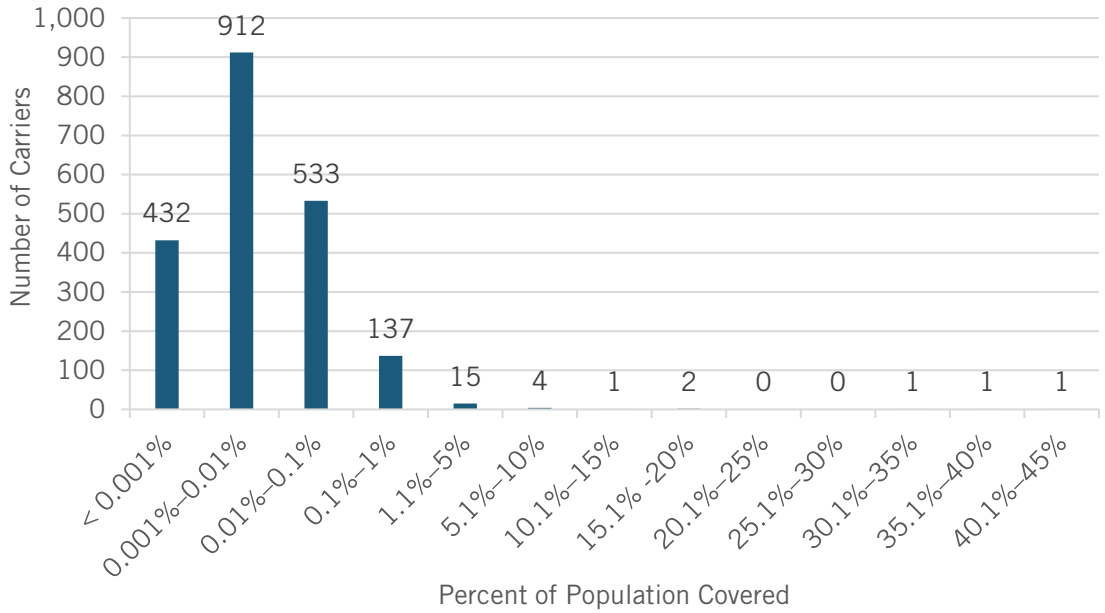
No matter the exact amount Congress chooses to allocate to rural broadband, what's important is how many locations to connect, and ensuring that it is done cost effectively.

Again, to effectively close the rural broadband gap, a large infusion of capital to expand and upgrade networks must be designed in a way that encourages large providers with significant economies of scale to participate. For too long, support for politically powerful rate-of-return carriers has seen a tremendous amount of money flowing to small, relatively inefficient firms, with little to show for it. Everyone likes the idea of a plucky, small broadband start-up, and there are several companies in every state that sell themselves as such (each Senate office likely knows theirs well). But funding thousands of tiny firms is a wildly inefficient way to solve this problem.

The ETC designation process should be eliminated. Red tape and restrictions inherent to the ETC process, which often only make sense to limit fraud from small fly-by-night operations,

discourage participation by larger carriers. Auctions should also not be hyper-scaling small providers. Instead, auction awardees should only qualify to receive a certain percentage of their current revenue. Not only would this limit the participation by tiny companies with small economies of scale, but it would also ensure that the majority of the funds go to companies with a proven track record that are likely to succeed in serving high-cost areas.

Figure 6: Number of U.S. fixed residential broadband providers by population coverage[68]



A single auction, if well designed, should see a far more effective deployment of robust networks than the current system of small ongoing payments does. As Levin and Mattey explained, funding projects through small, incremental payments means "it can take years before carriers recoup their capital investments. Thus, carriers that can earn a greater return on investment in urban areas will take an incremental approach in rural areas, slowing next-generation deployments. Another outcome of this approach is that it creates an incentive for broadband providers to make decisions based on what they believe the government will fund, rather than on what consumers want."[69]

Step Three: Allocating Funding With Appropriate Standards

Future efforts aimed at increasing connectivity should have clear and appropriate standards and optimize funding distribution. The standards for receiving funding should be technology neutral; there is no need for set-asides for fiber or gigabit-speed networks. Restricting providers to noneconomic choices would reduce the scope of deployment per dollar of subsidy.

Importantly, reverse auctions should be used to do the heavy lifting of deciding the best access technology for any given service area. Funding should focus first on unserved areas with a single provider. Here, the expertise at the FCC would be instrumental in identifying legitimately unserved areas though its improved mapping-data collection process and overseeing a robust challenge process that will help ensure subsidies do not support locations that are already served with sufficient capacity.

Auction-network performance weighting should have reasonable connectivity targets. The demand for bandwidth is not going to increase forever, so the goal should not be to "future-proof" technology, but instead to achieve the broadest possible coverage.

Separately, standards should be reevaluated for non-funded incumbents that, as a result of an auction, will no longer be the primary federal partner. [70] Many legacy regulations fall on what is known as the "carrier of last resort." If, as a result of a new infrastructure support auction, a new carrier is receiving subsidies, it makes sense to transfer these obligations or revaluate whether they are still applicable. When a new carrier takes over subsidized service of a given area, the legacy incumbent may well wish to exit the area. As industry lawyers have argued, "The [FCC] should streamline or eliminate rules that prevent carriers from discontinuing service and exiting the market where competitive alternatives exist, particularly when the competitor is being funded by the government with support previously earmarked for the incumbent."[71] Revising historical and no longer necessary exit barriers would allow for natural market movement to ensure efficient expansion of broadband deployment without burdensome costs to the overall system.

Step Four: Set Up the Program for Long-Term Success

Lastly, any future broadband program should be set up for long-term success. The program should aim for broad participation by moving away from the ETC-designation process, and encourage large companies with economies of scale to participate. Moreover, the program should rely on existing expertise to determine funding requirements. Rather than requiring participating carriers to obtain letters of credit, Congress should rely on an expert agency—the FCC—to determine the worthiness of bidders. Letter-of-credit requirements functionally funnel 1 to 3 percent of the funds to banks that are not necessarily better positioned to determine the worthiness of bidders. The program should require build-out milestones and enforcement mechanisms up-front. Additionally, it is reasonable for high-cost rural broadband to be priced higher than urban broadband, especially considering many other services (e.g., food, car insurance, housing, etc.) are priced higher in urban areas. Restrictions that tie the price of subsidized rural networks to urban equivalents should be loosened, thereby allowing for more sustainable operational expenditure recovery.

Funding will be critical to the success of any program designed to close the digital divide. The FCC should act as administrator. While it may be easier to allocate funding through a cabinet agency versus an independent one, an independent agency would have more expertise and resources to ensure an efficient and effective execution of the program. Lessons learned from previous broadband programs point to the importance of having expert advisors available to evaluate broadband proposals in order to ensure the feasibility of any new broadband project, particularly those undertaken in high-cost, hard-to-connect areas.

Policymakers should also address additional barriers to deploying broadband that would limit the effectiveness of subsidies. Pole access in particular is in need of reform. This arcane area of law is significantly fragmented, with a wide variety of pole access regimes in place across different jurisdictions. Broader implementation of a One-Touch-Make-Ready is an important opportunity. One-Touch-Make-Ready allows a single, qualified contractor to perform all of the necessary make-ready work on a given utility pole—which can include rearranging communications equipment and ensuring appropriate load and compliance. Having one party do this work all at

once (instead of each attached party individually contracting for service) could significantly speed deployment and lower costs.

In some areas, aging poles need to be replaced. Disputes over who pays for this replacement can unreasonably slow deployment, especially if the entire cost burden is placed on the entity looking to deploy badly needed service. Legislation should look to ensure costs for pole replacement are shared fairly among all those that benefit from the new infrastructure.

CONCLUSION

Congress should find the political path of compromise to connect rural America. There is clear bipartisan support to help connect rural areas. A tailored, one-time infusion of capital, allocated through a reverse auction, would help to jump-start broadband deployment and upgrades in unserved or underserved areas. By incorporating the experience and knowledge gained from decades of various broadband programs across multiple departments and agencies, policymakers have an opportunity to build a sustainable solution to better connect America. Any program should encourage cost-effective infrastructure with goals based on reasonable expectations of broadband needs and aim for broad participation in a procurement-style auctions. Through curated legislation and modernized processes, Congress and the FCC can not only promote innovation, but also help to close the rural-urban digital divide for good.

ENDNOTES

1. See "FCC Reforms High Cost Program for Rate-of-Return Carriers," 31 FCC Rcd 3087, https://www.fcc.gov/document/fcc-reforms-high-cost-program-rate-return-carriers.
2. Doug Brake and Alexandra Bruer, "Broadband Myths: Is It a National Imperative to Achieve Ultra-Fast Download Speeds?" (ITIF, November 2020), https://itif.org/publications/2020/11/16/broadband-myths-it-national-imperative-achieve-ultra-fast-download-speeds.
3. Milton Mueller, *Universal Service: Competition, Interconnection and Monopoly in the Making of the American Telephone System,* Syracuse University (2013), https://surface.syr.edu/books/18/.
4. This quotation reportedly comes from a House committee report. Mark Lloyd, "AT&T and Whatever Happened to Antitrust?" Center for American Progress (April 2006), https://www.americanprogress.org/issues/economy/news/2006/04/05/1895/att-and-whatever-happened-to-antitrust/.
5. Richard Bennett, Luke Stewart, and Robert Atkinson, "The Whole Picture: Where America's Broadband Networks Really Stand" (ITIF, February 2013), http://www2.itif.org/2013-whole-picture-america-broadband-networks.pdf.
6. "2020 Broadband Deployment Report" (Federal Communications Commission, 2020), https://docs.fcc.gov/public/attachments/FCC-20-50A1.pdf.
7. "H.R.2 – Moving Forward Act," https://www.congress.gov/bill/116th-congress/house-bill/2.
8. See Doug Brake and Alexandra Bruer, "Broadband Myths."
9. Kelly Hill, "AT&T focuses on fiber, 5G and HBO Max" (March 2021), https://www.rcrwireless.com/20210315/carriers/att-focuses-on-fiber-5g-and-hbo-max (covering AT&T's projection that the ratio of download to upload use will shift from 10:1 to 5:1 in the coming years.)
10. "The Digital Divide and Economic Benefits of Broadband Access," *Council of Economic Advisers* (March 2016), https://obamawhitehouse.archives.gov/sites/default/files/page/files/20160308_broadband_cea_issue_brief.pdf.
11. Laurel Farrer, "5 Proven Benefits of Remote Work for Companies," *Forbes* (February 12, 2020), https://www.forbes.com/sites/laurelfarrer/2020/02/12/top-5-benefits-of-remote-work-for-companies.
12. Kristin Cooke, "WFH Survey Shows Better Internet in Rural Areas Would Attract New Residents," *Satellite Internet* (October 26, 2020), https://www.satelliteinternet.com/resources/wfh-internet-survey/.
13. "Broadband-Enabled Health Technologies Can Reduce Costs and Improve Care for People With Disabilities," *Federal Communications Commission* (updated October 24, 2017), https://www.fcc.gov/general/broadband-enabled-health-technologies-can-reduce-costs-and-improve-care-for-people-with-disabilities.
14. Jared Lindzon, "Remote work can't change everything until we fix this $80 billion problem," *Fast Company* (November 30, 2020), https://www.fastcompany.com/90578964/rural-internet-broadband-access.
15. "What Is the Internet of Things?" (ITIF, 2018), http://www2.itif.org/2018-tech-explainer-iot.pdf.
16. See, e.g., Farmers Business Network (FBN), (accessed March, 2021), https://www.fbn.com/.
17. Among other findings, the paper notes "doubling the number of 25+/3+ connections per 1,000 households is associated with a 3.6% increase in corn yields, as measured in bushels per acre." Katherine LoPiccalo, "Impact of Broadband Penetration on U.S. Farm Productivity," OEA Working Paper 50, FCC (Rel. December 2020), https://docs.fcc.gov/public/attachments/DOC-368773A1.pdf.
18. See Doug Brake and Alexandra Bruer, "Broadband Myths."

19. Doug Brake, "A Policymaker's Guide to Rural Broadband Infrastructure" (ITIF, April 2017), http://www2.itif.org/2017-rural-broadband-infrastructure.pdf.
20. Ibid.
21. Doug Brake, "To Strengthen our Infrastructure, Invest in Rural Broadband," *The Ripon Society* (April 2017), https://riponsociety.org/article/to-strengthen-our-infrastructure-invest-in-rural-broadband/.
22. "Eligible Service Area," U.S. Department of Agriculture, accessed January 28, 2021, https://www.usda.gov/reconnect/eligible-service-area.
23. FCC, Broadband Progress Reports, https://www.fcc.gov/reports-research/reports/broadband-progress-reports.
24. "Universal Service," Federal Communications Commission, accessed January 22, 2021, https://www.fcc.gov/general/universal-service .
25. Ibid.
26. Data derived from FY20 quarterly filings, see "Contribution Factor & Quarterly Filings – Universal Service Fund (USF) Management Support," Federal Communications Commission, accessed January 29, 2021, https://www.fcc.gov/general/contribution-factor-quarterly-filings-universal-service-fund-usf-management-support; "Program Overview," Universal Service Administrative Company, accessed January 22, 2021, https://www.usac.org/high-cost/program-overview/.
27. "FCC Chairman Genachowski Unveils 'Connect America Fund' Proposal to Reform and Modernize the Universal Service Fund & Intercarrier Compensation System," *Federal Communications Commission* (October 6, 2011), https://www.fcc.gov/document/genachowski-unveils-connect-america-fund.
28. Other services funded through this contribution mechanism include interstate telecommunications relay services (TRS), the administration of the North American Numbering Plan (NANP), and the shared administration costs of local number portability (LNP). See FCC "Contribution Methodology & Administrative Filings," accessed March 2021, https://www.fcc.gov/general/contribution-methodology-administrative-filings.
29. "Contribution Factor & Quarterly Filings – Universal Service Fund (USF) Management Support," Federal Communications Commission, accessed January 22, 2021, https://www.fcc.gov/general/contribution-factor-quarterly-filings-universal-service-fund-usf-management-support.
30. Data from FCC, "Contribution Factor & Quarterly Filings - Universal Service Fund (USF) Management Support," https://www.fcc.gov/general/contribution-factor-quarterly-filings-universal-service-fund-usf-management-support.
31. See, e.g., State of California Public Utilities Commission, "Universal Service Fund Reform," Staff White Paper (March 2011), https://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Communications_-_Telecommunications_and_Broadband/Reports_and_Presentations/USFReformWhitePaperFINAL.pdf.
32. Blair Levin, "Trump's FCC failed on broadband access. Now, Biden's FCC has to clean up the mess," Brookings (February 2021), https://www.brookings.edu/blog/the-avenue/2021/02/02/trumps-fcc-failed-on-broadband-access-now-bidens-fcc-has-to-clean-up-the-mess/.
33. "Universal Service," Federal Communications Commission, accessed January 22, 2021, https://www.fcc.gov/general/universal-service.
34. Jonathan Chambers, "Notes from the Sandbox – The Rural Broadband Experiment Auction Results," *Federal Communications Commission* (December 24, 2014), https://www.fcc.gov/news-events/blog/2014/12/24/notes-sandbox-rural-broadband-experiment-auction-results.
35. "Connect America Fund Phase II FAQS," Federal Communications Commission, accessed January 29, 2021, https://www.fcc.gov/consumers/guides/connect-america-fund-phase-ii-faqs.

36. Ibid.
37. Joseph Gillan, "Lessons from the CAF II Auction and the Implications for Rural Broadband Deployment and the IP Transition," NRRI Insights (April 2019), https://pubs.naruc.org/pub/9F958420-E885-F843-1AEC-4D290DC9A28E.
38. "Rural Digital Opportunity Fund, Connect America Fund," *Federal Register* (March 10, 2020), https://www.federalregister.gov/documents/2020/03/10/2020-03135/rural-digital-opportunity-fund-connect-america-fund.
39. Mike Robuck, "Charter scores big in Phase I of the FCC's RDOF auction for rural broadband builds," *Fierce Telecom* (December 7, 2020), https://www.fiercetelecom.com/telecom/charter-scores-big-phase-i-fcc-s-rdof-auction.
40. "Rural Digital Opportunity Fund, Connect America Fund," *Federal Register* (March 10, 2020), https://www.federalregister.gov/documents/2020/03/10/2020-03135/rural-digital-opportunity-fund-connect-america-fund.
41. "Rural Digital Opportunity Fund Phase I Results," Federal Communications Commission (Data as of December 7, 2020), https://www.fcc.gov/reports-research/maps/rdof-phase-i-dec-2020/.
42. Mike Dano, "Here are all the winners of the FCC's $9.2B RDOF auction," *Light Reading* (December 7, 2020), https://www.lightreading.com/opticalip/here-are-all-winners-of-fccs-$92b-rdof-auction/d/d-id/765937.
43. Mike Dano, "RDOF auction results already raising questions," *Light Reading* (December 11, 2020), https://www.lightreading.com/opticalip/rdof-auction-results-already-raising-questions/d/d-id/766083.
44. "Auction 904: Rural Digital Opportunity Fund," Federal Communications Commission, accessed January 28, 2021, https://www.fcc.gov/auction/904/factsheet.
45. Joan Engebretson, "RDOF Auction Winners: Charter, SpaceX, Windstream, $9.2B for Rural Broadband Awarded," *Telecompetitor* (December 7, 2020), https://www.telecompetitor.com/rdof-auction-winners-charter-spacex-windstream-9-2b-for-rural-broadband-awarded/.
46. FCC, Report and Order, Rural Digital Opportunity Fund, WC Docket No. 19-126, (January 2020), https://docs.fcc.gov/public/attachments/DOC-361785A1.pdf.
47. Mike Dano, "RDOF auction results already raising questions,"
48. Tim Walberg et al., "Walberg Leads Bipartisan Letter to FCC on Rural Broadband Deployment," *Congressman Tim Walberg* (January 19, 2021), https://walberg.house.gov/media/press-releases/walberg-leads-bipartisan-letter-fcc-rural-broadband-deployment.
49. Joan Engebretson, "Frontier, CenturyLink Again May Have Missed CAF II Deadlines for Rural Broadband Buildouts," *Telecompetitor* (January 19, 2021), https://www.telecompetitor.com/frontier-centurylink-again-may-have-missed-caf-ii-deadlines-for-rural-broadband-buildouts/.
50. Mike Dano, "Here are all the winners of the FCC's $9.2B RDOF auction"; Mike Dano, "Incoming FCC chief could inherit RDOF boondoggle," *Light Reading* (January 20, 2021), https://www.lightreading.com/opticalip/incoming-fcc-chief-could-inherit-rdof-boondoggle-/d/d-id/766787.
51. Tony Romm "Wired to fail," *Politico* (July 28, 2015), https://www.politico.com/story/2015/07/broadband-coverage-rural-area-fund-mishandled-120601.
52. "Broadband Loan and Grant Programs in the USDA's Rural Utilities Service" (Congressional Research Service, March 2019), https://fas.org/sgp/crs/misc/RL33816.pdf.
53. Doug Brake, "A Policymaker's Guide to Rural Broadband Infrastructure."
54. "Broadband Loan and Grant Programs in the USDA's Rural Utilities Service" (Congressional Research Service, March 2019), https://fas.org/sgp/crs/misc/RL33816.pdf.
55. Ibid.

56. "Broadband Technology Opportunities Program," National Telecommunications and Information Administration, accessed January 25, 2021, https://www.ntia.doc.gov/category/broadband-technology-opportunities-program.
57. "Forty-fifth Quarterly Status Report to Congress Regarding BTOP" (NTIA, July 2020), https://www.ntia.doc.gov/files/ntia/publications/ntia_btop_45th_quarterly_congressional_report.pdf.
58. "Broadband Technology Opportunities Program (BTOP) Quarterly Program Status Report" (National Telecommunications and Information Administration, September 2013), https://www.ntia.doc.gov/files/ntia/publications/ntia_btop_18th_quarterly_report.pdf.
59. Hal Singer, "The Do's And Don'ts of Bringing Broadband to Unserved and Underserved America," *Forbes* (July 3, 2020), https://www.forbes.com/sites/washingtonbytes/2020/07/03/the-dos-and-donts-of-bringing-broadband-to-unserved-and-underserved-america.
60. Sarah Oh, "Using Reverse Auctions to Stretch Broadband Subsidy Dollars: Lessons from the Recovery Act of 2009" (Technology Policy Institute, January 2021), https://techpolicyinstitute.org/wp-content/uploads/2021/01/Oh-Reverse-Auctions-Lessons-from-BTOP-Jan-2021.pdf.
61. Ibid.
62. Gregory Rosston and Scott Wallsten, "The Broadband Stimulus: A Rural Boondoggle and Missed Opportunity" (Stanford Institute for Economic Policy Research, November 2013), https://siepr.stanford.edu/sites/default/files/publications/RosstonWallstenNov2013_6.pdf.
63. Kathy Smith et al., "Ex Parte Comments in Modernizing the FCC Form 477 Data Program, WC Docket No. 11-10," *National Telecommunications and Information Administration* (January 2, 2018), https://www.ntia.doc.gov/files/ntia/publications/ntia_comments_on_modernizing_the_fcc_form_477_data_program.pdf.
64. Joan Engebretson, "FCC Adopts New Broadband Data Collection Rules with an Accurate U.S. Broadband Map at Stake," *Telecompetitor* (July 16, 2020), https://www.telecompetitor.com/fcc-adopts-new-broadband-data-collection-rules-with-an-accurate-u-s-broadband-map-at-stake/.
65. Blair Levin and Carol Mattey, "In infrastructure plan, a big opening for rural broadband," Brookings Institution (February 13, 2017), https://www.brookings.edu/blog/the-avenue/2017/02/13/in-infrastructure-plan-a-big-opening-for-rural-broadband/.
66. See Paul de Sa, "Improving the Nation's Digital Infrastructure," FCC Office of Strategic Planning and Policy Analysis (2016), https://docs.fcc.gov/public/attachments/DOC-343135A1.pdf.
67. Ibid.
68. FCC, "Communications Marketplace Report," GN Docket No 20-60 (December 2020), at 61, https://docs.fcc.gov/public/attachments/FCC-20-188A1.pdf.
69. Blair Levin and Carol Mattey, "In infrastructure plan, a big opening for rural broadband."
70. Tony Clark and Monica Martinez, "The More Things Change, The More Things Need to Change: Why New Realities Require New Rules" (USTelecom, September 2019), https://www.ustelecom.org/wp-content/uploads/2019/09/More-Things-Change-Report.pdf.
71. Ibid.

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