

THE NTIA SHOULD CONSIDER AUTHORIZING BROADBAND VOUCHERS TO RURAL HOUSEHOLDS AND GRANTS FOR PASSIVE INFRASTRUCTURE

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The Fourth Branch project of the Mercatus Center at George Mason University is dedicated to advancing knowledge about the effects of regulation on society, commerce, and innovation. As part of its mission, the program conducts independent legal and economic analyses to assess agency rulemakings and proposals from the perspective of consumers and the public. In the past, it has published research related to broadband policy.

I welcome the opportunity to submit comments regarding the notice and request for comment about how the Office of Internet Connectivity and Growth should spend over \$48 billion of new funding.¹ The Broadband Equity, Access, and Deployment (BEAD) program offers grantees significant funds to expand broadband services in rural areas. In this comment, I propose that the National Telecommunications and Information Administration (NTIA) authorize grantees to distribute broadband vouchers to rural households, and I propose that the NTIA authorize grantees to construct “passive infrastructure”—the conduits, roadside poles, and roadside vaults on public rights-of-way. Later, I elaborate on broadband vouchers. Attached to this comment is a Mercatus Center policy brief about cost-effective public funding for passive infrastructure.²

1. National Telecommunications and Information Administration, Infrastructure Investment and Jobs Act Implementation, 87 Fed. Reg. 1122 (January 10, 2022).

2. Brent Skorup and Michael Kotrous, “Narrowing the Rural Digital Divide with Consumer Vouchers” (Mercatus Policy Brief, Mercatus Center at George Mason University, Arlington, VA, October 2020), 9–10, table A1; Korok Ray and Brent Skorup, “Smart Cities, Dumb Infrastructure: Policy-Induced Competition in Vehicle-to-Infrastructure Systems” (Mercatus Working Paper, Mercatus Center at George Mason University, Arlington, VA, October 2019).

This voucher framework has many benefits over traditional grant programs:

- *Consumer choice.* Rural broadband users determine which providers ultimately receive BEAD funds.
- *No crowding out or overbuilding.* No provider faces a competitive disadvantage owing to BEAD funding because all providers have equal access to consumers' vouchers.
- *No new mapping.* Providers need not perform time-consuming and contentious broadband mapping, given that overbuilding is precluded. Grantees can use currently available map data and maps, such as the Census Bureau's map of rural areas,³ to determine eligible geographic areas.
- *Compatibility with concurrent rural broadband programs.* No provider who participates in existing programs (such as the Rural Deployment Opportunity Fund or state programs) is penalized or excluded from receiving consumer vouchers.

The notice asks, "How can NTIA ensure that all potential subrecipients, including small and medium providers, cooperatives, non-profits, municipalities, electric utilities, and larger for-profit companies alike have meaningful and robust opportunities to partner and compete for funding under the programs?"⁴

One way to ensure robust and fair participation by all sizes and types of internet access providers is for the NTIA to authorize, and for state grantees to distribute, broadband vouchers to rural households. For instance, in two years of distributing broadband vouchers to rural households in the United Kingdom, nearly 90 percent of funding has gone to small providers.⁵ The BEAD program's statutory language about use of broadband funds is broad and seems to permit vouchers to households.⁶ Such a voucher, if authorized, would operate much like the FCC's Affordable Connectivity Program, a \$30–\$75 monthly benefit to low-income households.⁷

If the NTIA were to authorize voucher programs, state and local BEAD grantees could identify unserved or underserved geographic areas and issue vouchers to every household in those areas. With a voucher, households could simply choose the internet service provider that works best for them—whether it is a rural cable company, wireless internet service provider, phone company, electric co-op, satellite company, or cellular provider. There would be no subsidizing of monopolists and no risk of anticompetitive overbuilding.

Providers—whether large or small, for-profit or nonprofit—would compete to be the recipient of those households' BEAD-funded monthly bill credits. Regional and local governments

3. "At the time of the 2010 Decennial Census, almost 60 million people, about 19 percent of the population, lived in rural areas of the United States." "Rural America," Census Bureau, accessed January 24, 2022, <https://mtgis-portal.geo.census.gov/arcgis/apps/MapSeries/index.html?appid=49cd4bc9c8eb444ab51218c1d5001ef6>. The Census Bureau generally defines a town, village, or area as rural if it has a population less than 2,500. "2010 Census Urban and Rural Classification and Urban Area Criteria," Census Bureau, last updated October 8, 2021, <https://www.census.gov/programs-surveys/geography/guidance/geo-areas/urban-rural/2010-urban-rural.html>.

4. National Telecommunications and Information Administration, Infrastructure Investment and Jobs Act Implementation, 87 Fed. Reg. 1122, 1124 (January 10, 2022).

5. UK Government, Department for Culture, Media, and Sport, *Broadband Connection Voucher Scheme Impact and Benefits Study*, August 2017, 6.

6. "An eligible entity may use grant funds received under this section to competitively award subgrants for any use determined necessary by the Assistant Secretary to facilitate the goals of the Program." Infrastructure Investment and Jobs Act, H.R. 3684, 117th Cong. § 60102(f)(6) (2021).

7. "Affordable Connectivity Program," Federal Communications Commission, last updated January 21, 2022, <https://www.fcc.gov/acp>.

could easily supplement or match the BEAD funds with local funding, much like is done under the UK voucher program,⁸ increasing the voucher amount to rural households.

State and national governments have successfully used broadband vouchers. At least two states—Alabama and Delaware—have used Coronavirus Aid, Relief, and Economic Security Act funding to create broadband voucher programs that extend broadband coverage to households with students. Under the Delaware voucher program, AT&T, Comcast, Mediacom, and Verizon have provided landline service and mobile hotspots to eligible households with students.⁹ More than 20,000 students have benefited.¹⁰ Alabama’s emergency broadband voucher program for students began in the summer of 2020 and within 10 months connected over 200,000 students.¹¹ Program costs were lower than expected and participation by small phone and electric co-ops was significant.¹²

A common objection to broadband vouchers is that they cannot induce buildout to unserved areas. Nevertheless, the experience of a vouchers program in the United Kingdom suggests that vouchers encourage service expansion to rural areas. The United Kingdom established a rural voucher program around 2014, and providers found “great success” in voucher take-up by encouraging neighbors and communities to pool their vouchers together and commit to a fixed term of service (for instance, a one-year agreement).¹³ Voucher pooling is now required by the UK government, and that reliable stream of new revenue and customers induces providers to build out to new areas, with fiber optics in many cases.¹⁴

In a 2020 study, Michael Kotrous and I illustrate how a rural voucher program could operate.¹⁵ That study is attached. We estimate that, with \$4.6 billion annually, regulators could assign a sizable voucher—between \$5 and \$45 monthly—to every rural household in the United States.¹⁶ The BEAD program dedicates \$42.5 billion to rural broadband deployment, so our study shows that the BEAD program could fund a large national voucher program over 10 years.

8. Mark Jackson, “Gov Hails £22m Top-Up for UK Rural Gigabit Broadband Vouchers,” *ISP Review*, September 12, 2020.

9. Delaware Department of Technology and Information, *Connect Delaware—Needs Assessment*, n.d., 4.

10. Delaware Department of Education, *American Rescue Plan ESSER Funding*, July 13, 2021, 8.

11. Trisha Powell Crain, “Alabama Internet Voucher Program for Students Extended through Spring 2021,” *AL.com*, December 28, 2020; “Over 200,000 Alabama students were connected to broadband service through the ABC for Students Program.” Alabama Broadband Connectivity for Students (website), accessed January 24, 2022, <https://abcstudents.org/>.

12. “Over the summer time, state officials expected the program to cost \$400 per student. Current estimates . . . peg it at closer to \$225 per student.” Brian Lyman, “State Officials Hope for Extension of Broadband Student Voucher Program,” *Montgomery Advertiser*, November 26, 2020. The *Times-Journal* of Fort Payne, Alabama, lists several participating rural phone and electric co-ops. “Alabama Broadband Providers Connecting Eligible K–12 Students This Fall,” *Times-Journal*, September 4, 2020.

13. UK Government, Department for Culture, Media, and Sport, Supplier Guidance: Gigabit Broadband Voucher Scheme, November 7, 2018, 7. “Residents are asked to commit to ordering a full fibre service from a provider of their choice for at least 12 months once the new network is available.” Openreach, “Cambridgeshire Residents Urged to Pool Government-Backed Vouchers to Secure Ultrafast Broadband,” news release, February 2, 2021, <https://www.connectingcambridgeshire.co.uk/2021/02/cambridgeshire-residents-urged-to-pool-government-backed-vouchers-to-secure-ultrafast-broadband/>.

14. “Residents of the village of 55 properties—including five farms and around 20 other small businesses—clubbed together to pool vouchers provided through the government’s £200m Rural Gigabit Connectivity (RGC) programme.” Alex Scropton, “Buckinghamshire Village Pools Broadband Vouchers to Fund Full-Fibre Dig,” *Computer Weekly*, July 8, 2019. “After circulating leaflets and door-knocking to get the required buy-in, some 30 houses agreed to apply for vouchers via Openreach. The system went live in early 2020 and final connections were completed in May.” “How Connected Was My Valley?,” Gigabit Broadband Voucher Scheme, accessed January 24, 2022, <https://gigabitvoucher.culture.gov.uk/for-businesses/case-studies/how-connected-was-my-valley/>.

15. Skorup and Kotrous, “Narrowing the Rural Digital Divide.”

16. Skorup and Kotrous. Using Census Bureau data from 2010, we estimate that there are around 23.2 million households in rural areas. Skorup and Kotrous, 10, table A1.

A handful of states have shown interest in and the capacity to operate a broadband voucher program, and the NTIA should permit and encourage states to consider a rural voucher program. The BEAD program’s statutory language seems broad enough to authorize voucher programs. The NTIA should consider allowing grantees to use BEAD program funds to upgrade and extend broadband networks in rural areas. Given the real-world experience of voucher programs, large and small providers would participate and expand their network coverage.

ATTACHMENTS (2)

Brent Skorup and Michael Kotrous, “Narrowing the Rural Digital Divide with Consumer Vouchers” (Mercatus Policy Brief)

Korok Ray and Brent Skorup, “Smart Cities, Dumb Infrastructure: Policy-Induced Competition in Vehicle-to-Infrastructure Systems” (Mercatus Working Paper)



Narrowing the Rural Digital Divide with Consumer Vouchers

Brent Skorup and Michael Kotrous

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Rural broadband became an issue of national conversation in January 2018 when President Trump signed an executive order instructing agencies to prioritize pro-deployment policies in rural areas.¹ Further, recently in the wake of nationwide school and business closures in 2020, millions of Americans have found themselves more reliant than ever on home broadband service in order to engage in remote work or distance learning. This has made measures to close the rural “digital divide”—the gap between wealthier, urban households and poorer, rural households in broadband service quality—more urgent for policymakers and industry members. Congressional leaders and the Trump administration, for instance, have identified rural broadband support as a priority of proposed coronavirus relief legislation.²

Congress has debated and legislated rural telecommunications funding before. The Telecommunications Act of 1996 added a statutory “universal service” objective that the Federal Communications Commission (FCC) ensure that telecom services in rural areas (1) “are reasonably comparable to those services provided in urban areas” and (2) “are available at rates that are reasonably comparable to rates charged for similar services in urban areas.”³ Congress required interstate telecommunications providers to set aside a portion of their revenues to subsidize, according to FCC guidance, telecommunications in rural areas consistent with these statutory objectives.⁴

Since 1996, the FCC, regardless of which party has led it, has determined that rural areas don’t have reasonably comparable services to urban areas. In 2018, for instance, 98 percent of urban households had access to fixed, high-speed broadband (typically via coaxial cable or fiber-optic lines), but only 78 percent of rural households had access to such services.⁵ The rural digital divide persists, even though efforts to close it have received bipartisan support and substantial public

public outlays. Over two decades, the federal government has granted more than \$100 billion in subsidies to telecommunications and broadband providers in high-cost areas under the Universal Service Fund's (USF's) Connect America Fund program, also known as High-Cost Support.⁶

We argue that the structure of rural broadband support programs merits change. The digital divide, while shrinking, requires a new approach to minimize wasteful overhead spending, complex eligibility requirements for providers, and substantial inequities in fund disbursements between similarly situated states and regions. Congress has delegated funding decisions to the FCC, which has delegated disbursement decisions to the private Universal Service Administrative Company, which has relied on a proprietary model developed by another private firm to define major program funding mechanisms.⁷ These convoluted subsidy programs, which have built up over 25 years, defy accountability to the public and government auditors.

As an alternative to directly subsidizing telecom providers in rural areas through these complex mechanisms, we propose that the FCC convert most High-Cost Support into a broadband voucher program for rural households. Essentially, the rural telecom subsidy programs should resemble Lifeline, the long-running program which credits \$9.25 toward every eligible low-income user's monthly smartphone or phone bill. By converting High-Cost Support into a voucher program, tens of millions of rural households could receive a substantial monthly rebate on their broadband and wireless bills. Using today's High-Cost Support budget to illustrate the principle, we show that every rural household in the United States could receive between \$5 and \$45 per month (\$60 to \$540 annually) depending on how High-Cost Support funding is currently disbursed among the states. If participation by eligible households resembles participation rates in Lifeline, these rebates could be higher.

This rural broadband voucher idea has circulated for years. Rural broadband vouchers have proved popular in the United Kingdom and are gaining attention in the United States.⁸ The idea was recently endorsed, for instance, by Pennsylvania's Communications and Technology Committee.⁹ Former FCC Commissioners Mignon Clyburn and Robert McDowell, a Democrat and a Republican, respectively, in May 2020 called for a temporary \$100 voucher program for households struggling to pay bills because of the COVID-19 pandemic.¹⁰ Telecommunications experts Blair Levin and Larry Downes endorsed a similar temporary voucher program that same month.¹¹ Finally, a novel broadband policy was recently announced in Arkansas that resembles a broadband voucher: in July 2020, Governor Asa Hutchinson created a statewide program that would use \$10 million in federal funding from the Coronavirus Aid, Relief, and Economic Security (CARES) Act to provide wireless hotspots (and internet access) to up to 20,000 homes with children for two years.¹²

Rather than propose a new law and new funding, we apply this idea using today's High-Cost Support budget and current law as constraints. First, we summarize the state of the rural-urban broadband deployment gap. Second, we highlight deficiencies with the current subsidy programs, particularly their complex structure, perverse incentives, and inequitable disbursements. Finally, we illustrate

a simple consumer voucher scheme using today’s High-Cost Support subsidies. Though a voucher program would represent an abrupt policy change, it would accomplish statutory goals while being less costly to administer and more transparent than today’s broadband subsidy programs.

THE STATE OF THE DIGITAL DIVIDE

Rural broadband deployment has improved considerably in the past few years. The FCC tracks the number of people in rural and urban areas who lack options for fixed, high-speed broadband (25 megabits per second or greater) . In 2013, according to the FCC, most Americans living in rural areas in the 50 states—nearly 32 million people—had no fixed, high-speed options.¹³ By 2018, those numbers had shrunk to just 22 percent of the total rural population in the 50 states—over 14 million people—with no fixed, high-speed options.¹⁴ As the FCC acknowledges,¹⁵ the agency does not measure how much of this coverage expansion is caused by the disbursement of High-Cost Support funding;¹⁶ much of the broadband expansion into rural areas in recent years has been from unsubsidized cable operators.¹⁷

Nevertheless, high-speed buildout in rural areas lags behind the buildout occurring in urban areas. In 2013, for instance, only 8 percent of urban residents in the 50 states and the District of Columbia—just over 20 million people—had no fixed, high-speed options.¹⁸ At the end of 2018, only 2 percent of urban residents, about 4 million people, had no fixed, high-speed options.¹⁹ That gap—22 percent in rural areas having no options versus 2 percent in urban areas having no options (or about 10 million more rural people having no options, in absolute terms)—is the rural digital divide.

In total, about 6 percent of US households lack fixed, high-speed options.²⁰ However, bringing landline services (namely, fiber optics) to those final few unconnected homes raises costs exponentially, likely exceeding \$30,000 per subscriber.²¹ According to 2017 FCC estimates, providing fiber broadband to the last 2 percent of US households would cost \$40 billion up front and require \$2 billion of subsidies annually for operational costs.²² Since the Telecommunications Act of 1996 instructs the FCC to ensure that telecommunications rates and service options in rural areas are “reasonably comparable” to those of urban areas, the FCC will continue to disburse billions of dollars annually to narrow that urban-rural gap. Before spending those billions, the FCC should consider whether existing programs are up to the task of bringing broadband to the most rural households in a fiscally responsible way.

DEFICIENCIES WITH HIGH-COST SUPPORT

While the COVID-19 pandemic has brought the digital divide into the limelight, a tremendous amount of public resources, over \$100 billion, has been spent to connect rural households to telecommunications service over the past two decades.²³ Under High-Cost Support, the FCC distributed about \$4.8 billion dollars to providers in 2018 with the aim of stimulating rural broad-

band deployment, about 30 percent more than the \$3.7 billion in High-Cost Support funding disbursed in 2001, adjusted to 2018 dollars.²⁴ While drafters of the relevant statutes believed subsidies would eventually decrease,²⁵ deployment costs rise exponentially as the percentage of households served increases,²⁶ which makes the goal of reasonably comparable services and rates in rural areas extremely costly to achieve.²⁷

Inefficient Funding Design

When Congress passed the Telecommunications Act of 1996, Congress left the particulars of the USF to the FCC. The FCC chose to require telecommunications providers to pay into the fund on the basis of the amount of their long-distance phone revenues.²⁸ As a result, USF programs currently suffer from a puzzling and counterproductive funding design: retail rates subsidized by long-distance telecommunications revenues.²⁹

This funding design extends what had occurred before the AT&T breakup: regulators reducing local phone rates by shifting long-distance revenues to local phone companies. As Milton Mueller points out, this cross-subsidization policy was more an accident of history driven by political realities than a coherent universal service policy. State lawmakers, who regulated intrastate phone rates that were highly visible to consumers, had more success in driving down local phone rates than the FCC, which regulated interstate phone rates, had in driving down long-distance phone rates. In the years preceding the AT&T breakup and the Telecommunications Act of 1996, local phone services were increasingly subsidized by long-distance revenues.³⁰

Excessive Complexity

High-Cost Support has numerous moving parts in its funding model. When the FCC introduced the Connect America Cost Model a few years ago, for instance, which represented a major change to the program, the commission noted that the model is “considerably more complex . . . and relies on more extensive data sets” than prior funding models.³¹ According to FCC documents, modelers participated in workshops for 10 months to incorporate “twenty-eight topics related to economic and engineering assumptions and input values” into the initial Connect America Cost Model.³² Constructing the model took an additional 16 months and 11 further iterations to complete.³³ Furthermore, elements of this model are nonpublic and subject to protective orders, which makes independent review and validation difficult.³⁴

The FCC’s bespoke funding model incorporates highly specific inputs—occasionally modified at the level of individual rural telecommunications companies³⁵—which drove the more than two years of development, derivative models, and regulatory overhead described later.³⁶ The result is a model that, per the FCC, includes “assumptions about literally hundreds of individual inputs.”³⁷ This complexity in design drives some of the inexplicable disbursements and overhead waste.

Inequity in Disbursements

There is currently substantial variance in the distribution of High-Cost Support funding among the states. Given the other weaknesses of the program, this variance suggests a distorted funding system where providers serving a small number of households receive a disproportionate amount of subsidies. Some variance in benefits is to be expected given differences in population density and geography among the states. However, a handful of states see huge amounts of High-Cost Support funding flow in.

For instance, Alaska received over \$2,100 in High-Cost Support funding per rural household in 2018. By contrast, Rhode Island received \$0.76 per rural household in 2018.³⁸ This disparity exists despite the fact that increasing the total amount of subsidy support per household has little effect on overall penetration rates.³⁹

These excessive disparities are likely caused by the existing subsidy model formulas, which incorporate the costs to provide landline service in low-population areas. Other inequities abound. Pennsylvania residents, for instance, have in recent years seen \$800 million in federal USF fees (on net) leave the state despite Pennsylvania facing significant rural deployment challenges.⁴⁰ In 2018, less than half of the estimated \$384 million in USF fees collected from Pennsylvania residents was used to support Pennsylvania telecom providers participating in the four USF programs, including High-Cost Support.⁴¹

States with similar numbers of rural households and similar geography have hard-to-explain discrepancies in High-Cost Support funding. For instance, Alabama has about 34 percent more rural households than Mississippi and similar geography, yet the providers serving rural Mississippi received almost two times as much total High-Cost Support funding as the providers serving rural Alabama in 2018. Similarly, New Hampshire has about 30 percent more rural households than neighboring Vermont, yet providers in Vermont received over 60 percent more total High-Cost Support funding for rural broadband. Table A1 in the appendix shows our estimate of rural USF support per rural household for all 50 states in 2018.

Excessive Overhead

These disparities do not necessarily mean that customers in states such as Alaska, with greater amounts of subsidies per rural household, are benefiting meaningfully more than those in states such as Rhode Island, with low subsidy-to-rural-household rates. Much of the subsidies never result in increased deployment for rural customers because the subsidies are spent on regulatory compliance and firm overhead. The design of High-Cost Support encourages significant waste and excess, despite regular efforts by the FCC to reform and restructure the program.

Scott Wallsten estimates that of all High-Cost Support subsidies between 1998 and 2008, 59 percent went to eligible providers' "general and administrative expenses."⁴² With expenditures under

High-Cost Support totaling around \$45 billion over those 10 years, that means about \$26 billion was directed to overhead expenses, not to capital upgrades and network expansion. Even the estimates of spending on capital improvements should be viewed skeptically. Three studies of carriers receiving High-Cost Support funding in the 1990s and early in the following decade indicate that carriers were inflating their fixed costs in order to receive more subsidies.⁴³ This “goldplating” technique—using public funds to make eligible but unneeded network upgrades—is difficult to identify and estimate. Poor oversight and a lack of measurement for analysis of program effectiveness remain problems with contemporary USF funds.⁴⁴

BROADBAND VOUCHERS PUT CONSUMERS IN CHARGE

An alternative mechanism for the federal government to encourage broadband adoption in high-cost rural areas is to offer broadband vouchers that households could use as an internet coupon. Subsidizing consumers, rather than providers, would better align the program with economic theory and the principles of public finance. Three factors are relevant for this proposed change:

1. high-speed broadband is near universal, exceeding 90 percent coverage of US households;
2. the costs of extending fiber broadband to the last small percentage of households rise exponentially; and
3. wireless solutions such as fixed wireless, cellular, and satellite broadband are increasingly a substitute for wired broadband.

In practical terms, vouchers reduce the risk of disbursements being used for gold-plated services or being sunk in inflated operating costs. Vouchers also allow consumers to purchase cellular, fixed-wireless, and satellite broadband subscriptions, which provide service in rural areas at much lower costs than fiber-optic broadband but have been historically excluded from FCC programs to serve high-cost areas.

We illustrate how a tiered voucher system could be established, using the High-Cost Support disbursements across the United States in 2018 as a benchmark.⁴⁵ Rural households in states that have received the most support historically (on a per-rural-household basis) receive the biggest coupons in our proposal. Historically, High-Cost Support subsidies have been based in part on “ruralness” and actual costs of buildout (i.e., areas receive more funding as the geographic distance between subscribers increases).⁴⁶ Any rural telecommunications subsidy plan needs to recognize that rural households in a state such as Montana cost more to serve on average than rural households in Connecticut, and our tiered program does so by classifying today’s high-subsidy states in tier 1 and today’s low-subsidy states in tier 6. Also, there are statewide reliance interests that would be undermined by a sudden move toward strictly equal support among rural households across the states. The disparities we discussed earlier cannot be eliminated overnight, but in time some of the more puzzling disparities (like Alabama vs. Mississippi) should be smoothed.

Basing our calculations on the total High-Cost Support disbursements of \$4.6 billion to the 50 states in 2018 and assuming 100 percent uptake among rural households in each state,⁴⁷ we find that rural households in Alaska, Kansas, Montana, North Dakota, and South Dakota could be eligible for a monthly discount of up to \$45, and rural residents in the remaining tiers of states would be eligible for \$30, \$19, \$13, \$9, and \$5 monthly coupons.⁴⁸ We arrive at these amounts by grouping like states together (based on historical disbursements) and stipulating that total voucher program costs would be equal to or slightly less than the current High-Cost Support budget. Table 1 shows the proposed tiers and states eligible for each tier.

A \$5 monthly coupon may not seem like much for rural residents of the lowest-tier states (mostly small states in the Northeast), but the \$39 million those states receive under our plan (again, if uptake equals 100 percent) represents a big increase over the current subsidy level to those states, which was about \$4 million in 2018. The FCC’s Connect America Cost Model assumes average revenue per user of \$75 monthly,⁴⁹ which means that our most generous voucher—\$45 monthly—reduces rural households’ expected out-of-pocket expense to \$30 monthly.

Overall, the voucher system would be much more equitable among the states. A consumer voucher ensures that public funds are not spent disproportionately on a tiny percentage of rural households—a very real possibility as FCC subsidies under the current system increasingly go to the remaining households that are most expensive to serve.

Table 1. Structure of \$4.6 Billion Broadband Voucher Program for Rural Households		
TIER	MONTHLY COUPON	STATES
Tier 1	\$45	Alaska, Kansas, Montana, North Dakota, South Dakota
Tier 2	\$30	Arizona, Iowa, Minnesota, Mississippi, Nebraska, New Mexico, Oklahoma, Utah, Wisconsin, Wyoming
Tier 3	\$19	Arkansas, California, Colorado, Idaho, Illinois, Kentucky, Missouri, Nevada, Oregon, Texas
Tier 4	\$13	Alabama, Georgia, Hawaii, Indiana, Louisiana, South Carolina, Vermont, Virginia, Washington, West Virginia
Tier 5	\$9	Florida, Maine, Maryland, Michigan, New Hampshire, New York, North Carolina, Ohio, Pennsylvania, Tennessee
Tier 6	\$5	Connecticut, Delaware, Massachusetts, New Jersey, Rhode Island

Note: To establish tiers of support for rural households, we use FCC data on 2018 High-Cost Support disbursements for each state. We estimate the number of rural households in each state by dividing each state’s total rural population by its average household size. Sources: Authors’ calculations. **High-Cost Support Disbursements:** Federal Communications Commission, *Universal Service Monitoring Report*, 2019. **Total Rural Population:** Census Bureau, “Summary File 1” (dataset), 2010 Decennial Census, accessed June 26, 2020, <https://data.census.gov/cedsci/table?q=urban%20and%20rural&g=0100000US.04000.001&tid=DECENNIALSF12010.P2&vintage=2010&hidePreview=true&tp=true>, table P2. **Average Number of People per Household:** Census Bureau, “5-Year Estimates Detailed Tables” (dataset), 2018 American Community Survey, accessed June 26, 2020, <https://data.census.gov/cedsci/table?q=B25010%3A%20AVERAGE%20HOUSEHOLD%20SIZE%20OF%20OCCUPIED%20HOUSING%20UNITS%20BY%20TENURE&g=0100000US.04000.001&tid=ACSDT5Y2018.B25010&hidePreview=true&tp=true&moe=false&vintage=2018&y=2018>, table B25010.

Consider that currently under High-Cost Support, carriers in the most supported state (Alaska) receive over 2,500 times more in disbursements per rural household than carriers in the least supported state (Rhode Island). Under our proposed voucher system, Alaska's rural households would receive only nine times more support than rural households in Rhode Island. Our proposed coupons compress those disparities (here, 9:1 rather than 2,500:1) in order to bring more equity between rural households and to give rural households incentives to use lower-cost, wireless broadband substitutes to fiber optics.

The voucher program treats all market participants equally. Subsidies are portable between competitors, and consumer preferences, not local or federal regulators, determine which providers succeed in the program. Another benefit of consumer vouchers is that they would make it administratively easier for consumers to add state USF vouchers or existing Lifeline vouchers, further reducing the out-of-pocket cost of service and increasing consumer demand for services. If participation is 50 percent or less for these vouchers, which is plausible given the participation rates in Lifeline, the program would have hundreds of millions of dollars unspent. Therefore, the FCC could either increase the subsidy to eligible households, refund subsidies to the states, or reduce USF fees. In time, the voucher program could simultaneously fulfill statutory goals and decrease public expense.

CONCLUSION

The gap in broadband access and quality between rural and urban households remains a pressing concern for state and federal policymakers, made even more urgent by the demands of social distancing during the COVID-19 pandemic. A lack of public investment or “political will” is not the reason that the digital divide persists. Up to \$100 billion has been disbursed under various rural telecommunications programs over the past two decades, but a sizable share of those subsidies has gone to overhead or gold-plating costs that divert public funds from investment that benefits underserved and unserved rural households.

In its efforts to address the digital divide amid the COVID-19 pandemic, a future FCC ought to pursue an alternative plan that provides assistance to rural households that want a broadband connection, rather than disbursing public funds with the current complex programs. A monthly broadband voucher would align consumer preferences with subsidy disbursement and simplify the current administrative processes. Accordingly, we expect that this voucher program would see considerable uptake, and it would more efficiently and equitably disburse funds among the states and residents that fund these programs.

ABOUT THE AUTHORS

Brent Skorup is a senior research fellow at the Mercatus Center at George Mason University. His research areas include transportation technology, telecommunications, aviation, and wireless policy. He serves on the Federal Communications Commission’s Broadband Deployment Advisory Committee and on the Texas Department of Transportation’s Connected and Autonomous Vehicle Task Force. He also served on the advisory committee for the Arkansas State Broadband Plan.

Michael Kotrous is a program manager for Innovation and Governance at the Mercatus Center at George Mason University. He manages research projects that focus on regulatory processes, technological innovation, and entrepreneurship, and his writings have appeared in *Politico Magazine*, *USA Today*, and *U.S. News & World Report*. Kotrous earned his BA in economics and journalism-advertising at Creighton University in 2015.

APPENDIX

STATE	RURAL USF SUPPORT (THOUSANDS)	RURAL HOUSEHOLDS (ESTIMATED)	RURAL USF SUPPORT PER RURAL HOUSEHOLD (ESTIMATED)
Alaska	\$183,794	85,885	\$2,139.99
North Dakota	\$140,261	116,761	\$1,201.26
South Dakota	\$108,351	145,240	\$746.01
Montana	\$134,876	182,595	\$738.66
Kansas	\$173,189	292,126	\$592.86
Wyoming	\$45,262	80,745	\$560.55
Nebraska	\$110,616	199,453	\$554.60
Utah	\$40,861	83,160	\$491.36
New Mexico	\$82,330	176,067	\$467.60
Iowa	\$201,286	454,813	\$442.57
Minnesota	\$215,340	569,323	\$378.24
Wisconsin	\$222,379	707,228	\$314.44
Arizona	\$75,380	242,141	\$311.31
Oklahoma	\$151,946	490,822	\$309.57
Mississippi	\$173,907	573,692	\$303.14
Nevada	\$17,408	58,490	\$297.62
Idaho	\$50,566	172,094	\$293.83
Oregon	\$83,908	289,519	\$289.82
Missouri	\$176,962	716,824	\$246.87
California	\$144,059	635,253	\$226.77

Table A1 (continued)

STATE	RURAL USF SUPPORT (THOUSANDS)	RURAL HOUSEHOLDS (ESTIMATED)	RURAL USF SUPPORT PER RURAL HOUSEHOLD (ESTIMATED)
Arkansas	\$113,567	507,273	\$223.88
Colorado	\$59,709	272,045	\$219.48
Texas	\$283,776	1,345,287	\$210.94
Illinois	\$119,548	570,301	\$209.62
Kentucky	\$148,722	725,311	\$205.05
Washington	\$85,164	420,655	\$202.46
Louisiana	\$83,914	465,734	\$180.18
South Carolina	\$109,496	613,211	\$178.56
Indiana	\$118,014	706,206	\$167.11
West Virginia	\$57,370	392,638	\$146.11
Georgia	\$114,949	891,329	\$128.96
Vermont	\$21,306	165,522	\$128.72
Hawaii	\$4,418	36,362	\$121.50
Alabama	\$90,555	767,816	\$117.94
Virginia	\$87,911	752,464	\$116.83
Michigan	\$110,050	1,009,511	\$109.01
Tennessee	\$89,610	843,028	\$106.30
Maine	\$33,602	349,708	\$96.09
Florida	\$55,575	626,968	\$88.64
Ohio	\$84,335	1,048,070	\$80.47
New York	\$62,037	903,845	\$68.64
New Hampshire	\$13,200	212,438	\$62.14
Pennsylvania	\$63,748	1,102,070	\$57.84
North Carolina	\$70,293	1,283,225	\$54.78
Maryland	\$3,610	276,862	\$13.04
Massachusetts	\$2,333	207,763	\$11.23
New Jersey	\$1,030	172,608	\$5.97
Delaware	\$228	58,134	\$3.92
Connecticut	\$439	168,959	\$2.60
Rhode Island	\$30	39,483	\$0.76
US state total	\$4,621,220	23,207,059	\$199.13

Note: High-Cost Support disbursements for each state are from 2018. We estimate the number of rural households in each state by dividing each state's total rural population by its average household size.

Sources: Authors' calculations. **High-Cost Support Disbursements:** Federal Communications Commission, *Universal Service Monitoring Report*, 2019. **Total Rural Population:** Census Bureau, "Summary File 1" (dataset). **Average Number of People per Household:** Census Bureau, "5-Year Estimates Detailed Tables" (dataset).

NOTES

1. Exec. Order No. 13821, 83 Fed. Reg. 1507 (January 8, 2018).
2. In an April 21 White House press conference, US Treasury Secretary Steven Mnuchin said, “Well, first of all, I very much appreciate the President’s support for phase four. . . . The President has been talking about infrastructure since the campaign: roads, bridges, broadband. Especially, broadband now to rural America is very important.” “Remarks by President Trump and Members of the Coronavirus Task Force in Press Briefing,” White House, April 21, 2020, <https://www.whitehouse.gov/briefings-statements/remarks-president-trump-members-coronavirus-task-force-press-briefing-3/>. See also John D. McKinnon and Ryan Tracy, “Pandemic Builds Momentum for Broadband Infrastructure Upgrade,” *Wall Street Journal*, April 23, 2020.
3. Telecommunications Act of 1996, 47 U.S.C. § 254(b) (2018).
4. 47 U.S.C. § 254(d).
5. Federal Communications Commission, “In the Matter of Inquiry Concerning Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion” (FCC 20-50, Federal Communications Commission, Washington, DC, April 2020), 19, figure 1.
6. Scott Wallsten and Lucia Gamboa, *Public Investment in Broadband Infrastructure: Lessons from the U.S. and Abroad* (Washington, DC: Technology Policy Institute, 2017), 4.
7. The FCC notes that the Wireline Competition Bureau refers parties to CostQuest when they have technical questions about disbursement amounts. Federal Communications Commission, “In the Matter of Connect America Fund High-Cost Universal Service Support” (DA 15-534, Federal Communications Commission, Washington, DC, April 22, 2014), 31.
8. Mark Jackson, “Government’s UK Gigabit Broadband Voucher Scheme Ends Today,” *ISPReview*, May 14, 2020. The UK rural broadband program provides a £1,500 voucher to homeowners and a £3,500 voucher for businesses. Resident applications and funds are pooled to make fiber-to-the-premises services economical. As of August 2020, about 45,000 applicants had been approved and nearly 30,000 had received services. “Gigabit Broadband: Rural Households Urged to Claim Upgrade Cash,” *BBC*, August 8, 2020.
9. The Pennsylvania State Senate Communications & Technology Committee called on the FCC “to transform the Universal Service Fund program into a rural broadband voucher program that would directly benefit rural customers.” Pennsylvania State Senate, Communications & Technology Committee, *Closing PA’s Digital Divide*, November 2019, 2.
10. Mignon Clyburn and Robert McDowell, “Congress Can Help America Stay Connected during the COVID Crisis,” *Morning Consult*, May 15, 2020.
11. Blair Levin and Larry Downes, “Keeping Americans Connected after ‘Keep Americans Connected’ Expires,” *The Hill*, May 18, 2020.
12. Arkansas Governor’s Office, “Governor Hutchinson Announces \$10 Million for Wi-Fi Access Devices for Arkansas Schools,” press release, July 27, 2020, <https://governor.arkansas.gov/news-media/press-releases/governor-hutchinson-announces-10-million-for-wi-fi-access-devices-for-arkan>.
13. Federal Communications Commission, “Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996, as Amended by the Broadband Data Improvement Act” (FCC 15-10, Federal Communications Commission, Washington, DC, January 29, 2015), 97, appendix D.
14. Federal Communications Commission, “In the Matter of Inquiry Concerning Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion” (FCC 20-50, Federal Communications Commission, Washington, DC, April 2020), 19, figure 1.
15. Federal Communications Commission, “In the Matter of Connect America Fund; A National Broadband Plan for Our Future; Establishing Just and Reasonable Rates for Local Exchange Carriers; High-Cost Universal Service Support; Developing an Unified Intercarrier Compensation Regime; Federal-State Joint Board on Universal Service; Lifeline and

- Link-Up; Universal Service Reform – Mobility Fund” (FCC 11-161, Federal Communications Commission, Washington, DC, November 18, 2011), 19.
16. Jerry Brito and Jerry Ellig, “Public Interest Comment on the Connect America Fund” (Public Interest Comment, Mercatus Center at George Mason University, Arlington, VA, April 15, 2011); Scott Wallsten, *How to Create a More Efficient Broadband Universal Service Program by Incorporating Demand and Cost-Effectiveness Analysis* (Washington, DC: Technology Policy Institute, September 2011).
 17. Cable operators rarely participated in High-Cost Support before 2017, but internet access subscriptions have increased in rural areas in large part because of adoption of cable broadband. Compare Federal Communications Commission, *Internet Access Services: Status as of December 31, 2014*, March 2016, 61, figure 51; and Federal Communications Commission, *Internet Access Services: Status as of December 31, 2017*, August 2019, 53, figure 48.
 18. Federal Communications Commission, “In the Matter of Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996, as Amended by the Broadband Data Improvement Act” (FCC 15-10, Federal Communications Commission, Washington, DC, January 29, 2015), 97, appendix D.
 19. Federal Communications Commission, “In the Matter of Inquiry Concerning Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion” (FCC 20-50, Federal Communications Commission, Washington, DC, April 2020), 19, figure 1.
 20. Federal Communications Commission, “In the Matter of Inquiry Concerning Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion” (FCC 20-50, Federal Communications Commission, Washington, DC, April 2020), 19, figure 1.
 21. Steve G. Parsons and James Stegeman, *Rural Broadband Economics: A Review of Rural Subsidies* (Cincinnati, OH: CostQuest Associates, July 2018), 20–23.
 22. Paul de Sa, *Improving the Nation’s Digital Infrastructure* (Washington, DC: Federal Communications Commission, 2017), 3, figure 1.
 23. Thomas W. Hazlett and Scott J. Wallsten, *Unrepentant Policy Failure: Universal Service Subsidies in Voice & Broadband* (Clemson, SC: Arlington Economics, June 2013), 6.
 24. Federal Communications Commission, *Universal Service Monitoring Report*, 2019, 21, table 1.10.
 25. Telecommunications Act of 1996, 47 U.S.C. 254 (2018).
 26. Paul de Sa estimates that exponential increases in cumulative investment are required to deploy fixed broadband in unserved locations. De Sa, *Improving the Nation’s Digital Infrastructure*, 3, figure 1. See also Parsons and Stegeman, *Rural Broadband Economics*, 20–23.
 27. When the USF was created by the Telecommunications Act of 1996, members of Congress and the Congressional Budget Office (CBO) expected it to require less public funding over time. Senator Ted Stevens said during debate on the act, “In fact, I find it interesting that the Congressional Budget Office has said that this bill will reduce the cost of universal service from the existing system by at least \$3 billion over the next five years.” 141 CONG. REC. S7,881 (1995). Arnold & Porter Legislative History, S. REP. NO. 104-104, at 210 (1995); “Over time, CBO expects . . . the total amount of [USF] subsidies necessary would decline.” Arnold & Porter Legislative History, S. REP. NO. 104-204, at 60 (1995).
 28. Federal Communications Commission, “In the Matter of Federal-State Joint Board on Universal Service” (FCC 98-67, Federal Communications Commission, Washington, DC, May 8, 2001). Other funding options include a per-line charge, a per-account charge, and a per-assigned-phone-number charge.
 29. Hazlett and Wallsten, *Unrepentant Policy Failure*, 6.
 30. Milton Mueller shows that local subscriber costs were increasingly cross-subsidized by long-distance revenues from 1965 to 1982. Milton Mueller, *Universal Service: Competition, Interconnection and Monopoly in the Making of the American Telephone System* (Washington, DC: AEI Press, 1997), 162–65.

31. Federal Communications Commission, “In the Matter of Connect America Fund; High-Cost Universal Service Support” (DA 14-534, Federal Communications Commission, Washington, DC, April 22, 2014), 6.
32. Federal Communications Commission, “In the Matter of Connect America Fund; High-Cost Universal Service Support” (DA 14-534, Federal Communications Commission, Washington, DC, April 22, 2014), 5–6.
33. Federal Communications Commission, “In the Matter of Connect America Fund; High-Cost Universal Service Support” (DA 14-534, Federal Communications Commission, Washington, DC, April 22, 2014), 7.
34. There appears to be a certification process to access the nonpublic model elements. Federal Communications Commission, “In the Matter of Connect America Fund; High-Cost Universal Service Support” (DA 14-534, Federal Communications Commission, Washington, DC, April 22, 2014), 15–16.
35. “This version . . . modified the OCNCoSize table to change the size categorization of Fremont Telephone from medium to small.” Federal Communications Commission, “In the Matter of Connect America Fund; High-Cost Universal Service Support” (DA 14-534, Federal Communications Commission, Washington, DC, April 22, 2014), 11.
36. The FCC notes “the more than two year model development process.” Federal Communications Commission, “In the Matter of Connect America Fund; High-Cost Universal Service Support” (DA 14-534, Federal Communications Commission, Washington, DC, April 22, 2014), 15.
37. Federal Communications Commission, “In the Matter of Connect America Fund; High-Cost Universal Service Support” (DA 14-534, Federal Communications Commission, Washington, DC, April 22, 2014), 19.
38. Brent Skorup, “Reform Proposals for Broadband Policy in Pennsylvania” (Testimony before the Pennsylvania Senate Communications & Technology Committee, Mercatus Center at George Mason University, Arlington, VA, September 23, 2019).
39. “At current expenditure levels, these results imply that each additional household is added to voice networks at an annual USF cost of about \$25,000 or, just factoring in the HCF expenditures, some \$14,000.” Hazlett and Wallsten, *Unrepentant Policy Failure*, 24–25; Christopher Garbacz and Herbert G. Thompson Jr., “Universal Telecommunication Service: A World Perspective,” *Information Economics and Policy* 17, no. 4 (2005): 495, 505.
40. Skorup, “Reform Proposals for Broadband Policy in Pennsylvania,” 2.
41. Providers received just over \$172 million in payments from the four USF programs in Pennsylvania in 2018, \$64 million of which came from High-Cost Support. Meanwhile, USF contributions from Pennsylvania in 2018 are estimated to total \$384 million, meaning the net dollar flow of all USF programs was about –\$212 million. Federal Communications Commission, *Universal Service Monitoring Report*, 19, table 1.9.
42. Scott Wallsten, *The Universal Service Fund: What Do High-Cost Subsidies Subsidize?* (Washington, DC: Technology Policy Institute, February 2011).
43. Sanford V. Berg, Liangliang Jiang, and Chen Lin, “Universal Service Subsidies and Cost Overstatement: Evidence from the US Telecommunications Sector,” *Telecommunications Policy* 35, no. 7 (2011): 583; Sanford Berg, Liangliang Jiang, and Chen Lin, “Incentives for Cost Shifting and Misreporting: US Rural Universal Service Subsidies, 1991–2002,” *Information Economics* 23, no. 3 (2011): 287; James O. Zolnierek, “Loop Density and Telephone Company Cost: Panel Data Evidence,” *Telecommunications Policy* 32, no. 3-4 (2008): 262.
44. “In particular, FCC has not addressed its inability to determine the effect of the fund and lacks a specific data-analysis plan for carrier data it will collect. Such analysis would enable FCC to adjust the size of the Connect America Fund based on data-driven evaluation and would allow Congress and FCC to make better informed decisions about the program’s future and how program efficiency could be improved.” Government Accountability Office, “FCC Has Reformed the High-Cost Program, but Oversight and Management Could Be Improved” (GAO-12-738, Government Accountability Office, Washington, DC, July 2012).
45. Brent Skorup, “Tech Vouchers: Putting Consumers in Control of the FCC’s \$4.5 Billion Rural Telecom Fund,” *Tech Liberation Front*, August 27, 2018.
46. High-Cost Support funding models, for instance, are driven in large part by “wire center boundaries,” which are a unit of measurement for geographic coverage by telecommunications providers, and “plant mix,” which is a function

of cheaper, aerial deployment and more expensive, underground deployment. The FCC incorporates wire center boundaries and plant mix in the Connect America Cost Model in Federal Communications Commission, “In the Matter of Connect America Fund; High-Cost Universal Service Support” (DA 14-534, Federal Communications Commission, Washington, DC, April 22, 2014), 33-36.

47. The total of \$4.8 billion in High-Cost Support disbursements in 2018 includes just over \$200 million in disbursements to American Samoa, Guam, the Northern Mariana Islands, Puerto Rico, and the Virgin Islands. The sum total of High-Cost Support disbursements in the 50 US states equals \$4.62 billion. Washington, DC, received no High-Cost Support funding in 2018. Federal Communications Commission, *Universal Service Monitoring Report*, 19, table 1.9.
48. A \$45 monthly coupon, which would reduce annual broadband subscription expenses by \$540 annually, would put this broadband voucher program on par with the “Better Broadband Subsidy Scheme” in the United Kingdom. That program allowed underserved rural households to save £350 in 2017 on installation and subscription fees, which is about \$500 in current US dollars. UK Government, *Guide to the Better Broadband Subsidy Scheme*, 2017, <https://basicbroadbandchecker.culture.gov.uk/guide-to-better-broadband-subsidy-scheme.pdf>. Those subsidies were supplemented by local or regional subsidies, £1,500 for households in Cornwall, for instance. “Alternative Solutions and Grants,” Superfast Cornwall, accessed June 26, 2020, <https://www.superfastcornwall.org/getting-connected/alternative-solutions/>.
49. Federal Communications Commission, “In the Matter of Connect America Fund; High-Cost Universal Service Support” (DA 14-534, Federal Communications Commission, Washington, DC, April 22, 2014), 14.

Smart Cities, Dumb Infrastructure

Policy-Induced Competition in Vehicle-to-Infrastructure Systems

Korok Ray and Brent Skorup

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Abstract

The coinciding development of 5G wireless technology, autonomous vehicles, and smart city applications is creating commercial demand for vehicle-to-infrastructure (V2I) systems. In theory, roadside V2I systems and sensors could provide real-time services, such as supplementary mapping information to autonomous vehicles, traffic detection, and congestion pricing. Although federal funding of V2I systems has ramped up in recent years, federal regulators have largely retreated from their top-down design of V2I services and devices. These trends—undirected government funding and private construction of V2I applications and devices—leave state and local transportation officials with powerful discretion over the construction and design of V2I systems. We describe and anticipate the tradeoffs that lawmakers, regulators, and state authorities will face as they budget for and fund V2I roadside networks. We find that public-private partnerships likely will have greater prominence in the construction of roadside V2I networks. Finally, we apply the “policy-induced competition model” to inform when public intervention into V2I funding and design is effective. We propose regulator adoption of an open access model for long-lasting roadside assets. This “dumb infrastructure” model promotes competition and innovation in V2I while minimizing use of regulator resources and public funding of networks.

JEL codes: O3, L5, R42, R48

Keywords: autonomous, infrastructure, technology, V2I, V2V, car, transportation, innovation, P3, roadside, vehicles

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**Smart Cities, Dumb Infrastructure:
Policy-Induced Competition in Vehicle-to-Infrastructure Systems**

Korok Ray and Brent Skorup

Introduction

For 25 years, federal and state transportation regulators have anticipated the widespread use of wireless systems to improve traffic, road financing, and roadway safety. Only recently has the necessary technology—including fiber optic networks, wireless networks, spectrum availability, and inexpensive devices—progressed to the point that widespread vehicle-to-infrastructure (V2I) communication is a possibility. Although federal funding of V2I systems has increased in recent years, federal regulators largely have retreated from their top-down design of V2I systems and devices. Technology and telecommunications companies are building V2I systems and devices that don't resemble earlier federal designs. These trends—government funding combined with commercial design of V2I and “smart city” applications—create uncertainty about the role of state and local transportation regulators.

V2I is related to the older vehicle-to-vehicle (V2V) paradigm, where connected vehicles communicate with other connected vehicles to increase travel efficiency and safety. Collectively, these technologies are called vehicle-to-infrastructure (V2I) technology, a subset of what transportation experts call intelligent transportation systems (ITS) and vehicle-to-everything (V2X). V2I builds on connected vehicle and V2V technology to include connected infrastructure, allowing connected vehicles to communicate not only with each other but also with roads, street signs, and intersections.

This push for more V2I systems will create more demand for rights-of-way access. Two developments have made road rights of way and “street furniture”—such as light poles and utility

poles—increasingly valuable assets for transportation technology. First, the introduction of automated vehicles onto public roads has boosted demand for high-bandwidth and supplemental wireless services such as V2I and V2X. Second, operators around the country are installing cellular and wireless devices for “smart city,” 5G, and internet-of-things services. Many of these services will include V2I services or will be installed alongside V2I-only devices and on street furniture. Technology overlap and convergence seem likely—these services all require roadside data networks and devices—and the commercial viability of these wireless services could serve to jumpstart the ITS and V2I networks that use similar inputs for deployment.

Given the quasi-public nature of roadways, rights of way, and smart city services, some form of public-private partnerships (P3s) likely will be used to deploy V2I systems.¹ We describe and anticipate the tradeoffs that lawmakers, regulators, and state authorities will face as they budget for and fund V2I and smart city systems. In particular, we provide a framework for where V2I investment should be allocated. We believe the policy-induced competition model we describe can help inform federal, state, and local transportation authorities as they consider P3s and V2I construction.

This paper proceeds as follows: The first section outlines the history of V2I in the United States, the recent government pullback from design of V2I systems, and the current capabilities of V2I networks. The next section discusses barriers to P3s and the various public-private mixes that could be effective to build and operate V2I and related infrastructure. The third section introduces “policy-induced competition” and its history in network regulation. That section also demarcates different categories of infrastructure needed for widespread V2I—basic

¹ See, e.g., Clifford Winston, *How the Private Sector Can Improve Public Transportation Infrastructure* 16–32 (Mercatus Ctr. at George Mason Univ., Working Paper, 2013) (citing transportation privatization case studies).

infrastructure, network infrastructure, and devices—and their potential for competitive entry. The paper concludes with an application of policy-induced competition to V2I infrastructure.

Background on Intelligent Transportation and V2I Systems

In 1991, Congress created the Intelligent Transportation Systems Joint Program Office, which is administered by the US Department of Transportation (USDOT).² V2I systems are the primary component of ITS. The USDOT committed at the time to develop ITS via “a top-down, systematic process”³ in which, the department said, “each component of the system” is prescribed by regulators.⁴ In the decades since, the USDOT has retreated from that regulation-intensive approach. Nevertheless, federal funding for ITS and V2I systems has increased. Today, transportation authorities wanting V2I systems can draw from federal highway programs totaling more than \$30 billion annually.⁵

The Retreat of Prescriptive Regulations

In the 1990s, ITS was developed because regulators and auto companies anticipated that V2I and connected vehicle applications would improve traffic light signaling, detect road anomalies (such as road construction and accidents), detect imminent auto collisions, and provide in-car

² FCC, In the Matter of Amendment of the Commission’s Rules Regarding Dedicated Short-Range Communication Services in the 5.850–5.925 GHz Band, WT Dkt. No. 01-90, para 6 (rel. Feb. 10, 2004).

³ DEPT. OF TRANSP., NATIONAL ITS PROGRAM PLAN: SYNOPSIS 21 (1st ed. Mar. 1995), <https://rosap.ntl.bts.gov/view/dot/2706>.

⁴ *Id.*

⁵ The National Highway Performance Program allowed \$22.8 billion in funding in FY 2017 for “[i]nfrastructure-based intelligent transportation systems capital improvements, including the installation of vehicle-to-infrastructure communication equipment.” 23 U.S.C. § 119(d)(2)(L) (2018). The Surface Transportation Block Grant Program allowed \$11.4 billion in funding in FY 2017 for “[c]onstruction of . . . infrastructure-based intelligent transportation systems capital improvements, including the installation of vehicle-to-infrastructure communication equipment.” 23 U.S.C. 133(b)(1)(D) (2018). Most of this funding will go to more traditional transportation projects, but funding toward V2I likely will increase as the benefits of V2I systems become more evident.

entertainment, as well as perform many other functions.⁶ For years, through their funding of pilot programs and tests, the USDOT and state departments of transportation (DOTs) were extensively involved in the specific design of ITS and its subsets, such as V2I and V2V technology. Despite their involvement, the complexity of wireless safety technology and the extensive infrastructure upgrades needed for ITS mean that progress has been slow. As the Government Accountability Office noted in a 2015 report to Congress, “V2I technologies are not likely to be extensively deployed in the United States for the next few decades.”⁷

The most notable ITS development—the creation of dedicated short-range communications (DSRC) technology—revealed some of the drawbacks of the top-down design approach toward ITS. After spectrum was set aside for ITS uses in 1999, the Federal Communications Commission (FCC) codified DSRC transmission standards in 2003, and DSRC device development commenced in pilot deployments of ITS.⁸ However, the USDOT perceived a slow development of DSRC devices; therefore, around 2010, the USDOT “took a lead role in the device development process.”⁹ To jump-start widespread DSRC adoption, in the waning days

⁶ See FCC, In the Matter of Amendment of Part 2 and 90 of the Commission’s Rules to Allocate the 5.850–5.925 GHz Band to the Mobile Service for Dedicated Short Range Communications of Intelligent Transportation Services, ET Docket No. 98-95, RM-9006, Report and Order, para 10 (rel. October 22, 1999) (articulating “a need for up to 32 different DSRC” functions).

⁷ U.S. GOV’T ACCOUNTABILITY OFFICE, GAO-15-775, INTELLIGENT TRANSPORTATION SYSTEMS: VEHICLE-TO-VEHICLE TECHNOLOGIES EXPECTED TO OFFER BENEFITS, BUT DEPLOYMENT CHALLENGES EXIST 16 (2015).

⁸ The FCC set aside 75 MHz of radio spectrum in the 5.9 GHz band for ITS uses in 1999. FCC, In the Matter of Amendment of Part 2 and 90 of the Commission’s Rules to Allocate the 5.850–5.925 GHz Band to the Mobile Service for Dedicated Short Range Communications of Intelligent Transportation Services, ET Docket No. 98-95, RM-9006, Report and Order (rel. October 22, 1999). In 2004, the FCC required ITS users to abide by DSRC standards. FCC, In the Matter of Amendment of the Commission’s Rules Regarding Dedicated Short-Range Communication Services in the 5.850–5.925 GHz Band, WT Dkt. No. 01-90, para 19 (rel. Feb. 10, 2004). Two years later, the FCC updated channel designations and power limits after parties petitioned for changes. FCC, In the Matter of Amendment of the Commission’s Rules Regarding Dedicated Short-Range Communication Services in the 5.850–5.925 GHz Band, Memorandum and Order, WT Dkt. No. 01-90 (rel. July 26, 2006).

⁹ U.S. DEPT. OF TRANSP., SAFETY PILOT MODEL DEPLOYMENT, 50 FHWA-JPO-16-363 (Sept. 2015). See also U.S. GOV’T ACCOUNTABILITY OFFICE, *supra* note 7, at 12 (“[T]o date, only small research deployments . . . have occurred to test V2I technologies.”). Possibly because of the nonuse of the ITS spectrum, a 2012 law opened the door to non-ITS use of the band. Middle Class Tax Relief and Job Creation Act of 2012, Pub. L. No. 112-96, § 6406, 126 Stat. 156, 231 (2012).

of the Obama administration, the USDOT proposed mandating DSRC-based V2V devices for most new vehicles.¹⁰ With widespread V2V devices, the thinking went, state and local governments would have incentives to install V2I infrastructure needed for ITS.

Today, the federal government seems ambivalent about its top-down approach to designing ITS as it freezes (or withdraws) prescriptive regulation for ITS devices while it increases funding for ITS networks. On the one hand, regulatory directives for the USDOT have changed with the change of administration in 2017. During the past few years there has been steady improvement of non-DSRC V2I technologies, such as cellular, radar, and cameras. On the other hand, there is a growing sense, noted by the Government Accountability Office and others, that the state and local transportation authorities will not have the personnel and funding necessary to install and maintain an extensive ITS system.¹¹

As a result, the USDOT is getting away from its earlier, prescriptive development of V2I. The most significant sign of this change is that the 2017 USDOT proposal to mandate DSRC V2V devices appears to have lost momentum in the federal government. The Trump administration has articulated a preference for a “tech-neutral” and deregulatory approach to ITS technologies.¹² Furthermore, USDOT-commissioned research published a few months before the proposed V2V mandate in 2016 identified technical deficiencies with DSRC.¹³ To

¹⁰ 82 Fed. Reg. 3854, 3893 (Jan. 12, 2017).

¹¹ See, e.g., U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 7, at 21–24 (“Ten experts we interviewed, including six experts from state and local transportation agencies, agreed that the lack of state and local resources will be a significant challenge to deploying V2I technologies.”).

¹² See, e.g., Joan Lowy, *Gov't Won't Pursue Talking Car Mandate*, ASSOCIATED PRESS, Nov. 1, 2017, <https://apnews.com/9a605019eeba4ad2934741091105de42>. Since fall 2017, the USDOT position on ITS spectrum has been “technology neutral, meaning in this instance, DOT doesn't favor limiting the manner in which vehicles and infrastructure communicate with each other.” Sam Mintz, *DOT Tries to Clear up Connected Car Stance*, POLITICO (Oct. 25, 2018) (quoting a USDOT statement submitted to *Politico*).

¹³ The researchers found, *inter alia*, that the current error tolerances for DSRC V2V units “will fail to provide the desired levels of intended and reliable safety benefits.” Ed Adams et al., *Development of DSRC Device and Communication System Performance Measures*, 5 REP. NO. FHWA-JPO-17-483 (May 22, 2016), <http://ntl.bts.gov/lib/60000/60500/60536/FHWA-JPO-17-483.pdf>.

preserve more technology neutrality and to avoid the premature mandate of a developing technology, the USDOT has recently paused the proposal to mandate DSRC V2V in new vehicles.¹⁴ The Federal Highway Administration policy guidance therefore encourages private deployment of V2I systems.¹⁵

An Increase in V2I Funding

Despite this pause on the V2V mandate, federal funding for V2I has spiked to up to tens of billions of dollars annually. The 2015 FAST Act, for instance, authorized V2I reimbursements and grants to state DOTs across most of its Trust Fund programs.¹⁶ The majority of federal highway funding is through the National Highway Performance Program (NHPP)¹⁷ and the Surface Transportation Block Grant Program (STBGP).¹⁸ NHPP funding for 2020 is estimated to be \$24.2 billion.¹⁹ This funding is typically allocated to state transportation officials, and the American Association of State Highway and Transportation Officials, the transportation standards body, would like to make 20 percent of US intersections V2I-capable by 2025.²⁰

¹⁴ For instance, in fall 2017, the White House’s Office of Information and Regulatory Affairs reclassified the V2V NPRM as a “Long-Term Action.” See OFF. OF INFO. AND REG. AFF., FEDERAL MOTOR VEHICLE SAFETY STANDARD (FMVSS) 150—VEHICLE TO VEHICLE (V2V) COMMUNICATION, RIN 2127-AL55 (2017), <https://www.reginfo.gov/public/do/eAgendaViewRule?pubId=201704&RIN=2127-AL55>. This classification means that no agency action is to be expected for 12 months. See Marc Scribner, *V2V Mandate Nixed*, COMPETITIVE ENTERPRISE INSTITUTE (Nov. 1, 2017), <https://cei.org/blog/v2v-mandate-nixed-dot-ends-second-most-costly-us-regulatory-proposal>.

¹⁵ FED. HIGHWAY ADMIN., 2015 FHWA VEHICLE TO INFRASTRUCTURE DEPLOYMENT GUIDANCE AND PRODUCTS (2015), https://transops.s3.amazonaws.com/uploaded_files/V2I_DeploymentGuidanceDraftv9.pdf.

¹⁶ NHPP, Highway Safety Improvement Program, Congestion Mitigation and Air Quality, Advanced Transportation and Congestion Management Technologies Deployment.

¹⁷ The NHPP allowed \$22.8 billion in funding in FY 2017 for “[i]nfrastructure-based intelligent transportation systems capital improvements, including the installation of vehicle-to-infrastructure communication equipment.” 23 U.S.C. § 119(d)(2)(L) (2018).

¹⁸ The Surface Transportation Block Grant Program allowed \$11.4 billion in funding in FY 2017 for “[c]onstruction of . . . infrastructure-based intelligent transportation systems capital improvements, including the installation of vehicle-to-infrastructure communication equipment. 23 U.S.C. § 133(b)(1)(D) (2018).

¹⁹ See FED. HIGHWAY ADMIN., *Fixing America’s Surface Transportation Act or “FAST,”* FHWA WEBSITE (Feb. 2016), <https://www.fhwa.dot.gov/fastact/factsheets/nhppfs.cfm>.

²⁰ U.S. GOV’T ACCOUNTABILITY OFFICE, *supra* note 7, at 17.

Promising Commercial V2I Applications

The parallel development of autonomous vehicles (AVs) and smart city applications has created new demands for V2I applications. A widespread ITS system requires many of the same inputs as smart city, AV, and 5G systems: namely, roadside real estate, vertical assets for device attachment, and fiber broadband networks to connect nodes and devices. A fiber-connected light pole constructed for traffic signaling, for instance, could also serve commercial firms offering 5G, WiFi, or other wireless connectivity for pedestrians, residents, city services, and connected vehicles. There are about 25 million streetlights owned by cities around the country,²¹ and 5G and smart city operators are interested in installing transmitters on many of those streetlights.²² That means, in effect, that ITS need not be limited to government funding, tolling, or ads for revenue—wireless subscriptions (as the tens of thousands of macro cell towers show) can fund network deployments.

AV companies could be one of those new enterprise subscribers to always-on roadside wireless networks. Most computer processing of autonomous vehicle functions will occur using onboard computers and sensors, such as LiDAR and radar, but autonomous car company representatives have stated that their vehicles will use V2I and smart city applications to supplement their onboard units.²³ One possible area is assistance with lane detection:

observations of lane markings are only as strong as the visibility of the markings themselves.²⁴

²¹ Matt Kapko, *Sacramento's 5G Story Dimmed by Legal Spat Involving Verizon, XG*, FIERCE WIRELESS, Nov. 12, 2018, <https://www.fiercewireless.com/wireless/sacramento-s-5g-story-dimmed-by-legal-spat-involving-verizon-xg>.

²² *Id.*

²³ Dmitri Dolgov, chief technology officer of Waymo, has made this point. See Dmitri Dolgov, *From Self-Driving Cars to a Vision for Future Mobility*, OFC PLENARY (Mar. 15, 2019, 2:53 PM), <https://www.youtube.com/watch?reload=9&v=z0QWTw-WuFc&feature=youtu.be&t=631> (“[A]ll of our vehicle driving decisions are performed onboard. So while we don’t rely on cell networks to make driving decisions, we can leverage it for expanded capability. So the promise of high-bandwidth and low-latency networks is something that we’re very interested in and it’s very welcome.”).

²⁴ U.S. DEPT. OF TRANSP., INFRASTRUCTURE INITIATIVES TO APPLY CONNECTED- AND AUTOMATED-VEHICLE TECHNOLOGY TO ROADWAY DEPARTURES 38 (2018).

Unfortunately, when weather or lighting conditions are poor, lane markings are hard to see for both man and machine, which makes navigation difficult and dangerous.²⁵

In the United States, there is progress with embedding solar-powered LEDs into lane markings to provide visibility of edge lines in poor lighting and difficult weather conditions.²⁶ This relatively simple technology costs \$50 per pavement marking, inclusive of materials and labor. If LED markers were embedded in 50-yard increments, a one-mile stretch would cost only about \$1,760. With such markings, the pavement marker is visible from a greater distance, which allows for a longer reaction time of 30 seconds, versus the three-second response time of traditional lane markings. Again, this technology could assist both human and machine drivers.²⁷ Therefore, it could be valuable for mixed traffic that includes both kinds of drivers on the road simultaneously.

Smart roadway lighting is a more significant and sophisticated technology, often contemplated in smart city plans. Today, lampposts and lights run all night, regardless of traffic.²⁸ This is especially wasteful on rural roads without much traffic. Adaptive roadway lighting can sense vehicles on the road and turn off and on as needed.²⁹ In addition, fully adaptive lighting can modulate depending on the time of day and weather conditions.³⁰ This kind of adaptive lighting could drastically save on energy costs, because the lights would turn off when there is no traffic.³¹

²⁵ *Id.*

²⁶ *Id.* at 32; U.S. DEPT. OF TRANSP., *LED Raised Pavement Markers*, Rep. No. FHWA-SA-09-007 (2009).

²⁷ U.S. DEPT. OF TRANSP., *supra* note 24, at 39.

²⁸ *Id.* at 33.

²⁹ MARTIJN TIDEMAN ET AL., INST. OF ELECTRICAL AND ELECTRONICS ENGINEERS, *A REVIEW OF LATERAL DRIVER SUPPORT SYSTEMS* 992–99 (2007).

³⁰ *Id.*

³¹ U.S. DEPT. OF TRANSP., *supra* note 24, at 33.

Pairing a roadside unit with a lamppost would allow the roadside unit to detect and communicate with autonomous vehicles and simultaneously adjust the light as needed.³² This technology would require some investment up front but would provide benefits over time from the energy savings. The Virginia Tech Transportation Institute prototyped a simple system of on-demand lighting using DSRC, wireless lighting, and LED lights.³³ In this implementation, the vehicles send their location, speed, and route to a central server through DSRC, and the server sends the information back to the lights to control illumination and duration.

More advanced V2I technology involves dynamic speed harmonization. In roads across the United States, speed limits change depending on road curvature, traffic conditions, and other individual needs.³⁴ If sensors in the road automatically communicated speed limits to vehicles, autonomous vehicles could modulate their speed on the basis of those limits. One way that could occur is through variable speed limits, which are useful for reducing speed limits on an as-needed basis, such as when cars are approaching a crash area or during inclement weather.³⁵ Most drivers are not even aware when speed limits change, so not only could this technology improve compliance with the law, but it also could increase safety.³⁶

Another smart city and V2I application is cooperative intersection controls.³⁷ If a sensor on a stoplight communicated with an autonomous vehicle, it could prevent navigation if the stoplight were red, allow navigation if the light were green, and slow navigation if the light

³² *Id.* at 33; *see also* Tideman et al, *supra* note 29.

³³ U.S. DEPT. OF TRANSP., *supra* note 24 at 33; RON GIBBONS ET AL., CONNECTED VEHICLE/INFRASTRUCTURE U. TRANSP. CTR., CONNECTED VEHICLE APPLICATIONS FOR ADAPTIVE OVERHEAD LIGHTING (ON-DEMAND LIGHTING) (2016).

³⁴ *Speed Limits*, TEX. DEPT. OF TRANSP., <https://www.txdot.gov/driver/laws/speed-limits.html>.

³⁵ Mehrdad Tajalli & Ali Hajbabaie, *Dynamic Speed Harmonization in Connected Urban Street Networks*, 33 COMPUTER-AIDED CIV. AND INFRASTRUCTURE ENGINEERING 510 (2018).

³⁶ U.S. DEPT. OF TRANSP., *supra* note 24.

³⁷ Lei Chen & Cristofer Englund, *Cooperative Intersection Management: A Survey*, 17 IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS 570 (2016).

turned yellow.³⁸ In this sense, traffic signals would not be mere suggestions to the driver but would actually be embedded into algorithms in the autonomous vehicle, just as with the variable speed limits.³⁹ This technology not only would increase compliance with the law but also likely would decrease accidents, given that autonomous vehicles no longer would run red lights. This is especially important because intersections are involved in 40 percent of crashes, 50 percent of crash injuries, and 25 percent of crash fatalities each year in the United States.⁴⁰

Finally, perhaps the most advanced kind of technology to emerge with V2I is advanced road pricing. Tolls today simply allow a user to pay a certain amount for the right to travel on a road. In a more complex world, the tolls could be tailored to the specific attributes of the driver or the vehicle, such as vehicle size, weight, number of passengers, driving history, or accident record.⁴¹ Little of that information is available in the pricing function today. Because of their size and weight, larger vehicles create more traffic and wear down road infrastructure more than smaller vehicles. A general principle known to transportation experts is that the damage caused to a road by a vehicle is the vehicle's axle load to the fourth power.⁴² For example, vehicles with double-axle weight create 16 times more damage than those with single-axle weight. In principle, larger vehicles should pay higher tolls. Otherwise, large vehicles impose negative externalities and do not bear the social costs they create. More dynamic and adaptive granular

³⁸ YINGYAN LOU & PEIHENG LI, SOLARIS CONSORTIUM, IMPACTS OF TRAFFIC SIGNAL CONTROLS ON A DISTRIBUTED TRAFFIC MONITORING SYSTEM USING V2V COMMUNICATIONS (2018).

³⁹ Alejandro I. Medina et al., *Cooperative Intersection Control Based on Virtual Platooning*, 19 IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS 1727 (2018).

⁴⁰ U.S. DEPT. OF TRANSP., *supra* note 24; Fed. Highway Admin., *Intersection Safety* (July 24, 2018), <https://highways.dot.gov/research-programs/safety/intersection-safety>.

⁴¹ THE WHITE HOUSE, ECONOMIC REPORT OF THE PRESIDENT 181 (2018), https://www.whitehouse.gov/wp-content/uploads/2018/02/ERP_2018_Final-FINAL.pdf.

⁴² This is called the Generalized Fourth Power Law. See U.S. DEPT. OF TRANSP., *Pavement*, in U.S. DEPARTMENT OF TRANSPORTATION'S COMPREHENSIVE TRUCK SIZE AND WEIGHT STUDY (2000), <https://www.fhwa.dot.gov/reports/tswstudy/Vol3-Chapter5.pdf>.

tolling would force those drivers and vehicles to bear their social cost, thereby moving society closer to efficient road usage.

Public and Private Models for V2I Construction and Financing

As is true with all infrastructure projects, financing V2I technology must balance competing needs, recovering fixed costs, and ongoing maintenance. Such projects would still require large upfront investments of capital and resources. Thus, the question becomes how to finance and structure the contract between the government, the user, the private sector, and the provider of technology. There is a long history of using P3s in transportation projects given the public nature of roadways and the efficacy or risk mitigation of contracting out elements of road projects to commercial firms.⁴³

Public-Private Partnerships for V2I

Federal Highway Administration (FHWA) guidance currently allows private-sector use of roadside infrastructure for V2I devices, but private use must yield to public transportation uses.⁴⁴ How public and private use of roadside infrastructure is shared will depend on the terms of P3 contractual terms. A P3 is a contract between a private-sector entity, the service provider, and the government (the ultimate owner of the asset). For example, in the case of state highways, private parties can design, build, maintain, and collect revenue from a bridge or highway, while the state remains the ultimate owner of the asset.⁴⁵ The flexibility of a P3 allows the contract to farm out the regulatory or business risk to the commercial party.

⁴³ See, e.g., Tracy C. Miller, *Role of the Private Sector in the Management of Highways: A Primer on Public-Private Partnerships* (Mercatus Ctr. at George Mason Univ., Working Paper, 2018).

⁴⁴ See FED. HIGHWAY ADMIN., 2015 FHWA VEHICLE TO INFRASTRUCTURE DEPLOYMENT GUIDANCE AND PRODUCTS 11–12 (2015), https://transops.s3.amazonaws.com/uploaded_files/V2I_DeploymentGuidanceDraftv9.pdf.

⁴⁵ See generally Miller, *supra* note 43.

In 2015, the FHWA announced guidance on V2I deployment.⁴⁶ It recommended private-sector involvement in V2I, given its relative strengths in technology, innovation, and deployment.⁴⁷ Primarily, the guidance aimed to encourage private-sector entities to develop these technologies and work with states and municipalities through P3 agreements.⁴⁸ For example, the private sector needed to ensure that the roadside units it developed complied fully with state and local laws and allowed public owner-operators to control traffic signals, monitor traffic, distribute security certificates to vehicles, and provide traveler information to vehicles through V2I communications.⁴⁹ The FHWA guidance also asked for priority treatment of public-sector fleets, including incident responder vehicles (e.g., ambulances).⁵⁰ At the highest level, the guidance insisted that P3 agreements guarantee V2I safety first and provide an exit option for termination should the private-sector uses degrade the V2V or V2I environment.⁵¹

P3s are still relatively rare in the United States.⁵² Nonetheless, V2I presents an opportunity for new uses of P3s. The FHWA allows state DOTs to use federal funds to structure these P3 agreements so that the private developer can deploy and operate the V2I system even if

⁴⁶ See generally FED. HIGHWAY ADMIN, *supra* note 44.

⁴⁷ *Id.*

⁴⁸ *Id.* at 20.

⁴⁹ *Id.*

⁵⁰ *Id.* at 13.

⁵¹ *Id.* at 11; 61 Fed. Reg. 45,618 (Aug. 29, 1996), as amended at 63 Fed. Reg. 12,025 (Mar. 12, 1998).

⁵² The House of Representatives Transportation and Infrastructure Committee found that between 1989 and 2013, only 1.5 percent of the \$4 trillion spent on highways was conducted and executed through P3 agreements. COUNCIL OF ECONOMIC ADVISERS, ECONOMIC REPORT OF THE PRESIDENT 196 (2018), https://www.whitehouse.gov/wp-content/uploads/2018/02/ERP_2018_Final-FINAL.pdf. A 2014 report from the Congressional Research Service predicts P3s to be capable of bringing in no more than 7–8 percent of overall transportation spending. WILLIAM MALLET, CONG. RESEARCH SERV., R43410, HIGHWAY AND PUBLIC TRANSPORTATION INFRASTRUCTURE PROVISION USING PUBLIC-PRIVATE PARTNERSHIPS (P3s) (2014), <https://fas.org/sgp/crs/misc/R43410.pdf>. There is widespread public support for more private investment in national transportation projects, where 78 percent of registered voters support the idea, according to a Rockefeller Foundation survey. HART RESEARCH ASSOCIATES/PUBLIC OPINION STRATEGIES, THE ROCKEFELLER FOUNDATION INFRASTRUCTURE SURVEY 4 (2011), https://www.swmpc.org/downloads/rockefeller_foundation_infrastructure_survey.pdf.

it exists on top of a public asset.⁵³ In that instance, the private developer becomes responsible for the highway (e.g., construction and maintenance).⁵⁴

The FHWA guidance is not binding, but it establishes principles the federal government would like to see as this new area unfolds.⁵⁵ Most of the guidance is uncontroversial, with the small exception of the business model that the government recommends. The FHWA discourages private entities from receiving revenue directly from the user but encourages the revenue to come from use of the communications channel, such as through advertising.⁵⁶ Although advertising is one possibility, there is no need for the government to specify the right business model in advance. Instead, the government should let the market decide how best to monetize and finance the new technology.

In a typical P3, the private entity signs a design, build, finance, operate, and maintain (DBFOM) contract, and the state or city retains ownership and can restrict the terms of the contract in various ways.⁵⁷ These contracts are typically toll concessions to private firms, which

⁵³ FED. HIGHWAY ADMIN., *supra* note 44, at 20.

⁵⁴ *Id.*

⁵⁵ *Id.* at 1. “Deployment of V2I technologies *is not mandated* and is not coupled with the National Highway Traffic Safety Administration’s (NHTSA) advance notice of *proposed* rulemaking for Vehicle-to-Vehicle (V2V) communications. . . . The guidance, associated guides, toolkits, and products are to be a *useful resource* to help those considering V2I deployment and to leverage developments in V2V communications” (emphasis added).

⁵⁶ *Id.*

⁵⁷ CTR. FOR INNOVATIVE FIN. SUPPORT, FED. HIGHWAY ADMIN., P3 PROJECTS (2019), https://www.fhwa.dot.gov/ipd/p3/p3_projects/. For example, a private consortium built the 91 Express Lane, a 10-mile, four-lane express toll facility in southern California. CTR. FOR INNOVATIVE FIN. SUPPORT, FED. HIGHWAY ADMIN., PROJECT PROFILE: 91 EXPRESS LANES (2019), https://www.fhwa.dot.gov/ipd/project_profiles/ca_91expresslanes.aspx. This P3 gave the private consortium control for 35 years, but the state capped the rate of return. *Id.* Another example is the Dulles Greenway in Loudoun County. Va. CTR. FOR INNOVATIVE FIN. SUPPORT, FED. HIGHWAY ADMIN., PROJECT PROFILE: DULLES GREENWAY (2019), https://www.fhwa.dot.gov/ipd/project_profiles/va_dulles_greenway.aspx. A private consortium put together \$40 million in equity and \$310 million in privately placed debt. *Id.* The consortium repaid these loans with toll revenues. *Id.* The state set caps at roughly 2.8 percent per year as the limit at which tolls would increase. *Id.* Another example is the Indiana Toll Road. ITR Concession Company LLC, a private company, operates this 157-mile road after it was awarded a 75-year lease for \$3.8 billion in 2006. The Indiana Finance Authority owns the toll road. IND. DEPT. OF TRANSP., INDIANA TOLL ROAD (2019), <https://www.in.gov/indot/2413.htm>. Since 2016, ITR has invested more than \$200 million in improvements on the Indianan section of the toll road. ITR CONCESSION CO. LLC., INDIANA TOLL ROAD, *ABOUT US* (2019), <https://www.indianatollroad.org/about-us/>. The toll road spans three states.

construct and maintain roadways and collect tolls as a funding mechanism.⁵⁸ Virginia has successfully completed several transportation projects through DBFOM P3s. For example, a DBFOM contract between the Virginia DOT and Capital Beltway Express created the Capital Beltway Express Lanes. Other types of P3s, such as revenue-risk P3s, have also seen relative success in this area.⁵⁹ P3s can finance more than just the construction of roads, however; other examples include roadside infrastructure such as park-and-ride facilities and bus corridors.⁶⁰

Budget and Expertise Constraints on Public Operation of V2I

Many state and local transportation authorities may find it useful to seek P3 alternatives to exclusively public construction and management of V2I systems. V2I deployment can be a costly investment for a state. The Government Accountability Office (GAO) estimates, for instance, that V2I intersections will have average nonrecurring costs of \$50,000 apiece.⁶¹ The nature of transportation funding does not always encourage purchases of high-quality, long-lasting V2I devices. As the FHWA's updated Traffic Detector Handbook noted,

Budgetary problems that continue to plague traffic agencies have resulted in a cost consciousness that frequently focuses only on initial cost, rather than on lifetime cost. Consequently, less expensive products, materials, and processes are used in the original installation because of their lower initial cost.⁶²

⁵⁸ Miller, *supra* note 43, at 21–22.

⁵⁹ In 2017, a revenue-risk P3 contract was established between Cintra, Meridiam, and Va. DOT to rebuild a section of Interstate 66.

⁶⁰ In the Washington, DC, metropolitan area, a P3 to expand 22.5 miles of I-66 in Virginia included modifications such as reconfiguring on and off ramps; modifying toll collection; providing bridge and utility upgrades; constructing park and ride facilities with access to pedestrian and bike facilities; preserving a large median strip for future transit use; and providing new, expanded bus services along the corridor. CTR. FOR INNOVATIVE FIN. SUPPORT, FED. HIGHWAY ADMIN., PROJECT PROFILE: TRANSFORM 66 – OUTSIDE THE BELTWAY (2019), https://www.fhwa.dot.gov/ipd/project_profiles/va_transform_66.aspx.

⁶¹ U.S. GOV'T ACCOUNTABILITY OFFICE, *supra* note 7, at 39–40.

⁶² DEPT. OF TRANSP., TRAFFIC DETECTOR HANDBOOK: THIRD EDITION–VOLUME II 6-1 (2006), <https://www.fhwa.dot.gov/publications/research/operations/its/06139/06139.pdf>.

This cost consciousness caused significant problems within the Michigan V2I pilot programs. There, the USDOT installed 58 DSRC units in the Detroit area. Roughly half of the units failed within a year of installation, typically as a result of water intrusion.⁶³ As a California V2I program showed, V2I units require regular upgrades and represent ongoing costs as older generations of units become obsolete.⁶⁴ Furthermore, there has been a general degradation in transportation funding and infrastructure maintenance in the United States. Federal and state transportation departments employ more than 200,000 workers, many of whom are full-time employees devoted to regulatory compliance.

For many authorities, the prospect of V2I maintenance (which requires repairs, software updates, and cybersecurity patches for huge IT systems) is too risky for public operation. Other good reasons to consider private operation of V2I networks include the up-front costs, ongoing maintenance and management, and innovation losses from public operation and ownership of V2I street furniture, networks, and devices. There is also increasing public wariness of publicly operated networks that collect location information, audio, and video of people via ITS and smart city networks. Transportation regulators are, in other words, ill equipped to build, maintain, and upgrade V2I networks and devices citywide or statewide.

Framework for Competitive V2I

V2I systems represent transportation projects that are ancillary to road projects. These systems typically will occupy public rights of way, utility poles, and other street furniture. For new

⁶³ RICHARD WALLACE & VALERIE SATHE BRUGEMAN, MICHIGAN DEPARTMENT OF TRANSPORTATION VII TEST BED INVENTORY REPORT (Apr. 20, 2009), http://www.michigan.gov/documents/mdot/MDOTVIITestBedInventoryReport-20Apr2009_320014_7.pdf.

⁶⁴ STEVEN SHLADOVER, VEHICLE-INFRASTRUCTURE COOPERATION USING DEDICATED SHORT RANGE COMMUNICATIONS (DSRC) 1 (2015), <https://dot.ca.gov/-/media/dot-media/programs/research-innovation-system-information/documents/final-report-task-2297-a11y.pdf>.

infrastructure investments that have yet to begin, V2I technology should be an integral part of the P3 that will govern the creation and maintenance of that project. More to the point, lawmakers should keep V2I technology in mind when they fund infrastructure improvements; although the cost of V2I technology is relatively low when compared to the total cost of a project, V2I technology will have an impact in determining the overall design and operation of the road.⁶⁵ Federal guidelines anticipate that private contractors of ITS services will provide many V2I services.⁶⁶ However, private and P3 construction of V2I infrastructure and devices could raise the prospect of anticompetitive treatment toward 5G and smart city operators. To allow for competitive ITS services, V2I infrastructure contracts with private firms should be designed with competitive device makers in mind.⁶⁷

This allowance for device competition is important, because most V2I and connected vehicle services can be competitively provided (particularly the consumer services, such as traffic alerts, traffic metering, incident reports, and real-time public transit updates). Furthermore, V2I can be one of several data services provided by a wireless broadband network, alongside services such as consumer smartphone applications, smart city applications, and internet-of-things applications. The terms of a P3 contract for roadway projects are complex, but the policy-induced competition framework can help illuminate where competition is likely to succeed without unnecessarily damaging the financial viability of a project.

⁶⁵ Khair Jadaan et al., *Connected Vehicles: An Innovative Transport Technology*, 187 *PROCEDIA ENGINEERING* 641, 642–43 (2017). For example, it matters greatly whether V2I will attach to a dedicated single road for autonomous vehicles or work on all lanes with both human and machine drivers. FED. HIGHWAY ADMIN., *MULTIPLE SOURCES OF SAFETY INFORMATION FROM V2V AND V2I: REDUNDANCY, DECISION MAKING, AND TRUST* 14 (2015), <https://www.fhwa.dot.gov/publications/research/safety/15007/15007.pdf>.

⁶⁶ FED. HIGHWAY ADMIN., *supra* note 44, at 20.

⁶⁷ Some V2I services, by their nature, must have a single service provider. There can't be "competitive" operation of traffic signaling. Similarly, tolling services likely will remain with a single operator.

Policy-Induced Competition

One method for introducing private competition into a network industry is through policy-induced competition. Policy-induced competition means that firms are required to interoperate at a specified market boundary, be it spatial, temporal, or customer based. Not every interoperability mandate works well. The approach has been proposed in many areas, such as internet service provider competition⁶⁸ and cable TV box competition,⁶⁹ though success has been rare. For that reason, we attempt to specify where policy-induced competition has the best shot at succeeding in creating competition with minimal monitoring by regulators.

In the literature, the seminal example of successful policy-induced competition is the development of a competitive market for phone equipment despite the monopoly power of the AT&T network in the mid-20th century.⁷⁰ In the 1970s, after complaints of vertical exclusion by AT&T of competitive device makers and a change in regulatory philosophy at the federal level, the FCC looked for ways to create a competitive networked device industry.⁷¹ The FCC adopted simple standards specifying an open interface to connect a non-AT&T device to the AT&T public switched telephone network.⁷² For telephony, there wasn't a market boundary for competitive devices—the FCC created one.

⁶⁸ Anupam Banerjee & Marvin Sirbu, *Towards Technologically and Competitively Neutral Fiber to the Home Infrastructure*, CARNEGIE MELLON UNIVERSITY (2005), http://www.andrew.cmu.edu/user/sirbu/pubs/Banerjee_Sirbu.pdf.

⁶⁹ Brent Skorup, *Why the FCC's Plan to Improve Set Top Boxes Will Backfire*, PLAIN TEXT (Feb. 6, 2016), <https://readplaintext.com/why-the-fcc-s-plan-to-improve-set-top-boxes-will-backfire-32e148e665c> (“When the dust had settled, despite ten years of FCC efforts, Motorola and Cisco, who supply cable set top boxes to cable companies, [still] comprised about 95% of the STB market.”).

⁷⁰ See, e.g., Philip J. Weiser, *Regulating Interoperability: Lessons from AT&T, Microsoft, and Beyond*, 76 ANTITRUST L.J. 271, 274 (2009) (stating that the FCC regime “is viewed as an enormous success”); Gerald Faulhaber, *Policy-Induced Competition: The Telecommunications Experiments*, 15 INFO. ECON. & POL’Y 73 (2003).

⁷¹ Faulhaber, *supra* note 70, at 76.

⁷² PROPOSALS FOR NEW OR REVISED CLASSES OF INTERSTATE AND FOREIGN MESSAGE TOLL TELEPHONE SERVICE (MTS) AND WIDE AREA TELEPHONE SERVICE (WATS), First Report & Order, 56 F.C.C. 2d 593, 594–96 (1975), modified, 58 F.C.C.2d 716, modified, 58 F.C.C. 2d 736 (1976), *aff’d sub nom.* North Carolina Utils. Comm’n v. FCC, 552 F.2d 1036 (4th Cir. 1977).

As professor and former FCC economist Gerald Faulhaber writes about the AT&T experience,⁷³ the introduction of competition in a market in which competitors must interoperate with a monopolist in a vertically related market will be successful only if either of the following two conditions obtain:

- 1) The market boundary is simple, easy to monitor, and requires little information (that is, transaction costs across this market boundary are small); or
- 2) The residual monopolist is successfully enjoined from operating in the newly competitive market.

In a P3 agreement for the construction of V2I, the private contractor-operator will be a monopolist controlling roadside right of way, street furniture (such as utility poles and lampposts), and certain network equipment. The second condition won't obtain—the V2I contractor-operator won't be enjoined from operating a roadside wireless network. Therefore, for competitors to interoperate successfully and attach their equipment to roadside infrastructure, the first condition will need to obtain. To have competitive V2I systems, the market boundary specified in P3 contracts will need to be simple and easy for public officials to monitor.

Antitrust goes a long way toward opening platforms to competition; however, as Judge Richard Posner has written about the “new economy,” it's the case that “the [antitrust] enforcement agencies and the courts do not have adequate technical resources, and do not move fast enough, to cope effectively with a very complex business sector that changes very rapidly.”⁷⁴ Federal guidance currently places a premium on interoperability for V2I-related deployments, primarily on compatibility with DSRC technology.⁷⁵ Compatibility with DSRC is unlikely to

⁷³ Faulhaber, *supra* note 70, at 76.

⁷⁴ Richard A. Posner, *Antitrust in the New Economy*, 68 ANTITRUST L.J. 925, 925 (2001).

⁷⁵ See FED. HIGHWAY ADMIN., *supra* note 44, at 7–8.

succeed given the complex nature of wireless standards like DSRC. Rather than interoperability mandates with DSRC technology, regulators should consider access requirements to physical infrastructure, which need fewer prescriptive mandates and monitoring.

Competitive access requirements can be less socially costly than intensive device regulation or structural relief.⁷⁶ Adopting and enforcing access requirements, however, is feasible and worth the regulatory overhead only in certain circumstances.⁷⁷ Because V2I deployment often will be contracted out to private companies, resistance to access requirements from the private contractor is to be expected. However, in American competition law, preventing the loss of customers, assuring profits, and promoting a company's conception of the public interest are not cognizable efficiency defenses by firms resisting oversight.⁷⁸ Access requirements often fail in their purposes, but there are circumstances (such as with telephone devices during the Bell phone monopoly⁷⁹ or gasoline nozzles at fuel pumps⁸⁰) where they succeed at preventing vertical exclusion.

Policy-Induced Competition Applied to V2I and the Right of Way

The vast majority of V2I infrastructure will take place in the public right of way, typically along roadsides, on utility poles and light poles, and on overpass bridges. The quasi-public nature of the right of way means that decisions about demarcating which V2I assets receive public investment and operation and which assets receive private investment and operation must be made carefully.

⁷⁶ See generally Weiser, *supra* note 70.

⁷⁷ See generally *id.*

⁷⁸ See *Otter Tail Power Co. v. United States*, 410 U.S. 366, 380–82 (1973).

⁷⁹ As telecom scholar Weiser points out, the simplicity of enforcing the phone interface standards was so straightforward that the FCC delegated the policy administration to third parties in 2000. See generally Weiser, *supra* note 70.

⁸⁰ See 40 C.F.R. § 80.22 (2009).

We identify three main components needed for V2I systems, which mirror those of 5G and smart city systems: basic infrastructure, network infrastructure, and devices. Broadly speaking, we believe that public funding and policy-induced competition regulation is best directed at basic infrastructure used for V2I. This would resemble an open access model to street furniture.⁸¹ V2I devices, on the other hand, are best left to competitive provision by the market. We find that the appropriate amount of regulation and funding of network infrastructure is fact dependent and difficult to characterize a priori.

Basic infrastructure. This category of basic infrastructure includes “passive” infrastructure, including the rights-of-way real estate, vertical poles, cabinets, and electric service. These assets are semipermanent installations that often last decades. We believe this category is where policy-induced competition is most likely to succeed.

Since basic infrastructure is, by government design,⁸² largely a monopoly market, price regulation is required to prevent monopoly pricing.⁸³ It is generally feasible to have rate regulation and nondiscriminatory policy for basic infrastructure, and this has indeed been accomplished successfully for 150 years.⁸⁴ As a result, basic infrastructure such as roadside real

⁸¹ There is at least one provider in the United Kingdom proposing this approach. *BT Calls for Open Access to Street Furniture*, SMARTCITIES WORLD (Mar. 27, 2019), <https://www.smartcitiesworld.net/news/news/bt-calls-for-open-access-to-street-furniture-4008>.

⁸² For more than a century, municipalities have limited the number of poles in the rights of way because of inconvenience and clutter. As the Pennsylvania Supreme Court noted in an 1888 case,

The streets are already lined with masts sustaining an intricate web of wires, actually or potentially charged with an electric current. . . . [N]o argument is requisite to show the inconvenience that might result if the number could be infinitely increased. . . . [M]uch as they have multiplied in the past, we may believe that in the new future they will be still more numerous.

W. Union Tel. Co. v. City of Philadelphia, 12 A. 144, 145 (Pa. 1888).

⁸³ See, e.g., Thomas W. Hazlett, *Cable TV Franchises as Barriers to Video Competition*, 12 VA. J.L. & TECH. 2, 15–16 (2007).

⁸⁴ As early as 1866, federal law opened up the rights of way along post roads to telegraph infrastructure, which included all roads in some major cities (St. Louis, for example). *City of St. Louis v. W. Union Tel. Co.*, 148 U.S. 92, 100 (1893).

estate is used by multiple parties for different commercial uses. Coaxial cable, copper lines, and fiber optics, used for transmitting telephony, television, and data services, all make use of the right of way as well as electrical systems.

In many ways, basic infrastructure is a “utility for utilities.” Basic infrastructure typically is owned by a regulated phone company, a regulated electrical utility, or a local government. Roadside real estate is an important element of basic infrastructure. Municipalities own or control most of the ground and air rights of way used by utility distribution systems.⁸⁵ Roads and the public rights of way are held for public, not proprietary, use by the municipality.⁸⁶ Cities already often contract out the negotiations with wireless operators to install devices on city property.⁸⁷

It is fairly easy to monitor access requirement compliance to basic infrastructure, and regulation resembles classic common-carrier regulation of rates and terms.⁸⁸ Professor Christopher Yoo of the University of Pennsylvania Law School notes that access requirements and rate regulation work best “when the product is a commodity and where the quality of the

⁸⁵ Harold Demsetz, *Why Regulate Utilities*, 11 J.L. & ECON. 55, 62 (1968).

⁸⁶ As a seminal treatise on public streets stated, “[I]f the state should take land for the purpose of a public way the purpose would be essentially public.” 1 BYRON K. ELLIOTT & WILLIAM F. ELLIOTT, *A TREATISE ON THE LAW OF ROADS AND STREETS* 150 (4th ed. 1926).

⁸⁷ Kapko, *supra* note 21.

⁸⁸ As Prof. Christopher Yoo has said, “[T]he core elements of common carriage are the duty to serve, nondiscrimination, and rate regulation.” Christopher S. Yoo, *Common Carriage’s Domain*, 35 YALE J. ON REG. 991, 997 (2018) [hereinafter Yoo, *Common Carriage*]. Common carriage has never been adequately defined, but we hesitate to call the pole rates common carriage, because common carriage in most other contexts—telephony, air transportation, hotels, ferries—refers to “holding oneself out” indiscriminately to the public. Nat’l Ass’n of Reg. Util. Comm’rs v. FCC (NARUC 1), 525 F.2d 630, 641, 642 (D.C. Cir. 1976). However, rights-of-way access should be distinguished from complex franchise agreements, derived from rights-of-way access, containing many issues distinct from time, place, and manner of attachment. *See, e.g.*, Thomas W. Hazlett, *Cable TV Franchises as Barriers to Video Competition*, 12 VA. J.L. & TECH. 2, 20–21 (2007) (“Cable television franchises can easily run 100 pages” and regulate service area coverage, public television channels to transmit, connecting government networks, and customer service rules.). These requirements can be a significant part of the cost of deploying network facilities. Mark A. Zupan, *The Efficacy of Franchise Bidding Schemes in the Case of Cable Television: Some Systematic Evidence*, 32 J.L. & ECON. 401, 405 (1989) (estimating that more than 25 percent of capital costs are required by local authorities but deliver negligible value to consumers).

product does not vary.”⁸⁹ Access requirements and price regulation, then, work tolerably well for water, natural gas, traditional telephony, and electricity distribution.⁹⁰

There is already a history of policy-induced competition to basic infrastructure in other contexts. Federal standards for gasoline nozzles create a simple interface so that fueling stations can “interoperate” with any passenger vehicle. The interface is a clearly articulated nozzle dimension that can be monitored easily.⁹¹

Access requirements for utility poles have been federal policy since at least 1978. Pole access is a commodity:⁹² the “quality” of the resource sought—typically, a foot of unoccupied wooden pole⁹³—does not vary much. The Pole Attachment Act of 1978 gave the FCC authority to regulate attachments to investor-owned electric and telephone utility poles.⁹⁴ The legislation was originally intended for cable television companies but was expanded to all “telecommunications providers” in 1996. There is typically a “functional equivalence” test to see if the buyers view the alleged commodity asset as performing the same function.⁹⁵

⁸⁹ Yoo, *Common Carriage*, *supra* note 88, at 1013.

⁹⁰ *Id.*

⁹¹ The *Code of Federal Regulations* states,

Every retailer and wholesale purchaser-consumer shall equip all gasoline pumps from which gasoline is dispensed into motor vehicles with a nozzle spout that meets all the following specifications:

- (1) The outside diameter of the terminal end shall not be greater than 0.840 inches (2.134 centimeters).
- (2) The terminal end shall have a straight section of at least 2.5 inches (6.34 centimeters).
- (3) The retaining spring shall terminate at least 3.0 inches (7.6 centimeters) from the terminal end.

40 C.F.R. § 80.22(f) (2009).

⁹² Yoo, *Common Carriage*, *supra* note 88, at 1007.

⁹³ Federal Communications Commission, In the Matter of Implementation of Section 703(e) of the Telecommunications Act of 1996, Amendment of the Commission’s Rules and Policies Governing Pole Attachments, Report and Order, CS Docket No. 97-151 (Rel. 6 Feb. 1998), 22.

⁹⁴ 47 U.S.C. § 224 (2018).

⁹⁵ Yoo, *Common Carriage*, *supra* note 88, at 1008; *Competitive Telecomms. Ass’n. v. FCC*, 998 F.2d 1058, 1061 (D.C. Cir. 1993) (citing *MCI Telecomms. Corp. v. FCC*, 917 F.2d 30, 39 (D.C. Cir. 1990)); *Ad Hoc Telecomms. Users. Comm. v. FCC*, 680 F.2d 790, 795 (D.C. Cir. 1982).

Federal and state pole access laws are, in the words of the US Court of Appeals for the Seventh Circuit, “intended to facilitate prompt and economical extensions of telephone service by preventing municipalities and other local governments from using their locational monopolies to delay and extort monopolistic fees from companies that, in order to provide service, must frequently run wires and cables across local governmental boundaries.”⁹⁶

Basic infrastructure regulation has many of the major elements of utility regulation, namely the regulation of prices charged and a requirement for reasonable practices.⁹⁷ At present, federal regulation approximates marginal cost pricing for pole access. Pole and other rights-of-way lease rates typically are conceived of as “rent” paid to a municipality or private utility pole owner for access to the quasi-public property.⁹⁸ Access mandates and utility regulation can depress investment because the regulated firm loses some control over contracting pricing and terms.⁹⁹ However, most basic infrastructure is already constructed. This means that owners of basic infrastructure will seek to extract a portion of the producer surplus well in excess of their opportunity costs—the so-called holdout problem. Typically, the excessive rates are not plowed back into more infrastructure investment, and price regulation can have salutary effects. As the FCC points out in its pole access proceeding,¹⁰⁰

⁹⁶ *Dignet, Inc. v. W. Union ATS, Inc.*, 958 F.2d 1388, 1397 (7th Cir. 1992).

⁹⁷ Joseph D. Kearney & Thomas W. Merrill, *The Great Transformation of Regulated Industries Law*, 98 COLUM. L. REV. 1323, 1330–31 (1998) (“For almost a century, public utility companies and common carriers had one common characteristic: All were required to offer their customers service under rates and practices that were just, reasonable, and non-discriminatory.”). *See, e.g.*, *MCI Telecomms. Corp. v. AT&T Co.*, 512 U.S. 218, 229–32 (1994) (calling the tariff-filing requirement “the heart of the common-carrier section of the Communications Act” and essential to ensuring reasonable rates).

⁹⁸ *See City of Dallas v. FCC*, 118 F.3d 393, 397 (5th Cir. 1997) (noting that a cable franchise fee is “essentially a form of rent: the price paid to rent use of public right-of-ways”).

⁹⁹ *See Yoo, Common Carriage*, *supra* note 88, at 1011–12 (“Requiring providers to adhere to defined products and a posted, uniform rate schedule provides the type of standardization and information sharing that has long been recognized as a facilitating practice for collusion.”). Nondiscriminatory access regulations for commodities can sometimes have the effect of legalizing collusion in cartel markets. To date, however, we are unaware of any claim that the federal laws about nondiscriminatory pole access have facilitated collusion.

¹⁰⁰ Amendments of the Commission’s Rules and Policies Governing Pole Attachments, Consolidated Partial Order on Reconsideration, 16 FCC Rcd. 12103, 12118 ¶ 24, 12119 ¶ 25 (2001).

The dampening of investment incentives matters less when the network is already built out. When that is the case, employing rate regulation that dampens investment signals is less important. Moreover, if further entry is impossible, then short-run high prices will not stimulate new entry sufficient to shift out the supply curve and dissipate the supra-competitive returns. When “attachers . . . do not face a realistic ‘make or buy’ decision, the benefits of giving proper cost signals to new entrants are less pronounced.”

V2I P3 contracts should be drafted to accommodate access requirements to basic infrastructure. If the V2I investment includes the installation of tolling V2I devices, the agreement should have terms related to nonexclusive use of the assets. If a P3 were to establish roadside units on lampposts across a high-occupancy toll (HOT) lane, the terms of the DBFOM contract would guarantee exclusive rights to tolling revenues. However, the terms should allow for nonexclusive attachment rights for V2I operators for nontolling services.

Network infrastructure. This category includes long-lasting network inputs such as fiber strands, data networks, and network handholds. Such systems are harder to monitor and separate into component parts than basic infrastructure. Fiber optics quality, for instance, varies more than for other roadside objects and street furniture. Product complexity means regulators need multifactor tariffing and quality dimensions when deciding fair rates and terms.¹⁰¹ As Yoo notes, “The more complex the interface, the more problematic and protracted these disputes will be.”¹⁰²

Network infrastructure, such as data networks, has become fairly complex, which is why regulatory attempts to create competition in local phone and broadband have generally failed in

¹⁰¹ Yoo, *Common Carriage*, *supra* note 88, at 1012; Eli M. Noam, *Towards an Integrated Communications Market: Overcoming the Local Monopoly of Cable Television*, 34 FED. COMM. L.J. 209, 219 (1982) (“Historically, rate regulation is easiest to administer where the product can be clearly defined and quantified. . . . Rate regulation is much more difficult when it deals with complex and variable mixtures of services.”).

¹⁰² Yoo, *Common Carriage*, *supra* note 88, at 1014.

the United States.¹⁰³ For instance, the FCC failed at requiring AT&T to provide nondiscriminatory access to long-distance phone providers in part because of the information-richness of the market boundary—the long-distance and local phone networks.¹⁰⁴ Similar regulatory efforts failed in the United Kingdom.¹⁰⁵ The complexity of data networks and interoperation of networks meant that regulators had a difficult time monitoring compliance with access requirements.

Likewise, the “unbundling” mandates in the 1996 Telecom Act failed to generate local phone competition.¹⁰⁶ Under those legal provisions, local phone companies had to “provide nondiscriminatory access to all elements of their networks at any technically feasible point.”¹⁰⁷ That “centerpiece” of the 1996 Telecom Act failed, despite the intense regulatory scrutiny of network operators.¹⁰⁸ Relatedly, the FCC’s “leased access” regime for cable television¹⁰⁹ and the CableCARD regime are regarded as policy failures.¹¹⁰ In short, utility regulation and

¹⁰³ Christopher S. Yoo, *Modularity Theory and Internet Regulation*, 2016 U. ILL. L. REV. 1, 40 (2016) [hereinafter Yoo, *Modularity Theory*] (“If the element is tightly integrated with other components, any attempt to mandate access would be expected to fail regardless of whether it is a natural monopoly or is unavailable through other means.”).

¹⁰⁴ As Yoo noted,

The impact of the complexity of the interface on the implementation of a nondiscrimination mandate is demonstrated eloquently by the FCC’s experience attempting to require AT&T to provide nondiscriminatory access to unaffiliated long distance providers. The complexity and information-richness of the interface of the boundary between long distance service and the local service needed to connect to that service “permitted a thousand ways in which a reluctant Bell System local access provider could hamper and restrict potential long distance competitors.” The result is that long distance access was plagued by complaints that about non-price terms, such as delays by the incumbent in provisioning lines for new subscribers signed up by competitors and the number of digits required to access long distance services.

Yoo, *Common Carriage*, *supra* note 88, at 1014.

¹⁰⁵ Iain Moore, *BT Needs a Kick in the Ducts*, LIGHT READING (Nov. 12, 2018), <https://www.lightreading.com/services/broadband-services/bt-needs-a-kick-in-the-ducts/a/d-id/747467> (“[L]egal separation [of BT and Openreach] has made not an iota of difference to UK broadband.”).

¹⁰⁶ Mark A. Lemley & Philip J. Weiser, *Should Property or Liability Rules Govern Information?*, 85 TEX. L. REV. 783, 811 (2007) (“[T]he unbundling regime of the 1996 Act represents, on almost all accounts, a policy failure.”).

¹⁰⁷ Yoo, *Common Carriage*, *supra* note 88, at 1014; 47 U.S.C. § 251(c)(3) (2018).

¹⁰⁸ Yoo, *Modularity Theory*, *supra* note 103, at 40.

¹⁰⁹ Yoo, *Common Carriage*, *supra* note 88, at 1016.

¹¹⁰ Nate Anderson, *FCC Admits CableCARD a Failure, Vows to Try Something Else*, ARS TECHNICA (Dec. 4, 2009), <https://arstechnica.com/tech-policy/2009/12/fcc-admits-cablecard-a-failure-vows-to-try-something-else/>.

policy-induced competition fail when quality is variable.¹¹¹ We suspect that interoperability at the V2I network “layer” would often fail to generate the competition sought, but such competition cannot be ruled out in all cases. The history of open-access networks indicates that success or failure is dependent on fact and place.

Devices. Devices include customer-facing devices, typically radio frequency (RF) transceivers and wireless backhaul systems. According to a study conducted by the Government Accountability Office, more than 70 percent of identified experts on V2I technology believe that standardization and interoperability were significant or moderate challenges in the deployment of V2I.¹¹² The reticence about developing interoperability is well founded—the interface complexity problems mentioned for network infrastructure are even more pronounced for devices. As Yoo says, “Modular interfaces cannot be established anywhere; they can be created only at thin crossing points where the number of interdependencies is relatively low.”¹¹³ Devices are information rich, and attempting to create access requirements for competitive wireless services is unlikely to succeed.

Connected cars and AVs are simply the latest generation of “devices” attaching to wireless networks. There are innovation losses when the government is selecting device and transmission technologies. The DSRC saga, described earlier, suggests why there is widespread skepticism of device interoperability mandates’ succeeding in the foreseeable future. The US government made a bet on Wi-Fi–derived DSRC V2I technology nearly 20 years ago, and the FCC set aside valuable spectrum real estate exclusively for DSRC technologies. Despite that,

¹¹¹ See Frank Kahn, *Economic Regulation of Broadcasting as a Utility*, 7 J. BROADCASTING 97, 110 (1963) (proposing “quasi-utility” classification of broadcast given the variable quality of content).

¹¹² U.S. GOV’T ACCOUNTABILITY OFFICE, *supra* note 7, at 51.

¹¹³ Yoo, *Modularity Theory*, *supra* note 103, at 40.

DSRC is still in an early stage of development and deployment—the first vehicle with DSRC capability in the United States was released in 2016. In the meantime, alternative connected vehicle technologies (such as radar, LiDAR, and cellular) have accomplished and superseded many DSRC functions.

Just as government agencies do not prescribe wireless phone communications standards, they should avoid prescribing wireless V2I standards and interoperability. The widespread deployment of small cells and 5G transmitters is evidence that there can be a competitive market for V2I devices.

Policy Obstacles to Effective V2I Deployment

Presently, P3s are seeing increased use in the United States for major transportation projects. However, federal restrictions on transportation projects pose a significant barrier to P3 use and to the policy-induced competition framework. One of the most disincentivizing regulations for states is the federal law that prohibits the collection of tolls by states on any federal-aid highway.¹¹⁴ Because tolls are the main mechanism for states to recoup construction costs, this regulation removes a major revenue source.¹¹⁵

There are some exceptions to this general prohibition. For example, federal law permits federal participation in the “initial construction” of or “approach to” a toll highway, bridge, or tunnel.¹¹⁶ Furthermore, there can be federal participation in the “initial construction” of lanes to increase the capacity of a highway or convert the highway to a toll facility, as long as the

¹¹⁴ 23 U.S.C. § 301 (2018).

¹¹⁵ The only exceptions to this rule are specific exemptions for states tolling on federally funded highways. 23 U.S.C. §§ 129, 166 (2018).

¹¹⁶ 23 U.S.C. § 129 (2018).

number of toll-free lanes after construction is not reduced.¹¹⁷ If the highway is part of the interstate system, the section permits federal participation in the “initial construction” of lanes to increase the highway’s capacity, as long as the number of toll-free non-HOV lanes after construction is not less than the number of toll-free non-HOV lanes before construction.¹¹⁸ Finally, the section permits federal participation in “the conversion of” an HOV lane on a highway to a toll facility.¹¹⁹

Pilot programs, such as the Interstate System Reconstruction and Rehabilitation Pilot Program (ISRRPP) and the Value Pricing Pilot Program (VPPP), have provided states with slightly more flexibility. The ISRRPP allows for no more than “three existing Interstate facilities,” which must be located in different states, “to be tolled to fund needed reconstruction or rehabilitation on Interstate corridors that could not otherwise be adequately maintained or functionally improved.” Meanwhile, the VPPP aims to “demonstrate whether and to what extent roadway congestion may be reduced through . . . congestion pricing strategies, and the magnitude of the impact of such strategies on driver behavior, traffic volumes, transit ridership, air quality and availability of funds for transportation programs.” Studies completed through the VPPP provide encouragement for congestion pricing efficacy.

The increased flexibility for P3s in transportation projects is an encouraging recent trend, but policy and budgetary obstacles remain.¹²⁰ If rules liberalization is not expanded, commercial operators may be dissuaded from road and ITS projects.

¹¹⁷ *Id.*

¹¹⁸ *Id.*

¹¹⁹ *Id.*; 23 U.S.C. § 166 (expanding upon 23 U.S.C. § 129 by permitting state authorities to allow certain vehicles access to and use of HOV facilities that they otherwise would not be allowed to use, as long as the state collects a toll from such users).

¹²⁰ Financial barriers provide an additional and substantial barrier to the formation of P3s. For example, 26 U.S.C. § 124(m)(2)(A) (2018) places a \$15 billion lifetime cap on private surface transportation projects. Since that section’s enactment, two-thirds of that \$15 billion has already been granted.

Conclusion

Substantial federal and state funding is dedicated to improving safety and services on US roadways. Given the financial risks of constructing and maintaining a V2I network, P3s for V2I network construction will be increasingly common. A selected V2I operator should be prevented from leveraging control over infrastructure into ancillary markets, such as smart cities and wireless data services. The policy-induced competition model can help inform federal and state transportation departments as they consider V2I improvements. Access requirements for “dumb” infrastructure could support orderly V2I network construction while also permitting a competitive and innovative market for V2I technologies, smart cities, and related wireless services.