TESTIMONY
of
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PRESIDENT OF COSTQUEST ASSOCIATES

Before the
SUBCOMMITTEE ON TELECOMMUNICATIONS AND TECHNOLOGY

UNITED STATES HOUSE OF REPRESENTATIVES

March 21, 2017

Contents

Availability and Economics of Broadband in the U.S.

An assessment of current broadband coverage and costs, and an evaluation of the data available to inform decisions on advancing broadband across the U.S.

Chairman Blackburn, Vice Chairman Lance, Ranking Member Doyle, and Members of the Subcommittee:

My name is James Stegeman, I am President of CostQuest Associates. Thank you for holding this hearing and inviting me to testify. It is an honor to be here to discuss the status of Broadband in the U.S.

In my testimony today, I will provide an assessment of current broadband coverage and costs and an evaluation of the data available to inform decisions on advancing broadband across the U.S.

Introduction

Let me first start with a brief introduction to CostQuest Associates.

CostQuest Associates ("CQA") is the foremost leader in designing, developing and implementing economic models for the telecommunications industry. Through our information systems, data and services we deliver comprehensive solutions to a myriad of complicated business challenges. Our focus is on understanding the drivers of investments and costs and how this information can be used to allow business, government, and regulatory agencies to make informed decisions.

Utilizing an "economic basis" we seek to thoroughly understand and capture the true drivers of a business' cost structure or proposed future plans. We approach our work from a unique perspective of examining complicated work processes and capital expenditures to better understand the nature of their cost and to model why a cost is produced and when that cost needs to be incurred.

The team of telecommunications experts at CQA have developed, deployed and supported Network, UNE, Interconnection, Broadband, and Universal Service models around the world and have worked in and on most telecommunication regulatory issues. Examples include:

- Designed, developed and maintained the FCC's economic network model that was the basis of the National Broadband Plan
- Designed, developed and maintained the FCC's Connect America Cost model that is used to disperse over $3 billion annually
- Designed, developed and maintained profitability, universal service and interconnection models used in Hong Kong, Australia, New Zealand and Bermuda
- Designed, developed and maintained the Unbundled Network Element models used in various proceedings to set rates for competitive carriers

- Designed, developed and maintained the application used by USAC to review all fiber build proposals under the FCC's e-Rate program.
- Reviewed for cost reasonableness all the bids in the New York Broadband reverse auction geared to providing 100Mbps service in all areas of New York
- Assisted various cities and states in reviewing the business case of fiber deployment
- Assisted the largest ILECS, the largest Cable, and largest Wireless carriers in the valuation of their networks
- …and more

For over 17 years, the CQA team has been at the forefront of Network Modeling, Economic Analysis and Regulatory Support. Our many satisfied clients include multinational corporations, governments, trade associations and industry regulators. CQA is a valued advisor because it can bring the breadth of applied experience, information, support, tools, techniques, and analysis so decisions can be informed.

In short, my company specializes in understanding cost, assets, and the geography of Broadband coverage. As such, my testimony will describe the results of our analysis of coverage data, provide a review of costs and deployment issues, and describe innovative approaches to addressing the challenging economics of Broadband deployment.

Broadband Geography, the State of Broadband Availability

To have a clear understanding of Broadband Availability, we need to have a clear understanding of what we are comparing to. In the material that follows, I examine terrestrial (non-mobile) and mobile broadband coverage separately, using FCC information which is currently collected and made available.

Terrestrial (non-mobile)

As part of the Connect America Fund orders, the FCC currently defines benchmark, fixed location (non-mobile), broadband service as the ability to obtain service that provides a downstream bandwidth of 25Mbps[1]. The state of New York, in their current broadband auction defines "unserved" as access to service less than 25Mbps. This aligns with the FCC. However, New York adds in an "underserved" category for areas that have access to service speed between 25Mbps and 100Mbps. "Served" is defined as having access to speeds equal to or above 100Mbps. I believe this New York distinction is informative to understanding broadband coverage nationwide and is consistent with measuring success under the FCC's National Broadband Goal No. 1[2].

> **Goal No. 1: At least 100 million U.S. homes should have affordable access to actual download speeds of at least 100 megabits per second and actual upload speeds of at least 50 megabits per second.**

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[1] Please see https://www.fcc.gov/reports-research/reports/broadband-progress-reports/2015-broadband-progress-report

[2] Please see page XIV in the FCC's National Broadband Plan *available at* https://transition.fcc.gov/national-broadband-plan/national-broadband-plan.pdf

Using this New York classification, we can review the status of the terrestrial based, non-mobile provider[3] broadband deployment in the U.S. using the FCC's latest 477 data[4]. Nationwide, 76.3% of homes have access to broadband service of at least 100Mbps, representing over 100 million U.S. homes. Regarding underserved homes, 13.6% have access to speeds between 25 and 100Mbps, while 10.1% of homes remain unserved. The figure below provides a graphical depiction of coverage across the country.

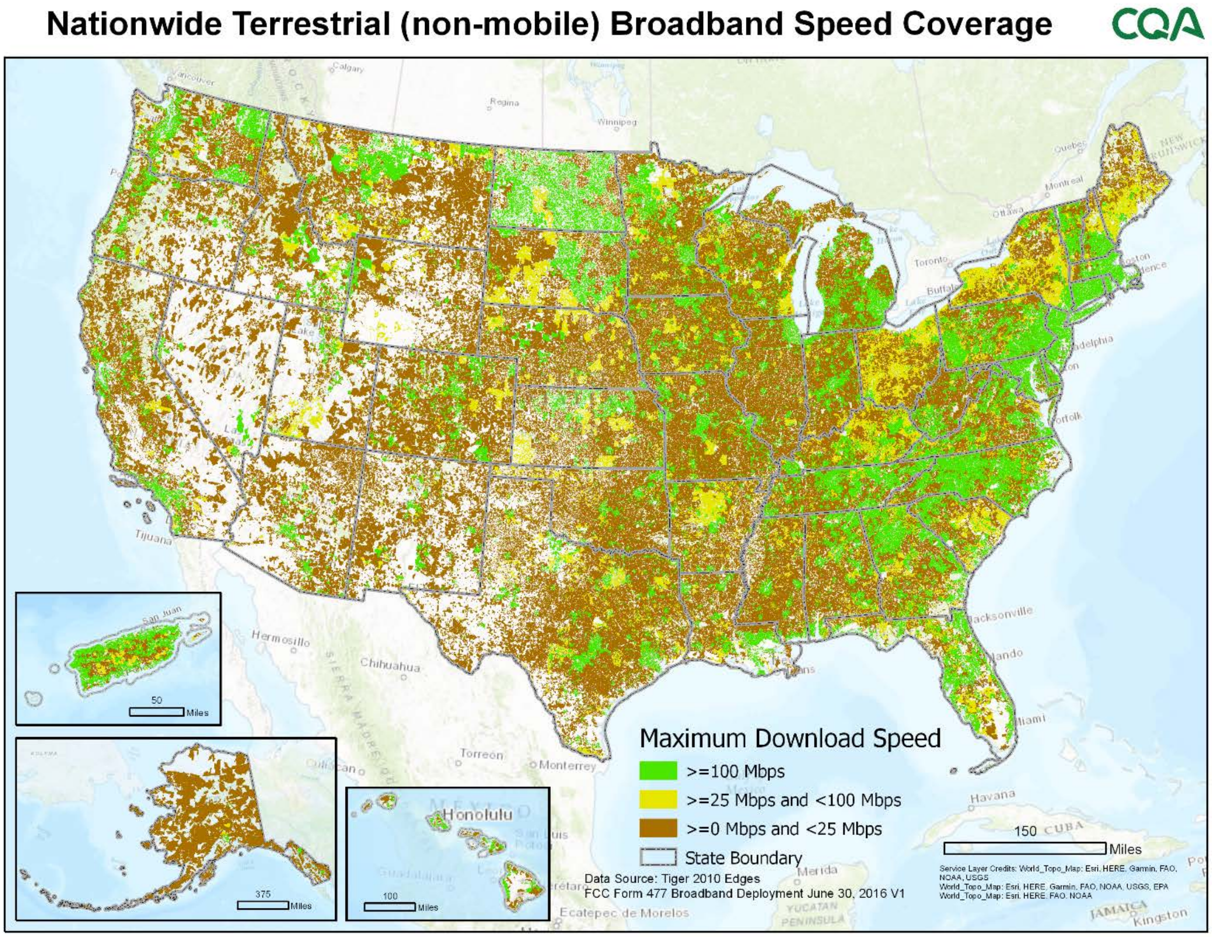

Figure 1: Terrestrial Broadband availability across the U.S.

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[3] For purposes of terrestrial service, I include copper, fiber and coax technologies identified for consumers.
[4] For the analysis, I used the June 2016 data, which is the latest available and posted at https://www.fcc.gov/general/form-477-resources-filers#block-menu-block-4. As presented, these data do not reflect affordability measures.

The FCC 477 data allows a party to examine deployment all the way down to Census blocks, if desired. The table below provides the broadband speed coverage by state:

State by State Terrestrial Broadband Speed Coverage

State	Served	UNDERserved	UNserved	State	Served	UNDERserved	UNserved
AK	69.3%	3.9%	26.8%	MS	55.6%	12.5%	31.9%
AL	65.8%	16.2%	18.1%	MT	59.7%	10.0%	30.3%
AR	52.9%	24.9%	22.2%	NC	89.5%	2.9%	7.6%
AS	0.0%	0.0%	100.0%	ND	88.2%	3.9%	7.8%
AZ	81.2%	4.6%	14.2%	NE	61.0%	22.6%	16.5%
CA	86.4%	7.6%	6.0%	NH	78.6%	15.2%	6.2%
CO	85.4%	2.9%	11.7%	NJ	98.8%	0.0%	1.2%
CT	99.0%	0.0%	1.0%	NM	71.5%	6.9%	21.6%
DC	98.6%	0.0%	1.4%	NV	88.7%	2.5%	8.8%
DE	96.8%	0.0%	3.2%	NY	70.6%	26.5%	2.9%
FL	91.3%	3.8%	5.0%	OH	22.0%	70.8%	7.2%
GA	85.1%	5.3%	9.6%	OK	68.1%	6.1%	25.8%
GU	0.0%	100.0%	0.0%	OR	86.7%	2.1%	11.2%
HI	94.9%	0.0%	5.1%	PA	87.7%	6.1%	6.2%
IA	76.9%	5.4%	17.7%	PR	86.9%	2.6%	10.5%
ID	66.5%	12.2%	21.3%	RI	98.3%	0.0%	1.7%
IL	89.5%	1.7%	8.8%	SC	48.7%	40.2%	11.1%
IN	74.1%	11.5%	14.3%	SD	71.7%	12.4%	15.9%
KS	72.6%	11.0%	16.4%	TN	85.7%	3.1%	11.3%
KY	25.2%	61.3%	13.5%	TX	53.7%	31.5%	14.8%
LA	78.8%	4.6%	16.6%	UT	86.8%	5.6%	7.6%
MA	94.8%	2.7%	2.5%	VA	85.5%	4.0%	10.5%
MD	95.5%	0.3%	4.2%	VI	0.0%	98.3%	1.7%
ME	17.6%	72.1%	10.3%	VT	76.5%	8.3%	15.2%
MI	84.6%	1.9%	13.5%	WA	91.0%	2.7%	6.3%
MN	82.1%	5.1%	12.8%	WI	40.3%	44.1%	15.6%
MO	76.7%	3.8%	19.5%	WV	68.1%	5.3%	26.6%
MP	0.0%	0.0%	100.0%	WY	65.6%	8.5%	25.9%

Source: June 2016 FCC 477 Data

Produced by: CQA

Figure 2: Terrestrial Broadband Coverage in the U.S. based on FCC 477 June 2016.

And for members of this Subcommittee, the figure below provides broadband speed coverage by Congressional District.

Congressional District Terrestrial Broadband Speed Coverage

Congressional District	Representative	Served	UNDERserved	UNserved
CA Congressional District 18	Anna G. Eshoo	89.9%	0.7%	9.4%
CA Congressional District 36	Raul Ruiz	99.3%	0.1%	0.7%
CA Congressional District 45	Mimi Walters	42.7%	51.6%	5.7%
CA Congressional District 6	Doris O. Matsui	93.2%	2.7%	4.1%
CA Congressional District 9	Jerry McNerney	98.3%	1.0%	0.8%
FL Congressional District 12	Gus M. Bilirakis	93.4%	0.6%	6.0%
IA Congressional District 2	David Loebsack	78.8%	5.1%	16.1%
IL Congressional District 1	Bobby L. Rush	97.1%	1.1%	1.8%
IL Congressional District 15	John Shimkus	77.6%	0.7%	21.7%
IL Congressional District 16	Adam Kinzinger	87.7%	0.5%	11.8%
IN Congressional District 5	Susan W. Brooks	87.8%	1.7%	10.5%
KY Congressional District 2	Brett Guthrie	28.3%	53.8%	17.9%
LA Congressional District 1	Steve Scalise	88.2%	2.3%	9.5%
MI Congressional District 12	Debbie Dingell	96.5%	2.1%	1.3%
MO Congressional District 7	Billy Long	68.0%	11.0%	20.9%
NC Congressional District 1	G. K. Butterfield	80.0%	6.5%	13.4%
ND Congressional District (at Large)	Kevin Cramer	88.2%	3.9%	7.8%
NJ Congressional District 6	Frank Pallone	99.6%	0.0%	0.4%
NJ Congressional District 7	Leonard Lance	99.1%	0.1%	0.8%
NY Congressional District 16	Eliot L. Engel	100.0%	0.0%	0.0%
NY Congressional District 27	Chris Collins	31.4%	65.3%	3.3%
NY Congressional District 9	Yvette D. Clarke	100.0%	0.0%	0.0%
OH Congressional District 5	Robert E. Latta	11.2%	71.7%	17.1%
OH Congressional District 6	Bill Johnson	44.2%	32.6%	23.2%
OR Congressional District 2	Greg Walden	72.9%	5.8%	21.3%
PA Congressional District 14	Michael F. Doyle	99.0%	0.0%	1.0%
PA Congressional District 6	Ryan A. Costello	98.5%	0.1%	1.4%
TN Congressional District 7	Marsha Blackburn	81.2%	3.6%	15.2%
TX Congressional District 17	Bill Flores	57.9%	17.5%	24.5%
TX Congressional District 22	Pete Olson	92.0%	2.5%	5.6%
VT Congressional District (at Large)	Peter Welch	76.5%	8.3%	15.2%

Source: June 2016 FCC 477 Data

Produced by: CQA

Figure 3: Congressional District Broadband Speed Coverage

This Congressional District data is displayed graphically in the next figure.

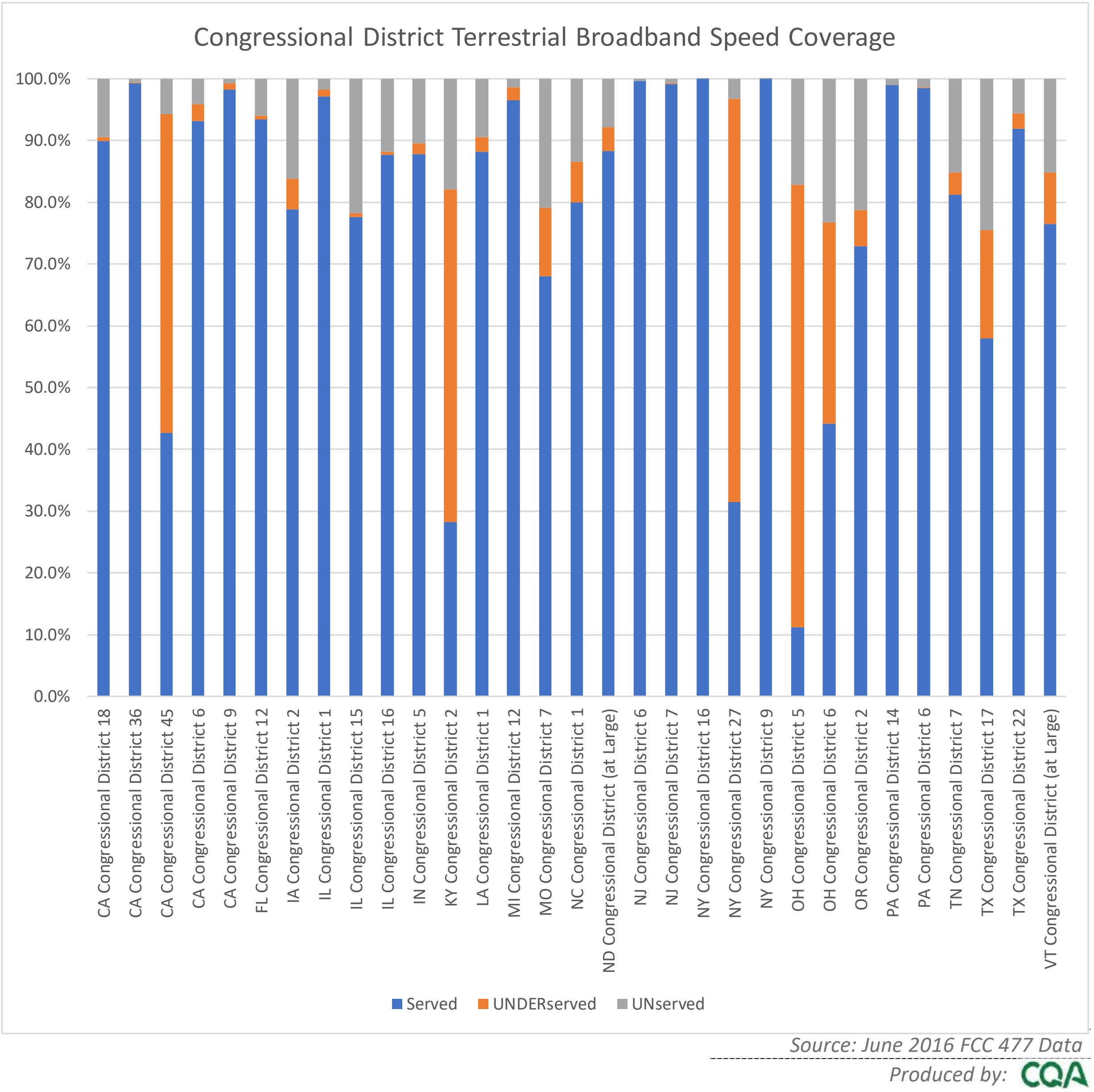


Figure 4: Congressional District Broadband Speed Coverage

Maps of broadband speed coverage for the Congressional Districts represented by this Subcommittee are provided in Appendix A.

Before I leave this section, I present additional views of the broadband coverage data to help identify what the root causes of non-coverage may be.

In the figure that follows, I show coverage information based on the density of the coverage area. It appears, from this summary, that household density is a good predictor of the level of service to which a consumer may have access.

Density Based Terrestrial Broadband Speed Coverage

Density	Served	UNDERserved	UNserved
Rural	50.4%	17.7%	31.9%
Suburban	84.2%	13.2%	2.6%
Urban	91.7%	6.2%	2.0%

Source: June 2016 FCC 477 Data

Produced by: CQA

Figure 5: Density Based Terrestrial Broadband Speed Coverage

In the figure below, I look at the coverage differences between service in Tribal areas[5] versus non-Tribal areas. At this high level, it appears that Tribal area coverage is consistent with coverage outside Tribal areas.

Tribal Land Terrestrial Broadband Speed Coverage

Tribal	Served	UNDERserved	UNserved
Yes	78.6%	11.8%	9.6%
No	76.1%	13.7%	10.2%

Source: June 2016 FCC 477 Data

Produced by: CQA

Figure 6: Tribal Land Terrestrial Broadband Speed Coverage

Mobility

As part of the upcoming CAF Mobility auction, the FCC considers access to LTE[6] service as served. While this presents an objective measurement difference with our fixed service analysis, I believe this is an adequate measure of broadband availability as it indicates what today's consumers desire. However, there is the issue of how one defines the basis of coverage.

Some have asked, is mobility coverage defined as service to homes and businesses or is coverage based on the roads we drive. My goal is not to identify which basis is ideal but rather provide information on both so that informed decisions can be made.

Nationally, based on FCC 477 data, 99.5% of households have access to LTE, while 90.1% of roads have access to LTE.

In the figure below, I show those roads in the U.S. that are not served by mobile LTE coverage.

[5] For this analysis, Tribal was defined using US Census TIGER 2010 American Indian Alaska Native, Hawaiian Homeland (AIANHH) designated Census blocks.

[6] LTE stands for Long Term Evolution and represents what the industry refers to as 4G technology.

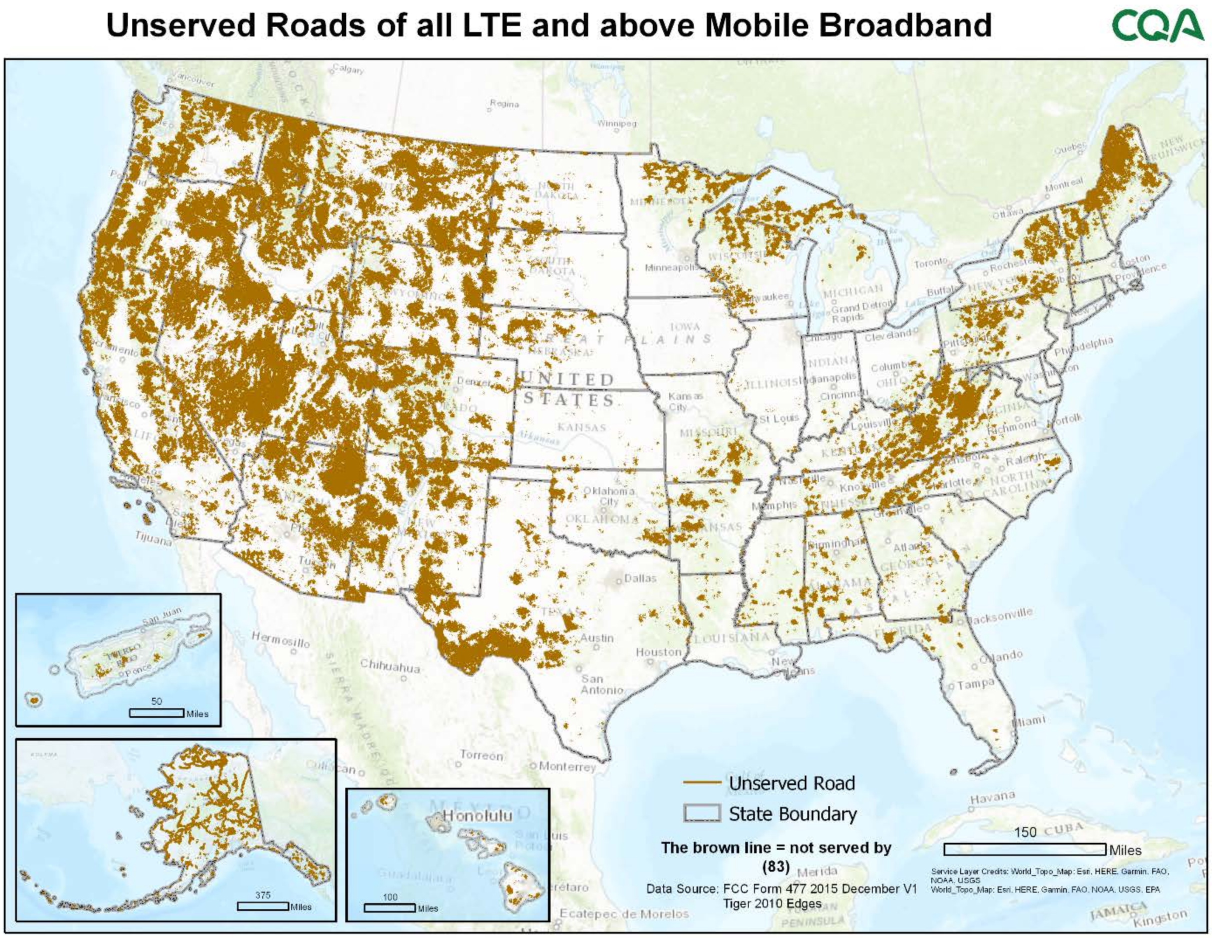


Figure 7: Roads uncovered in by LTE.

Digging below the national map, the figure below provides the LTE road coverage by state:

Road Based LTE Coverage

State	LTE Road Coverage	State	LTE Road Coverage
AL	97.2%	NV	60.4%
AK	27.0%	NH	90.3%
AZ	75.2%	NJ	99.9%
AR	94.6%	NM	80.5%
CA	88.9%	NY	94.8%
CO	83.9%	NC	96.4%
CT	99.9%	ND	96.2%
DE	100.0%	OH	98.2%
DC	100.0%	OK	97.0%
FL	98.5%	OR	71.3%
GA	98.1%	PA	94.1%
HI	95.6%	RI	100.0%
ID	71.7%	SC	99.0%
IL	99.8%	SD	97.3%
IN	99.6%	TN	97.0%
IA	99.9%	TX	94.3%
KS	99.8%	UT	70.8%
KY	89.7%	VT	82.9%
LA	98.4%	VA	93.1%
ME	74.2%	WA	80.3%
MD	99.8%	WV	74.5%
MA	99.1%	WI	94.0%
MI	93.5%	WY	81.4%
MN	95.7%	AS	0.0%
MS	98.3%	GU	100.0%
MO	98.3%	MP	0.0%
MT	61.8%	PR	99.1%
NE	98.2%	VI	98.1%

Source: Dec 2014 FCC 477 Data

Produced by: CQA

Figure 8 : Road Percentage without Access to LTE Coverage

Maps of roads not covered by LTE for each Congressional District for the members of this Subcommittee are provided in Appendix B.

We also can look at LTE coverage by household percentages. In the figure below I show LTE coverage to households.

Household Based LTE Coverage

State	LTE Road Coverage	State	LTE Road Coverage
AL	99.5%	NV	99.5%
AK	79.8%	NH	98.8%
AZ	98.8%	NJ	100.0%
AR	99.6%	NM	98.1%
CA	99.8%	NY	99.6%
CO	99.0%	NC	99.6%
CT	100.0%	ND	99.6%
DE	100.0%	OH	99.9%
DC	100.0%	OK	99.9%
FL	100.0%	OR	99.3%
GA	99.9%	PA	99.6%
HI	99.7%	RI	100.0%
ID	97.6%	SC	100.0%
IL	100.0%	SD	99.2%
IN	100.0%	TN	99.4%
IA	100.0%	TX	99.9%
KS	100.0%	UT	99.0%
KY	99.1%	VT	95.3%
LA	99.9%	VA	99.4%
ME	97.7%	WA	99.2%
MD	100.0%	WV	91.5%
MA	100.0%	WI	99.2%
MI	99.7%	WY	97.4%
MN	99.5%	AS	0.0%
MS	99.6%	GU	100.0%
MO	99.8%	MP	27.3%
MT	95.0%	PR	99.8%
NE	99.8%	VI	99.5%

Source: June 2016 FCC 477 Data

Produced by: CQA

Figure 9: Household based LTE coverage

Obstacles to deployment

With an understanding of the aforementioned coverage data, I can now turn our attention to the expansion of coverage. In the National Broadband Plan, the FCC described issues that present an obstacle to deployment. These included: access to poles and conduit, access to middle mile transport and a host of other items. While these are critical to address, in the material to follow I focus on what I view as the key to broadband deployment: economic viability. That is, when-do the economics of deployment make sense for a commercial provider to invest their limited capital and operational resources.

Mass scale commercial communication networks are expensive

Commercial communication networks are expensive. Network infrastructure: telephone poles, cellular antennas, conduit networks, generators, and data centers are not cheap. The employees who design, engineer install, upgrade and maintain this plant tend to be highly skilled and well trained.

In economic terms, these factors combine to make the cost structure of a commercial broadband provider highly fixed with lumpy investment. Put differently, when a provider starts build out, they do so in units of significant capacity. They can't add 1/8 of a cell tower, two streets in a subdivision, or ½ of a telephone pole. Much of the business challenge in operating a broadband network is understanding where the business case exists for network deployment and upgrades--identifying areas in which there is sufficient demand to make the capital and operational investment profitable.

The National Broadband Plan used a simple diagram to illustrate what I describe as the hockey stick nature of costs. In this figure, you can see as population density decreases (left axis) the investment necessary to provide broadband services increases dramatically. The particular challenge we are now facing is in terms of deployment into the very steep portion of the cost curve. Different types of networks have different shapes-but they all tend to demonstrate that at the lowest ranges of density, the investment to serve a customer becomes extremely high.

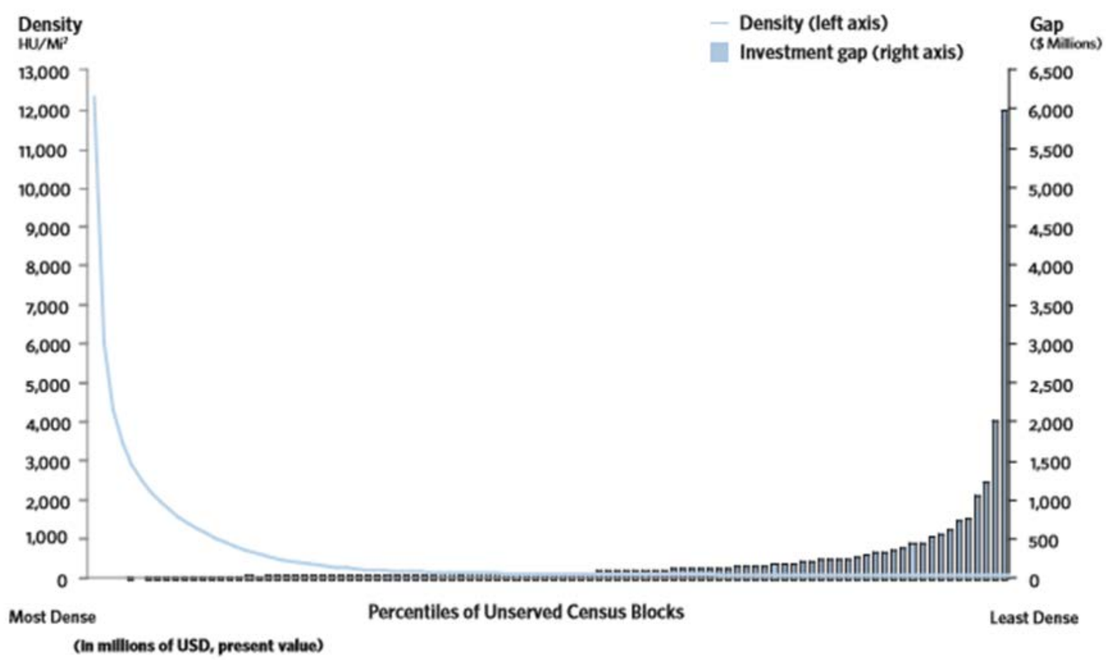


Figure 10: The "Hockey Stick" nature of network cost

Funding the Future of Broadband

Well informed decisions always include a look into the future far enough to ensure that the investments that are made in the near term are sufficient to meet forthcoming demand. It's a reasonable assumption that, as time moves, so will the definition of broadband. Indeed, practical uses of broadband technology will move beyond what we can even envision today. Knowing this, it is not possible to "future-proof" a network build as there will always be the need to meet future demand with infrastructure, software and electronics that have not been conceptualized at this time. However, we know enough about bandwidth need trends to say with reasonable certainty that bandwidth requirements are growing exponentially. Existing and upcoming use scenarios (such as the growth in IoT[7] and the potential for autonomous driving) indicate that it would be foolish to ignore these forthcoming demands. Gigabit speeds will likely be the expected standard for both fixed and mobile broadband solutions in the not-to-distant future. What will achieving these speeds cost in real dollars? Equally important, what will be the costs in not achieving those speeds?

Understanding Costs is the Basis for A Rational Business Case to Expand Coverage

As a basis of the data to follow, CQA has developed a State Broadband Cost Model ("SBCM") that develops the capital requirements and cost of service based on a fiber to the premise ("FTTp") service delivery. This FTTp approach provides a service that is capable of providing 100Mbps service and even Gigabit speeds. And from an economic standpoint, it represents the lowest total-cost approach if a carrier were to deploy new facilities today for 100Mbps service and above.

Within the SBCM, we start with 160 million residential and business locations across the U.S. Our model then develops a network topology to connect each of these locations with fiber along the road network. From this network topology, we can identify the capital requirements (incorporating density and terrain drivers of costs) and resulting estimated monthly operational costs.

As a first step to examining the cost to build out, we need to determine if there are business case issues to expand service to the non-served portions of the country. Using our SBCM output overlaid with the FCC's 477 coverage described earlier, I identify the average monthly cost[8] for service broken out by the density of the area served in the following figure:

Estimated Monthly Cost for Fiber Based Service

Density	Served	UnderServed	UnServed
Rural	$ 47.67	$ 56.56	$ 101.66
Suburban	$ 33.68	$ 32.80	$ 38.05
Urban	$ 31.88	$ 29.23	$ 29.65

Source: CQA's SBCM

Produced by: CQA

Figure 11: Estimated Monthly Cost for Fiber Based Service

From this, we see that unserved areas are higher in cost and can present a hurdle to investing in new networks.

The question that flows from this is, if a carrier can find a business case to invest (this can include government funds or other forms of direct/indirect subsidy), what level of capital would be required? In the following figure, the capital requirements by density to build out service in the Underserved and Unserved portions of the country based on SBCM are provided. These estimates are based on full fiber to

[7] IoT stands for Internet of Things.

[8] I have assumed that 80% of customers will take service to develop the estimated monthly costs. As one can imagine, if the carrier cannot achieve this level of customer uptake, the cost of monthly service for those who do take service will escalate.

the premise deployment with an inclusion of all outside plant facilities, including poles and conduit systems[9]. If these facilities are already available or made available for a carrier, the impact could be a reduction in the capital estimates shown below. Nationally, the capital required to build out a fiber to the premise network in the Underserved and Unserved portions of the country is over $95 billion.

Estimated Capital Requirements for Fiber Based Service

Density	UnderServed	UnServed
Rural	$ 16,886,144,281	$ 60,881,564,817
Suburban	$ 13,447,785,320	$ 3,199,315,186
Urban	$ 846,650,118	$ 273,274,935

Source: CQA's SBCM

Produced by: CQA

Figure 12: Estimated Capital Requirements for Fiber Based Service, by Density

In the following figures and charts, I present the estimated capital requirements by State and for the Congressional Districts represented by this Subcommittee.

[9] Parties have referred to this type of cost as a "Greenfield" cost. That is, what is the cost if we assume we are building from scratch.

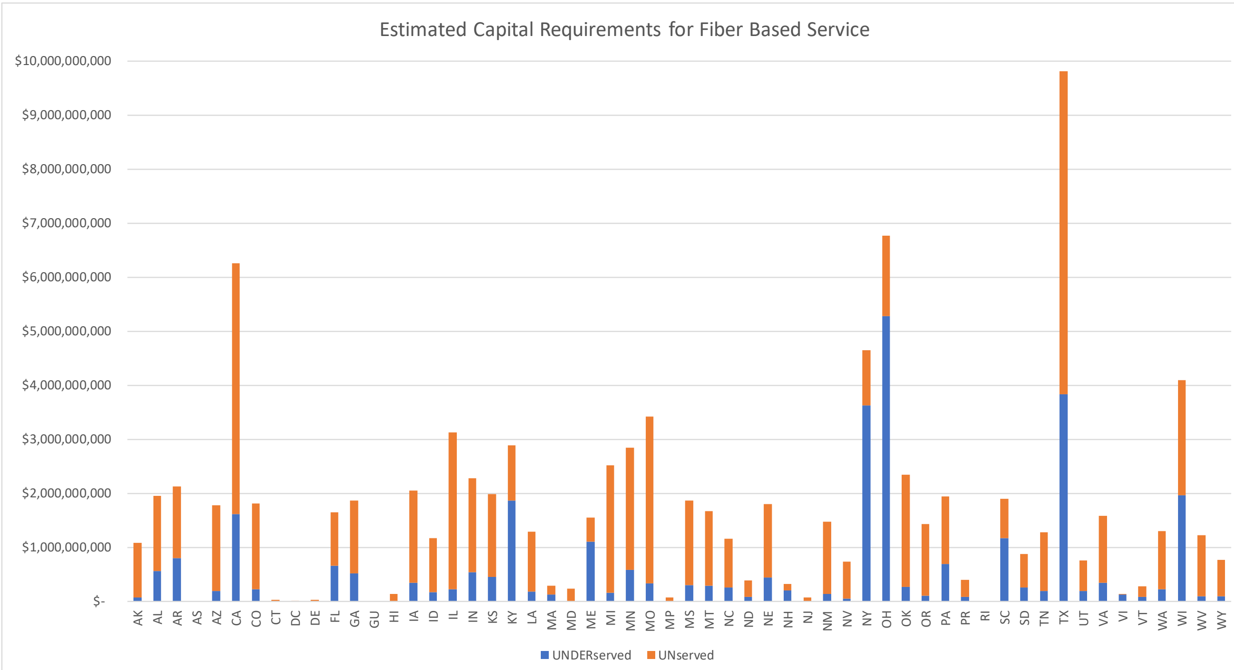
Estimated Capital Requirements for Fiber Based Service

State	UNDERserved	UNserved	State	UNDERserved	UNserved
AK	$ 71,388,303	$ 1,011,469,104	MS	$ 303,751,123	$ 1,568,434,266
AL	$ 565,157,254	$ 1,383,679,404	MT	$ 287,858,172	$ 1,380,637,327
AR	$ 806,300,164	$ 1,318,360,481	NC	$ 260,556,123	$ 904,318,653
AS	$ -	$ -	ND	$ 80,059,898	$ 313,416,159
AZ	$ 193,431,931	$ 1,591,403,826	NE	$ 443,809,408	$ 1,352,664,579
CA	$ 1,619,193,127	$ 4,643,001,751	NH	$ 200,821,386	$ 124,656,544
CO	$ 220,651,052	$ 1,591,476,302	NJ	$ 865,339	$ 73,912,391
CT	$ 24,255	$ 28,457,790	NM	$ 140,293,381	$ 1,330,327,250
DC	$ -	$ 3,819,826	NV	$ 56,726,648	$ 685,302,533
DE	$ -	$ 35,499,293	NY	$ 3,630,056,952	$ 1,016,200,270
FL	$ 656,729,853	$ 990,742,057	OH	$ 5,285,382,139	$ 1,482,072,385
GA	$ 519,251,041	$ 1,344,581,402	OK	$ 274,304,030	$ 2,072,822,676
GU	$ -	$ -	OR	$ 101,404,583	$ 1,330,898,392
HI	$ 478,562	$ 133,781,501	PA	$ 695,798,189	$ 1,251,119,834
IA	$ 350,003,799	$ 1,705,336,123	PR	$ 83,633,268	$ 313,634,860
ID	$ 169,517,589	$ 1,005,400,927	RI	$ -	$ 12,923,073
IL	$ 223,144,256	$ 2,901,473,242	SC	$ 1,169,466,128	$ 727,542,129
IN	$ 539,733,318	$ 1,735,645,874	SD	$ 254,632,725	$ 621,612,075
KS	$ 456,004,774	$ 1,528,208,822	TN	$ 188,521,841	$ 1,090,604,353
KY	$ 1,871,694,065	$ 1,014,137,125	TX	$ 3,834,113,882	$ 5,983,311,562
LA	$ 182,558,514	$ 1,106,175,246	UT	$ 192,031,024	$ 566,205,657
MA	$ 127,781,017	$ 167,349,976	VA	$ 348,883,430	$ 1,239,491,476
MD	$ 13,482,974	$ 223,071,818	VI	$ 123,480,451	$ 4,706,182
ME	$ 1,111,644,257	$ 441,059,461	VT	$ 85,492,349	$ 191,227,034
MI	$ 155,877,199	$ 2,364,769,924	WA	$ 224,802,261	$ 1,074,675,557
MN	$ 580,273,305	$ 2,264,942,690	WI	$ 1,960,109,165	$ 2,138,992,167
MO	$ 331,851,707	$ 3,086,646,866	WV	$ 95,052,729	$ 1,132,894,235
MP	$ -	$ 69,639,814	WY	$ 92,500,779	$ 679,420,673

Source: CQA's SBCM

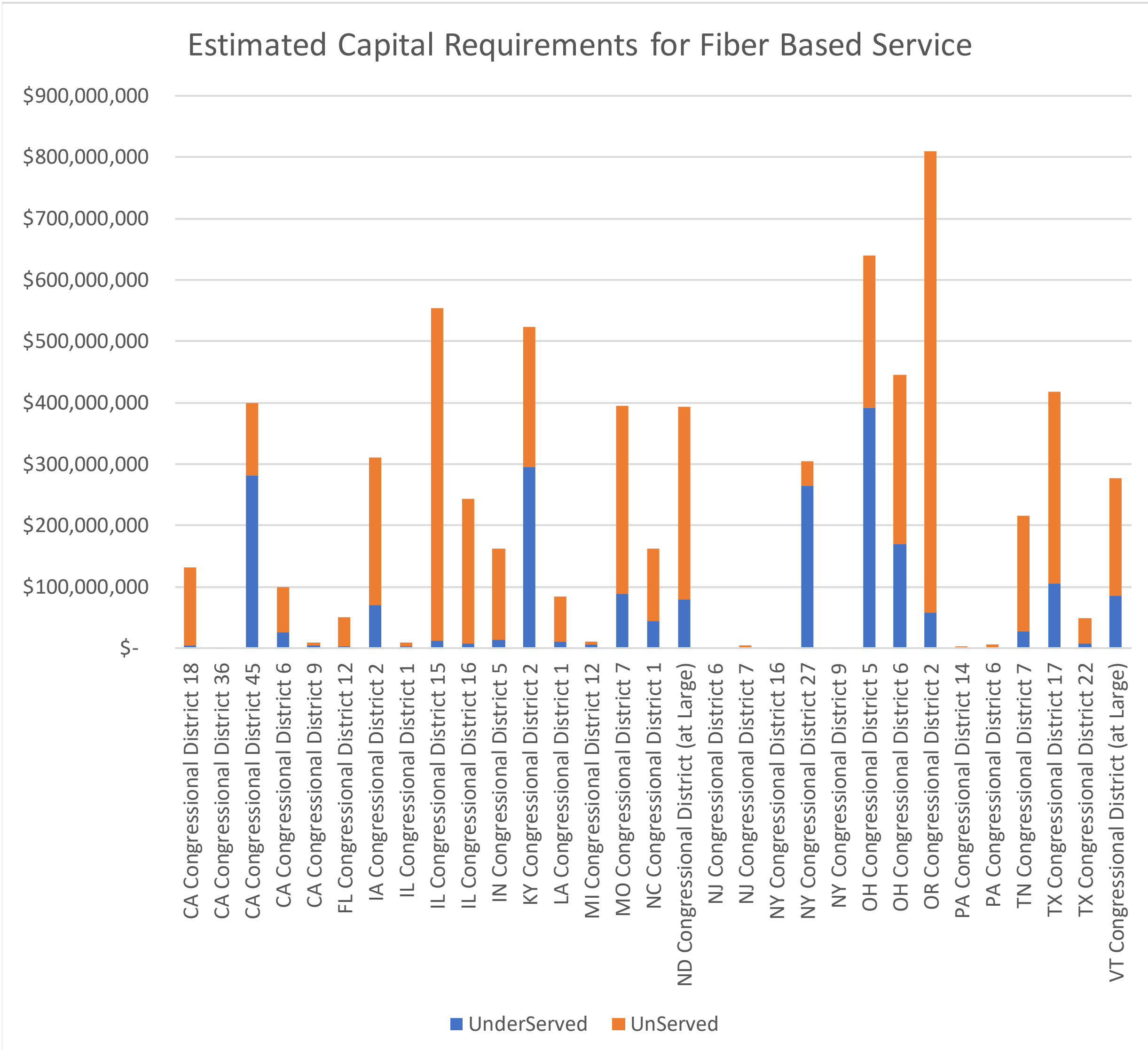
Produced by: CQA

Figure 13: Estimated Capex by State for Underserved and Unserved portions of the country



Source: CQA's SBCM
Produced by: CQA

Figure 14: Capital Requirements by State for Underserved and Unserved areas



Source: CQA's SBCM
Produced by: CQA

Figure 15: Capital Requirements by Congressional District for Underserved and Unserved areas.

Finishing 4G LTE Deployment

As mentioned earlier, almost 10% of the roads in the nation remain unserved by mobile broadband. This includes roads across many states, not just those in the West. Clearly, a lack of economic viability in these areas has left them unserved by mobile carriers, large and small. Factors that contribute to leaving these markets un-built include density, lack of middle mile networks to transport the traffic back from remote sites, difficult terrain and the high-cost of ongoing maintenance in places far-removed from the core network.

CQA recently developed a high-level overview of the total estimated investment for all unserved areas across the U.S.[10] The Study included all costs related to building a 4G LTE network and maintaining that network over 10 years. The results show that bringing 4G LTE to the remainder of unserved roads in the U.S. would cost an estimated $12.5 billion in initial investment and another roughly $2.1 billion in annual operations and maintenance costs. An additional ~37,500 towers / sites would need to be deployed to support this ubiquitous 4G LTE coverage. Expected annual revenue in these areas would not be expected to exceed $240 million annually. This leaves the commercial viability of 4G LTE ubiquity far in the net negative territory.

As with fiber build-out, the challenge of mobile broadband deployment in rural areas is a matter of creating a long-term business case in areas with sparse demand. While terrain and proximity to facilities play a role as gating factors to achieving a positive financial outcome for rural mobile carriers, user density is the single most important factor. CQA studied the costs of building and maintaining rural mobile broadband in February, 2016[11]. This study showed that, depending on the Average Revenue per User (ARPU), a 5-year breakeven for carriers falls somewhere between 800 and 1,200 subscribers per tower. This analysis is inclusive of roaming and other revenue that is shared across the network. Given that most counties in the rural U.S. don't approach 250 people per square mile, there is a clear challenge to produce a positive business case. The image below shows the breakeven point for a modeled provider with an ARPU of $52.50 per month. This chart shows the breakeven on a cash flow basis and for the overall business case.

Figure 16 - Breakeven Analysis for a modeled Rural Carrier

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[10] See https://www.costquest.com/uploads/pdf/2017/cs_4g-unserved-areas.pdf
[11] See https://ecfsapi.fcc.gov/file/60001518777.pdf

Costs of 5G Deployment

Although parts of the country remain unserved by 4G, there has been much recent discussion about 5G mobile deployment. While the standards for 5G technology are still being worked on, questions abound. When is 5G coming? How will it mesh with the existing 4G macro network? How much new infrastructure will be needed to support a fully ubiquitous 5G meshed deployment?

My firm developed a model earlier this year to estimate the upfront investment needed to deploy a mesh 5G to the entire U.S., to cover all roads, buildings and homes[12]. The resulting report gives a glimpse into the costs of deploying 5G at different standards of demand and use, specifically to meet a 50Gb per user monthly demand and for the support of autonomous vehicles. The most robust scenario of meeting the high threshold for demand, while also supporting autonomous vehicles estimates an initial investment of $250 billion[13]. It is important to note that a significant portion of this initial investment is the fiber backhaul required to connect all the 5G cell locations.

Study Description		User Demand	Total Investment
Scenario 1	Ubiquitous Coverage	2Gb/Mo.	$61B
Scenario 2	Ubiquitous Coverage, Future Demand	50Gb/Mo.	$145B
Scenario 3	Ubiquitous Coverage, Autonomous Vehicle support	2Gb/Mo.	$185B
Scenario 4	Ubiquitous Coverage, Autonomous Vehicle support, Future Demand	50Gb/Mo.	$250B

Figure 17 - 5G Deployment Costs by Demand and Use Case

Broadband Coverage and Facility Data

In the material above, I described the coverage and cost of expansion based on information we have today. Much of that information framework—how we analyze the world of today—came from a data needs assessment developed as part of the National Broadband Plan. As we conceive the future, we need to examine what data and tools we have today and will need in the future to make sure that the information framework can support future goals and policy objectives.

For example, can the mobile broadband data provided in the 477 be improved; can we improve on the one-served, all-served approach of the 477 data collection; would access to broadband infrastructure data help our understanding of costs and help carriers expand in the market? Before I examine those questions, let's review where we are today.

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[12] See https://www.costquest.com/blog/news-and-events/our-work/the-5g-mobile-ubiquity-price-tag

[13] As with the Fiber build estimate, this value is a Greenfield value that does not account for existing deployments.

Understanding what areas are covered by broadband is a formidable task. The cost and complexity of the data challenge is driven by the level of detail incorporated.

Beginning in 2009, under the direction of NTIA, States and State grantees assembled a comprehensive data set of terrestrial and mobile broadband availability at the Census block[14] level. My firm collected and assembled this data in four states.

After the close of the NTIA program [15], the FCC Form 477 data collection filled this data requirement. Carriers now submit broadband deployment information at the Census block level every 6 months. The FCC has been publishing the non-confidential portions of the carrier's 477 filing on a more or less periodic basis.

Beyond the constant questions of data accuracy, there is a need for more granular broadband coverage and infrastructure information to help improve our decisions. Currently, 477 coverage standards allow a Census block to be identified as served as long as one location in that block has access to service – what has been referred to as the one-served, all-served assumption. On the infrastructure side, there is no public FCC source for the location of all poles, conduits, fiber routes, cell locations and other important broadband network components.

As efforts to understand broadband availability gaps and efficiently targeting public funds have become more sophisticated, those efforts are frustrated by the potential one-served, all-served assumption inherent in the current 477 data and the lack of infrastructure data.

In a way, broadband data collection efforts are becoming a victim of their own success. In our own work with the State of New York, I have seen the issues that arise from the one served all-served assumption of 477 data. My sense is that as more organizations attempt to micro- target availability gaps, the more troublesome the one-served, all-served assumption embedded in the Census block level data collections becomes. Plainly put, when a home-owner is looking for service what matters to them is the status of their house not the status of the Census block.

South Carolina Mobile Broadband Coverage and Quality

On the mobility side, our efforts drive testing South Carolina mobile coverage show a difference between the carrier-submitted 477 mobility coverage and the experience of traveling in a car and trying to download data.

CQA independently assessed the ground realities of availability and speeds of mobile broadband in South Carolina. First, we developed drive test scenarios for assessing mobile Broadband coverage. Then, RootMetrics® conducted the drive tests[16] under our direction. Finally, we analyzed the data and arrived at the following conclusions:

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[14] A Census block is the smallest unit of area that the US Census bureau enumerates population and housing units. The area of a Census block varies considerably between Urban and Rural areas.

[15] Data collection by State grantees for the National Broadband Map began in 2010 and ended in 2015. See; https://www.broadbandmap.gov/about

[16] See https://www.costquest.com/blog/case-studies/gis-and-mapping/south-carolina-mobile-broadband-performance-study

- Network reliability, when viewed as the ability to connect to a network and transmit or receive mobile data, differs a great deal inside and outside of Census Designated Places (cities and towns). Successful connection rates and throughput speeds are generally lower outside of city and town boundary limits.
- Network reliability across road classifications differs a great deal as well. Connection rates, signal strength and throughput are all lower on roads that are not within primary travel corridors between population centers.
- Throughput speeds are generally much lower in areas with lower population density.
- The FCC's Form 477 data on mobile network availability, while helpful when trying to understand general presence of mobile providers, does not appear to accurately represent customer experience with respect to access and use of networks. Many areas that are shown as covered by mobile providers in the 477 data may be completely unserved or served at speeds below what would be reasonably considered as broadband (i.e., at least 4Mbps down).
- Neither of the FCC's methods for displaying mobile broadband service areas, the Centroid approach or Actual Area approach, allow users to accurately measure customer experience against likely paths of travel.

The map below shows drive test results in southeast South Carolina. The red dots on the map indicate tests below the 4Mbps downlink, while the black dots are where the tests failed to connect to a network. The blue shading on the map indicates 4G LTE mobile broadband coverage according to the FCC 477 data.

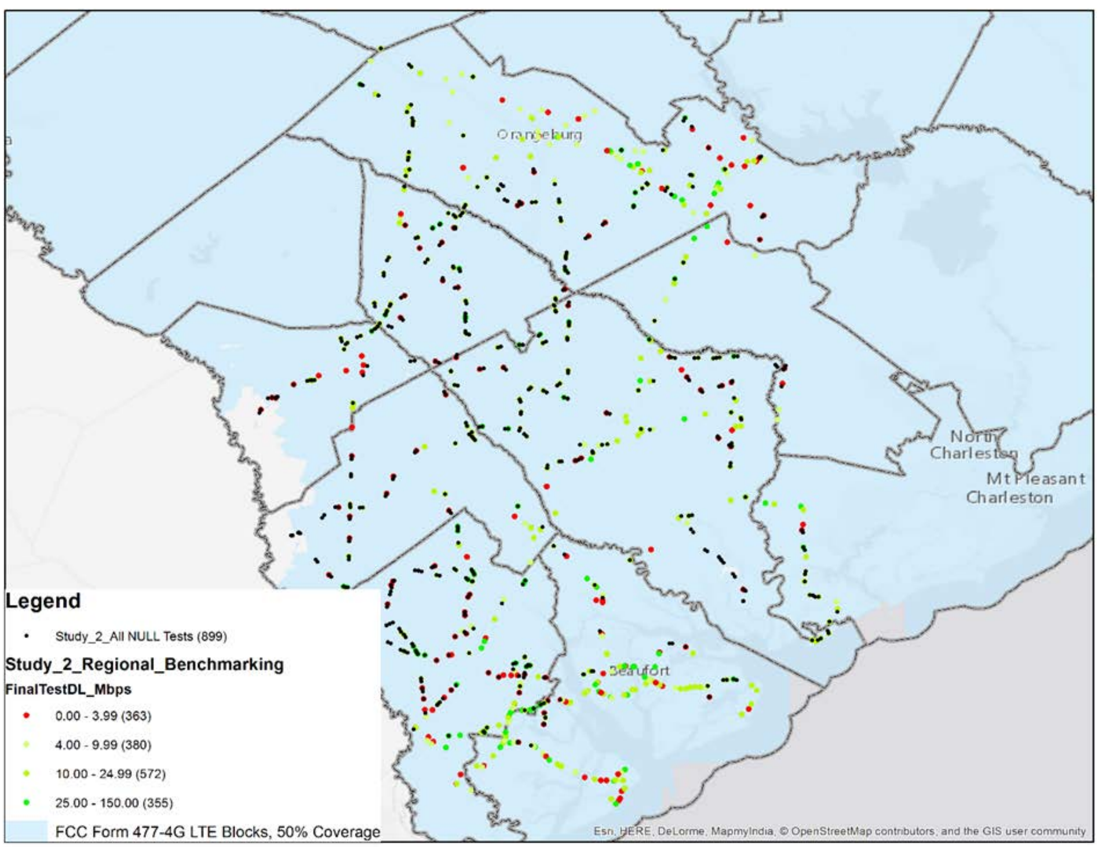

Figure 18: Regional Benchmarking Throughput Results w/477 Overlay

The issues with the mobility data, whether collected through the Form 477 program or with other publicly available data, appears to be the lack of standards by which a carrier can claim coverage.

Addressing the Information Availability Gap

One way to address the data gaps within the 477 data would be to modify the data requirements and collection. For example, the collection for non-mobile networks could be re-oriented to ask providers to submit data on what level of coverage is uniformly available in the reported area. A carrier could also indicate not simply which block is “served” but what portion of the block is served (e.g., 100, 75, 50, 25 percent of the block is covered by the claimed speed).

A second way to address the information gaps for all providers is to collect or request from providers their facility information. By facility, I mean the location of antennas, poles, manholes, electronics and copper/fiber cables necessary for providing broadband service. With a transparent database of facilities, finding those area in a broadband gap areas would become faster and more accurate.

Specific to the mobility collection, the data could be improved by adopting standards for data submitted to the 477 process. The 477 data for mobile providers does not provide any public information regarding what the speed is, the quality of the signal, or how the carrier developed the deployment information. From the public data, we do not know what standard each carrier is using for assuming propagation of signal and the signal strength as measured in the ratio of power in decibels per milliwatt (dBm). This and other issues are described in our South Carolina Mobile Broadband Performance Study[17].

As I mentioned above, the more detailed understanding we have on the accurate availability of broadband, the more efficient we can be at understanding and targeting efforts to close the gaps. But, as a small business owner, I am well aware of the costs involved in data collection and verification. The tension that exists between the need for more information and the cost of producing that information is real. This is a problem that will not be solved overnight.

Encouraging Build Out

Earlier I described the cost hurdles to expanding broadband coverage in the country. In addition, there are other issues beyond cost that are likely holding back deployment. Working at multiple 'levels' in the communication industry allows me to interact with many participants. In this way, I have seen several exciting and innovative approaches to addressing these collective challenges.

While the FCC has implemented the Connect America Fund (CAF) to address some of the financial viability issues, I will not cover the FCC CAF program today. Rather, in the material to follow, I will look at some state and municipal approaches to expand the conversation on what has and can be done.

[17] See pages 19 – 23 https://www.costquest.com/blog/case-studies/gis-and-mapping/south-carolina-mobile-broadband-performance-study

State and Municipal Government Involvement

Several States have established funds that can used for the initial capital investment, or to support the ongoing operations and maintenance of broadband networks over time, or both.

A Partial Inventory of State-Funded Programs

Colorado, Delaware, Kentucky, Maine, Massachusetts, Minnesota, Nebraska, New York, Vermont, Virginia, West Virginia and Wisconsin, as examples, all have funding programs to support infrastructure investment in largely unserved areas. Most of these states have relied on publicly available information, such as the FCC Form 477 data, to support their decisions regarding where funds would be spent. Many of these states found the need to supplement that data with locally collected information on availability, and estimations on costs, to support an even more efficient spend of public funds.

The material below focuses on two State programs.

New York

Governor Cuomo, with the support of the New York State Legislature, established a broadband investment program to deliver $500 million in investment to unserved and underserved areas across the State. The size of the fund, along with the goal of achieving statewide broadband access by the end of 2018, make this program the largest and most ambitious of its kind in the U.S. This multi-phased program is being carried out by Empire State Development (ESD) in a manner that calls on deep analysis of data, including geospatial and cost data, to efficiently spend funds using a reverse-auction model. Phases I and II of the program have committed funds in-excess of $340 million, including private matching funds, to more than 125,000 locations (housing units and business/organization locations). For this project, ESD's use of various forms of data represents the quintessential example of leveraging information for an informed, efficient allocation of resources.

While I may have a bias from having the honor to work on the program, the New York program is an innovative and successful approach that will expand terrestrial coverage of 100Mbps to well over 98% by the end of next year.

Wisconsin

During 2016, the Public Service Commission of Wisconsin awarded 17 Broadband Expansion Grants. The grant awards amounted to $1.5 million in total, and provided funds for 4 business-oriented and 13 residential projects in 17 different counties, passing over 4,500 locations. When completed, the projects will provide improved broadband service to more than 270 business and 7,100 residential locations in the state. The Public Service Commission used availability and bandwidth data they collected to target funds to the areas of greatest need. Less than $350 of public money was spent per location to bring services to unserved areas in 2016. Additional matching funds from broadband providers and from County and Local government were spent on each grant project.

Municipal Involvement

Municipalities, large and small, have become involved in broadband-related public works projects in recent years. There are a growing number of public-private partnership and ownership models for municipal government to choose from. I'll focus the discussion on our work with the City and County of San Francisco.

San Francisco

The City and County of San Francisco have put a considerable amount of thought and analysis into publicly-supported broadband solutions. There is the assumption among many stakeholders in San Francisco that full FTTP deployment to all corners of San Francisco will not happen without some form of government intervention. With that in mind, the Budget and Legislative Analyst's Office and the Department of Technology engaged CQA and others in conducting an analysis of the economic viability and risks for different public, private and public-private partnership (P3) funding options for fiber deployment.[18] All viable approaches to ownership were assessed for their costs, cost recovery, risks and ability to close the digital divide. The image below gives a glimpse into that analysis. One of the keys for San Francisco to move closer to a solution is having accurate data on costs, demand and existing infrastructure.

Model	**Public Model**		**Public-Private Partnership**		**Private Model**
Build out approach	**Utility - Based**	**Demand-Driven**	**Concessionaire, Utility -Based**	**Dark Fiber, Demand-Driven**	**Demand-Driven**
Cost to City	$$$$	$$$	$$$$	$$	$
Risk to City	↑↑↑↑	↑↑↑	↑↑	↑↑	↑
Reduction in digital divide	🖱🖱🖱	🖱🖱	🖱🖱🖱	🖱🖱	🖱
Gigabit speed to all premises at affordable prices	⟲⟲⟲⟲	⟲⟲	⟲⟲⟲	⟲⟲	⟲

Figure 19 - City and County of San Francisco BLA Report, 3/15/16

[18] See http://sfbos.org/sites/default/files/FileCenter/Documents/55324-BLA.MuniGigabitFiberFinance031516.pdf

Conclusion

I have worked in the telecommunication industry for over 25 years. There have been drastic changes in both technology and regulation. It is one of the most dynamic industries in the world and it has been an exciting industry in which to be involved.

My testimony today focused on coverage data and estimates of potential cost to build out and maintain broadband. While high-speed communications is exciting, the underlying data and analyses are less glamorous; for example, I have never been asked at a cocktail party to explain the hockey stick nature of a cost curve.

While efforts to model and understand this information may be tedious, cumbersome, time and data intensive, we need to make every effort to collect accurate information and analyze that information in a way that contributes to a wise and efficient allocation of resources. In short, as with all my client work, we need strive to collect the best information to help make informed decisions.

As I mentioned previously, we are at a stage in which we are becoming victims of the success of prior efforts. To continue moving forward I urge members of the Subcommittee to consider the following:

1. No decision is perfect, but better decisions result from better data, solid analysis and rigorous debate. If we want to make good decisions about tomorrow, we need to assess today's data limitations.
2. We build our network cost models not as an absolute of the future, but to have an understanding of what could drive costs and potential economic viability of a service build. My core belief in building these network economic models is that to better understand economic viability and the costs/benefits of service there needs to be a thorough and quantitative understanding of the business case.
3. Technologically we are in a position to leverage information from a number of disciplines to potentially lower the costs of broadband networks. That information—location of shared/sharable ducts, open tower spaces—needs to be reasonably open and available to everyone. In short, parties should be aware of what is available, and the costs involved in using the infrastructure should be predictable and fair.
4. Policy decisions should be targeted to the smallest areas practicable. The granularity of data sources will drive the level of policy that can be reasonably defined. If we can't target policy to specific places, we risk impacting areas that require no intervention and ignoring unserved or underserved segments that appear to be served.

The challenge ahead to expand coverage to all citizens will be challenging and costly. But to keep the pain and cost to a minimum, we must be informed in what we do using the best tools and data we have.

Thank you for your time today.