Addressing Gaps in Broadband Infrastructure Availability and Service Adoption

A Cost Estimation & Prioritization Framework

June 2021

ACA CONNECTS

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Summary

The digital divide is both an availability problem and an adoption problem

Approximately 12M households do not have access to 25/3 Mbps broadband service (the FCC's current definition), and about 30M do not subscribe to such service when it is available

Policymakers can address both broadband needs with funding under discussion

This analysis offers a framework that policymakers can use to help determine the proper allocation of funding to maximize both the availability of robust broadband service and the number of low-income households that subscribe

More ambitious goals require broadband infrastructure funding amounts to be set at higher levels than what has so far been proposed

For example, building future-proof networks to all locations with less than 100/100 Mbps service would cost approximately $106B - $179B

Source: ACA Connects, Cartesian

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U.S. Broadband | Objectives

There is broad agreement among policymakers that we should deploy future-proof networks in unserved areas, and that all Americans should be able to connect to broadband service

"Our mission [is] to address the digital divide. The disparate effects of that divide have been amplified during the COVID-19 pandemic and exposed the **urgency of ensuring universal access to high-speed internet**."

***– Congressman Jim Clyburn** (D-SC)*

"**High-speed broadband is essential in the 21st Century economy**…
Just like rural electrification several generations ago, universal broadband is long overdue and critical to broadly shared economic success."

– JoeBiden.com

"Our country's technological capabilities are revolutionizing the way Americans communicate and work with each other, but many Americans who live in rural communities are being left behind… **it is critical to support efforts to close the digital divide**."

***– Congressman Bob Latta** (R-OH)*

"Congress needs to explore the feasibility of allocating **more resources for broadband deployment to areas that are not economical to serve or to families that have experienced economic hardships** because of the pandemic."

***– Senator Roger Wicker** (R-MS)*

"With the COVID-19 pandemic now plaguing our nation, our urgency to **ensure all Americans have access to affordable, high-speed broadband** internet has only increased."

***– Congressman Frank Pallone** (D-NJ)*

"When we invest in broadband infrastructure, we invest in opportunity for all Americans … we should be able to **bring high-speed internet to every family in America**."

***– Senator Amy Klobuchar** (D-MN)*

Source: klobuchar.senate.gov, joebiden.com, latta.house.gov, energycommerce.house.gov, connectamericansnow.com, ACA Connects, Cartesian

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U.S. Broadband | Key Questions

As policymakers seek to close the digital divide in America, there are three key questions to consider in developing a comprehensive plan for universal broadband availability and adoption

Key Questions

1. **What is the state of broadband service availability and adoption today?**
2. **What would it cost to address both the availability and adoption gaps?**
3. **How can available funds be prioritized in order to make meaningful progress towards both objectives?**

Source: ACA Connects, Cartesian

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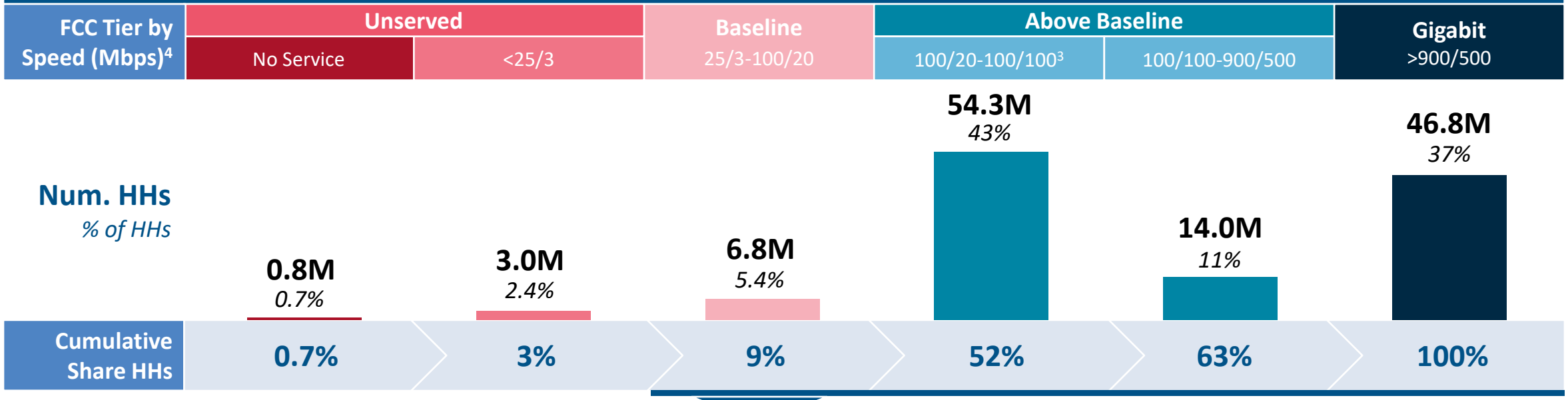
U.S. Broadband | Availability: 2020

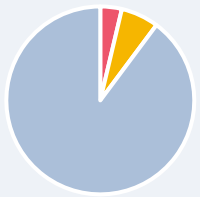
U.S. Households (HH)[1] by Census Block (CB) Max Speed[2] (as of June 2020)

Based on FCC Form 477 Reported Maximum Speeds Available to Each Census Block – Assumes Fully Served Census Blocks



Unserved Households in Partially Served Census Blocks

There are an additional estimated **8.2M households** in census blocks that are reported as 'served'[5] that do not have broadband service available



12M Total HHs without 25/3 Mbps

Accounting for partially served census blocks, an estimated 12M households nationwide do not have access to 25/3 Mbps service

1 Includes all households in the U.S., irrespective of federal or state subsidy status (e.g., including 5.2M locations recently awarded funding through the Rural Digital Opportunity Fund (RDOF))
2 Based on FCC Form 477 data that considers all households in a census block to have access to a given speed tier if any household in the block has access to that speed
3 95% of the 100/20 – 100/100 Mbps group have gigabit or near-gigabit download speeds but below 100 Mbps upload speeds, as a result of being served by cable
4 Speed tiers include all households passed by at least the bottom of the range (i.e., inclusive) without access to the speed at the top of the range (i.e., exclusive)
5 Reflects known issue in FCC Form 477 reporting where a census block is reported with a given speed if a single household in the block is served with that speed, estimated from a BroadbandNow study (see appendix)
Source: FCC Form 477 June 2020 (Apr 7 2021 release), U.S. Census, BroadbandNow, ACA Connects, Cartesian

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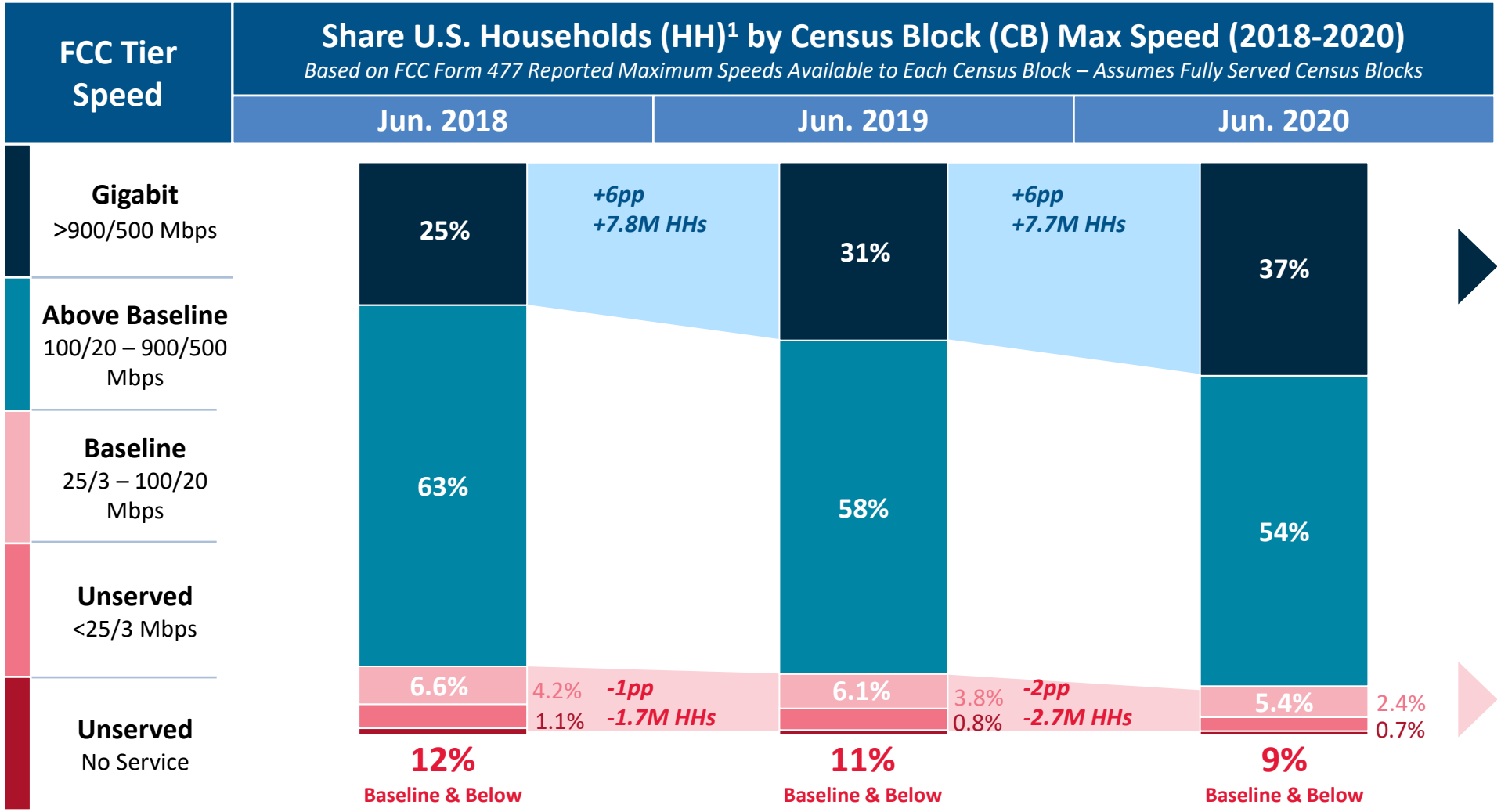
U.S. Broadband | Availability: 2018-2020

Gigabit availability has increased, but many areas continue to have only baseline and below service options



Significant Growth in Gigabit Service

- Gigabit availability has increased by 50% since 2018 as competition drives network upgrades
- Approximately 90% of this growth comes from households that previously had access to above-baseline service

Minimal Reduction in Baseline & Below

- Recent investment has missed the unserved – availability of baseline and below service declined by just 3 percentage points since 2018
- Market forces alone seem unlikely to deliver gigabit service to these areas

Note: pp = percentage points
1 Includes all households, irrespective of state or federal funding status (e.g., includes those recently assigned RDOF funding), does not consider partially served CBs, and reflects share of 2020 households for each year to enable consistent comparison between years
Source: FCC Form 477 June 2020 (Apr 7 2021 release), U.S. Census, ACA Connects, Cartesian

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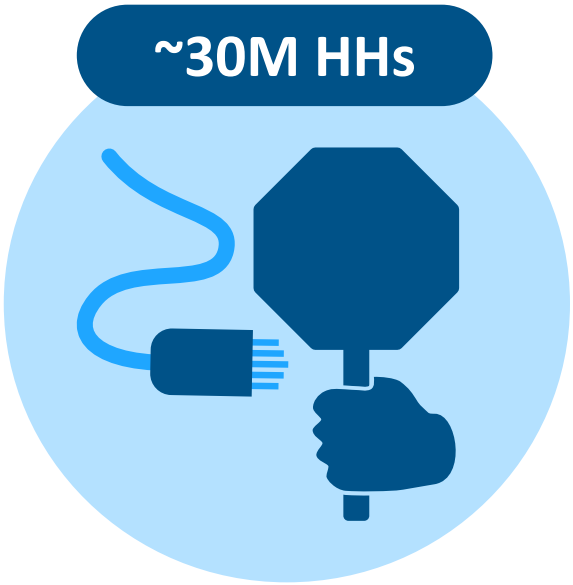
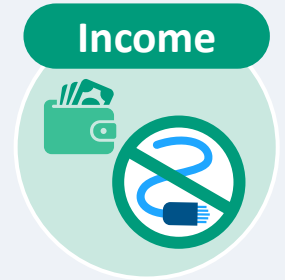
U.S. Broadband | Adoption

Affordability is a significant barrier for lower-income households to adopt fixed broadband



An estimated **30 million households** do not subscribe to fixed broadband at home for "reasons other than network availability"[1]

— National Urban League

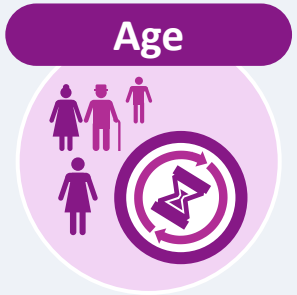


Household income is highly correlated with internet adoption – **36% of all households without a fixed broadband connection make below $20K/year, and 14% make above $75K/year[3]**

— American Community Survey (ACS) 2019[3]

Broadband adoption is a concern in both rural and non-rural areas – **29% of rural homes and 28% of non-rural homes do not subscribe** to fixed broadband when it is available[4]

— Cartesian Analysis of 2019 ACS[3] and Census Data



Age does not seem to be correlated with broadband adoption – **adoption is approximately 28% in areas with and without higher proportions of senior citizens** (i.e., age 65+)[5]

— Cartesian Analysis of 2019 ACS[3] and Census Data

In addition to affordability, studies suggest that digital readiness and perceived lack of relevance are also barriers to broadband adoption[6]

1 Approximation from the National Urban League, which assumes that 80-90% of ACS' 36M non-adoption households have access to at least one available fixed terrestrial service. NUL approximation is based on American Community Survey tally of households with "broadband such as cable, fiber optic or DSL" – this excludes households whose only connectivity is through a mobile provider, but may include a small number of households with a sub-25/3 connection (refer to appendix for further detail)
2 The federal poverty line for a 3-person household in 2020 was $21,720 | 3 Based on American Community Survey 2019 5-year rolling average estimate of households without access to home internet through any technology (e.g., fixed broadband, mobile, satellite, etc.)
4 Around 10% of total households subscribe only to a cellular data plan, which provides some connectivity but is unsuitable for many of the use cases enabled by fixed broadband
5 Higher 65+ population = at least 25% of the census block group as 65+ (see appendix) | 6 Based on the Lewis Latimer Plan For Digital Equity And Inclusion, published by the National Urban League
Source: FCC Form 477 June 2020 (Apr 7 2021 release), American Community Survey 2019 5-year Estimates, Pew Research Center, National Urban League Lewis Latimer Report, ACA Connects, Cartesian

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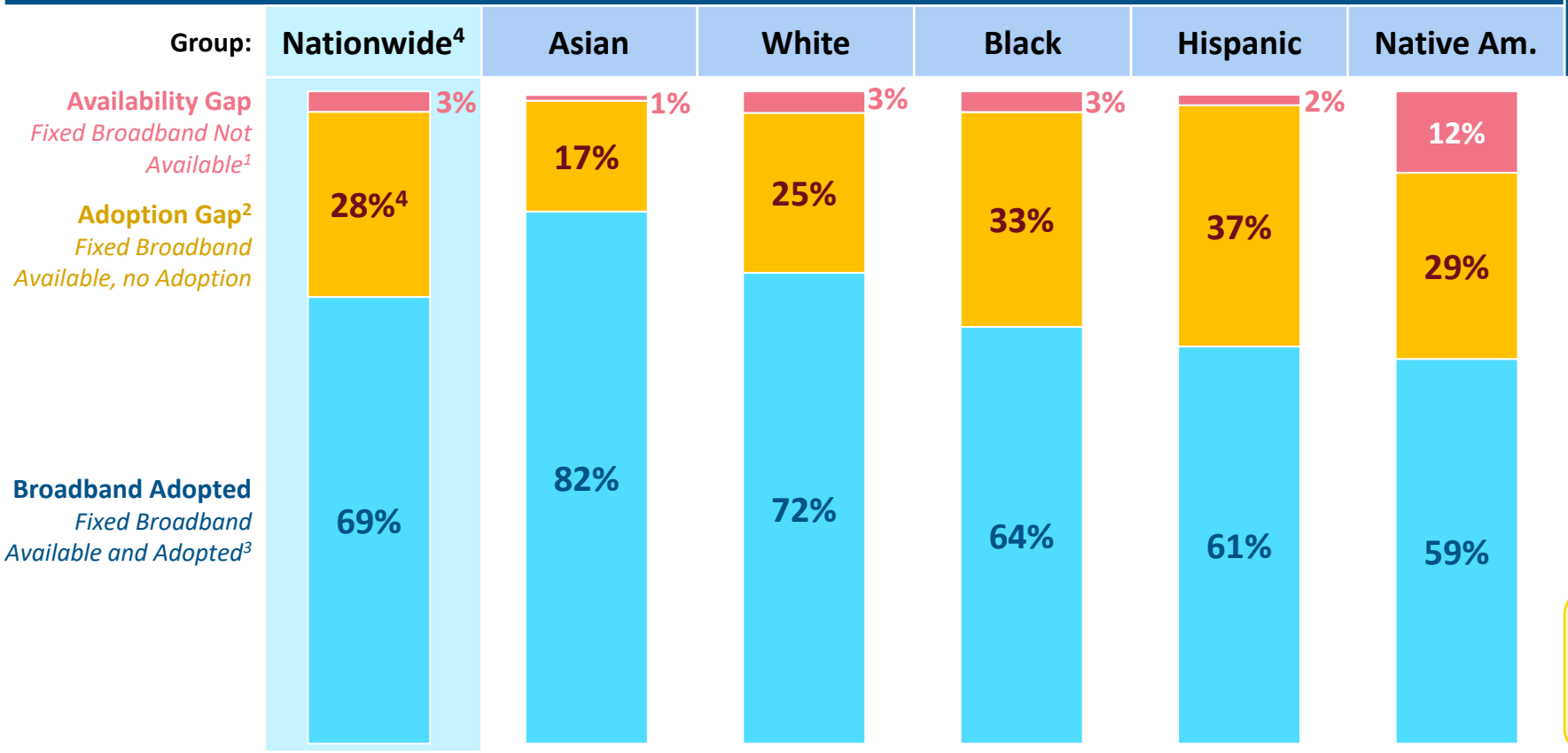
The Digital Divide | Availability, Adoption, Demographics

More households don't subscribe to broadband than don't have it available – availability and adoption both need to be addressed in order to close the digital divide

Broadband Availability and Adoption by Demographic (Approximate)



Notes

Minimal Availability Gap:

- Across all groups except Native Americans, broadband[1] is available to 97%+ of HHs
- This does not account for partially served census blocks, which may represent an additional ~6.5% of U.S. households

Sizeable Adoption Gap:

- There is a gap in broadband adoption across all populations – Hispanic and Black populations have the largest adoption gap
- While **about one third** of households without a fixed broadband connection have mobile connectivity, this is insufficient for some use cases (e.g., remote learning)[5]

Accounting for partially served census blocks, there may be ~2x as many households that don't subscribe to broadband when it's available (22%) than don't have access (10%)

1 Based on availability data from Form 477 of households with access to speeds of at least 25/3 Mbps – availability by demographic is estimated based on demographic and geographic distribution data from Experian
2 Defined as the share of population with broadband available minus the share of population that subscribe to broadband | 3 From a National Urban League report on the share of each demographic with fixed broadband at home based on ACS data. Nationwide data also uses ACS estimates of households with "broadband such as cable, fiber optic or DSL" – this excludes households whose only connectivity is through mobile, but may include a small number of households with a sub-25/3 connection
4 Nationwide average adoption gap implies 34M households that choose not to subscribe to broadband – this is slightly different to National Urban League estimate of 29-32M households as a result of slight differences in methodology
5 Of total U.S. households, ~10% have an internet connection through mobile only – this group is approximately one third of the 28% that do not subscribe to fixed broadband
Source: FCC Form 477 June 2020 (Apr 7 2021 release), Experian, National Urban League, ACA Connects, Cartesian

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ACA Connects Broadband Study | Most Recent, Comprehensive Assessment

Our study uses the most recent data and comprehensive analysis for gigabit deployment cost assessment

2016	2018	2019	2021
Paul de Sa FCC Office of Strategic Planning & Policy Analysis	**Jim Stegeman**[1] CQA	Fiber Broadband Association Cartesian®	ACA CONNECTS Cartesian®
Where prior studies fall short in determining gig availability costs for 2021			***Latest data, most comprehensive***
• Uses outdated (2015) data *(14% of locations were <25/3 Mbps, vs 3% now)* • Only estimates costs to deploy fiber to areas with service below 25/3 Mbps	• Uses outdated (2016 A-CAM) cost estimates • Only estimates costs to deploy fiber to areas with broadband service below 25/3 Mbps	• Uses outdated (December 2017) deployment data • Model only evaluated costs for 90% of U.S. households • Government support amounts assume a high level of private sector investment over a ten-year period (i.e., does not consider minimum support needed to incentivize deployment)	✓ Uses latest data (June 2020) ✓ Incorporates estimates for businesses, anchor institutions, and partially served census blocks and adoption subsidies ✓ Estimates deployment costs[2] for all locations across multiple deployment scenarios (e.g., all locations with <25/3 Mbps service, <100/20 Mbps, etc.)

1 In a webinar titled "Rural Broadband Economics: A Review of Rural Subsides", sponsored by USTelecom and NTCA – The Rural Broadband Association. CostQuest created the cost model used to determine broadband deployment costs for CAF program
2 Our high-end cost estimates use the density-based FTTH cost model derived in the 2019 FBA study, which was based on data collected on historical fiber deployments
Source: Fiber Broadband Association, USTelecom, NTCA, FCC Office of Strategic Planning and Policy Analysis, ACA Connects, Cartesian

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Estimated Costs | Gigabit Deployment

There are three categories of locations that require funding to ensure gigabit is available to all Americans – for each category, we estimate a range of costs to make gigabit available

Location-Based Cost Model Estimation[1]	We estimate a gigabit deployment cost range for each of the location categories below: • **Low end**: Based on winning gigabit bids in the RDOF auction, which estimates the minimum government support needed to incentivize deployment using a reverse auction • **High end**: Full fiber deployment costs based upon actual builds, which estimates the maximum possible support amount, should subsidies for the full cost be needed
Unfunded, Unserved Census Blocks	The cost to provide access to gigabit to all locations – households/housing units, businesses, and anchor institutions – in unserved census blocks that are not currently receiving funding under RDOF or other FCC programs
Partially Served Census Blocks[2]	The cost to provide gigabit to unserved households in census blocks that are reported as served due to a known FCC reporting issue[2]
Unserved Areas Receiving Sub-Gigabit FCC Funding[3]	The cost to provide gigabit to households and businesses in unserved census blocks that are currently receiving funding under FCC programs (i.e., ROR, ACAM, and CAF Phase II Auction) – most of these programs do not require the provision of speeds above 25/3 Mbps and therefore may require supplemental funding

1 Cost assessment is based on model that relies on household density, agnostic of proximity to existing infrastructure – see page 21 in appendix for more detail
2 Reflects known reporting issue in FCC Form 477 data that counts a census block as 'served' with a given speed if any household in that census block is able to purchase that speed – estimates based on a 2021 study from BroadbandNow measuring the extent of this issue
3 Excludes areas that were funded under RDOF, because FCC review of longform applications is still ongoing
Source: ACA Connects, Cartesian

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Estimated Costs | Gigabit Deployment

Estimated deployment costs increase as the 'unserved' threshold increases to higher levels of service

Cumulative Costs to Fund Gigabit for:	All Locations[1] with **<25/3 Mbps** *Current FCC Definition of Broadband*	All Locations[1] with **<100/20 Mbps** *RDOF "Above Baseline" Threshold*	All Locations[1] with **<100/100 Mbps** *LIFT Act Proposed Threshold*	All Locations[1] with **<Gigabit[2]** *RDOF Gigabit Threshold*
Unfunded, Unserved Census Blocks[3]	$4B – $7B *2.2M locations*	$16B – $31B *8.8M locations*	$91B – $150B *75M locations*	$103B – $170B *91M locations*
+ **Partially Served Census Blocks[4]**	$14B – $25B *7.7M locations*	$13B – $24B *7.4M locations*	$7B – $12B *3.9M locations*	$5B – $10B *3.0M locations*
+ **Unserved Areas Receiving Sub-Gbps FCC Funding[5]**	$3B – $5B *1.0M locations*	$6B – $12B *2.3M locations*	$8B – $17B *3.7M locations*	$9B – $18B *5.0M locations*
= **Total** *(Cumulative)*	**$20B – $37B** ***11M locations***	**$35B – $67B** ***19M locations***	**$106B – $179B** ***82M locations***	**$117B – $198B** ***99M locations***

The cost to build to all locations <100/100 Mbps is ~90% the cost of building to all locations <gigabit. In most cases, locations with at least 100/100 Mbps available already have fiber available, and upgrades to provide gigabit (i.e., upgrades to electronics) are significantly less expensive than laying new fiber

Note: Range reflects an approximate subsidy amount based on historical gigabit support amounts awarded in RDOF at the low end, and an approximate fiber build cost at the high end. Both estimates are based on household densities, and costs for both the low end and high end are approximated at 10% of density-based costs in cases where fiber is available, but speeds listed are below gigabit (typically due to constraints that are less expensive to mitigate than laying new fiber, such as upgrading electronics)

1 Not including areas that received funding under RDOF Phase I, as nearly all locations were bid at 100/20 Mbps or Gigabit speeds | 2 Reflects speeds of below 900/500 Mbps | 3 Including household locations, businesses, and anchor institutions – see appendix for methodology

4 Based on a study that estimated unserved households by BroadbandNow – see appendix for methodology. As the threshold increases, the number of potentially unserved households that are missed in other funding categories decreases

5 Including locations previously receiving ACAM, ROR, or CAF II auction funding but excluding RDOF since FCC review of longform applications is currently ongoing – see appendix for cost assessment methodology

Source: FCC Form 477 June 2020 (Apr 7 2021 release), U.S. Census, ACA Connects, Cartesian

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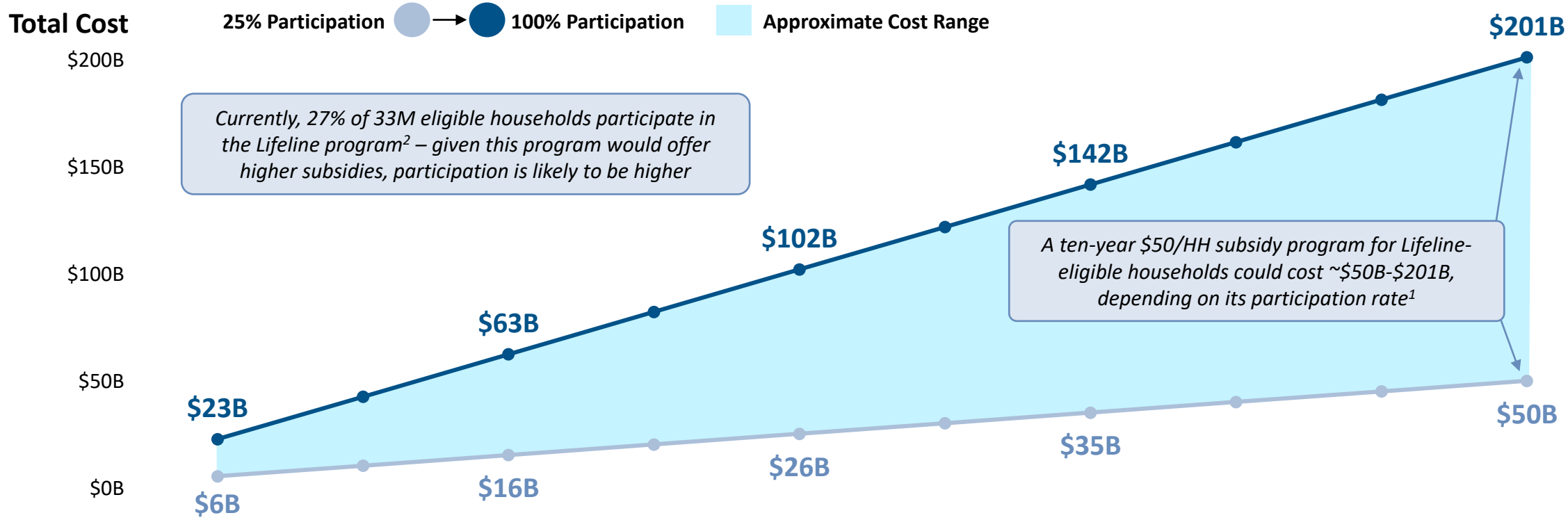
Estimated Costs | Broadband Adoption

Estimated adoption subsidy costs increase as program participation rate and duration increase

Broadband Adoption Cost[1] by Program Participation Rate and Duration										
Duration (Years):	1	2	3	4	5	6	7	8	9	10



1 Based on estimated 33 million households that are currently eligible for the Lifeline program, and $50/mo broadband subsidy plus $100 one-time connected device subsidy
2 From program data on USAC.org (accessed May 2021)
Source: USAC, ACA Connects, Cartesian

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Estimated Costs | Fully Fund Gigabit Availability & Broadband Adoption

With **$400B**, policymakers could ensure full gigabit availability and fund an extended adoption program

Full Gigabit Availability		Full Broadband Adoption		Grand Total
$117B - $198B	+	**$50B - $201B**	=	**$167B - $399B**
ENSURE EVERY HOUSEHOLD, BUSINESS, AND INSTITUTION HAS GIGABIT SPEED BROADBAND AVAILABLE[1]		OFFER HIGH-SPEED BROADBAND SUBSIDIES TO EVERY LOW-INCOME FAMILY FOR 10 YEARS		ALL-IN ESTIMATED COST OF FULLY FUNDING GIGABIT AVAILABILITY AND BROADBAND ADOPTION

1 Not including locations in areas that were assigned RDOF support, where winning providers are mandated to begin offering 100/20 Mbps+ or gigabit service in almost all areas by 2030
Source: ACA Connects, Cartesian

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Prioritizing Broadband Funding

Given the finite – albeit substantial – funding available, how might policymakers set priorities?

Funding Goal: ***Maximize the number of Americans that can access essential digital resources***

Key Questions: How should funding be allocated between programs to address the availability and adoption gaps?

1 Availability Gap

- What threshold should constitute 'unserved' areas that are prioritized for funding?
- What mechanisms[1] should be utilized to allocate funds?
- How should new deployment program(s) coordinate with existing federal and state programs?

2 Adoption Gap

- What households should be eligible for support?
- What per-month subsidy amount should be provided to each eligible household?
- How many eligible households are likely to participate in the program?
- How long should the program last?

1 E.g., Reverse auctions (as seen in RDOF Phase I) prioritize providers that can connect locations the most cheaply, resulting in a subsidy-efficient mix of new builds and upgrade to existing networks

Source: ACA Connects, Cartesian

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Example Funding Approach | Cost Assessment

For **$61B-$118B**, the U.S. could make gigabit available to 19M locations with less than 100/20 Mbps service and substantially increase broadband adoption

Availability

Ensure that the U.S. has adequate infrastructure to enable all households, businesses, and anchor institutions to access speeds of at least 100/20 Mbps

Unfunded, Price Cap Areas[1]

Unfunded, Unserved CBs
All locations in census blocks reported as not receiving 100/20 Mbps service
$16B-$31B
8.8M locations

Partially Served CBs[2]
Households lacking 100/20 Mbps service, in census blocks reported as receiving such service
$13B-$24B
7.4M locations

Areas Receiving Sub-Gigabit FCC Funding[1]

ROR/ACAM
All locations in ROR/ACAM census blocks that lack access to 100/20 Mbps service
$4.4B-$9.1B
1.8M locations

CAF II Auction
All locations in CAF II auction census blocks that lack access to 100/20 Mbps service
$1.4B-$2.9B
522K locations

$35B-$67B, 19M Locations

Adoption

Provide support to low-income households to increase broadband adoption rates

Low-Income Household Broadband Subsidy[3]
5-year subsidy program for Lifeline-eligible households, 25-50% adoption rate
$26B-$51B
8.3M-17M HHs

$26B-$51B

Total Cost of $61B-$118B to Ensure Available, Affordable High-Speed Broadband

1 Not including areas that received funding under RDOF Phase I Auction, as nearly all locations were won at 100/20 Mbps or greater
2 Estimate based on a study by BroadbandNow – data from the FCC around broadband availability will be needed to more precisely assess the number of households impacted by partially served CBs
3 Includes $50/month service subsidy and $100 one-time connected device subsidy for participating households
Source: FCC Form 477 June 2020 (Apr 7 2021 release), U.S. Census, BroadbandNow, ACA Connects, Cartesian

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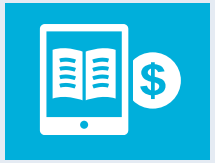
Other Broadband-Related Initiatives

Additional broadband-related initiatives are competing with broadband deployment and adoption programs for limited infrastructure funding

Digital Equity & Inclusion[1]
Investments in digital inclusion initiatives aimed at historically under-connected communities

~$1B



Additional E-Rate Support[2]
Expansion of existing E-Rate funding program to provide support for connectivity and connected devices

~$3B

School Bus WiFi Support[2]
Outfitting school buses for connectivity for commuting students

~$1B

Next-Gen 911[1]
Completion of the transition of all 911 systems from analog to IP-based systems

~$15B

Low Interest Deployment Financing[1]
Provide below market debt financing to accelerate deployments

~$5B

Network Backup Generators[3]
Redundancies to keep Americans connected through climate-related environmental contingencies

~$2.3B

Climate Resilience for New Builds[3]
Funding for new deployments to ensure resilience to climate events (e.g., floods, wildfires, hurricanes)

~$6-10B

Sustainability Incentives[3]
Incentive programs to provide add'l funding for sustainable new builds (e.g., sourcing sustainable materials)

~$4-7B

+ Additional sustainability objectives:

- Installing renewable energy sources to power infrastructure
- Incorporating sustainable materials and processes in network upgrades
- And more…

Education

Environment & Sustainability

Community Investments

1 Cost estimates are as quoted in the LIFT Act legislation – remaining estimates explained in appendix (page 29) | 2 Programs enumerated in the Accessible, Affordable Internet for All Act | 3 Programs enumerated in the GREEN Communications Act (S. 1506)
Source: LIFT Act, Accessible Affordable Internet for All Act, GREEN Communications Act (S. 1506), ACA Connects, Cartesian

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Conclusion

The digital divide is both an availability problem and an adoption problem

Policymakers can address both broadband needs with funding under discussion

More ambitious goals require broadband infrastructure funding amounts to be set at higher levels than what has so far been proposed

See appendix for additional material documenting approaches, calculation methodologies, and supplemental detail

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Appendix

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Cost Assessment Methodology

Additional Availability & Adoption Analyses

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Cost Assessment Methodology & Example Funding Approach Overview

Estimation methods for each cost item of the example funding approach outlined below are explained in further detail in this section

Item in Example Funding Approach	Methodology Summary	Cost Estimate	Pages
Unfunded, Unserved Census Blocks *All locations in census blocks reported as not receiving 100/20 Mbps service*	Estimate household and business counts using Census and FCC data, anchor institutions using Experian and USAF data, and apply cost model framework	**$16B-$31B** *8.8M locations* ($)	22-25
Partially Served Census Blocks *Households lacking 100/20 Mbps service, in CBs reported as receiving such service*	Derive estimate of unserved locations in CBs reported to have service based on FCC and BroadbandNow data and apply average costs from cost model framework	**$13B-$24B** *7.4M locations*	26
ROR/ACAM *All locations in ROR/ACAM census blocks that lack access to 100/20 Mbps service*	Map reported ROR/ACAM-supported locations against FCC Form 477 deployment data and apply cost model framework to remaining unserved census blocks	**$4.4B-$9.1B** *1.8M locations* ($)	27
CAF II Auction *All locations in CAF II Auction census blocks that lack access to 100/20 Mbps service*	Map reported CAF II-supported locations against FCC deployment and apply cost model framework to remaining unserved census blocks	**$1.4B-$2.9B** *522K locations* ($)	
Low-Income Household Broadband Subsidy *5-year subsidy program for Lifeline-eligible households, 25-50% adoption rate*	Model total cost of subsidy based on Lifeline adoption rates, program duration, and stipulated subsidy amounts	**$26B-$51B** *8.3M-17M HHs*	28

($) **Uses location-based cost model estimation explained on page 21**

Source: ACA Connects, Cartesian

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Location-Based Cost Model Estimation

We used RDOF auction funding data and a full FTTH deployment model to establish low- and high-end gigabit deployment cost estimates

Gigabit Deployment Cost Estimation

Approximates range of cost to provide gigabit (i.e., future-proof speeds) to all 'unserved' locations, where 'unserved' threshold varies based on the scenario modeled

Low End: RDOF Auction-Based Gigabit Subsidy Estimates

Use data from the recent RDOF (904) auction around funding per location to predict minimum funds needed to incentivize deployment

We examined the results of the RDOF allocation auction (904):

Winning subsidy per location for each census block to receive gigabit

Assessment of the relationship between HH density and auction subsidies

We used the relationship between HH density and cost to predict support costs associated with new census blocks:

Density Range (HHs/mi²)	Support per Location
1 – 10	$2.7K
10 – 100	$1.4K
100 – 1000	$1.1K
1000 – 10000	$732
10000+	$635

Support = $3,449 - $845 * $\log_{10}$(Density)

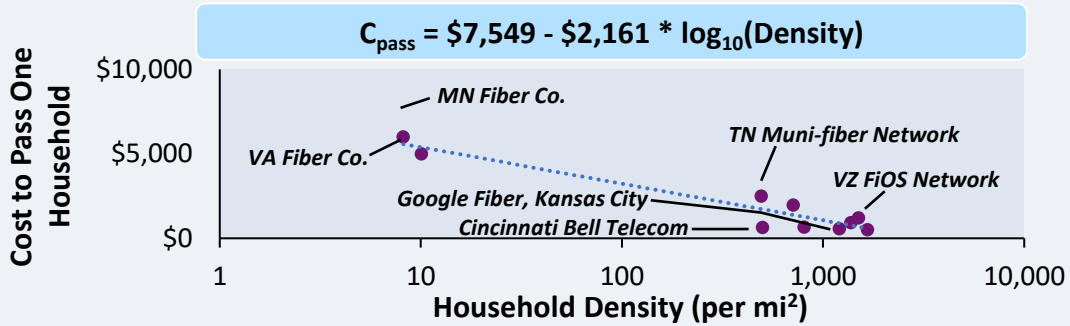
High End: FTTH Build Cost Estimates

Use density-based modeling around cost of fiber to the home deployment to estimate full fiber build costs

FTTH build costs are a good high-end estimate:

- FTTH is currently the only commercially available technology capable of delivering gigabit (i.e., >900/500 Mbps)
- Cost estimates capture the maximum possible support amount, should subsidies for the full build cost be needed to incentivize deployment

We estimate the cost to pass a household with fiber based on the density of that household's surrounding area:[1]



1 Deployment data and analysis conducted in a 2019 Cartesian/Fiber Broadband Association study estimating the cost of increasing fiber deployment in the United States

Note: Locations already served with fiber that have at least 50 Mbps upload have a cheaper upgrade path to gigabit than other technologies – costs in these areas were estimated to be 10% of our model predictions, since existing fiber infrastructure generally removes the need for new pipes, and instead only requires upgrades to electronics

Source: FBA, FCC, ACA Connects, Cartesian

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Unfunded, Unserved Census Blocks

Locations in Unfunded, Unserved CBs

We identified unserved census blocks and calculated a range of estimated gigabit deployment costs

Identify Applicable Census Blocks

- **Exclude Previously Funded Census Blocks**
  Remove census blocks that received funding through existing FCC programs (i.e., ROR, ACAM, RDOF, CAF Phase II Auction) in order to prioritize blocks that have not yet been allocated FCC support

Identify Census Blocks that Are Unserved

- **Exclude Geostationary Satellite Providers**
  Geostationary satellite internet has lower capacity with higher latency, and is therefore insufficient for many critical internet use cases (e.g., video conferencing)
- **Identify Maximum Available Speeds**
  Use FCC Form 477 data (June 2020) to identify reported maximum speeds to each census block
- **Group Census Blocks According to Available Speeds**
  Identify which census blocks are unserved, e.g., with less than 100/20 Mbps speeds available

Identify Households, Businesses, Anchor Institutions

- **Locations within Unfunded Unserved Census Blocks**
  Estimate total locations in each category using various data sources:

Households
Append 2010-2020 U.S. Census Data to census blocks that were unfunded or unserved

Businesses
Estimate based on a ratio of RDOF-supported businesses to household locations

Anchor Institutions
Identify unfunded anchor institutions using Experian and published FCC E-Rate recipients

Source: FCC Form 477 June 2020 (Apr 7 2021 release), U.S. Census, ACA Connects, Cartesian

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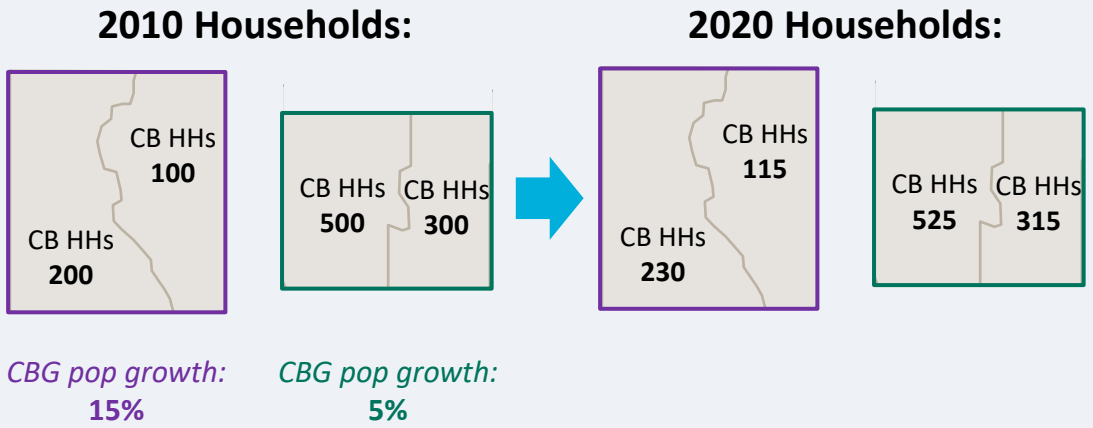
Household Location Tabulation

Locations in Unfunded, Unserved CBs

We estimate households per census block using 2020 census block group level population

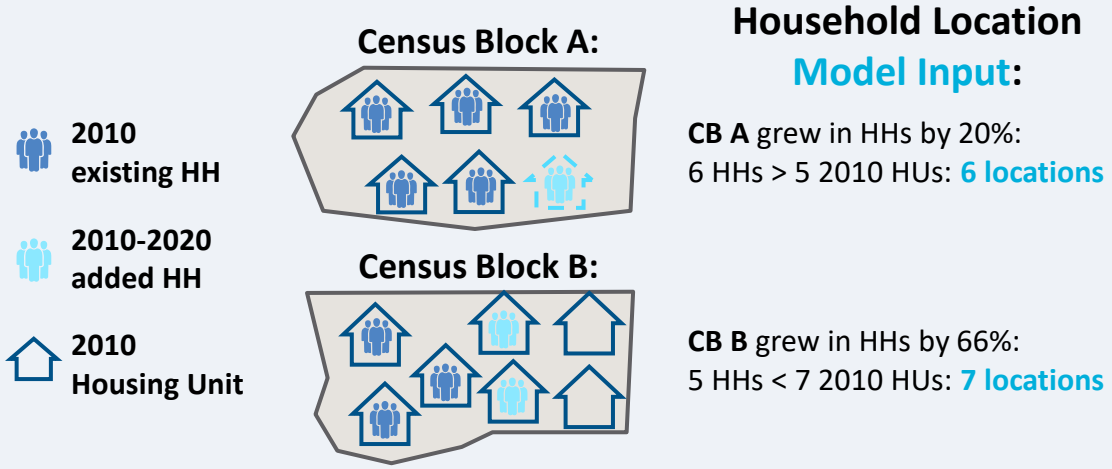
2020 Household Estimation

- **Data Limitations:** At the time this report was created, 2020 census block-level tabulations were unavailable
- **Population Growth**: To approximate 2020 households, we obtained block-group-level 2010-2020 population growth rates from the American Community Survey (via Experian) and applied them to all blocks in each group



Final Household Location Determination

- **Choosing Housing Units or Households**: We use the greater of 2010 housing units or 2020 households per census block to ensure that housing stock with no residents would not be unfairly excluded from our cost model



Estimated Costs to Connect Unserved, Unfunded Households

7.4M UNSERVED, UNFUNDED HOUSEHOLDS <100/20 MBPS → *Location-Based Cost Model* → $14B - $27B

Source: Cartesian, U.S. Census, Experian

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Unserved Businesses

Locations in Unfunded, Unserved CBs

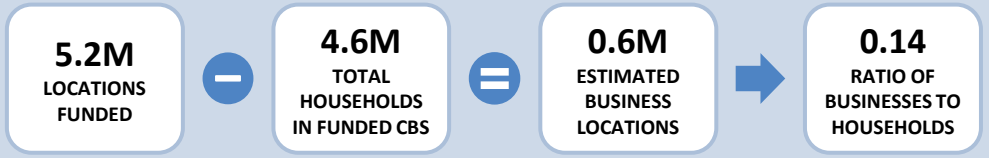
We used the ratio of households to businesses from the RDOF auction to approximate business locations

Calculate RDOF Business to Household Ratio

We approximated the ratio between households and business locations included as part of the RDOF auction

- **Identified Locations for Funded Census Blocks:** Using the FCC RDOF Dashboard, we found all census blocks that received support, and the corresponding number of locations
- **Assessed Households in Each Census Block:** For each census block, we identified the number of households associated with the census block using U.S. census data
- **Inferred Difference as Business Locations:** We subtracted the number of households in these census blocks from number of locations – remaining locations should correspond to businesses

Estimated Business Locations in RDOF (904) Auction:

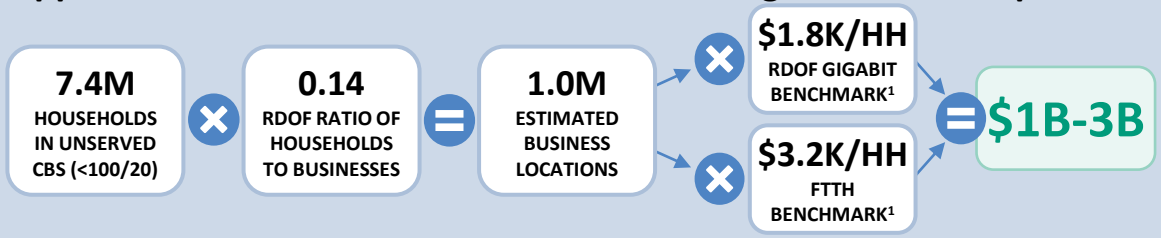


Approximate Businesses in Prioritized Census Blocks

We used this ratio from the RDOF auction to approximate the number of businesses in prioritized unserved census blocks

- **Identified Unserved Households:** Using Form 477, we identified all 'unserved' census blocks, and calculated the number of households in these census blocks
- **Applied Previous RDOF Business Ratio:** We applied the previous RDOF household-to-business ratio to approximate the total businesses that would also require funding in that area
- **Approximated Range of Costs:** We estimated a range of costs associated with gigabit deployment using the average gigabit RDOF award per location (low end), and average fiber deployment cost per location (high end)

Approximate Business Locations and Costs, E.g., <100/20 Mbps:



1 Derived from costs associated with median density of populated census blocks using the location-based cost model

Source: FCC Form 477 June 2020 (Apr 7 2021 release), U.S. Census, AT&T, ACA Connects, Cartesian

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Anchor Institutions Cost Methodology

Locations in Unfunded, Unserved CBs

We identified anchor institutions without service, eliminating any with existing funding

Anchor Institutions

We identified all anchor institutions using Experian SIC and NAICS codes across the US:

- ***Educational Services*** *(320K)*
- ***Hospitals*** *(33K)*
- ***Museums*** *(375K)*
- ***Justice and Safety Activities*** *(79K)*
- ***Religious*** *(351K)*

Identify Unserved (E.g., <100/20 Mbps in Example Below)

818K
Total anchor Institutions

We then removed anchor institutions with sufficient service or those receiving funding through E-Rate:

− **112K**
Previously Funded

E-Rate Funded Institutions:
We removed all institutions that are receiving E-Rate support through other programs

− **321K**
Institutions with 100/20 Mbps+ service

Already 'Served' Institutions:
We removed all institutions in census block groups where service is already available (e.g., >100/20 Mbps)[1]

= **384K**
Remaining anchor Institutions

Unserved Institutions:
Remaining anchor institutions without access to service at the speed threshold (e.g., <100/20 Mbps service)

Estimated Costs to Connect Unserved, Unfunded Anchor Institutions (E.g., <100/20):

384K
Unserved, Unfunded Anchor Institutions

→ *Location-Based Cost Model*

$252M - $436M

1 Anchor institution totals estimated at the CBG level and assigned the lowest speed of any CB in the group.
Source: FCC Form 477 June 2020 (Apr 7 2021 release), U.S. Census, Cartesian

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Unserved Households in Partially Served CBs

There are additional households lacking service in 'served' census blocks due to a reporting limitation

Form 477 Methodology Limitation

Form 477 is known to systematically overstate broadband availability:

- Form 477 does not ask ISPs to report location-level service availability
- If an ISP serves at least one household in a census block, they simply report that the census block is served
- As a result, some census blocks are only ***'partially served'***, with some households in the block having either:
  - A Slower Speeds Than Reported
  - B No Service at All
- Most historical broadband funding programs, including CAF II and RDOF, have determined eligibility at the census block level, thereby withholding funding for households in partially served census blocks

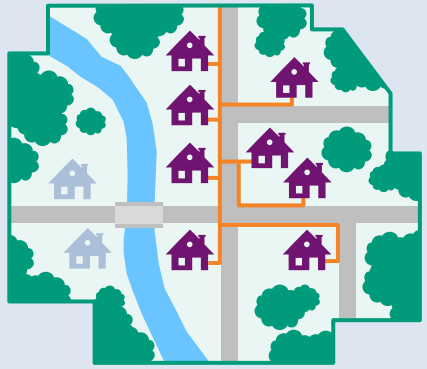
This limitation has been widely acknowledged:

"There's strong evidence…that the percentage of Americans without broadband access is much higher than the figures reported by the FCC."
— John Kahan, Chief Data Analytics Officer, Microsoft

Households in partially served census blocks should be identified and included in future broadband programs

Calculate Households in Partially Served Census Blocks

Illustrative Example of Partially Served 10 Household Census Block



Form 477 would suggest the ISP in this census block serves all 10 households

20% do not have any internet

ESTIMATION METHODOLOGY FOR HOUSEHOLDS IN PARTIALLY SERVED CBS

(E.G., BELOW 100/20 MBPS ESTIMATE)

There is no precise data on the number of households in partially served census blocks – we approximate based on the results of a recent study:[1]

6.7%[1] HHS LISTED AS SERVED THAT ARE NOT × **110.7M** US HHs WITH AT LEAST 100/20 SERVICE, EXCL PREVIOUSLY FUNDED[2] = **7.4M** HOUSEHOLDS IMPACTED × **$1.8K/HH** RDOF GIGABIT BENCHMARK[3] or × **$3.2K/HH** FTTH BENCHMARK[3] = **$13B - $24B**

This estimate assumes a similar distribution of households in partially served census blocks throughout the country, regardless of speeds available to the census block

1 Based on BroadbandNow study that sampled serviceability for 11.6k households and compared to Form 477 data – several assumptions in that study were conservative, including the assumption that smaller providers for which serviceability was not validated always provided Form 477 advertised speeds. Study found that ~6.5% of additional U.S. households are unserved, in addition to those that the FCC reports – these households are all concentrated in areas the FCC reports as having 25/3 Mbps+, which implies that 6.7% of 'served' households are not
2 Based on Cartesian analysis of U.S. households in Census Bureau data (see page 23) | 3 Derived from costs associated with median density of populated census blocks using the location-based cost model
Source: Cartesian, FCC Form 477 June 2020 (Apr 7 2021 release), Microsoft, BroadbandNow Research: 'FCC Reports Broadband Unavailable to 21.3 Million Americans, BroadbandNow Study Indicates 42 Million Do Not Have Access'

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Areas Receiving Sub-Gigabit FCC Funding

Unserved ROR/ACAM, CAF Phase II Locations

We modeled the cost of providing gigabit to unserved census blocks that are currently receiving funding under FCC programs – these programs may require supplemental funding to provide gigabit

Subsidy Program	ROR/ACAM	CAF PHASE II AUCTION
Timeframe	2017-2026	2018-2028
Methodology	Identified census blocks that were part of each FCC-funded program, and applied the location-based cost model to those below the 'unserved' threshold	
Estimated Costs to Connect (e.g., <100/20 Mbps)	5.8M TOTAL HH − 4.2M HHs WITH 100/20+ = 1.6M UNSERVED HHs × .14x BUSINESS TO HH RATIO = 217K UNSERVED BUSINESSES	617K TOTAL HH − 158K HHs WITH 100/20+ = 458K UNSERVED HHs × .14x BUSINESS TO HH RATIO = 64K UNSERVED BUSINESSES
	Location-Based Cost Model: $4.1B - $8.5B	*Location-Based Cost Model*: $1.3B - $2.7B
	$1.8K/HH RDOF GBPS BENCHMARK × $3.2K/HH FTTH BENCHMARK = $380M - $695M	$1.8K/HH RDOF GBPS BENCHMARK × $3.2K/HH FTTH BENCHMARK = $112M - $205M
	$4.4B - $9.1B	$1.4B - $2.9B

Source: FCC, Form 477 June 2020 (Apr 7 2021 release), USAC, U.S. Census, Cartesian

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Broadband Adoption Subsidy Estimated Costs

Low-Income Household Broadband Subsidy

With 25-50% participation, 5-year subsidies for broadband and connected devices would cost $26B-$51B

Program Participation Rate	Program Duration: 1 Year	2 Years	3 Years	5 Years	10 Years
10%	$2.3B	$4.3B	$6.3B	$10.2B	$20.1B
25%	$5.8B	$10.7B	$15.7B	$25.6B	$50.3B
50%	$11.6B	$21.5B	$31.4B	$51.2B	$100.7B
75%	$17.3B	$32.2B	$47.0B	$76.7B	$151.0B
100%	$23.1B	$42.9B	$62.7B	$102.3B	$201.3B

- Program cost[1] includes a $50/month broadband subsidy and $100 one-time connected device credit per participating household
- Overall cost is dependent on participation rate and program duration

- 27% of eligible households participate in the Lifeline program[2] – given this program would offer higher subsidies, adoption may be even higher

Low Cost → High Cost

1 Based on estimated 33 million households that are currently eligible for the Lifeline program, and $50/mo broadband subsidy plus $100 one-time connected device subsidy
2 From program data on USAC.org
Source: FCC Form 477 June 2020 (Apr 7 2021 release), U.S. Census, ACA Connects, USAC, Cartesian

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Costs Associated with Broadband-Related Initiatives

Other Broadband-Related Initiatives

There are significant costs associated with other proposed broadband-related initiatives

E.g., <100/20 Mbps

Line Item	Modeling Approach
Additional E-Rate Support[1] Subsidy to increase on premise connectivity across rural schools	$5K (SUBSIDY FOR MODEM AND/OR ROUTER) + $3K (SUBSIDY FOR HOTSPOTS AND REPEATERS) + $15K (SUBSIDY FOR CONNECTED DEVICES) × 146K (TOTAL E-RATE INSTITUTIONS[3]) = ~$3B
School Bus WiFi Support[1] Subsidy to subsidize WiFi connectivity for rural school buses	114K (CURRENT E-RATE SCHOOLS[3]) × 5 (BUSES PER SCHOOL[4]) × 90% (E-RATE PARTICIPATION RATE) × $1.5K (YEARLY COST FOR BUS WI-FI SERVICE) = ~$1B
Network Backup Generators[2] Redundancies to keep Americans connected through climate-related environmental emergencies	$143K (COST TO OUTFIT A NETWORK CENTRAL OFFICE WITH BACKUP GENERATORS AND FUEL SUPPLY, 2021 DOLLARS[5]) × 32K (CENTRAL OFFICES AND HEADENDS IN U.S. NETWORKS) × 50% (EXISTING LOCATIONS WITH BACKUP) = ~$2.3B
Climate Resilience[2] Funding for new deployments to incorporate additional underground fiber to ensure resilience with climate events (e.g. wildfires, hurricanes)	LOW: $8.5B + $28.5B ($37B) (IMPLIED ALLOCATION OF FUNDS TO AERIAL AND UNDERGROUND FIBER, ASSUMING 60/40 SPLIT[6]) → $7.1B + $35.6B ($6B INCR.) (IMPLIED ALLOCATION OF FUNDS TO AERIAL AND UNDERGROUND FIBER, ASSUMING EVEN SPLIT[7]) HIGH: $15.5B + $51.5B ($67B) (IMPLIED ALLOCATION OF FUNDS TO AERIAL AND UNDERGROUND FIBER, ASSUMING 60/40 SPLIT[6]) → $12.9B + $64.4B ($10B INCR.) (IMPLIED ALLOCATION OF FUNDS TO AERIAL AND UNDERGROUND FIBER, ASSUMING EVEN SPLIT[7]) = $6B - $10B
Sustainability Incentives[2] Incentive programs to provide additional funding for sustainable new builds	$37B - $67B (LOW AND HIGH-END ESTIMATES OF CONNECTING <100/20 MBPS AREAS WITH GIGABIT SERVICE) × 10% (INCREMENTAL PERCENTAGE OF FUNDING NEEDED TO INVEST IN LOWER-FOOTPRINT ENGINEERING TECHNIQUES) = $4B - $7B

1 Programs enumerated in the Accessible, Affordable Internet for All Act | 2 Programs enumerated in the GREEN Communications Act (S. 1506)
3 From USF E-Rate dataset
4 Approximated based on ratio between total school buses in the U.S. and schools in the U.S.
5 Based on Verizon case study of outfitting 8 Texas COs with backup to withstand hurricane-related outages
6 Assuming a 60 aerial/40 underground mile-on-mile split, and underground on average 5X as expensive as aerial
7 Assuming 10% of fiber miles should shift from aerial to underground to prevent cuts in areas prone to extreme climate events
Source: LIFT Act, Accessible Affordable Internet for All Act, GREEN Communications Act (S. 1506), USAC.org, ACA Connects, Cartesian

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Summary of Key Cost Model Assumptions

There are a number of assumptions involved in our cost model

1. Support amounts for gigabit deployment under the RDOF auction are a reasonable proxy for future deployment subsidy requirements in areas with similar household density
2. Future fiber deployment costs would be similar to previous fiber deployment costs in areas with similar household density (i.e., estimation does not account for proximity to existing infrastructure)
3. Number of households per census block would be equivalent to 2010 census data with proportional population growth applied
4. Deployment costs to households in partially served census blocks would be similar to average per-location costs from the location-based cost model
5. Areas currently receiving FCC funding would have similar costs of gigabit deployment as other areas (i.e., same models used to estimate cost of gigabit deployment for all areas)
6. Areas with fiber available but sub-gigabit speeds would require ~10% of modeled costs to upgrade to gigabit speeds (i.e., typically only electronics upgrades required)
7. Businesses have similar geographic dispersion as households (i.e., costs to deploy fiber to businesses are similar to that of households in areas with similar household density)

Source: ACA Connects, Cartesian

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Broadband Cost Assessment Studies

Our fiber deployment costs for unserved rural areas are lower than previously published studies – this is likely because we use updated deployment data, and unserved HHs have decreased over time

Study and Year	Key Finding	Comparison to This Assessment
Fiber Broadband Association **2019**	"…**90% of US HHs** can be passed with fiber for an estimated [incremental[2]] amount of **$70B**"	Fiber to **All Sub-Gigabit Areas**: **$128B – $210B** The Fiber Broadband Association study did not model costs for the top 10% most expensive areas, but methodologies are similar between our study and the FBA assessment
Jim Stegeman[1] CQA **2018**	"The cost to deploy **fiber to unserved U.S. rural areas [23/3 Mbps]** is about **$61 billion**…based on deploying GPON fiber-to-the-premises technology"	Fiber to **All Unserved (<25/3 Mbps) Areas**: **$21B – $37B** Our study estimates a lower cost to deploy fiber to all unserved U.S. areas – differences are likely related to cost modeling methodology, and/or the fact that our study uses later FCC deployment data (June '20)
Paul de Sa FCC Office of Strategic Planning & Policy Analysis **2016**	"We estimate that the total upfront capex required to deploy FTTP to the 14% of locations lacking access [to 25/3 Mbps broadband] would be **~$80B** but, because of the shape of the cost curve, **~98% coverage could be attained for ~$40b**"	Fiber to **All Unserved (<25/3 Mbps) Areas**: **$21B – $37B** Our study estimates a lower cost to deploy fiber to all unserved U.S. areas – differences are likely due to the fact that our study uses more recent FCC deployment data (June 2020, 3% of HHs unserved)

1 In a webinar titled "Rural Broadband Economics: A Review of Rural Subsides", sponsored by USTelecom and NTCA – The Rural Broadband Association. CostQuest created the cost model used to determine broadband deployment costs for CAF program
2 Reflects estimated costs beyond expected substantial private sector investment over 10 years
Source: Fiber Broadband Association, USTelecom, NCTA, FCC Office of Strategic Planning and Policy Analysis, ACA Connects, Cartesian

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Cost Assessment Methodology

Additional Availability & Adoption Analyses

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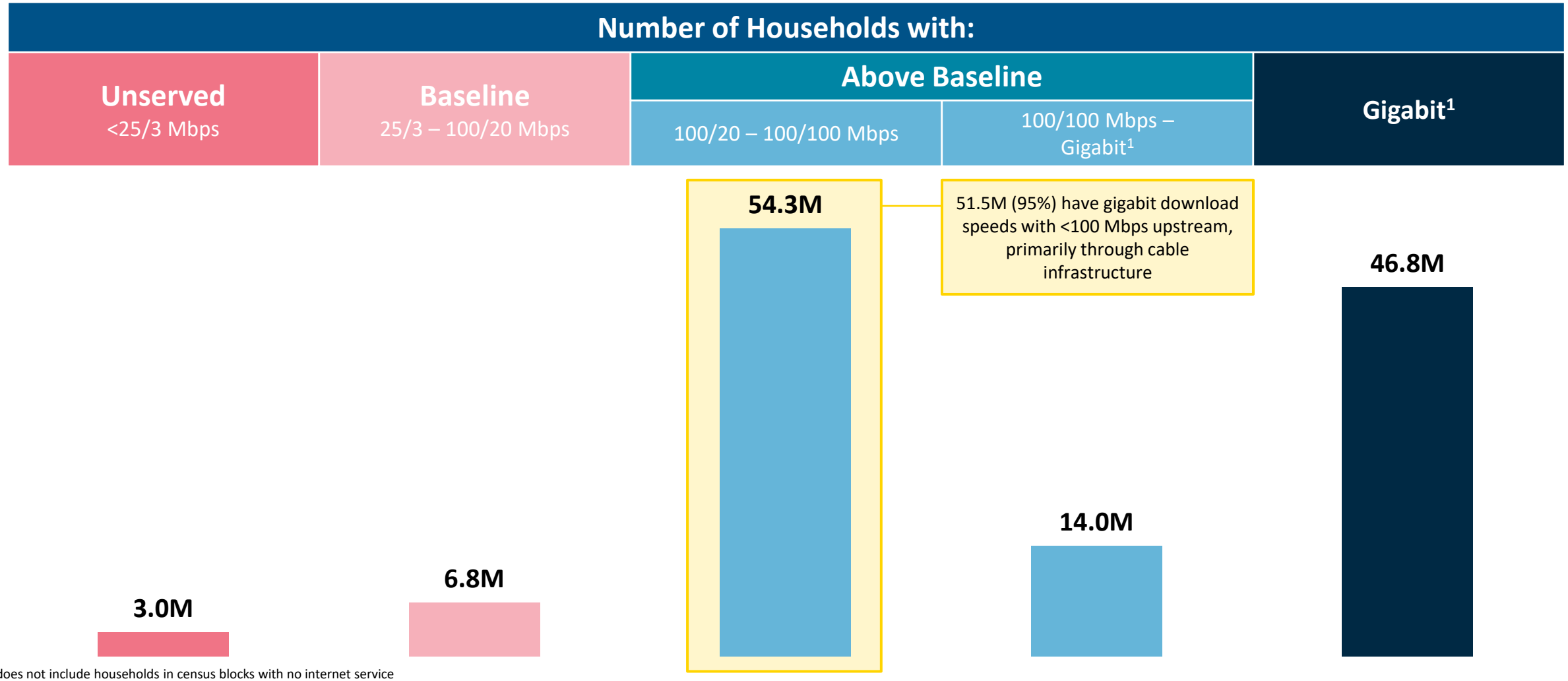
Gigabit Download Availability over Cable

Over 50 million U.S. households with cable broadband service have access to gigabit download speeds – these networks typically offer at least 20 Mbps upload



Note: does not include households in census blocks with no internet service
1 Reflects available speeds of greater than 900/500 Mbps
Source: FCC Form 477 June 2020 (Apr 7 2021 release), U.S. Census, Cartesian

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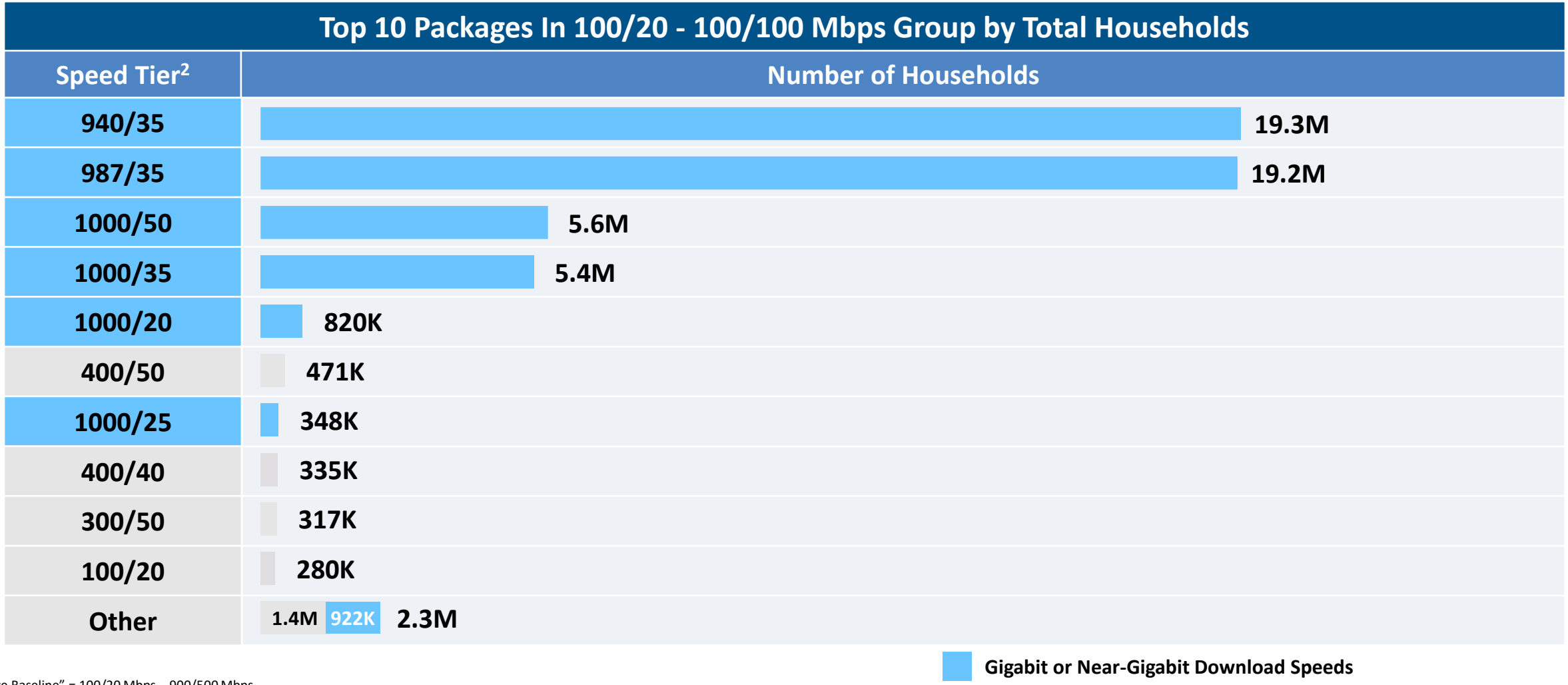
ISP Speed Tiers between 100/20 and 100/100 Mbps

Of 54.3M Americans with access to a sub-100/100 package but above baseline[1] service, 51.5M (95%) have access to gigabit or near-gigabit download speeds



1 "Above Baseline" = 100/20 Mbps – 900/500 Mbps
2 Reflects the maximum speeds available to each census block (highest download speed prioritized)
Source: FCC Form 477 June 2020 (Apr 7 2021 release), U.S. Census, ACA Connects, Cartesian

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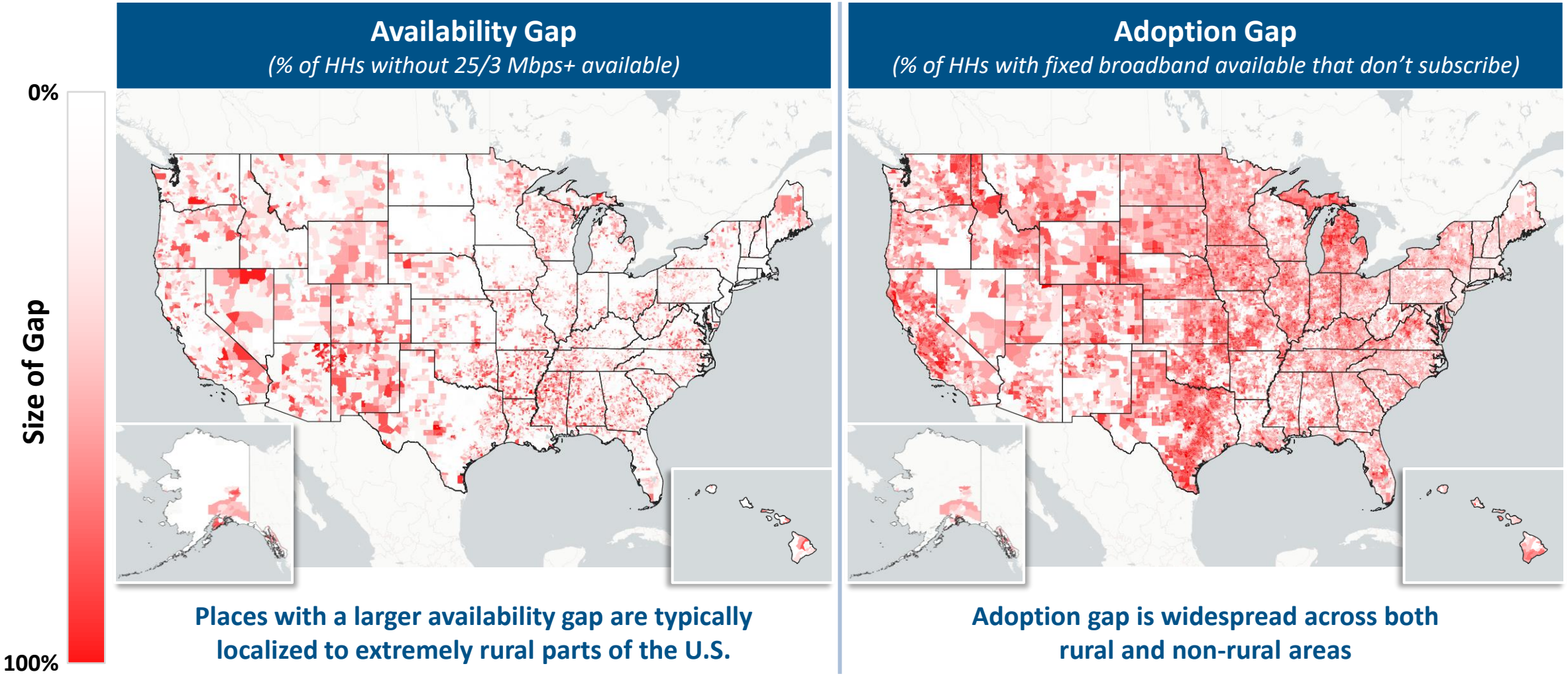
Geographic Distribution of Availability and Adoption Gap

Areas with a larger broadband availability gap are typically rural, while the problem of broadband non-adoption is geographically diverse



Source: FCC Form 477 June 2020 (Apr 7 2021 release), Experian, American Community Survey 2019, Cartesian

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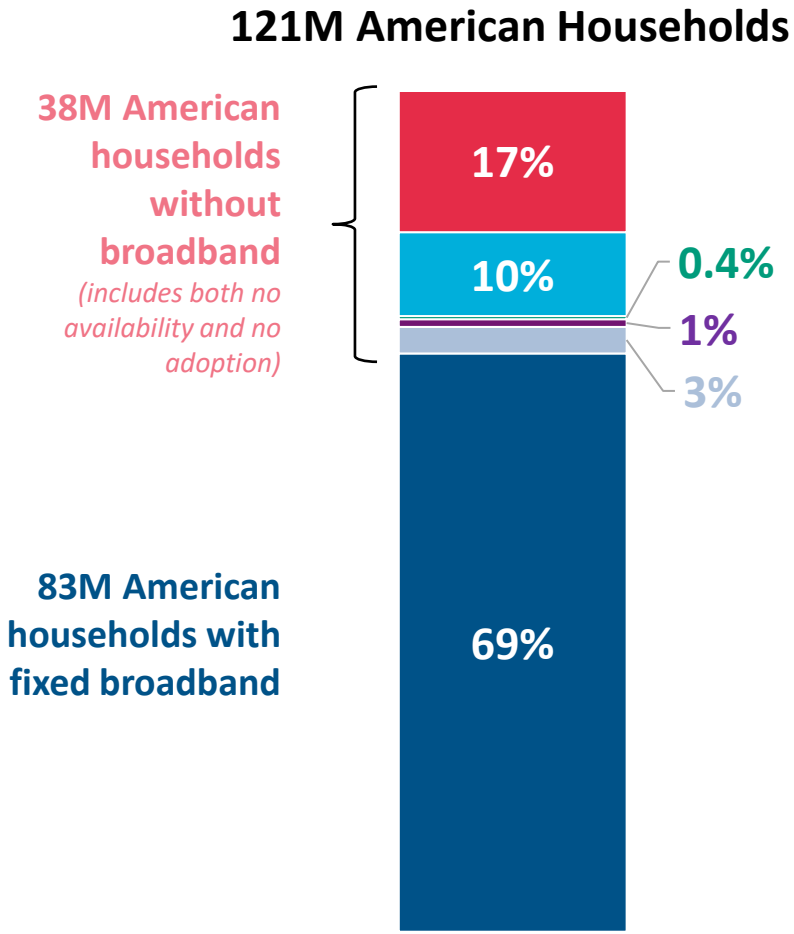
Overview of 2019 ACS Broadband Adoption Data

The American Community Survey provides the most recent statistics on broadband adoption for American families – results from the 2019 ACS are used throughout our report and are summarized below



Connectivity Types and Survey Questions:

	"No access to the Internet": 20.5M *At this house, apartment or mobile home – do you or any member of this household have access to the internet?*	No Internet
	"Cellular data plan with no other type of Internet subscription": 12.1M *Do you or any member of this household have access to the Internet using a cellular data plan for a smartphone or other mobile device?*	Unfixed or Likely Sub-Baseline Service
	"Dial-up Internet service with no other type of Internet subscription": 437K *Do you or any member of this household have access to the Internet using a dial-up Internet service installed in this household?*	
	"Satellite Internet service with no other type of Internet subscription": 1.1M *Do you or any member of this household have access to the Internet using a satellite Internet service installed in this household?*	
	Other combination of services[1]: 3.8M	
	"Broadband such as cable, fiber optic or DSL": 83.2M *Do you or any member of this household have access to the Internet using a broadband (high speed) Internet service such as cable, fiber optic, or DSL service installed in this household?*	Likely Baseline or Above

Note: Specific figures may differ slightly from NUL/Census reporting due to use of 5-year estimate vs. 1-year spot estimates (these figures reflect the 2019 5-year estimates)
1 Including any households with an internet subscription who do not fall under any of the previous four categories, or have some combination of cellular / satellite / dial-up connectivity
Source: FCC Form 477 June 2020 (Apr 7 2021 release), U.S. Census, American Community Survey 2019, Cartesian

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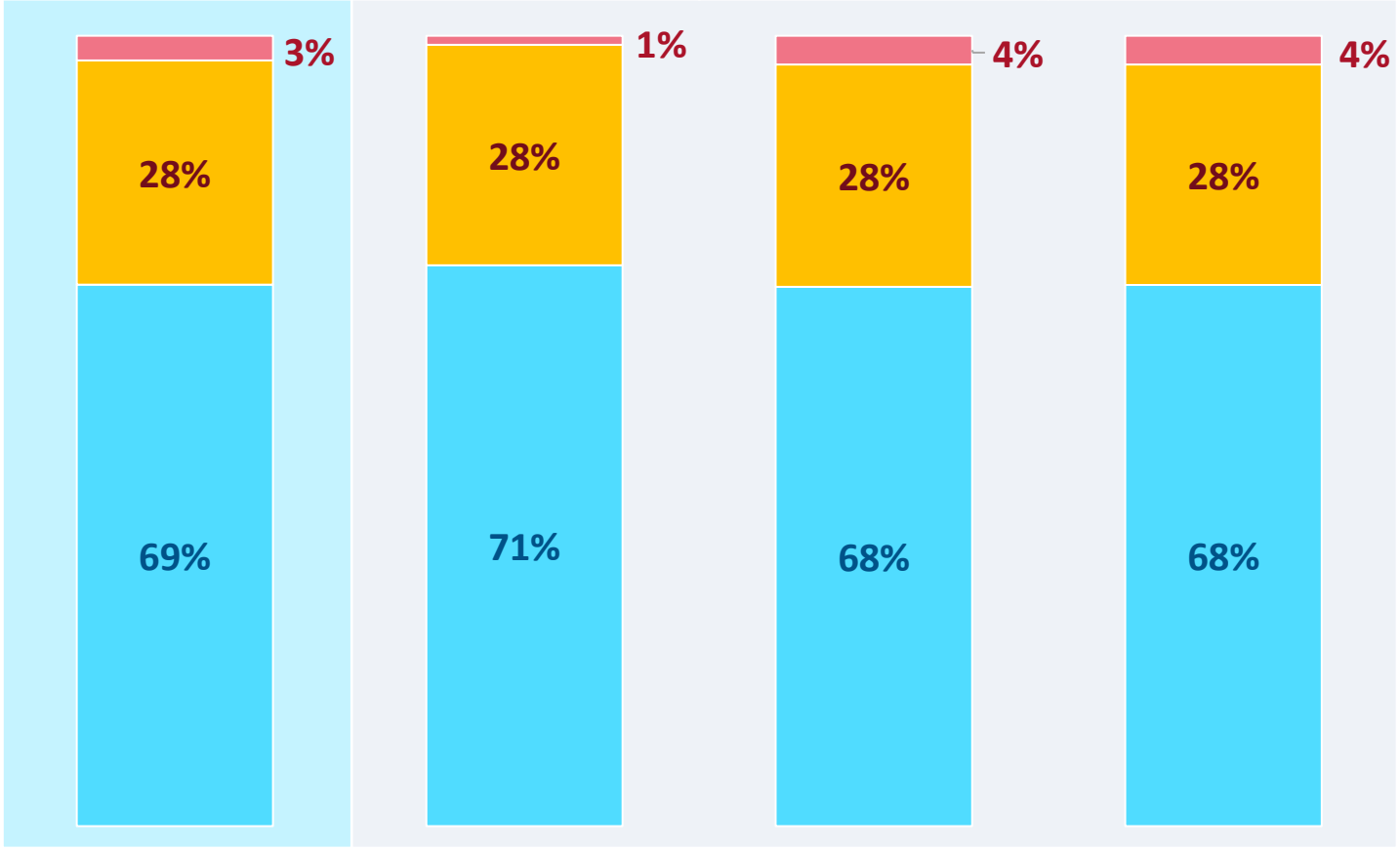
Adoption and Age

Areas with the greatest share of population 65+ have the same adoption gap as younger areas

Broadband Availability and Adoption by % of Population Above 65

Share of Census Block Group as 65+	Nationwide	< 10%	10-25%	>25%
% of Census Block Groups	100%	21%	66%	13%
Availability Gap *Fixed Broadband Not Available*[1]	3%	1%	4%	4%
Adoption Gap[2] *Fixed Broadband Available, no Adoption*	28%	28%	28%	28%
Broadband Adopted *Fixed Broadband Available and Adopted*[3]	69%	71%	68%	68%



Commentary

Based on this analysis, there does not seem to be a correlation between age and broadband adoption

Slight Difference in Availability Gap:
On average, about 16% of the population nationally is above 65. Areas with younger populations tend to have a smaller availability gap as they tend to be located in more developed urban areas

No Difference in Adoption Gap:
The population of retirement-age Americans is not correlated with a difference in the adoption gap – census blocks with a >25% of the population 65+ has a nearly identical adoption gap as the nationwide average

1 Based on availability data from Form 477 of households with access to speeds of at least 25/3 Mbps – availability by group is estimated based on age distribution data from Experian
Source: FCC Form 477 June 2020 (Apr 7 2021 release), Experian, Cartesian

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