Education SUPERHIGHWAY

January 2017

2016 State of the States

EducationSuperHighway's second annual report on the state of broadband connectivity in America's public schools

10.4 MILLION

MORE STUDENTS CONNECTED IN 2016

11.6 MILLION

STUDENTS ARE STILL LEFT BEHIND

34.9

MILLION

STUDENTS

2.4

MILLION

TEACHERS

70,000

SCHOOLS

NOW HAVE THE INTERNET ACCESS THEY NEED FOR DIGITAL LEARNING

Governors Take Action

"By ensuring that high-speed Internet is available in every Indiana classroom, we can connect Hoosier students to the latest digital learning tools and ultimately set our kids on a course to compete for the careers of tomorrow."

Former Indiana Governor Mike Pence

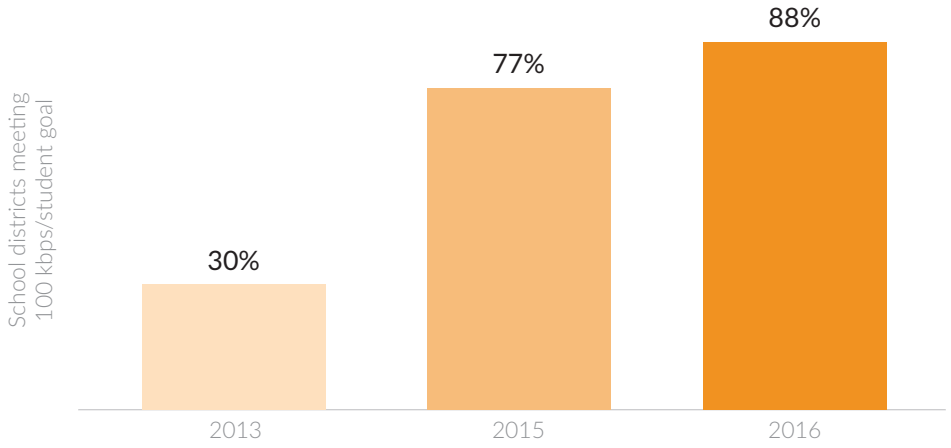
10.4 million more students connected

In 2015, 40 governors committed to providing their K-12 students with equal access to educational opportunity by ensuring that all of their classrooms were connected to high-speed broadband. During 2016, 34 of these governors took action, taking advantage of the opportunity presented by the modernization of the Federal Communications Commission (FCC) E-rate program, to begin the process of delivering on this commitment. As a result of their efforts, and those of state and district leaders across the country, 10.4 million more students and 700,000 additional teachers now have the connectivity they need to unleash the power of technology to enhance teaching and learning in the classroom.

34.9 million students and 2.4 million teachers in 70,000 schools now have the Internet access they need for digital learning

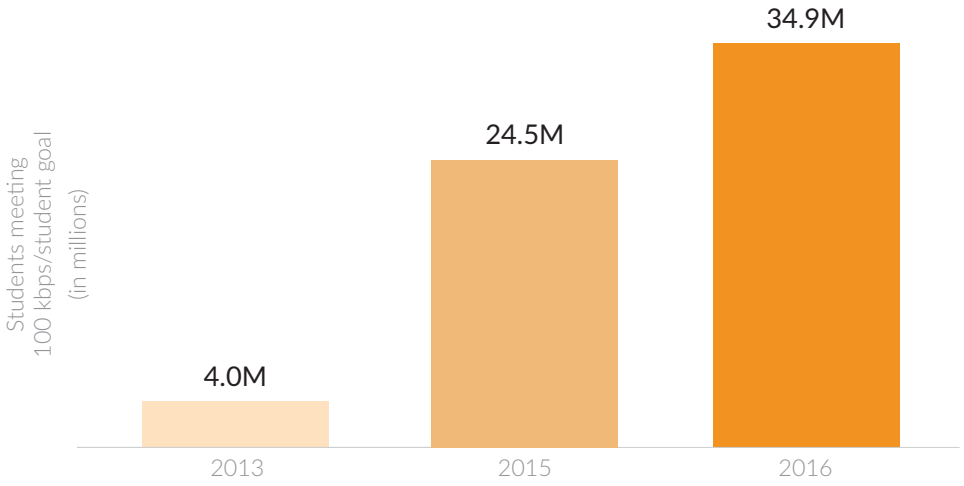
Since 2013, the bipartisan effort to connect America's students to 21st century learning has delivered high-speed broadband to 88% of public

Chart 1: 88% of school districts are now ready for digital learning



school districts, representing an increase of 30.9 million students and 2.1 million teachers who are now meeting the FCC minimum Internet access goal of 100 kbps per student. This dramatic improvement in connectivity has leveled the playing field for students regardless of their affluence level or geographic locale[1] and is catalyzing the adoption of digital learning across the country. With reliable, high-speed broadband available in their schools, 3,100 superintendents, representing 19 million students, have committed to transitioning their schools to personalized or blended digital learning strategies through the Future Ready pledge.[2] As these efforts take hold, school districts will need to substantially increase their Internet access to the FCC 1 Mbps per student goal — a level only 15% of school districts are meeting today — in order to keep up with the 50 percent year-over-year growth in demand for bandwidth.

Chart 2: An additional 30.9 million students gained access to the broadband they need for digital learning in the last three years



[1] Geographic locale categorizes students into urban, suburban, small town, and rural groupings.

[2] Future Ready Schools. "Take the Pledge." http://www.futurereadyschools.org/take-the-pledge. Web. November 7, 2015.

We have also dramatically improved the infrastructure needed to deliver high-speed broadband to classrooms

To deliver high-speed broadband to students and teachers, every school needs a fiber-optic connection and every classroom needs a Wi-Fi access point. Today, estimates show 95% of schools are connected by fiber and 83% of schools report having sufficient Wi-Fi in their classrooms.

Chart 3: 95% of schools have the fiber-optic connections required to meet current and future connectivity needs

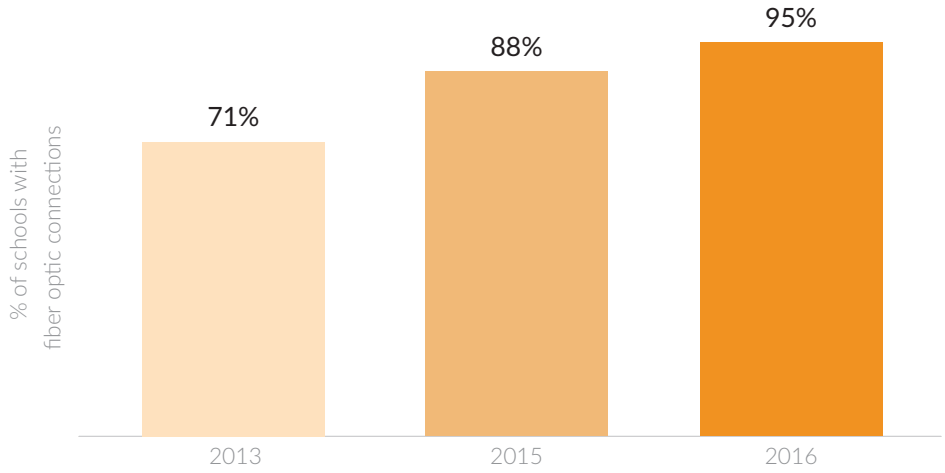
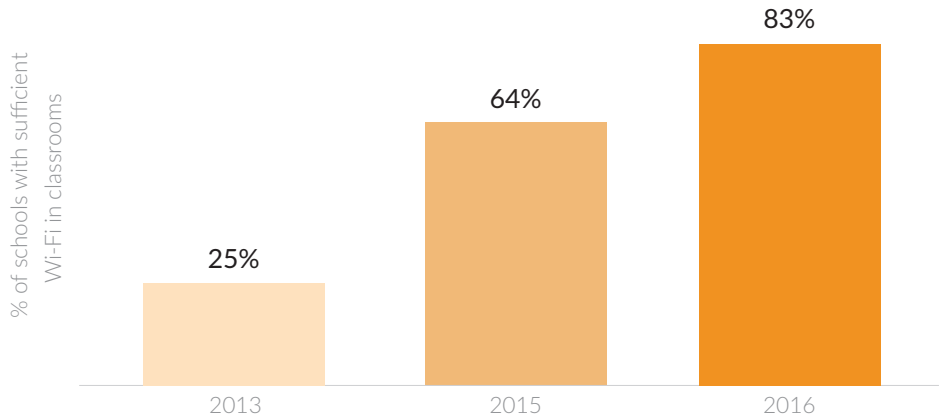


Chart 4: 83% of schools report having sufficient Wi-Fi in their classrooms



Many of America's K-12 schools now have the same connectivity as top performing schools across the globe

In 2013, America's K-12 students were being asked to compete for the jobs of the 21st century without the tools available to students in countries with leading education systems. Today, the efforts of governors and other state and district leaders are rapidly closing the global K-12 connectivity gap with countries like Singapore, South Korea, Finland, New Zealand, and Ireland, which have world-class school broadband and lead the world in the latest PISA rankings.[3]

Table 1: Leading education systems are supported by world-class broadband

Country	K-12 Network
Singapore	1 Gbps to every school by 2015
South Korea	100% of schools with high speed broadband
Finland	100 Mbps a legal right
New Zealand	Fiber to 99.9% of students by 2017
Ireland	100 Mbps to every school by 2014

Progress has been driven by more effective use of resources

The tremendous progress in connecting students to high-speed broadband has happened without significantly increasing America's investment in K-12 Internet access on a per student basis.[4] While individual districts may have had to increase their investment to provide sufficient bandwidth, in aggregate, districts are investing the same amount per student in 2016 as they did in 2015.

$1.09

School districts spent the same $1.09 per student per month in 2015 and 2016

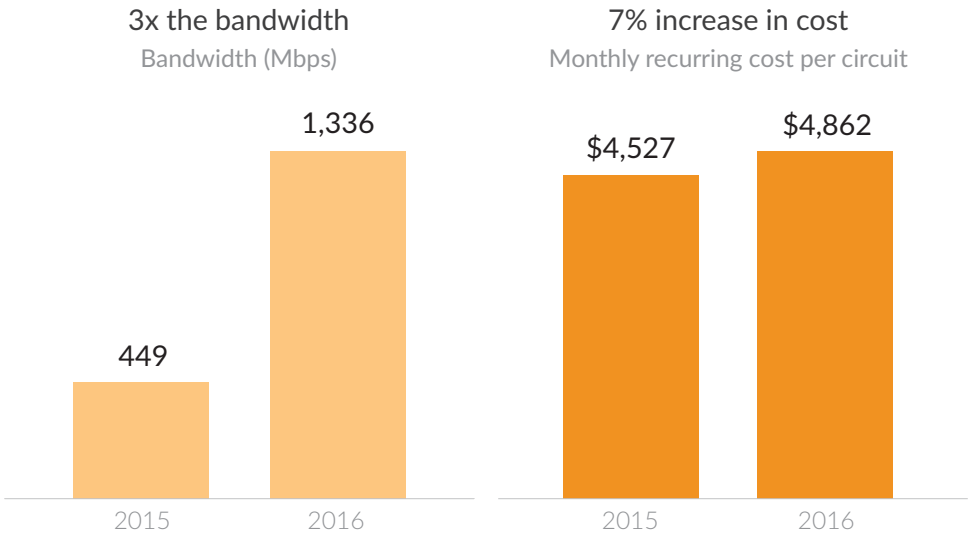
[3] PISA 2015 Rankings, http://www.oecd.org/pisa/pisa-2015-results-in-focus.pdf, December 2016

[4] While investment in Internet access has been stable, increased investment in fiber construction and Wi-Fi deployment, subsidized by the E-rate program, is driving the progress being made in improving the infrastructure needed to deliver high-speed broadband to classrooms

Upgrades focus on more bandwidth for the budget

In 2016, 42% of America's school districts upgraded their broadband. The overwhelming focus of districts that upgraded was to increase the bandwidth they received for their existing broadband budget. As seen in Chart 5, upgraders on average received 3x the bandwidth while only increasing cost by 7%. Interestingly, even when prioritizing bandwidth increases, 39% of districts were able to upgrade while also lowering or maintaining their monthly cost for Internet access.[5]

Chart 5: Upgraders are receiving 3x the bandwidth for only 7% more cost



Upgrades occurred most frequently in districts that did not have sufficient bandwidth to meet the FCC's 100 kbps per student Internet access minimum threshold. Districts with less than 100 kbps per student were twice as likely to upgrade their bandwidth. Importantly, 83% of the districts that had less than 100 kbps per student in 2015 were able to meet the FCC's minimum threshold for Internet access in 2016.

2x

School districts with less than 100 kbps per student were twice as likely to upgrade[6]

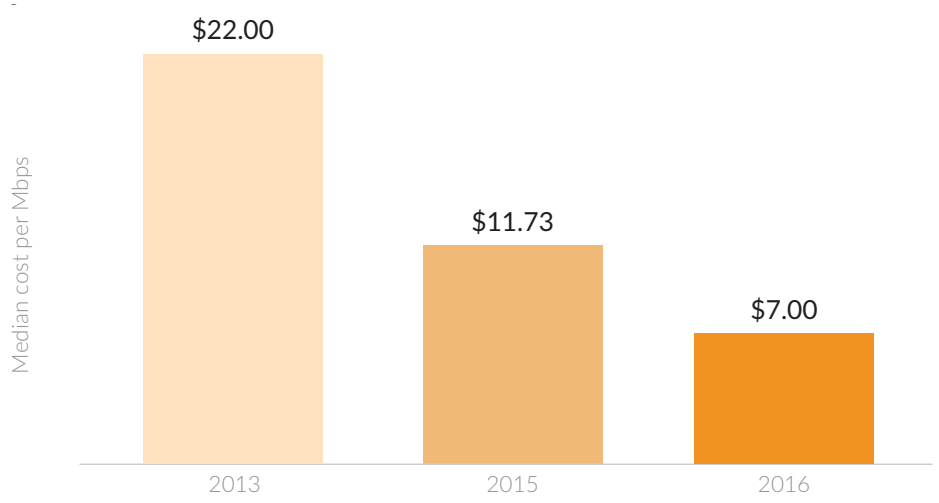
[5] 35% of districts lowered, while 4% of districts maintained, their monthly cost

[6] Districts meeting goals upgraded 34% of the time. Districts not meeting goals upgraded 68% of the time.

Service providers are making broadband significantly more affordable

In 2016, Internet service providers continued to dramatically increase the affordability of broadband by taking advantage of technological improvements that allowed them to provide significantly more bandwidth to districts for the same cost. **As a result, the cost of Internet access declined 40% from 2015 to 2016.**

Chart 6: The cost of K-12 Internet access has declined significantly in the last three years



These technology-driven improvements in affordability were most evident at higher bandwidths. As seen in Charts 7 and 8, price declines were steepest for both Internet access and Wide Area Network connections for the higher-capacity 1 Gbps and 10 Gbps connections that districts are increasingly purchasing. These higher-bandwidth circuits are necessary to provide the most innovative, video-rich digital learning opportunities to students.

Chart 7: Internet access costs are declining most significantly for high-bandwidth circuits

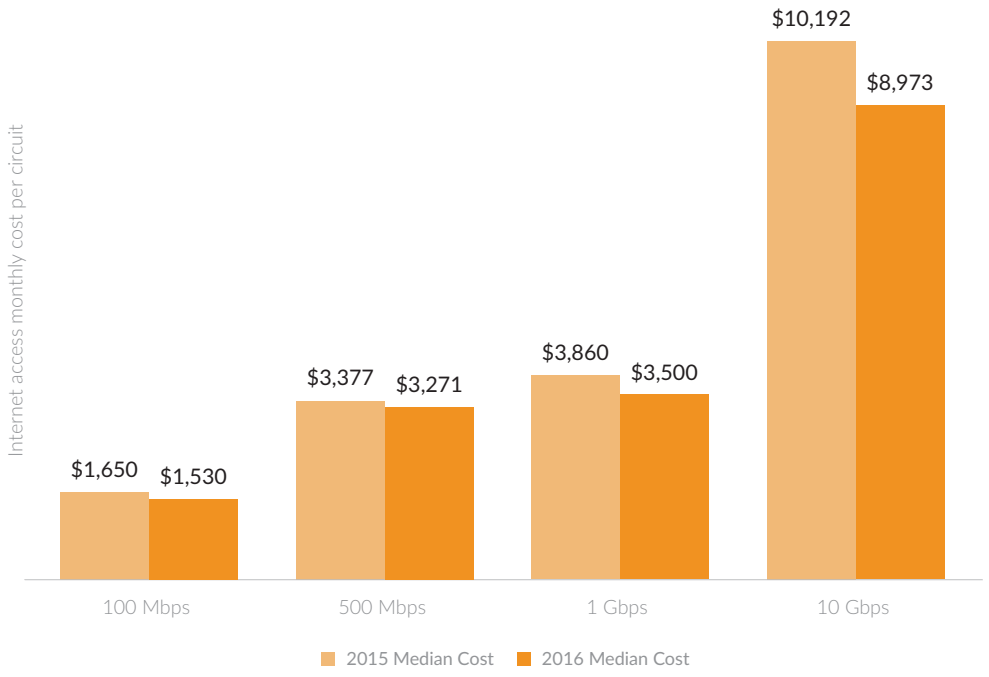
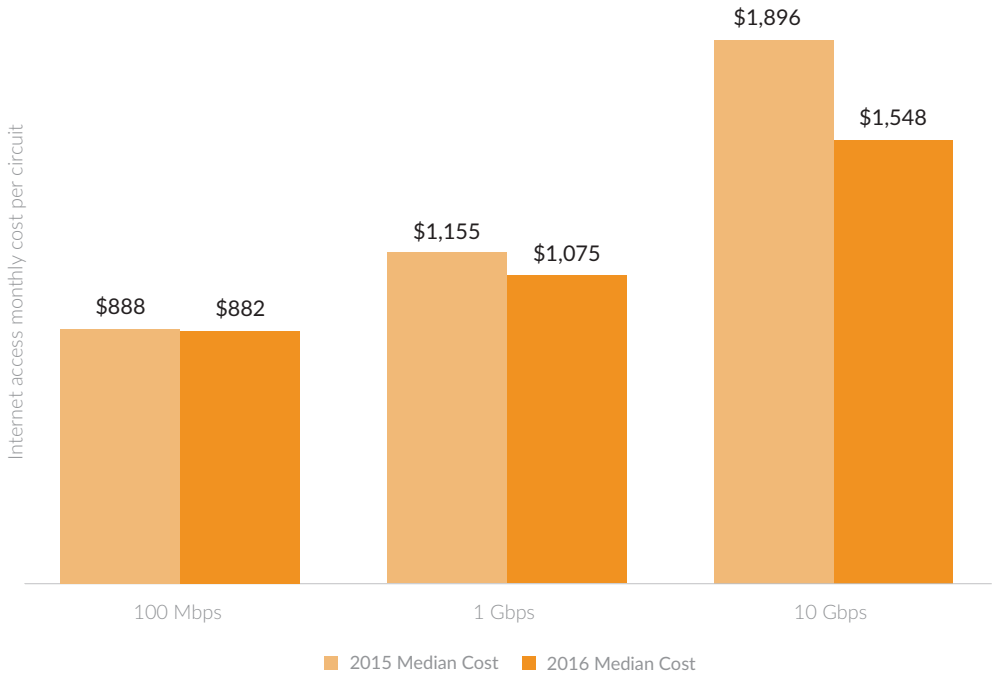


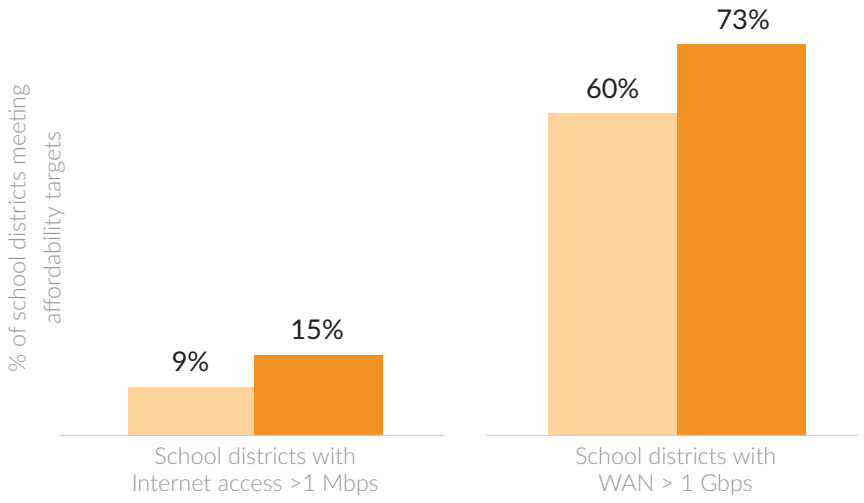
Chart 8: Wide Area Network costs are declining most for the 1 & 10 Gbps circuits schools need



Improved affordability is enabling districts to future-proof their networks

While state and district leaders are focused principally on ensuring that their students have the minimum connectivity required for digital learning, a growing number of school districts are taking advantage of the dramatic improvements in affordability to future-proof their networks for the 50% year-over-year growth in broadband demand that accompanies the adoption of digital learning. These future-proofing efforts are seen both in the 67% increase in districts that now meet the FCC's 2018 goal of 1 Mbps per student of Internet access and the fact that 73% of WAN connections are now 1 Gbps or greater – an amount sufficient to deliver 1 Mbps per student from the district office to each school building.

Chart 4: Districts are increasingly focused on delivering 1 Mbps per student for Internet access and 1 Gbps to every school for WAN circuits



Students Left Behind

11.6 million students in more than 19,000 schools are without the minimum connectivity necessary for digital learning

Action by governors during 2015-16 has cut in half the number of students and teachers without the tools they need for a 21st century education. Unfortunately, this still leaves 11.6 million students without equal access to educational opportunity. To make America's K-12 broadband infrastructure among the best in the world, state and district leaders need to close the bandwidth, fiber, and Wi-Fi gaps that remain in our K-12 schools.

Chart 9: The bandwidth gap: 11.6 million students in over 19,000 schools do not meet the FCC 100 kbps per student minimum connectivity goal

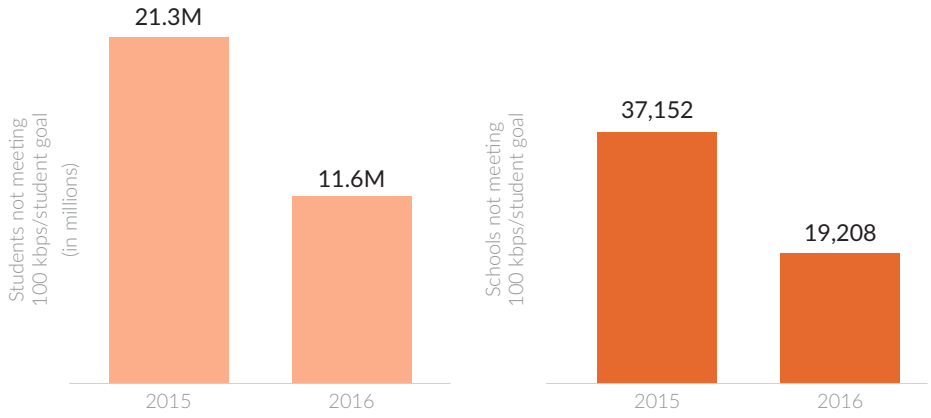


Chart 10: The fiber gap: 3,700 schools do not have the fiber-optic connections required to meet current and future connectivity needs

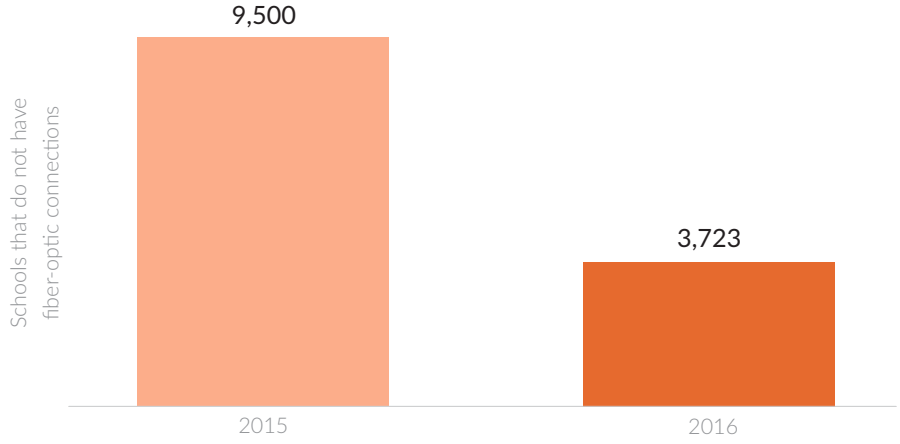
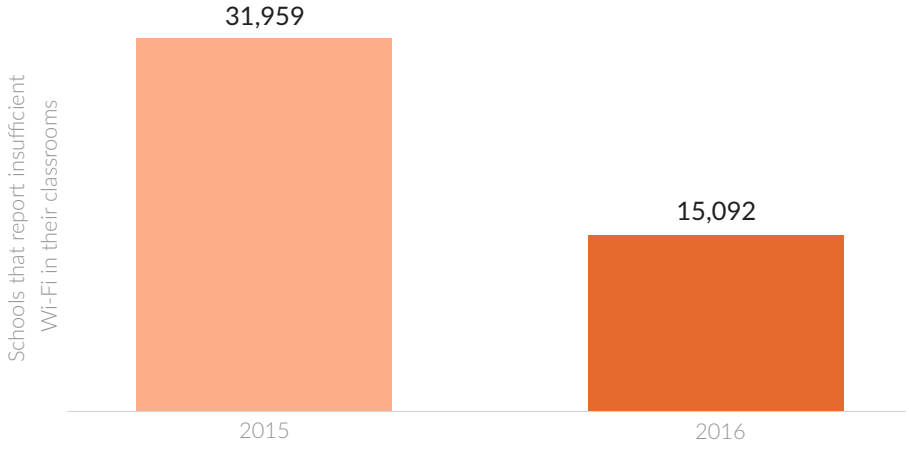


Chart 11: The Wi-Fi gap: 15,000 schools report insufficient Wi-Fi in their classrooms



Improving the affordability of broadband remains the most important lever for closing the connectivity gap

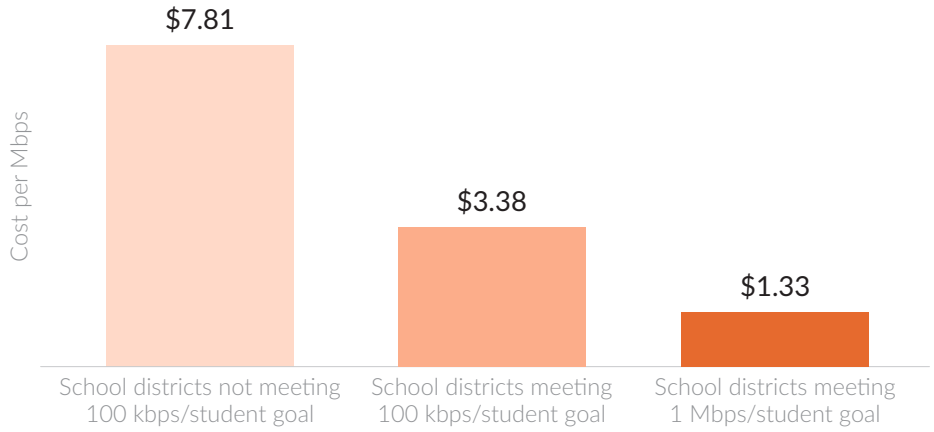
Despite tremendous improvements in the cost of broadband over the last three years, only half of all school districts are receiving the amount of Internet access they would if they were able to procure bandwidth at national benchmark prices.

1/2

Only half of school districts are meeting Internet access affordability targets

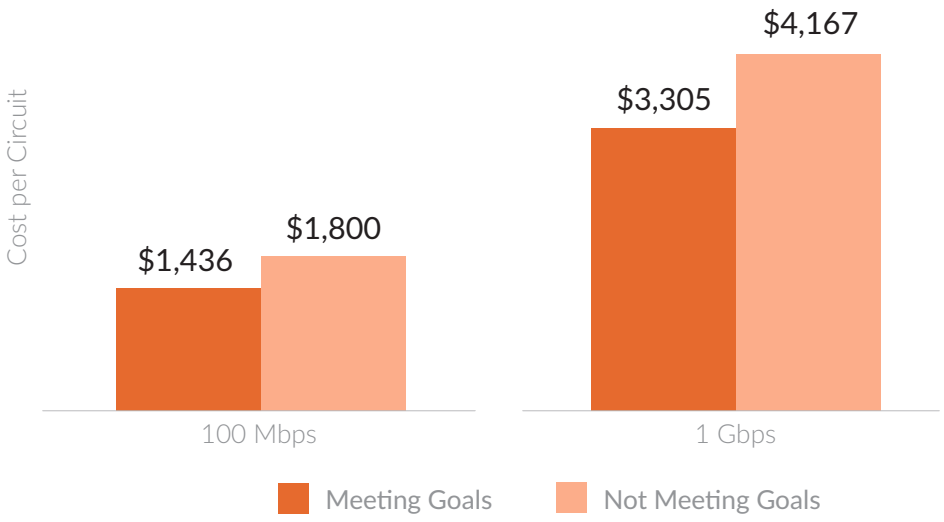
Not surprisingly, the cost of bandwidth has a significant impact on whether students and teachers have the Internet access they need for digital learning. As seen in Chart 12, districts that do not meet the FCC's 100 kbps per student minimum threshold pay 2.3x more for their bandwidth than districts meeting the FCC goal, while those meeting the 2018 goal of 1 Mbps per student pay 60% less than those at 100 kbps per student.

Chart 12: School districts meeting connectivity goals pay less for bandwidth



The impact of affordability on whether students and teachers have the bandwidth they need is also seen when comparing circuit costs, with those meeting goals paying 20% less for the same Internet access circuits.

Chart 13: Even when controlling for circuit size, districts meeting goals pay less for Internet access



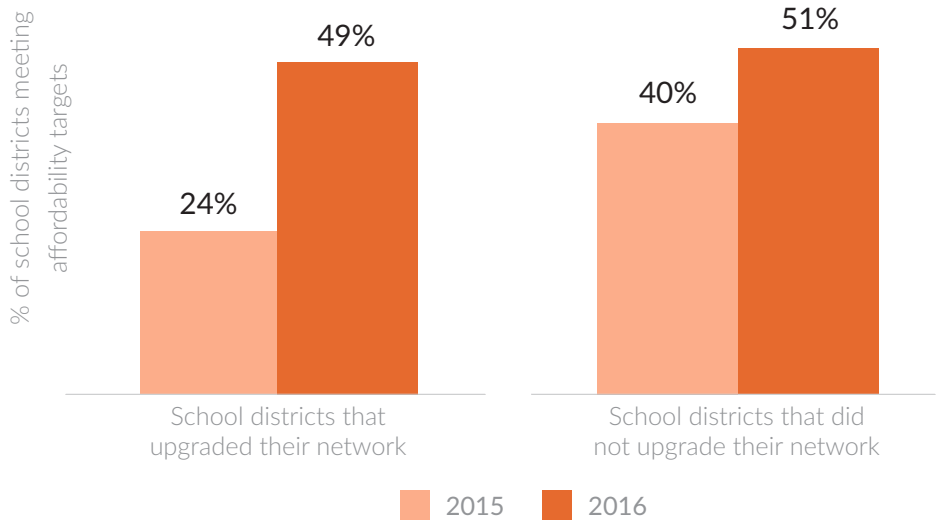
Closing the bandwidth gap: 7.4 million students would have the bandwidth they need if their districts received national benchmark pricing

By improving the affordability of broadband to national benchmark price levels for school districts that don't meet the 100 kbps per student goal, 7.4 million additional students and 440,000 teachers would have the Internet access they need for a 21st century education. As discussed earlier, the path to connecting these students is not to lower the school districts' monthly costs, but rather to significantly increase the bandwidth they receive for the amount they (or their states) are already spending on Internet access.

Affordability goals are helping districts achieve benchmark pricing

In 2015, we discussed how clearly articulated connectivity goals have been a significant driver of improvements in the number of school districts meeting the FCC 100 kbps per student Internet access goal and suggested that by setting and widely communicating affordability benchmarks, districts would have the information they need to be more effective buyers of broadband. As seen in Chart 14, the impact of well-known affordability benchmarks is significant, with districts that upgraded nearly doubling the rate at which they met affordability goals versus only a 25% increase among those that did not upgrade.

Chart 14: **Affordability targets are increasing the number of districts receiving national benchmark pricing**



With a larger data set in 2016, we are able to now provide Internet access affordability targets specific to the most commonly purchased circuit sizes while also reconfirming our 1 Gbps and 10 Gbps WAN affordability targets.

Table 2: **Internet access affordability targets by circuit size**[7]

Circuit Size	Cost per Mbps	Monthly cost per circuit
10,000 Mbps	**$0.75**	$7,500
1,000 Mbps	**$3.00**	$3,000
500 Mbps	**$5.50**	$2,750
200 Mbps	**$9.00**	$1,800
100 Mbps	**$12.00**	$1,200
50 Mbps	**$14.00**	$700
< 50 Mbps	**$14.00**	-

Table 3: **Wide Area Network affordability targets by circuit size**

Circuit Size	Monthly cost per circuit
10,000 Mbps	$1,000
1,000 Mbps	$750

For more details, see ***What are the price benchmarks for affordable broadband?***

[7] Identified as 30th percentile price of circuits in 2015, meaning nearly one-third of school districts were purchasing Internet access circuit sizes at this price.

5% of school districts need to invest more in Internet access to provide their students with equal access to educational opportunity

Unfortunately, buying Internet access at national benchmark prices will not connect all of America's K-12 students to the bandwidth they need for digital learning. Even with affordable broadband, 5% of school districts will still not meet the 100 kbps per student connectivity goal. This is because these districts are investing less than 30% as much per student as their peers.

$0.67

5% of school districts need to invest only $0.67 more per student per year to meet the 100 kbps/student goal

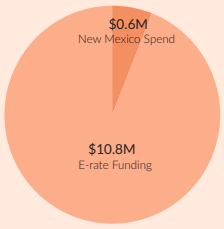
These school districts need to invest an additional $0.67 per student per year in Internet access to ensure that their students have the same access to educational opportunity as their well-connected peers.

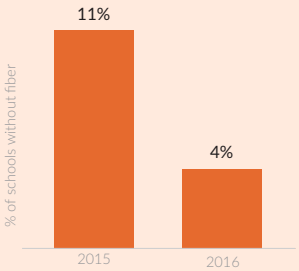
Closing the fiber gap: State matching funds bring fiber to unconnected schools and communities

An estimated 3,700 schools lack the fiber-optic connections required to meet their current and future digital learning connectivity needs. The primary barrier to bringing fiber to these predominantly rural schools[8] is the high one-time cost of construction, which can range from $75,000 to over $420,000 per school. Recognizing that few school districts could afford these one-time costs, the 2014 modernization of the E-rate program sought to close the fiber gap by allowing E-rate funds to be used for fiber construction and providing an additional 10% subsidy on upfront fiber construction costs when states contributed 10% of the cost.

[8] 79% of the schools without fiber are in rural (63%) or small town (16%) communities.

Chart 15: New Mexico's matching fund brought fiber to 40 schools with no cost to districts





School districts pay

$0

Fiber gap reduced by

64%

New Mexico connects 10,000 more students using a state matching fund

In New Mexico, a fiber construction matching fund was created from the state's school capital outlay budget, under the auspices of a cross-agency initiative launched by Governor Martinez. The state was able to reduce by two-thirds the percentage of schools without fiber in the first year its matching fund was available, with an investment of less than $1 million from the state. As a result, over 10,000 more students have the connectivity they need to reap the benefits of technology in the classroom.

To date, seven states have established matching funds to take advantage of this opportunity and eight additional states have proposed matching funds in 2017.

7 states already have existing state matching funds

California

Maine

Massachusetts

New Mexico

New York

North Carolina

Oklahoma

8 additional states are proposing state matching funds in 2017

Arizona

Illinois

Maryland

Michigan

Montana

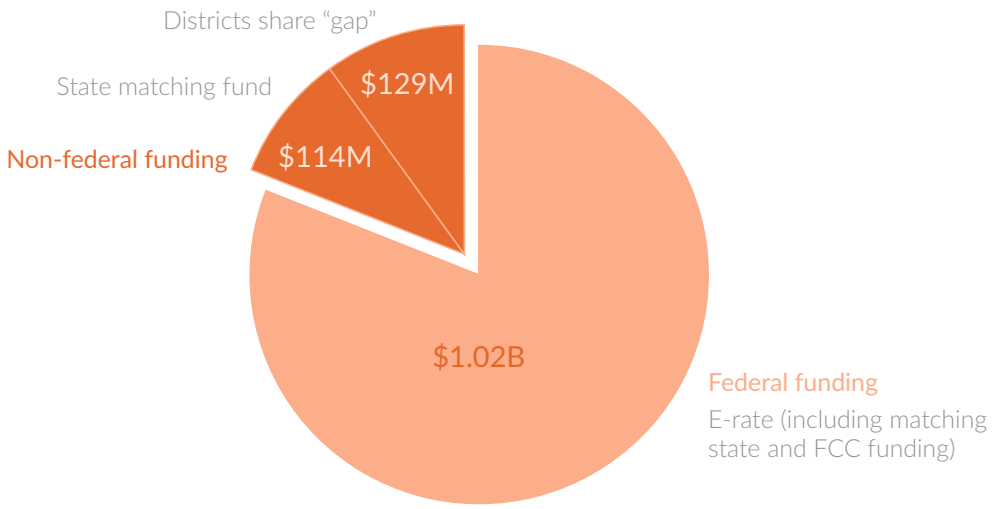
New Hampshire

Texas

Virginia

Across the country, a total of approximately $114 million in state matching funds are required to meet the 10% match requirement for all of the schools requiring fiber construction.[9] This will enable half of the schools without fiber to upgrade without the district providing any upfront capital.[10] Unfortunately, this still leaves half of districts with out-of-pocket costs to bring fiber to their schools, and experience in the field shows that few of these districts will move forward with upgrades due to tight capital budgets. Consequently, in order to ensure that no school is left without fiber, states should plan to provide additional subsidies for these districts so no school district is required to pay prohibitive one-time construction costs. This will increase the total one-time state contributions by an additional $129 million, but will level the playing field for all schools and ensure that no school is left without a critical fiber-optic connection.

Chart 16: With $243 million of non-federal funding, fiber could be built to all schools at no cost to districts



See ***How states can help close the gap on fiber connections for schools.***

Closing the Wi-Fi gap: State technical and procurement support helps districts maximize the impact of E-rate Wi-Fi funding

High-speed broadband that can support digital learning requires a combination of scalable fiber-optic connections, sufficient affordable bandwidth, and robust Wi-Fi networks that can deliver information to student devices in the classroom. In 2016, 17% of schools reported insufficient Wi-Fi in their classrooms. This is a dramatic improvement over 2013, when 75% of schools reported having insufficient Wi-Fi. [11]

[9] Matching-fund needs range in size from approximately $47,000 to $28.2 M (state match only) or from approximately $62,000 to $49.3 M (state match + the gap).

[10] Districts with 80% or higher E-rate discount rates are fully subsidized for fiber builds when a state matching fund contributes 10% of the construction costs and E-rate matches an additional 10%.

[11] See Consortium for School Networking, CoSN's E-rate and Broadband Survey 2013, released October 2013, http://www.cosn.org/sites/default/files/2013EratebroadbandFinal.pdf

Much of this progress can be attributed to the $150 per student budget for internal connections provided by modernization of the E-rate program in 2014. For the first time, every school district has access to the resources needed to put high-speed wired and Wi-Fi networks in each of its schools. In the last two years, districts have requested 57% of the available Category 2 E-rate funds to upgrade their networks and as a result over 1.3 million more classrooms have the Wi-Fi they need. [12]

Unfortunately, not all school districts have been able to close the Wi-Fi gap with their Category 2 E-rate funds. Twenty-five percent of districts that have used their entire $150 per student budget still report having insufficient Wi-Fi in their classrooms. This can often be the result of over-specification of equipment, the lack of competitive options in their procurements, or unusually large upgrade requirements. To address these issues, states are taking action to provide districts with technical and procurement support to ensure that schools get the wired and wireless networks they need for digital learning. Examples of state action include:

- Massachusetts launched the Digital Connections Initiative, which established a $38M grant program that helps schools upgrade their Wi-Fi networks. Seventy-four schools were upgraded in the first two years of the initiative.

- Virginia established statewide contracts for Wi-Fi and Local Area Networks, reducing E-rate and procurement burden on divisions.

- Wyoming administered a network infrastructure survey to all of the schools in the state. The survey responses are now being used to deliver weekly, tailor-made instructional sessions that help districts design, manage, and procure their networks.

See ***How to optimize Wi-Fi budgets for school districts*** for more details.

[12] The schools and libraries universal service support program, commonly known as the E-rate program, helps schools and libraries to obtain affordable broadband. Eligible schools, school districts, and libraries may apply individually or as part of a consortium. Funding may be requested under two categories of service: Category 1 services to a school or library (telecommunications, telecommunications services, and Internet access), and Category 2 services that deliver Internet access within schools and libraries (internal connections, basic maintenance of internal connections, and managed internal broadband services). For Category 2, see How to optimize Wi-Fi budgets for school districts for more details.

Opportunities for Action

Governors, service providers, and school districts can accelerate upgrades

With 11.6 million students still without the broadband speeds they need, it is clear that there is more work to be done to finish the job of connecting all of America's students to the transformational power of digital learning. By taking action, governors, service providers, and school districts can accelerate the pace at which the nation closes the school connectivity gap, giving all students access to the tools necessary to prosper in today's economy.

An action plan for governors: Provide leadership, resources, and expertise

Connecting America's students to high-speed broadband is a bipartisan issue that governors from both parties are embracing as a way to increase access to educational opportunity. In 2016, executive leadership enhanced the likelihood that districts upgraded to meet the FCC connectivity goals and accelerated the pace of fiber and Wi-Fi upgrades. They accomplished this by taking action in the following areas:

- **Set connectivity goals.** Governors across the country established and communicated specific connectivity goals for their states and then took action to identify which districts in their states needed to upgrade to meet these goals. These actions have helped raise the priority of broadband upgrades with superintendents and school boards.

- **Engage service providers.** Recognizing the important role of service providers in closing the fiber gap and improving the affordability of broadband, governors convened groups of service providers to enlist their support in upgrading schools. This has increased the number of service providers bidding on school district requests for proposals (RFPs), encouraged them to extend their fiber networks to nearby districts, and created a win-win environment where service providers are viewed as partners in delivering schools more bandwidth for their broadband budgets.

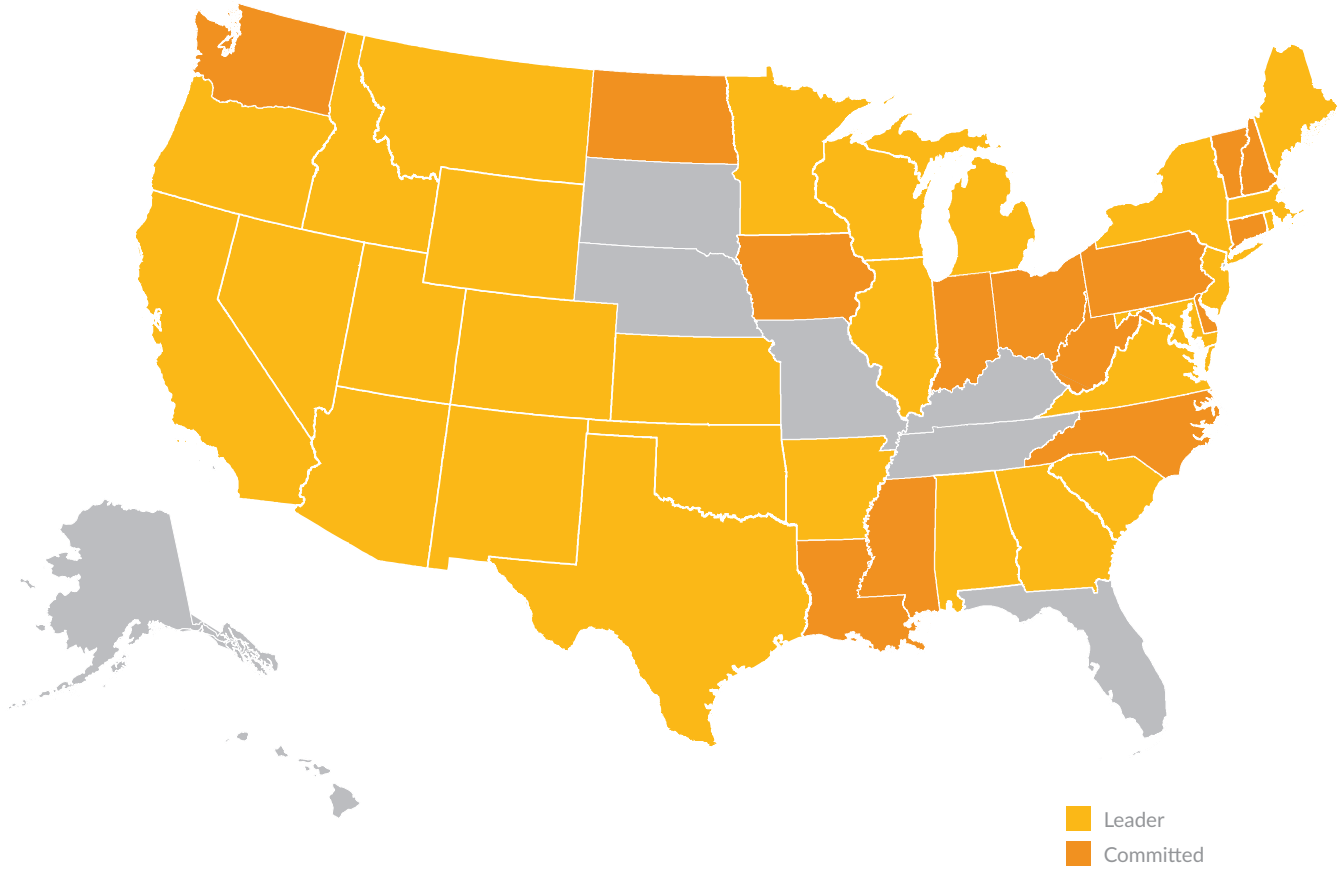
- **Establish state matching funds.** Governors are accelerating the pace of fiber deployments to underserved school districts and communities by eliminating or reducing the need for school districts to come up with capital for upfront construction costs. This is enabling service providers to extend their fiber networks to areas they were previously unable to cost justify (see ***How states can help close the gap on fiber connections for schools***). In addition, some states are accelerating Wi-Fi upgrades by providing districts with some or all of the matching funds needed to access their E-rate Category 2 subsidies.

- **Make broadband affordable.** States are directly improving school district purchasing power by aggregating the procurement of broadband under statewide RFPs and rebidding out-of-date state broadband contracts. In addition, they are helping districts obtain more bandwidth for their budget by providing access to price transparency tools and connecting districts with additional service providers during the procurement process (see ***Compare & Connect K-12***).

- **Provide technical and procurement assistance.** In many districts, the failure to upgrade their broadband is primarily a function of overburdened IT departments not having the time or expertise to pursue upgrades. Governors are addressing this issue and accelerating upgrades by providing districts with technical and procurement support. This facilitates the preparation of RFPs, maximizes competition, and improves the overall effectiveness of district-led broadband procurements.

42 governors are leading K-12 broadband upgrades

Building on the tremendous progress in connecting students and teachers to the broadband they need for digital learning, governors are increasing their commitment to upgrading schools. The map below identifies the governors who are committed to finishing the job of upgrading their schools and leading the way by taking state-level action. Importantly, 7 of the 8 newly-elected governors have already publicly committed to taking action and 5 governors who were not committed in 2015 are now taking action.



E-rate program enables state action

In 2014, the FCC modernized the E-rate program with the objective of accelerating the pace at which schools upgrade their networks. Specifically, E-rate set bandwidth goals, enabled the expansion of fiber-optic networks, funded Wi-Fi upgrades, increased competition and options for school districts, and promoted price transparency to improve affordability. Without E-rate modernization, states would not have been able to achieve the dramatic progress we have seen over the last three years. E-rate provides the foundation upon which governors, service providers, and school district leaders can finish the job of connecting all of their students to the promise of digital learning today and ensure every classroom can meet the growing bandwidth demands of the future.

An action plan for service providers: Take advantage of the K-12 business opportunity by extending fiber networks and providing more bandwidth for broadband budgets

As school districts adopt digital learning in their classrooms, their demand for bandwidth continues to grow more than 50% year-over-year. This will drive districts to upgrade to the FCC's 2018 goal of 1 Mbps per student of Internet access and deploy 1 Gbps fiber WAN connections to every school. Even with continued improvements in affordability, this will result in significant increases in broadband spending by school districts over time. Service providers can take advantage of the K-12 business opportunity in the following ways:

- **Utilize E-rate open data to identify districts requiring upgrades.** E-rate modernization made public all of the applications for funding submitted by school districts and consortia. Service providers can use the *Universal Service Administrative Company's Data Retrieval Tool* and websites like *Compare & Connect K-12* as a lead generation source to identify which districts need bandwidth, fiber, or Wi-Fi upgrades. They can also use these tools to identify where their offering is more competitive than what districts with expiring contracts are currently receiving.

- **Leverage E-rate funds to extend fiber networks.** By allowing E-rate funds to be used for fiber construction and enhancing subsidies through state matching funds, the FCC has given service providers the opportunity to extend their fiber networks to school districts and communities that they do not serve today. This enables service providers to expand their markets without any upfront capital costs while capturing new school district customers. In addition, by pulling extra fiber in conjunction with these network expansions, service providers can also increase their revenues by serving commercial and residential customers near school district facilities.

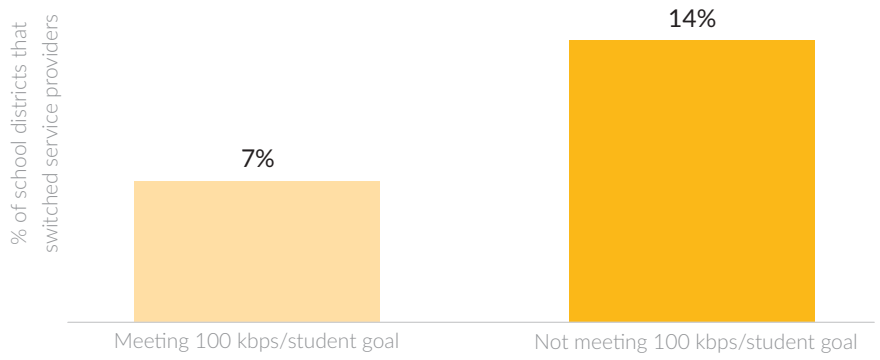
- **Upgrade existing customers to the FCC's minimum 100 kbps per student goal.** School districts meeting the 100 kbps per student goal are half as likely to switch providers when they rebid their contracts. Service providers can significantly reduce churn at virtually no cost by upgrading existing customers to this standard.

- **Compete on value, not price.** With school districts focused on increasing their bandwidth, service providers can compete for business by providing more bandwidth for the budget rather than lowering the monthly recurring cost. Given the near-zero incremental cost of bandwidth, this is an attractive opportunity for service providers to win new business and retain existing customers.

Fifteen service providers can close the bandwidth gap for over half of the students without equal access to educational opportunity at little to no cost

Today, 61% of service providers providing Internet access to schools are delivering at least 100 kbps per student to all of the districts they serve. This is both a tremendous service to their communities and good for business – school districts not meeting the 100 kbps per student Internet access goal are twice as likely to switch service providers when rebidding their contracts.

Chart 17: School districts not meeting 100 kbps per student Internet access goal are twice as likely to switch service providers



By taking advantage of the technological improvements that allow them to provide significantly more bandwidth to districts for the same cost, the 15 service providers listed below could upgrade approximately 6 million students by the start of the 2017 school year. Doing so would support the objectives of the governors in the states where they do business, create tremendous customer loyalty, and demonstrate to the rest of the service provider community the importance of giving students the tools they need to compete in the global economy.

Table 3: Fifteen service providers can level the playing field

Service Provider	% of students not meeting 100 kbps/student goal	# of students not meeting 100 kbps/student goal	# of students meeting 100 kbps/student goal
Level 3	81%	.36M	.08M
CenturyLink	46%	.81M	.96M
Windstream	44%	.31M	.39M
Grande Communications	42%	.07M	.09M
Cogent	37%	.16M	.28M
Cox	33%	.59M	1.19M
Sunesys	32%	.22M	.45M
Frontier	30%	.11M	.25M
Computer Sciences	26%	.14M	.39M
Charter	24%	.85M	2.73M
Phonoscope Lightwave	24%	.10M	.31M
Comcast	21%	.66M	2.43M
AT&T	20%	1.27M	5.05M
Education Networks of America	20%	.33M	1.33M
Zayo	11%	.09M	.66M

An action plan for school districts: Optimize upgrades

With increased technology use in the classroom comes an increase in the demand for bandwidth. As a result, school districts must not only meet the minimum connectivity goal of 100 kbps per student today, but also make progress toward the long-term goal of 1 Mbps per student to support future personalized and video-rich digital learning opportunities. This will require school district technology leaders and business officials to maximize the effectiveness of their broadband procurements in order to limit the impact of bandwidth demands on budgets. School districts can accomplish this by leveraging the following best practices in K-12 broadband procurement:

- **Determine bandwidth needs for the future.** Because most broadband contracts are long term, school districts should plan for bandwidth needs at least three years into the future. Districts that have fully adopted digital learning in the classroom are seeing 50% year-over-year growth in bandwidth usage. The FCC goal of 1 Mbps per student is a good guide for districts deploying large numbers of student devices and adopting media-rich technology. Districts that have more moderate technology use should consider a scaled approach to growing their bandwidth over time.

- **Prepare an effective Form 470 or RFP.** E-rate Form 470 applications can be short, but should include the following: technical and commercial requirements, specific legal language to cover contractual terms, and alignment with E-rate funding rules. A good Form 470 requests at least 100 kbps per student of Internet access; price quotes at higher bandwidth levels in anticipation of growth; and a contract term length of no greater than three years (except in the case of fiber builds where contracts may be longer). For more complex bids, create a comprehensive RFP that outlines the network topologies, technology options, and commercial considerations and allows vendors sufficient time to respond.

- **Find out what your upgrade should cost.** Understanding the potential cost of different upgrade scenarios will help you determine how to structure your RFP. The most effective procurements start with in-depth knowledge of prices and competition in your area. School district leaders can leverage peer relationships, professional associations, and price transparency tools (see ***Compare & Connect K-12***) to research what service providers are offering other school districts in their area or region. This research will help school districts identify new bidders for their RFPs and understand comparative price levels.

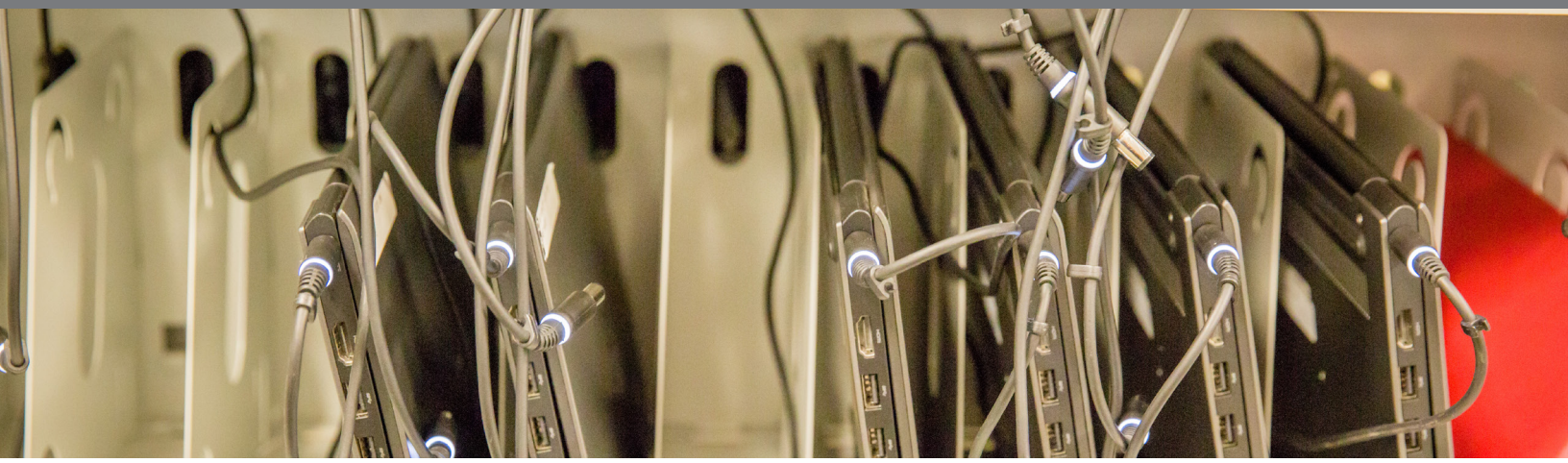
- **Maximize the number of bidders.** Increasing competition is the most effective way to increase the bandwidth a school district receives for its budget. To maximize the number of bidders for an RFP, districts should simplify their bidding requirements as much as possible and conduct proactive outreach to service providers in their area to invite bids.

- **Be open to switching service providers.** Many districts shy away from switching providers due to preexisting relationships or the additional effort required to change vendors. However, in 2016, school districts that switched service providers received twice as much additional bandwidth as those that remained with their existing providers, while seeing their monthly cost of Internet access decline 8% versus an increase of 12% for non-switchers. As a result, those that switched were 40% more likely to meet the FCC minimum connectivity goal and twice as likely to meet affordability targets. At a minimum, districts should ask service providers to explain why they cannot meet national benchmark prices for Internet access and WAN circuits (see ***What are the price benchmarks for affordable broadband?***).

- **Don't wait for contracts to expire.** In 2016, 38% of school districts' bandwidth upgrades took place mid-contract. In many cases, this was possible because districts included specific, mid-contract upgrade provisions in their original contracts that allowed them to upgrade at pre-set prices. In other instances, districts simply went back to their service providers and requested upgrades as their bandwidth needs increased – requests that service providers were able to easily accommodate using the districts' existing fiber-optic connections.

America has made tremendous progress in bringing high-speed broadband to its public school classrooms. The task now falls to governors, service providers, and districts, working in partnership, to finish the job of connecting every student to educational opportunity. Each state has its own unique challenges and opportunities, but by setting goals and focusing on closing the bandwidth, fiber, and Wi-Fi gaps, the combined efforts of governors, service providers, and districts can ensure that all students and teachers in America have the broadband they need for digital learning.

Methodology



Overview

The goal of the State of the States report is to track progress toward the K-12 connectivity goals established by the Federal Communications Commission (FCC) in 2014 and provide state leaders with the information they need to finish the job of connecting America's students to high-speed broadband. The report is published annually and reports on national and state progress toward achieving connectivity goals and key requirements for meeting future connectivity needs: access to fiber infrastructure, sufficient Wi-Fi equipment in classrooms to support 1:1 digital learning, and affordable broadband.

States are critical actors in the effort to provide and improve broadband access for K-12 students. To empower state leaders and agencies to take focused actions, we provide insights on the connectivity gap for each

state and propose concrete actions to improve broadband connectivity in schools.

The following methodological considerations provide district, state, and national practitioners, as well as researchers, with the information required to interpret the analyses in this report.

Data Collection and Sampling

DATA SOURCES

National Center for Education Statistics (NCES)

NCES is a part of the U.S. Department of Education (USDOE) and is responsible for collecting, analyzing, and publishing education data in the United States. For the purposes of this report, NCES's 2013-14 education agency directory provided a comprehensive list of public school districts as well as the following: a unique district identifier (NCES ID); district locale; number of schools; district type; number and percentage of students eligible for federal free and reduced lunch programs; a list of schools within each district; student race and ethnicity data; district physical address; student and staff counts; and contact information (telephone, fax, and address).

Due to the historical nature of NCES's 2013-14 education agency directory, all schools or school districts created since 2013 are unaccounted for in the analyses.

Universal Service Administrative Company (USAC) database

The Universal Service Administrative Company is an independent, not-for-profit corporation created by the Federal Communications Commission in 1997 to administer four universal service programs that help provide communities across the country with access to affordable telecommunications services. The Schools and Libraries Program ("E-rate") administers reimbursements and discounts for telecommunications services (including Internet services) to schools and libraries across the country.

When submitting funding requests for reimbursement, applicants begin by filing a Form 470, which details the services they are attempting to procure. Once the Form 470 has been filed, service providers have a 28-day window to submit bids in response to the requested services. Following this 28-day period, school districts choose their service provider and commit to terms. Once committed, school districts submit a Form 471, which identifies the service provider they have selected, the specific services for which they are requesting reimbursement, and the actual cost of the services. USAC reviews the application to ensure that the requests are eligible for reimbursement. Data from this process is warehoused and made available for public use.[13]

For this report, the following E-rate application data was sourced from the Form 471 filed with USAC: applicant name; service provider name; service connection type; bandwidth; purpose; service type; function; allocation of services; number of circuits; service contract length; cost per month of contract; total (annual) cost of services; unique USAC identifier (Billed Entity Number or "BEN"); contact information; connectivity survey responses.

Due to timing issues, this report is based on the original Form 471 requests (though "Current View"[14] was incorporated for 2015 data). It does not include any subsequent

[13] USAC Schools and Libraries website Download 471 tool: https://data.usac.org/publicreports/Forms/Form471Detail/Index

[14] The version of the data, available on the USAC website Download 471 tool, after modifications have been made by USAC's review process.

updates made to the Form 471 as part of USAC's Program Integrity Assurance (PIA) process, except those that were identified manually by EducationSuperHighway's Data Quality team.

Integration of USAC and NCES Data

Historically, USAC applicant data and NCES district directory data have been extremely difficult to correlate to one another. Integrating these two datasets, however, was critical for producing the insights in this report. The NCES dataset, which provides important demographic context, and the USAC dataset jointly paint a complete understanding of connectivity in school districts. EducationSuperHighway addressed the challenges associated with integrating these datasets as follows:

1. NCES unique identifiers submitted by applicants were compared to the 2012-13 NCES district and school directory.

2. For all incomplete matches, postal code, school and/or district name, and number of students (+/- 20%) were used to connect applicant data to the 2012-13 NCES district and school directory.

3. All remaining unmatched school districts were compared to the 2012-13 NCES district and school directory using only postal code and school and/or district name.

4. Our Data Quality team manually mapped all the remaining schools to the associated Billed Entity Numbers.

5. Utilizing the BEN-NCES mapping, we set up a data model that provided a comprehensive understanding of the relationships between consortia, school districts, and schools. We could then use the data model to more completely align recipients with the services for which they applied.

6. Any new school districts or schools in the 2013-14 NCES data had a similar process applied.

Additional data collected through outreach

EducationSuperHighway also incorporated external data on school district connectivity accumulated through outreach to individual school districts, consortium staff, E-rate consultants, and state experts. While the bulk of the information collected was used to clarify USAC funding request data, some district outreach efforts also identified additional broadband services outside of those listed on the district's E-rate application. For example, rather than leasing point-to-point transport circuits from a private provider, some school districts own the dark fiber connections used to connect their various school sites as part of a district Wide Area Network (WAN). Since there is no lease or procurement cost associated with these district-owned circuits, they are typically not captured on district E-rate applications. Whenever identified, these non-reimbursed services were manually added to the EducationSuperHighway database to ensure that a comprehensive understanding was captured of the school district's connectivity. Out of the sample of 23,603 total broadband line items, EducationSuperHighway staff manually created 1,473 line items (6%) to represent non-E-rate broadband services.

Data management process

Given that users with varying technical expertise and procurement needs are filing E-rate applications every year, data in its raw form often does not accurately represent the services that school districts receive. Therefore, EducationSuperHighway identified these inconsistencies and addressed them by implementing both manual and automated data-cleaning procedures. Throughout the cleaning process, EducationSuperHighway made all decisions to establish a consistent interpretation of E-rate applications.

DATA INCONSISTENCIES

In addressing inconsistent data, EducationSuperHighway focused on the following E-rate fields:

- Function and connection type: these fields indicate whether the network infrastructure connecting schools can scale to meet future connectivity needs. E-rate applicants select a function to indicate the primary technology connecting their schools, including fiber, copper, and wireless. Applicants further select from numerous sub-connection types including:

  - ATM
  - Broadband Over Power Lines
  - Cable Modem
  - DS-1
  - DS-3
  - DS-4
  - Dark Fiber (No Special Construction)
  - Dark Fiber IRU (No Special Construction)
  - Data plan for portable device
  - Digital Subscriber Line (DSL)
  - Fractional T-3
  - Frame Relay
  - ISDN-BRI
  - Lit Fiber Service
  - Microwave
  - Multi-Protocol Label Switching (MPLS)
  - OC-1
  - OC-12
  - OC-3
  - OC_12
  - OC-192
  - OC-256
  - OC-768
  - OC-N (TDM Fiber)
  - Radio Loop
  - Satellite Service
  - Switched Multimegabit Data Service
  - T-1
  - T-3
  - T-4

  Since there is a large number of connection types to choose from, selecting an option in error is common.

- Purpose: this field indicates where a circuit fits into the network architecture. Identifying the accurate purpose is important because the bandwidth needs are significantly different for circuits for Internet access versus those for Wide Area Networks. Additionally, costs associated can vary significantly. Options for this field are bulleted below. This year's descriptive layout of the choices greatly improved the applicant's ability to select the correct purpose of service.

- Internet access service that includes a connection from any applicant site directly to the Internet Service Provider

- Data connection between two or more sites entirely within the applicant's network

- Data connection(s) for an applicant's hub site to an Internet Service Provider or state/regional network where Internet access service is billed separately

- Internet access service with no circuit (data circuit to ISP state/regional network is billed separately)

- Backbone circuit for consortium that provides connectivity between aggregation points or other non-user facilities

- Bandwidth is the amount of connectivity a school district delivers to its students and indicates if the district is meeting the 100 kbps per student connectivity goal. While the information supplied was often reliable in 2015, the bandwidth fields for various connection types in the 2016 Form 471 were auto-populated and not editable by the applicant. As a result many applicants chose an auto-populated bandwidth that overestimated or underestimated the actual bandwidth and required clarification.

- Allocating services allows the applicant to identify which school districts or schools receive the applied-for service. This data improved our understanding of the services being received by school districts from consortia applicants that complete critical aspects of a school district's network.

- Quantity, or number of lines, specified the number of circuits an applicant was applying for in the funding request. This was a source of significant data quality inconsistencies in the 2016 E-rate data, as many applicants found the new form's correlation between cost and quantity confusing. This led many applicants to provide a quantity of "1" in order to match the total monthly recurring cost of the requested service. The number of recipients, cost, and 2015 data were all used to identify which line items required clarification.

- Cost was used to correlate against other data elements such as quantity, bandwidth, and connection type, to identify potential data inconsistencies that needed to be clarified or corrected.

EducationSuperHighway leveraged manual and automated processes to identify and correct data quality issues.

MANUAL CORRECTION OF DATA QUALITY ISSUES

Based on our experience with network technologies and knowledge of standard network architectures of school districts, we identified scenarios that were improbable and flagged them for manual review. In total, we developed 22 distinct line item and district flags to identify data inconsistencies across the 2016 dataset.

Table 1: Examples of the most common logic-based rules used to direct manual data verification efforts

Rule	Description
Applied at the line item level:	
Not Internet Access	Except in cases of isolated connection types, if an applicant submitted a line item having the purpose of "Internet access service that includes a connection from any applicant site directly to the Internet Service Provider" and had more than three circuits, we deemed the line item as likely not being used for Internet access to the school district.
Product Bandwidth	Excluding fiber, all eligible connection types have a limited range at which they can transmit data. Inaccurate data was flagged when an applicant provided a type of connection with a bandwidth outside of its physical circuit capacity.
Unknown Connection Type	With a choice of many different types of connections, in some cases applicants chose unusual connection types for broadband services, so we clarified these to make sure it was not an error. The connection types we flagged included Broadband Over Power Lines, Data plan for portable device, DS-1, DS-3, DS-4, Fractional T-1, Frame Relay, ISDN-BRI, OC-256, OC-768, Other, Radio Loop, Satellite Service, T-4, T-5 Telephone Dial-up, Unknown, and Wireless data service.
Applied at the school district level:	
District Missing Internet Access	If we did not detect data that indicated a school district was receiving one or more Internet access services, we contacted the applicant to clarify how the school district received access to the Internet.
District Receives Stand-alone Internet Access but Not Transport Connection	If a school district was shown to be receiving stand-alone Internet access but no transport connection was detected in the data, the district was flagged to ensure a holistic network architecture was captured.
District Internet Access to Connections	If a district received more Internet access connections than the number of total campuses, the district was flagged to ensure we clarified either the quantity or the purpose of the service.

The manual review of data quality challenges included a review of the service description and narrative fields, the 2016 connectivity questions, the 2015 E-rate broadband services, and direct outreach. Often information triangulated across these different sources helped us conclude what services school districts actually received. When the information provided was insufficient, our Data Quality team performed direct outreach to applicants and other involved parties such as E-rate consultants, service providers, and state network administrators.

AUTOMATED CORRECTION

To further improve data quality, EducationSuperHighway developed a machine learning algorithm for the remaining flagged 2016 line items. The algorithm was constructed using random forest models to clean connect categories and purpose. Predictions were made on fields flagged as incorrect based on 2015 data. Only predictions with a high probability of certainty were applied to flagged datasets. Out of the 23,603 EducationSuperHighway clean line item sample, 2,784 items were updated by the machine learning algorithm.

Dataset and exclusions

To ensure the validity of the data underlying our analyses, we only included a school district in our sample if it met both of the following conditions:

a. all of its line items had been cleared of all applied data quality indicators, and

b. the district itself was cleared of the district-level data quality indicators.

Only line items allocated to traditional public school districts were included in the analysis. EducationSuperHighway did not include charter school districts (except for charter schools that operate within a traditional public school district and use the same services as that school district), private schools, libraries, non-instructional facilities, non-traditional schools such as vocational schools or juvenile halls, and schools administered by the Bureau of Indian Education. The procurement patterns, as well as market dynamics, that impact broadband purchases for these entities may be different from those that affect traditional public school districts. These areas represent opportunities for future research.

Our final dataset for analyses includes verified records for 10,499 traditional public school districts (representing a total of 73,011 schools) that received broadband services through the E-rate program during the 2015-16 FY. These school districts represent approximately 81% of districts, 82% of schools, and 83% of students in all traditional public school districts, spread across 50 states and District of Columbia.

Table 2: Final dataset for analyses

	2015 population	2015 sample	2016 population	2016 sample	2015, 2016 sample overlap
Districts	13,025	**6,781**	13,037	10,499	6,044
Schools	90,252	**48,981**	88,774	73,011	42,728
Campuses	77,123	**41,634**	77,339	63,875	36,580
Students	45,839,819	**25,246,292**	46,470,760	38,394,938	21,831,830

Overall, these school districts were allocated 23,603 line items with a total annual cost of $1.8 billion for broadband services and $87 million for special construction services.

Table 3: Total annual costs

	2016 E-rate Cost for Services*	2016 E-rate Funding for Services
Category 1 Broadband	$1.8B	**$1.5B**
Broadband	$1.8B	**$1.4B**
Special Construction	$68M	**$52M**
Category 2	$1.2B	**$0.9B**

*Cost for services includes K-12, not libraries, charters, privates, non-instructional facilities, etc.

EducationSuperHighway defines a "school district" using criteria established by the NCES. For the purposes of this report Type 1 (regular local school district) and Type 2 (local school district that is a component of a supervisory union) entities have been selected for inclusion.

However, we used an alternative definition of district for the four states listed below due to their unique structure:

Table 4: Alternative definition of district for MA, MT, RI, and VT

Applicable states	Exception	Explanation
MA, RI	Type 4 agencies are considered districts when at least 2/3 of their schools are Type 1 schools (regular schools).	In these states, in addition to Type 1 and Type 2 entities, Type 4 (regional education service agency) agencies operate as districts for certain sets of schools.
VT	Type 3 agencies are considered districts when at least 2/3 of their schools are Type 1 schools (regular schools). Type 1 and Type 2 agencies are not considered districts in this state.	In Vermont, Type 1 and Type 2 agencies are predominantly single-school "town" districts with Type 3 (supervisory union) agencies operating as their supervising bodies. As such, Type 1 and Type 2 agencies are not considered as districts to avoid double counting.
MT	EducationSuperHighway designated "new" districts that do not exist in NCES. These are based on the district-level applications from USAC and the Montana Department of Education's own list of public school districts. Type 1 and Type 2 agencies are not considered districts in these states.	In Montana, USAC applicants file for E-rate using a district-level BEN (Billed Entity Number) for services to more than one school. However, NCES considers the individual schools to be distinct districts. These separate NCES districts share connectivity in some cases, but not all.

In order for district records to be fit for analysis, we required data for the following fields: number of schools, number of students, and locale. School districts missing any or all of these values, or with an indicator that the school district was closed in the past year, were excluded from analysis.

Table 5: District size and locale classification

District size classifications	
Description	# of Schools
Tiny	1
Small	2-5
Medium	6-15
Large	16-50
Mega	51+

Locale classifications	
Description	Locale Code from NCES
Urban	11 - City-Large, 12 - City-Midsize, 13 - City-Small
Suburban	21 - Suburb-Large, 22 - Suburb-Midsize, 23 - Suburb-Small
Small Town	31 - Town-Fringe, 32 - Town-Distant, 33 - Town-Remote
Rural	41 - Rural-Fringe, 42 - Rural-Distant, 43 - Rural-Remote

Assumptions

DISTRICT AND LINE ITEM ANALYSIS

All analyses were conducted using line item-, circuit-, or district-level records. In all cases, we only included records that we verified through our data management processes in the final sample.

Analysis of line items

Each line item in the data sample represents one distinct service reported in a district's Form 471. School districts or other entities such as consortia may submit multiple funding requests and each funding request may be coded as multiple line items. Ideally a district that reports several WAN connections for schools with various bandwidth speeds would have separate line items for each distinct service, one for each bandwidth level. For example, if a district's WAN consists of a 1 Gbps WAN connection, two 100 Mbps WAN connections, and ten 50 Mbps WAN connections, the applicant should provide three line items associated with those services.

The benefit of analyzing the data at the line item level is that it allows for granular analysis of a certain type of product across the market. For example, a line item analysis can be used to calculate the average market rate for a 100 Mbps Internet connection over Lit Fiber. Because much of our analysis was focused on supporting the procurement of broadband, this approach enabled us to look at all services obtained under a single negotiation as a single unit.

Aggregation of services at the school district level

Since the cost and bandwidth information available via E-rate is at the line item level, and a significant portion of our analysis involves understanding district connectivity, many analyses in this report aggregated services up to the school district level. Because school districts procure bandwidth in a variety of ways, our bandwidth and cost calculations take the following scenarios into account:

Bandwidth

- **Bundled Internet Services:** This scenario captured situations where both Internet access and the transport circuit back to the Internet Service Provider were procured together and listed for reimbursement as a single line item. Bandwidth was calculated as the sum of the bandwidth represented by all "verified" Internet line items.

- **Unbundled Internet Services:** This scenario captured situations where Internet access and transport were purchased separately. EducationSuperHighway calculated total bandwidth as the lesser of two values: either a) the sum of bandwidth of each transport circuit to the ISP or b) the total Internet access bandwidth purchased from the ISP. This logic recognized that constraints on district network capacity might be the result of either an insufficient amount of Internet bandwidth or a lack of scalable transport. As a result, either of these network components might serve as the limiting factor in bandwidth calculations.

- **Regional- or state-provided Internet:** This scenario captured situations where a district's Internet access is obtained through access to a regional or state network. The total bandwidth was determined by the capacity of the district's dedicated transport circuit.

Cost

- **Direct district purchase:** For school districts that procure their own Internet services, EducationSuperHighway calculated the total cost of these services as the monthly recurring cost multiplied by the months of service of the contract, unless the monthly recurring cost was $0, in which case we used the one-time cost divided by the months of service.

- **Internet access via a regional or state network:** In cases where a district accesses the Internet over a regional or state network, EducationSuperHighway estimated the district's proportionate share. We determined the number of students as well as the cost of the network's Internet access and "backbone" transport circuits and added the resulting value to the cost of the district's dedicated transport circuit back to the network.

Metric calculations

EXTRAPOLATION

Our analyses are performed against districts that have undergone the data correction process mentioned in the Data Management section. We extrapolate statistics and metrics for states and the nation based on our understanding of their respective districts. Extrapolation is performed by taking the percentage of districts affected by a statistic or metric and multiplying it by the state or national population.

CONNECTIVITY

The sample for Internet access connectivity calculations included only those school districts that:

1. received Internet access services, and
2. had student enrollment data available from either the NCES (National Center on Educational Statistics) or the USAC (Universal Service Administrative Company). Due to data limitations, EducationSuperHighway

Due to data limitations, EducationSuperHighway evaluated a district's progress toward 2014 FCC Internet access goals by using the number of K-12 students (including charter students only if they procured Internet access with the school district) in a school district instead of the number of users (students and staff).

Bandwidth calculation: Bandwidth per student was calculated as the school district's total Internet bandwidth divided by the total number of students in the district according to the 2013-14 NCES data.

- Meeting current connectivity goals: we compare a district's total bandwidth to the 2014 FCC target of 100 kbps per student and classify each district as either "Meeting Current Goals" (greater than or equal to 100 kbps per student) or "Not Meeting Current Goals" (less than 100 kbps per student).

- Meeting future goals: we compare a district's total bandwidth, adjusted for concurrency, to the 2018 FCC target of 1 Mbps per student and classify each district as either "Meeting Future Goals" (greater than or equal to 1 Mbps per student) or "Not Meeting Future Goals" (less than 1 Mbps per student).

INTERNET ACCESS COST

Cost per student

The Internet access cost per student is calculated by dividing the district's Internet access cost of services by the number of students enrolled in the district. A cohort of districts fit for analyses in both 2015 and 2016 were used to compare the 2015 and 2016 costs per student.

District share per student

The district share per student is the cost of services less the amount of funding requested from E-rate divided by the number of students in the district.

The additional Internet access cost for districts unable to meet bandwidth goals at affordability targets is calculated by taking the additional cost that is required for each district to buy the bandwidth required to have 100 kbps per student over the affordability target pricing for Lit Fiber circuits. We then divide by the number of students enrolled in those districts to determine the additional cost per student. The district share per student is the amount remaining from the cost of services less the amount of funding requested from E-rate (i.e., the cost multiplied by the Category 1 discount rate), assuming there are no other sources of funding.

FIBER

Assumptions about fiber access for schools

Throughout this report, you will see several analyses that refer to network infrastructure. Given the anticipated 50% per year increase in bandwidth demand, schools and service providers will have difficulties meeting demand on outdated network infrastructures that have strict capacity limits. Thus, we assume all schools not connected via fiber connections are in need of infrastructure upgrades.

Considerations when estimating fiber to schools

Typically there is a one-to-one relationship between the number of circuits allocated to a school district and the number of school locations, or campuses, within that school district. There are several reasons why schools may not have a connection allocated to them:

- **Co-located schools, or campuses:** Schools can sometimes be co-located within the same building or in close proximity, which may require only one fiber connection to connect all the schools in that same building to the Internet. EducationSuperHighway refers to these multiple school locations as "campuses." An elementary and middle school may share the same physical address and thus may share a single Internet connection, for example. Therefore, EducationSuperHighway estimates the number of campuses in a district by grouping schools with unique school addresses or schools in close proximity to one another. Additionally, through data clarification and outreach, our data quality team may have manually grouped schools that were otherwise not caught by the algorithm.

- **Closed schools:** Given delays in reporting between NCES and USAC, schools may have been closed and therefore not need a fiber connection. We leveraged the "closed schools" information from NCES to eliminate schools that did not need a connection, and manually eliminated schools we learned had closed through outreach and web research.

- **Allocations made by E-rate applicants:** Due to difficulties with the Form 471 application process, E-rate applicants may have allocated circuits to the district BEN instead of specifying the schools where the circuit is going.

- **Owned infrastructure:** School districts may have owned dark fiber connections or point-to-point wireless connections that are not reported through E-rate.

- **No E-rate reimbursement:** Smaller school districts with only one or two inexpensive connections may decide not to file for E-rate reimbursement, as the return may not be worth the investment in time.

- **Free service:** In rare instances, a school or school district may receive free service from a local provider or through the city.

Revised assumptions for missing connections

In 2015, we assumed a district had campuses with non-fiber connections if the total number of circuits allocated from E-rate was lower than the number of campuses within the district, except in the case where a district was large and did not receive any WAN circuits, as we assumed those schools were connected via owned dark fiber. In 2016, we administered extensive surveys and research to determine how schools were commonly connected in school districts that did not file for E-rate reimbursement for all of their specified campuses. We determined that 8% of these school districts have schools without fiber connections. Therefore, in 2016 we updated our assumption for non-fiber services, assuming that 8% of campuses in school districts with missing connections use a non-fiber connection.

Estimating the fiber need in schools

Due to a large number of inconsistencies and inaccuracies by E-rate applicants when identifying entities that receive broadband services, allocating all services received by a school district to its component schools is challenging. In instances where there is not enough information to determine if a campus has fiber, we apply a set of rule-based prediction models.

Fiber Rule Calculations

1. If a district is not in need of fiber, the district has no campuses served by non-fiber.
2. If a district is in need of fiber, and contains any of the dirty indicator flags mentioned in the data quality section, we count the number of fiber and non-fiber connections to this district. We assume each campus can only receive one connection and will receive any fiber lines before the non-fiber lines. If there are more remaining campuses than connections, we assume the district has owned fiber WAN connections for 92% of the remaining campuses.
3. If the following are true, we assume this is a high-need district and has one non-fiber campus:
   a. District is in need of fiber
   b. Contains any of the dirty indicator flags mentioned in the data quality section
   c. District has two campuses or fewer
4. If the following are true, we assume 34% of the district's campuses are non-fiber
   a. District is in need of fiber
   b. Contains any of the dirty indicator flags mentioned in the data quality section
   c. District has more than two campuses

5. If we were unable to make a determination about a district's need and there was no E-rate data, and the district has two campuses or fewer, we assume this is a high-need district and has one non-fiber campus
6. If a district was not in any of the previous categories, it was not in our sample of districts to analyze.

Due to variations in network topology across school districts in the sample, both Internet and WAN connections are included in the calculation of the number of fiber lines serving each district.

AFFORDABILITY

Lack of affordable broadband is one of the major roadblocks preventing school districts from meeting the FCC's minimum Internet access goals. EducationSuperHighway believes that improving affordability is a great lever for connecting the remaining 11.5 million students who have been left behind.

Method: A school district is meeting the affordability target if it is getting the maximum bandwidth under benchmark pricing. To determine benchmark prices, we selected circuit sizes that were most frequently purchased among Lit Fiber IA circuits that appear in the 2015-16 E-rate data. We then looked at the 30th percentile of monthly recurring cost per Mbps for each circuit size listed below:

Table 6: Pricing benchmarks cost per Mbps by circuit size

Circuit Size	Cost per Mbps
10,000 Mbps	$0.75
1,000 Mbps	$3.00
500 Mbps	$5.50
200 Mbps	$9.00
100 Mbps	$12.00
50 Mbps	$14.00

For instance, a school district that spends $3,000 should get at least 1 Gbps of bandwidth. If a school district has a budget of $5,800 it should be getting at least 1 Gbps ($3,000) plus 500 Mbps ($2,750), for a total of 1.5 Gbps ($5,750). If a district's monthly Internet access budget is smaller than $700, it is meeting the affordability target if it is purchasing bandwidth at a price lower than $14 per Mbps. If a district owns dark fiber or does not incur recurring costs on Internet items while getting a positive amount of bandwidth, it is meeting the affordability target. Districts with restricted cost information are excluded from consideration, which includes any applicant who answered "Yes" to the Form 471 question "Is there a statute, rule, or other restriction which prohibits publication of the pricing information?"

WI-FI

Sufficiency

Unlike broadband analyses, which were conducted on line item data, meticulously cleaned, and required to pass through a series of tests before being included in analyses, Wi-Fi analyses were done based on the answers to survey questions that E-rate applicants were required to respond to about the schools for which they were applying. A school has insufficient Wi-Fi if the applicant answered "Never" or "Sometimes" to the field "Wi-Fi Sufficient," and has sufficient Wi-Fi when answering "Mostly" or "Completely." If a school did not have an answer, it was not included in the sample. A district was determined to have insufficient Wi-Fi if it had at least one school with insufficient Wi-Fi. If a district had no schools with answers to the connectivity questions, it was not included in the sample.

Available E-rate Funds

EducationSuperHighway quantified both the magnitude of Wi-Fi purchasing and the opportunity for additional Wi-Fi upgrades by evaluating the Category 2 funding requests submitted by school districts. Since Category 2 services fell outside the scope of EducationSuperHighway's data verification efforts, these Wi-Fi metrics utilize data received by any school district in our universe as previously defined.

The "E-rate funds available" metric estimates the available funds remaining in the Category 2 budget. First, the theoretical maximum amount of funding was calculated by multiplying the number of students in each district by $150, the five-year Category 2 cap, while applying the minimum of $9,200 per school. The cost of the district's Category 2 services applied for during the 2015 and 2016 funding cycles was later subtracted and the remainder multiplied by the district's discount rate, determined by which is available: first, the 2016 C2 discount rate from the application; second, the 2015 C2 discount rate; and third, the statewide weighted average discount rate by cost (across all districts) to determine the remaining available funding.

UPGRADES

We classify a school district as upgraded if any of the following are true:

- The district's total Internet access bandwidth in the 2016-17 school year is at least 11% higher than its Internet access bandwidth in the 2015-16 school year.
- The district has added at least one 50 Mbps Internet access circuit since the 2015-16 school year.

FIBER BUILD COST ESTIMATES

Identifying campuses for cost calculations

We use the fiber metric methodology to estimate how many campuses are in need of fiber in a state. Since we do not know exactly which campus is unscalable in a specific district, we assume the campuses farthest away from the district office are unscalable. To calculate the farthest campuses for WAN builds, we use district and campus addresses provided by NCES. To calculate the farthest campuses for Internet access builds, we calculate the distance between the district office and the closest service provider point of presence. Once the unscalable campuses are identified, we use industry benchmarks and our in-house expertise to develop the total cost to build fiber.

When a district is calculated to have a fraction of an unscalable campus we apply the fraction as the total cost to cover builds. For example, if a district has .12 unscalable campuses, we consider its total cost 12% of the actual build cost.

Calculating funding sources

We determine the initial FCC subsidy using the Category 1 discount rate (based upon locale and FRL). In addition, the FCC will match the state subsidy amount, of up to 10% of the total cost. Fiber build costs not covered by the initial FCC subsidy, state subsidy or FCC match are considered the district's share.

For example, for a district with a 70% discount rate that has a build cost of $100,000, the initial FCC subsidy is 70% ($700,000), the state will provide 10% ($10,000), the FCC will match an additional 10% ($10,000), and the district will have to pay 10% ($10,000) out-of-pocket. Districts with higher than an 80% discount rate is assumed to receive a state subsidy and FCC match that would cover 100% of costs. Fiber build costs not covered by the FCC or state subsidy or FCC discount rate, and state match, are considered the district's share.

We aggregate total cost, E-rate share, state subsidies, FCC match and district share ("gap") at the state and national level.

CONCURRENCY

When there are many potential users on a network, it becomes highly unlikely that every student and teacher will be on the network at the same time or "concurrently." Larger school districts can therefore purchase bandwidth based on the anticipated number of concurrent users on the network, rather than the total number of users within the district, without impacting the connectivity of any individual user. Concurrency factors were chosen based upon internal research and feedback from contacts in larger school districts.

We applied concurrency factors in our calculations when assessing whether school districts are meeting the longer-term 2018 FCC goal of 1 Mbps per student.

Table 7: EducationSuperHighway Concurrency Factors

District Size	Concurrency Factor
Tiny and small	1
Medium	1.5
Large	1.75
Mega	2.25

Calculation

In both the state-level snapshots and the nationwide analyses contained in this report, EducationSuperHighway assessed progress against the 100 kbps per student connectivity goal laid out by the FCC. We also provided insight into what it will take to meet an anticipated 50% annual growth in bandwidth demand by quantifying the status and opportunity associated with providing access to fiber, affordable pricing, and sufficient Wi-Fi equipment.

National analysis

The national analysis contains a few key analyses that warrant additional explanation.

WIDE AREA NETWORK CONNECTIVITY AND COSTS

National analysis of WAN services looked at circuits rather than district-level information in order to avoid the complexities and potential inaccuracies associated with both the correct allocation of circuits and missing WAN data due to owned dark fiber and other factors.

PRIMARY SERVICE PROVIDERS

National analysis of service providers requires the assignment of a primary service provider for each school district. The calculation involves selecting the service provider that supplies the majority of Internet and/or upstream bandwidth to a district.

COHORT ANALYSIS

To quantify changes in the availability of affordable broadband over the past two years, EducationSuperHighway revisited the sample of 2015 E-rate data that previously informed our 2015 State of the States report. Some examples of these analyses include identification of upgrades, applicants who switched service providers, and various cost comparisons across years.

Definition of terms

Applicant – The entity applying for universal service support. The term can refer to a school, library, district, consortium, or other eligible entity that files program forms.

Bandwidth – A measure of the amount of data that can be transmitted per second. Upload bandwidth, or upload speed, refers to the amount of information that can be transmitted away from a site. Download bandwidth, or download speed, refers to the amount of information that can be transmitted to a site.

Billed Entity Number (BEN) – A unique number assigned by USAC to each billed entity that pays for or receives services.

Campus – A physical site containing at least one or more schools. Since schools that are co-located may be able to share a single Internet or WAN connection, we evaluate district connectivity at campus rather than school level. We calculate the number of campuses in each district using an algorithm based on street address and physical proximity between schools.

Note: This is different from the FCC's definition of a campus, which does not include multiple co-located schools as one campus, but rather separates out multiple campuses for one school. The FCC definition is as follows: "the geographically contiguous grounds where the instructional buildings of a single eligible school are located… Different schools, as opposed to different instructional buildings of the same school, located on the same grounds do not comprise a single campus" (http://transition.fcc.gov/Daily_Releases/Daily_Business/2016/db0912/DA-16-1023A1.pdf)

Category 1 services (C1) – Services used to connect broadband or Internet to eligible locations, or services that provide the basic conduit access to the Internet. Telecommunications services, Internet access, and voice services are Category 1 services.

Category 2 services (C2) – Items classified by the FCC as Category 2 services include: "internal connections, basic maintenance, and managed Internal broadband services (more commonly described as managed Wi-Fi)."

Competitive Local Exchange Carrier (CLEC) – Carriers that were allowed into the market after the Telecommunications Act of 1996 was enacted.

Concurrency – A networking concept that estimates overall bandwidth demand based on the number of simultaneous users. Logically, the probability that every potential user will access the network at the same time decreases as the total size of the user population rises. As a result, the additional bandwidth required to serve additional users is lower for larger networks.

Connection type – The material over which electronic data is transmitted.

Consortium – A consortium (plural "consortia") is a group of entities that apply together for funding.

Dark fiber – Fiber circuits that are purchased or leased without optical equipment; to "light" the fiber connection, the user must procure and install these optics themselves. Since the user thus controls the necessary optical devices, the bandwidth transported over dark fiber can be dramatically scaled via relatively inexpensive upgrades to this equipment after the initial build.

District – An entity that can apply for and receive services under E-rate. The district has schools under its jurisdiction that receive the services it applies for. In the Schools and Libraries Program, Internet connectivity will be measured at this level. Discounts will also be calculated at this level.

E-rate modernization order – The FCC Report and Order that modernized the E-rate Program and focused on high-speed broadband connectivity to schools and libraries (FCC 14-99).

E-rate Program – The common term used in place of the Schools and Libraries Program. The E-rate Program provides discounts to schools and libraries for eligible products and services.

Fiber – Fiber-optic technology converts electrical signals carrying data to light and sends the light through transparent glass fibers about the diameter of a human hair. Fiber transmits data at speeds far exceeding current DSL or cable modem speeds, typically by tens or even hundreds of Mbps.

Free and reduced lunch program (FRL) – This program provides school lunches to eligible students at a free or reduced rate. In order to be eligible, the family of the student must be under the poverty level by a certain percentage.

Incumbent local exchange carrier (ILEC) – The carrier, defined regionally, that historically held a monopoly in a certain area before other carriers were allowed in the market.

Internet access (IA) – Internet access services are those that provide eligible basic conduit access to the Internet. Ineligible access includes content, equipment purchases, or other services beyond basic conduit access. However, selected services that are an integral component part of an Internet access service (and other services designated as eligible by the FCC) may be eligible for discounts on interconnected VoIP, email service, and Web hosting.

Internet service provider (ISP) – A company that provides Internet access service (also referred to as a service provider).

kbps/Mbps/Gbps – The abbreviations for kilobits, megabits, and gigabits per second, respectively. These define the speed of an Internet connection. Higher numbers indicate that the connection is capable of transferring more information in a given period of time.

Line items – Services for which an organization has requested an E-rate reimbursement, including details on the service, the cost, and the service provider, if applicable.

Recipient – The entity receiving universal service support. In the Schools and Libraries Program the recipient is a school, library, or district.

Service provider – A company that participates in one of four universal service programs and provides telecommunications or Internet services, equipment, hardware, or software. Types of companies include but are not limited to: competitive access/competitive local exchange carriers (cellular, personal communications, or specialized mobile radio providers), incumbent local exchange carriers, interexchange carriers, Internet service providers, interconnected VoIP, or local resellers (coaxial cable, nontraditional, operator, paging, messaging, or payphone).

Transport – Transport is Internet infrastructure that is not a direct ISP connection, but which serves as the link from a building receiving Internet service to the ISP connection.

Wide Area Network (WAN) – A voice, data, and/or video network that provides connections from within an eligible school or library to other locations beyond the school or library. By definition, the service provided does not access the Internet.

About this report

The State of the States report tracks progress toward the K-12 connectivity goals established by the Federal Communications Commission (FCC) [13] and provides state leaders with the information they need to finish the job of connecting America's students to high-speed broadband. The report, which is published annually, does this by reporting on national and state progress toward achieving connectivity goals and the key requirements for meeting future connectivity needs: access to fiber or equivalent high-speed infrastructure, sufficient Wi-Fi equipment in classrooms to support 1:1 digital learning, and affordable pricing.

States are critical actors in the effort to provide and improve broadband access for K-12 students. School connectivity is often strongest in states where focused action has been taken by state leadership and state agencies. For that reason, the accompanying State of the States website at stateofthestates.educationsuperhighway.org provides insights, broken down by state, to help state leaders see where they stand relative to the FCC connectivity targets, understand potential actions they can take to dramatically improve broadband connectivity in schools, and find out what their state peers are doing.

About the data

The analysis in this report is based on application data from the FCC's Schools and Libraries Program ("E-rate"). [14] It includes data from 10,499 public school districts, representing over 38 million students in approximately 73,000 schools across all 50 states and the District of Columbia (to calculate growth metrics, data is available for both 2015 and 2016 in 8,898 school districts). These applicants reported a total of $2.77 billion in annual Category 1 broadband spending, corresponding to $2.11 billion in funding requested from the E-rate program. All E-rate applications are subject to review before funds are distributed, ensuring that school districts strive to accurately reflect their purchases. As a result, this data represents the best national source of current information on school district connectivity; specifically, what broadband services schools are buying and how much they are paying for these services.

For the last 21 months, EducationSuperHighway's team of 25 analysts, data quality specialists, and developers has been verifying and analyzing the 2015 and 2016 E-rate data. Over this period, the team has had a particular emphasis on clarifying the broadband services contained in E-rate applications, working closely with school districts, state partners, and E-rate consultants to verify that the data accurately represents the services they receive.

Our data verification and analysis efforts supplied us with a comprehensive understanding of connectivity for each school district included in the sample. State-level metrics were then calculated based on a sample of the total school districts in each state, which on average included 81% of districts. As with any sample-based methodology, there is a small margin of error that must be considered when interpreting state-level results. Regardless, we believe that this report identifies specific actions states can take to improve connectivity in America's K-12 public schools. We will continue to report on our national progress every year to help state leaders close the K-12 digital divide before the end of the decade.

A digital version of this report is available at stateofthestates.educationsuperhighway.org. To fully leverage the potential of the open E-rate data, the district-level connectivity and procurement information upon which the analysis of this report is based is available on *Compare & Connect K-12* at www.compareandconnectk12.org, an online tool designed to help school districts increase the effectiveness of their broadband procurement and to help state leaders and service providers identify which school districts need to upgrade.

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[13] See FCC Report and Order and Further Notice of Proposed Rulemaking, WC Docket 13-184, released July 23, 2014, ¶ 22-62, https://apps.fcc.gov/edocs_public/attachmatch/FCC-14-99A1.pdf

[14] The schools and libraries universal service support program, commonly known as the E-rate program, helps schools and libraries to obtain affordable broadband. Eligible schools, school districts, and libraries may apply individually or as part of a consortium. Funding may be requested under two categories of service: Category One services to a school or library (telecommunications, telecommunications services, and Internet access), and Category Two services that deliver Internet access within schools and libraries (internal connections, basic maintenance of internal connections, and managed internal broadband services). Discounts for support depend on the level of poverty and whether the school or library is located in an urban or rural area. The discounts range from 20 percent to 90 percent of the costs of eligible services. E-rate program funding is based on demand up to an annual Commission-established cap of $3.9 billion. See FCC, E-rate, https://www.fcc.gov/encyclopedia/e-rate-schools-libraries-usf-program

About EducationSuperHighway

EducationSuperHighway is the leading nonprofit focused on upgrading the Internet access in every public school classroom in America. We believe that digital learning has the potential to provide all students with equal access to educational opportunity and that every school requires high-speed broadband to make that opportunity a reality.

Our work focuses on catalyzing federal and state action on K-12 broadband initiatives and accelerating upgrades in school districts by connecting them to competitive service provider options. We are currently working with governors in 20 states covering 20 million students and providing technical and procurement support to hundreds of school districts. Our ***Compare & Connect K-12*** online tool helps schools, state leaders, and service providers view broadband services and bandwidth information for school districts nationwide so they can get and deliver more bandwidth for their broadband budgets. As a nonprofit, our tools and services are offered free of charge.

EducationSuperHighway is funded by national foundations including the Chan Zuckerberg Initiative and the Bill and Melinda Gates Foundation and our mission is supported by America's leading CEOs.