Infrastructure for the 21ˢᵗ Century

Infrastructure for the 21st Century

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"It's the broadband networks beneath us and the wireless signals around us, the local networks in our schools and hospitals and businesses, and the massive grids that power our nation. It's the classified military and intelligence networks that keep us safe, and the World Wide Web that has made us more interconnected than at any time in human history."

—President Barack Obama, Remarks on Securing Our Nation's Cyber Infrastructure, May 29, 2009

Introduction

Providing and maintaining infrastructure is one of government's most important roles, and perhaps one of the most underappreciated. Infrastructure improves the lives of individuals every day, providing electricity and water, the roads and public transportation needed for commuting and shopping, and the telecommunications networks needed for the free flow of information and ideas. Businesses rely on that same infrastructure to interact with suppliers, to produce their goods and services, and to provide those goods and services to their customers. In short, "infrastructure—freight ports, airports, bridges, roads, rail and transit networks, water and sewer systems, web of channel communications—is the connective tissue of our nation" and it "has a dramatic effect on the economic competitiveness of our nation, the health of our environment and our quality of life."[1]

In the past, the United States led the way in several key areas of infrastructure development, starting with the railroad system of the 1800s, an innovation that greatly reduced travel times and allowed more robust commerce between the states and the rest of the world. During the 20th century, electricity was brought to nearly all homes and businesses; the telephone system brought the ability to communicate instantly to virtually everyone; paved roads and highways were vastly increased, with the Eisenhower's Interstate Highway System at the center; and an air transportation system emerged to enable unprecedented personal mobility and access to global products and services. The United States must still be mindful about the condition of its existing infrastructure, as these investments remain crucial to its economic health and investments in these assets can provide high levels of return. Thus, repairing roads and bridges and maintaining the energy grid and the telecommunications networks need to remain priorities. Furthermore, these crucial investments in repairing and rebuilding the existing infrastructure should incorporate principles of sustainable design.

However, in today's economy—with global supply chains, exports to foreign markets, telework, and just-in-time inventories—the nature of infrastructure needed to compete is changing, and the United States needs a 21st century infrastructure to ensure that it remains competitive. This includes improvements to existing infrastructure, such as introducing advances into the highway system that will provide safety, mobility and energy efficiency. Infrastructure for the 21st century is led by the ever-growing presence and influence of broadband Internet. Definitions of what constitutes "broadband" can differ, but one useful measure put forth by the Federal Communications Commission (FCC) in its recent National Broadband Plan sets a goal of ensuring that 100 million households have access to broadband Internet with actual download speeds of 50 megabits per second (mbps) and actual upload speeds of 20 mbps by 2015, and that 100 million households should have access to actual download speeds of 100 mbps and actual upload speeds of 50 mbps by 2020. In addition, the FCC has set as a goal that every community should have affordable access to service with speeds of at least one gigabit per second at schools, hospitals and government buildings.[2]

Broadband Internet is used by more than 2 billion people and is still growing. Internet-related consumption and expenditure is now bigger than agriculture or energy. Research has shown that the Internet accounts for, on average, 3.4 percent of GDP across many major countries, reaching as much as 6 percent of GDP in advanced countries such as Sweden and the United Kingdom.[3] The Internet is also a critical element of growth; in a study of mature economies, the Internet accounted for 10 percent of GDP growth over the past 15 years, and this contribution has been increasing over time; the Internet's contribution to GDP growth was 21 percent in the last five years.[4]

Small and medium-sized enterprises (SMEs), in particular, have benefitted from the Internet. SMEs with a strong web presence have been found to grow faster and export more than those that had minimal or no presence. One survey found these firms also created more than twice the number of jobs as firms without an Internet presence, creating 2.6 jobs for each one eliminated.[5] The Internet also has created large amounts of consumer value. For example, it is estimated that the Internet generated $64 billion in consumer value in the United States in 2009.[6]

Also, a strong 21st century infrastructure is crucial because it is closely linked to the other key building blocks of competitiveness. Additional basic and applied research will lead to improvements in information infrastructure, and that

infrastructure is necessary to ensure that advances in research of all types can be efficiently shared among the research community. Education is also closely linked to infrastructure. Not only does traditional infrastructure, namely school buildings, need to be in good shape in order for students to learn, but information infrastructure, such as broadband, can help deliver new education technologies to the classroom.

Although private industry has led the way in many forms of infrastructure (most utilities are privately owned companies, for example), government maintains an important role because infrastructure can have positive spillover effects that a private investor would not take into account when deciding whether or not to invest in the project. As with R&D, it is likely that too little money would be spent on infrastructure without government intervention.[7] In addition, our society has affirmed repeatedly that we would like all of our citizens to have access to certain technologies. In the past, this meant providing phone access or electricity to all parts of the country. Today, expanded high-speed Internet access would not be available to certain areas without government assistance.

As discussed below, though the United States has made great strides in harnessing the transformational and economic power of the Internet and other aspects of a strong 21st century infrastructure, there remains substantial untapped potential.

Definition of 21st Century Infrastructure

Infrastructure is a broad concept and there is no single commonly accepted definition. Traditionally, infrastructure refers to the physical pathways used to transport goods, people, and basic utility services. Most commonly, this includes roads, bridges, seaports, airports, rail lines, the electrical grid, pipelines, and the water and sewage system. However, more recently, our economy and society have become more information intensive and "information infrastructure" has gained in importance. Until relatively recently, information infrastructure was limited to voice communication over the physical wires of our telephone system but now includes our broadband Internet connections (including fiber, cable modem and digital subscriber line (DSL) service) as well as satellites and cell phone towers. Further, information infrastructure also encompasses our burgeoning "cloud computing" capabilities and traditional forms of infrastructure that can be improved when used in conjunction with 21st century infrastructure, such as the "Smart Grid" for electricity.

How Does Our 21st Century Infrastructure Stack Up?

Electricity Grid

Much of our nation's traditional electricity infrastructure has changed little from its original design and form at the end of the 19th century.[8] The result, according to U.S. Energy Secretary Steven Chu, is that "the ability of the United States to meet the growing demand for reliable electricity is challenged."[9] Successfully addressing this challenge is critical. "America cannot," Secretary Chu has stated, "build a 21st century economy with a 20th century electricity system. By working with states, industry leaders, and the private sector, we can build a clean, smart, national electricity system that will create jobs, reduce energy use, and expand renewable energy production."[10]

President Obama has outlined a vision for doubling America's use of clean energy by 2035 and achieving the goal of putting one million electric vehicles on the road by 2015. Having a modernized, smarter electric system is an important step to meeting these goals. Building the necessary transmission infrastructure and utilizing smart grid technologies will facilitate the integration of renewable resources into the grid, accommodate a growing number of electric vehicles, help avoid blackouts, restore power more quickly when outages occur, and reduce the need for new power plants. Smart grid technologies also provide a foundation for innovation by entrepreneurs and others who can develop tools to empower consumers and help them make informed decisions about energy usage.

To lay out a path forward, the Federal government, in June 2011, released *A Policy Framework for the 21st Century Grid: Enabling Our Secure Energy Future.*[11] This framework features four pillars, which are supported by Administration actions, and includes further policy recommendations to promote investment, innovation, and job growth:

1. **Enabling cost-effective smart grid investments** by disseminating lessons learned from American Recovery and Reinvestment Act investments.

2. **Unlocking the potential of innovation in the electricity sector** through a greater focus on standards and interoperability (see box 5.1).

3. **Empowering consumers and enabling informed decision making** with enhanced information to save energy, ensure privacy, and shrink bills.

4. Securing the grid from cyber attacks and improving its recoverability in the event of such an attack.

The Administration is taking a number of concrete steps to put these principles into action. For example:

- The Department of Agriculture's Rural Utility Service is investing up to $250 million in cost-effective smart grid technology in rural America by June 2012.

Box 5.1

NIST and the Smart Grid[1]

Deploying an interoperable and secure Smart Grid cannot be accomplished without establishing interoperability standards. To accelerate the development of these standards, Congress, under the Energy Independence and Security Act of 2007 (EISA), assigned the National Institute of Standards and Technology (NIST) the "primary responsibility to coordinate development of a framework that includes protocols and model standards for information management to achieve interoperability of Smart Grid devices and systems..." [EISA Title XIII, Section 1305].

Recent Accomplishments

The Smart Grid Program has made significant progress in its mission to coordinate the development of interoperability standards over the course of its history. Below is an abbreviated list of recent accomplishments:

- NIST established the Smart Grid Interoperability Panel in November 2009 as a public-private partnership to provide technical support and provide an open forum for Smart Grid stakeholders.

- NIST published the Framework and Roadmap for Smart Grid Interoperability, an initial list of 75 interoperability standards, in January 2010.

- NIST published Guidelines for Smart Grid Cyber Security in September 2010, providing the technical background and details that inform organizations' efforts to securely implement Smart Grid technologies.

- NIST created a Smart Grid Advisory Committee in September 2010 to provide input on Smart Grid standards and NIST's research activities in this area.

- In July 2011, the Smart Grid Interoperability Panel approved the first set of Smart Grid standards, including standards focused on Internet protocols, energy usage information, vehicle charging stations, smart meter upgradeability, and wireless communication devices.

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1. For more information go to www.nist.gov/smartgrid/index.cfm.

- The Administration has also launched Energy.Data.gov, an open government platform that brings together free high-value datasets and tools, maps, and apps to increase awareness of and deepen insights into our nation's energy performance.

- The Department of Defense, through its "microgrid" initiatives, is working to test distributed generation and electricity distribution systems that will help enhance the security and efficiency of military bases both at home and abroad.

To empower consumers and foster innovation, the Administration will continue to promote the Green Button challenge to industry—the common-sense idea that consumers should be able to get access to and download their own energy usage information. And finally, the Administration is working to improve the overall quality and timeliness of electric transmission infrastructure permitting through the interagency Rapid Response Team for Transmission.

Information Infrastructure

Recent developments in information and communications technology (ICT), such as high-speed or broadband Internet access have transformed the social and economic environment in which we live. It provides an outstanding channel for gathering and disseminating information, entertainment, commerce, and education, and it can bring substantial benefits to our economy. For example, "electronic health records could alone save more than $500 billion over 15 years. Much of the electric grid is not connected to broadband, even though a Smart Grid could prevent 360 million metric tons of carbon emissions per year by 2030, equivalent to taking 65 million of today's cars off the road. Online courses can dramatically reduce the time required to learn a subject while greatly increasing course completion rates."[12]

In the United States, 68 percent of households had broadband Internet access in 2010, an almost eight-fold increase since 2001.[13] However, there are still a large number of Americans who do not use or lack access to the latest broadband and information technologies; a 68 percent adoption rate still leaves approximately one-third of American homes cut off from the digital economy. Furthermore, despite impressive gains, the United States trails behind a number of other nations in household-level broadband adoption[14] (see figure 5.1).

Figure 5.1

OECD Fixed (Wired) Broadband Subscriptions per 100 Inhabitants
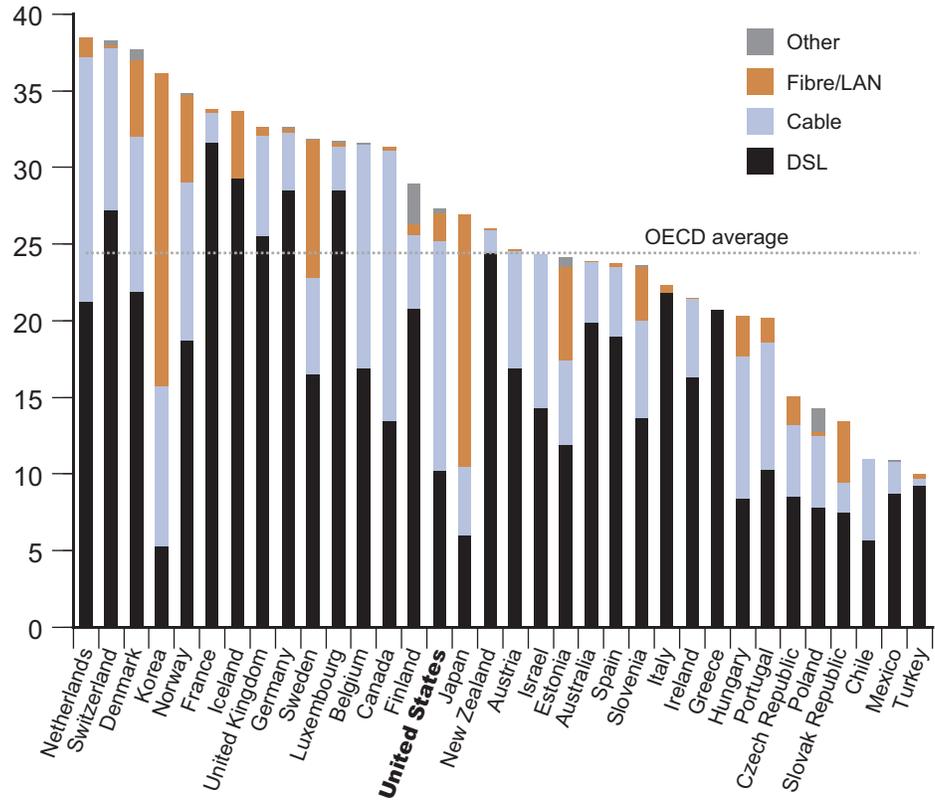
Source: OECD Broadband Portal, Table 1d, June 2011.

Moreover, the use of broadband continues to vary substantially across different demographic groups and geographic areas. People with lower household incomes, people with less education, those with disabilities, as well as Blacks, Hispanics, and rural residents generally lag in broadband use (see table 5.1). Bridging these socioeconomic gaps in household-level broadband connectivity in the United States is critical to capturing the potential economic and social gains that accompany more widespread adoption of broadband services.

At least part of these disparities is likely explained by the fact that, in some cases, particularly in rural parts of the country, broadband is simply not available,[15] largely due to the economic challenges faced by commercial providers seeking to profitably serve large geographic areas that are sparsely populated. The government has sought to address these needs, typically with grant and loan programs to providers such as the Broadband Technology Opportunities Program (BTOP) at

Table 5.1

Household Computer and Broadband Use

	Computer Use		Broadband Access	
	Urban	**Rural**	**Urban**	**Rural**
All households	78%	70%	70%	57%
Race and Ethnicity				
White, non-Hispanic	82%	72%	75%	60%
Black, non-Hispanic	66%	53%	57%	41%
Hispanic	67%	57%	58%	46%
Household Income				
$25,000 or less	56%	49%	45%	35%
$25,001–$50,000	76%	74%	67%	60%
$50,001–$75,000	88%	87%	82%	76%
$75,001–$100,000	93%	91%	89%	82%
$100,001 or more	96%	94%	93%	87%
Education				
Less than a high school degree	46%	39%	35%	26%
High school degree	68%	64%	59%	50%
Some college	84%	82%	75%	69%
College degree or more	93%	89%	88%	80%

Source: Economics and Statistics Administration and National Telecommunication and Information Administration. 2011. *Exploring the Digital Nation: Computer and Internet Use at Home.* Washington, D.C: U.S. Department of Commerce, November 2011; www.esa.doc.gov/sites/default/files/reports/documents/exploringthe digitalnation-computerandinternetuseathome.pdf.

the Department of Commerce, which has been successful in extending broadband to under-served communities (see box 5.2). Further, the FCC recently revised its universal service fund, which traditionally has subsidized the provision of basic telephone service to rural and high-cost areas, so that it will begin to support broadband service by commercial providers in those areas.[16] The lessons from these policy efforts should prove instructive as public and private stakeholders continue to bring broadband to more Americans.

Broadband also can be provided wirelessly, and the rapid growth of mobile communications clearly shows how important this technology has become to the American way of life. Wireless broadband, like wired broadband, has the potential to transform many different areas of the American economy by providing a platform for new innovation. The spread of wireless broadband will increase the

Box 5.2

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Broadband Technology Opportunities Program

The Broadband Technology Opportunities Program (BTOP) was created as part of the American Recovery and Reinvestment Act (ARRA) with the purpose of increasing broadband access and adoption in unserved and underserved areas; providing broadband training and support to schools, libraries, healthcare providers, and other organizations; improving broadband access to public safety agencies; and stimulating demand for broadband. The Department of Commerce's National Telecommunications and Information Administration (NTIA) administers the BTOP program[1] and has invested $4 billion in 233 BTOP projects throughout all U.S. states, territories and the District of Columbia. Funds are awarded in three categories:

- **Infrastructure.** $3.5 billion to 123 projects for the construction of broadband networks

- **Public Computer Centers.** $201 million to 66 projects that will provide access to broadband, computer equipment and training to the public and vulnerable populations

- **Sustainable Broadband Adoption.** $251 million to 44 projects that promote broadband adoption, especially among vulnerable populations

Examples of BTOP projects include:[2]

The University Corporation for Advanced Internet Development (UCAID), also known as Internet2, began upgrading its advanced middle-mile backbone network in March 2011. This upgraded network will extend across 50 states and will enable high-speed broadband connectivity for up to 121,000 additional community anchor institutions such as schools and libraries. This large-scale, public-private partnership will interconnect more than 30 existing research and education networks, creating a dedicated fiber-optic backbone that will enable advanced broadband capabilities such as video multicasting, telemedicine, distance learning, and other life-changing Internet-based applications. As of July 2011, more than 4,828 miles of its proposed 16,312 mile fiber network has been upgraded and activated with the entire network expected to be completed by early 2013.

The State Library of Louisiana's BTOP project, "Louisiana Libraries: Connecting People to Their Potential," has held more than 1,200 free digital literacy and software classes and supplied 640 laptop computers to libraries throughout the state by the end of 2011. The primary goal is to promote broadband use so that citizens may become comfortable and familiar with this technology. The State Library also seeks to improve the workforce skills of Louisiana citizens and provide a solid economic foundation for strengthening Louisiana communities.

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1. U.S. Department of Commerce, National Telecommunications and Information Administration 2010, *Expanding Broadband Access and Adoption in Communities Across America-Overview of Grant Awards*; www.ntia.doc.gov/files/ntia/publications/ntia_report_on_btop_12142010_0.pdf.

2. Additional BTOP projects and grants awarded, by state, can be found at www2.ntia.doc.gov/.

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rate of growth in per capita income and will spur economic activity through new business investment. There is the potential for many new high-quality jobs to be created, both directly through investments in wireless infrastructure, and indirectly through as yet unanticipated applications, services and more rapid innovation enabled by advanced wireless platforms. Although these effects are difficult to quantify precisely, evidence from the economics literature suggests that they are likely to be substantial. Areas where innovations using wireless technologies are likely to have significant effects include consumer products and services; products to enhance business productivity, including business process re-engineering; health care, through products like patient-physician video conferencing, personal handheld biosensors to generate diagnostic information, and remote transmission of diagnostic information and images; education; and public safety, where a nationwide interoperable wireless broadband network for public safety will ensure that first-responders have real-time access to critical information in an emergency.

The spectrum necessary for wireless communications, including broadband, has thus become an important resource to be integrated into the ICT infrastructure. Thus, a sensible policy for managing this spectrum is crucial if the United States is to improve its competitive position. The supply of spectrum is limited, however, and the rapid growth in demand driven by the high data consumption of smart phones and other mobile devices could result in a "spectrum crunch" in three to five years, severely inhibiting the development of next generation high-speed wireless technologies. Techniques such as improvements in spectral efficiency, increases in network density through cell site construction, and offloading traffic to wireline networks will not be sufficient to allow capacity to keep up with demand. In other words, wireless carriers will not be able to accommodate this surging demand without access to additional parts of the spectrum. It is vital that the government continue to address these spectrum challenges by reallocating spectrum from existing to more efficient uses.[18] One aspect of this reallocation is having Congress authorize the FCC to use auctions to reallocate spectrum from TV broadcasters to wireless broadband providers. This can also involve further research and development of technologies that enable more efficient use of spectrum.[19]

ICT also allows firms to collect huge amounts of data about their operations and use these data to improve productivity and increase innovation.[20] Big data—defined as "the large datasets generated from every customer interaction, every wired object, and every social network"[21]— as well as scientific and surveillance

data, such as weather data from satellites, have the potential to provide information to improve greatly the efficacy of businesses, governments, health care and education.[22] The production of global data is expected to grow at an annual rate of 40 percent, providing a treasure trove to businesses and industry sectors that can effectively use these data to create new business models, new products and services, improve marketing strategies, and gain a competitive advantage.[23] Research has shown that firms that make effective use of these large datasets improve their productivity by 5 or 6 percent.[24]

However, to take advantage of these data capabilities, firms need access to broadband Internet networks with sufficient capacity to collect and distribute this information quickly and efficiently. They also need to have access to various computing resources such as servers, storage, applications, and services. These services increasingly are being made available through cloud computing, which provide companies with convenient, on-demand access to a shared pool of these necessary resources. With cloud computing, innovators and small businesses can offer new products and services to a global market with a very low investment of upfront resources, enabling them to compete with much larger providers. A final, closely related element of a sound ICT policy is an open Internet, one that protects consumers and innovators. Innovators need to be able to compete on their merits and not face anticompetitive barriers. Internet privacy is also crucial, and cybersecurity concerns need to be addressed.[25]

President Obama has pledged to preserve the free and open nature of the Internet to encourage innovation, protect consumer choice, and defend free speech. The Administration has created an Internet Policy Task Force to bring together industry, consumer groups, and policy experts to identify ways of ensuring that the Internet remains a reliable and trustworthy resource for consumers and businesses and has recently called for an Online Privacy Bill of Rights. In July 2011, the Obama Administration joined with representatives from business, civil society, and Internet technical communities from 34 countries to reaffirm the importance of Internet policy principles that have enabled the open Internet to flourish with innovation and human connections beyond our wildest expectations.

Americans deserve an Internet that is safe and secure, so they can shop, bank, communicate, and learn online without fear their accounts will be hacked or their identities stolen. President Obama has declared that the "cyber threat is one of the most serious economic and national security challenges we face as a nation" and that "America's economic prosperity in the 21st century will depend

on cybersecurity." To help the country meet this challenge and to ensure the Internet can continue as an engine of growth and prosperity, the Administration is implementing the National Strategy for Trusted Identities in Cyberspace. The Administration also released the International Strategy for Cyberspace to promote the free flow of information, the security and privacy of data, and the integrity of the interconnected networks, which are all essential to American and global economic prosperity and security.

The Obama Administration has made cybersecurity at Federal departments and agencies a priority and it is moving forward on the government's implementation of the Federal Information Security Management Act (FISMA). In addition, the Obama Administration is working on the development of the National Initiative for Cybersecurity Education, which will establish an operational, sustainable, and continually improving public cybersecurity education program to promote sound cyber practices within the United States.

Satellites

An increasingly important part of the infrastructure of the United States can be found orbiting the earth in the form of our satellite system. Satellites are used for many crucial tasks, such as improving weather forecasting so that businesses have the most reliable and up-to-date information for planning purposes. To meet these goals, the Administration is acquiring and operating the satellites needed to support weather forecasting, climate monitoring, and ocean and coastal observations. The Administration also plans to launch a new generation of global positioning satellites and services in order to implement advanced navigation and timing applications that can support innovation in many sectors, including agriculture, communications, air travel, and highway safety.[26] For example, as discussed below, global positioning satellites will be a key part of a new, Next Generation (NextGen) air traffic control system. Finally, the Administration is committed to maintaining international partnerships to further improve on our capabilities in these areas.[27]

Ensuring the United States' 21st Century Infrastructure is Sound

Our nation faces significant challenges in rebuilding its infrastructure and wise investments in these areas have to be made. Below are several specific policy proposals that will address the problems discussed above.

NextGen Air Traffic Control System

Since there are often constraints on increasing the number of airports and runways, another way to increase the capacity of the existing physical air traffic infrastructure is by making it more efficient; that is, by increasing the number of flights that can be handled on existing runways. This can be achieved through the adoption of the NextGen air traffic control system, a comprehensive overhaul of the existing system.[28] The current system is based on radar, whereas NextGen will employ global positioning systems and new ground-based and airborne technologies to deliver new communications, navigation, surveillance, and information management capabilities. As a result of this more accurate information, NextGen will allow more aircrafts to fly safely closer together on more direct routes, reducing fuel usage, noise, and flight and ground delays by 35 percent. This reduction in delays will translate to $23 billion in cumulative benefits to the Federal Aviation Administration, airlines, and travelers. In addition, aviation fuel usage would decline by 1.4 billion gallons and carbon dioxide emissions would fall by 14 million tons.[29]

While NextGen's overall benefits are compelling, adoption of NextGen faces significant hurdles, such as the merging of varying technologies and interfaces, maintaining and retaining a skilled FAA workforce, and keeping to the current rollout schedule given the current budget climate. FAA authorization has been temporarily extended 22 times since the previous long-term FAA authorization expired in 2007. The current extension is set to expire on January 31, 2012.[30]

Wireless Communications

The Obama Administration has made it a priority to improve the wireless broadband infrastructure in the United States. A "National Wireless Initiative" was announced in February 2011 with the stated goals of doubling the amount of spectrum available for wireless broadband services and helping rural areas gain access to wireless broadband services through reform of the FCC Universal Service Fund so that it focuses more on wireless service rather than traditional phone service.

Cloud Computing

Various initiatives are underway to help companies process large amounts of data through cloud computing. For example, NSF has been working with Microsoft to provide free access to Microsoft's cloud products to researchers who

either want to investigate further the possible ways in which cloud computing can be used or have projects related to biotechnology or other industries that require large amounts of data storage. NASA has created a cloud computing platform called "Nebula" that allows NASA scientists to share large, complex data sets with research partners and the general public.

Open Innovation Strategy

Data is a critical component in information technology and the Administration's open innovation strategy is meant to increase access to data to help spur innovation. This strategy incorporates four major components:

- **Improve Access to Government Data.** On his first full day in office, President Obama signed a memorandum on transparency and open government. Part of this initiative was the launch of data.gov, a platform that provides public access to high value, machine readable datasets, now numbering in excess of 390,000.

- **Encourage Market Transparency.** A transparent "marketplace" will lower barriers to entry and unleash the creativity of entrepreneurs to compete in the development of new consumer-oriented products and services. The Obama Administration is working with the health, energy, and education sectors (among others) to simplify access to high value data by, for example, encouraging the creation of standards.

- **Cultivate Innovation Communities.** Bringing together communities of innovators will help spur innovation. To support these communities, the Administration has partnered with organizations to inspire participation in innovative activities through the use of challenges and prizes.

- **Create Capacity for Innovation.** To manage these policy tools, the Administration has actively recruited a group of technology and innovation leaders with direct reporting relationships to the Cabinet Secretaries. In turn, these leaders are recruiting three to five person "innovation teams" to tackle an identified problem with rapid results.

One example of the implementation of this strategy is HealthCare.gov, which launched on July 1, 2010. Its marquee attraction, the Insurance Finder, asks the user a few simple questions and then produces a customized menu of insurance

choices that draws from a huge inventory of offerings from over 1,000 insurance companies and every major public health coverage program in the country.

Smart Grids

As mentioned above, the Federal government recently released a policy framework to help promote investment, innovation, and job growth in the area of Smart Grids. The main elements of this framework include enabling cost-effective Smart Grid Investments; ensuring that there are appropriate standards in place so that grids can interconnect with each other; giving consumers the information needed to save energy; and ensuring that Smart Grids are protected from cyber attacks and, in the event of such an attack, the systems can quickly recover.

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1. Katz and Puentes 2008.

2. Federal Communications Commission 2011a, 25.

3. Pélissié du Rausas et al. 2011, 2.

4. Pélissié du Rausas et al. 2011, 2.

5. Pélissié du Rausas et al. 2011, 3.

6. Pélissié du Rausas et al. 2011, 3.

7. For a discussion of these concepts, see Appendix 2 in chapter 3.

8. Edison Electric Institute 2011, 6.

9. U.S. Department of Energy 2010.

10. Council on Environmental Quality 2011.

11. National Science and Technology Council 2011.

12. Federal Communications Commission 2011a, 20.

13. Economics and Statistics Administration and National Telecommunications and Information Administration 2011, 1.

14. Household adoption is but one measure of how broadband contributes to a country's productivity. According to a study that takes account of a wider array of factors, such as use of broadband by businesses and use of complementary technologies, the United States makes much more productive use of broadband than almost every other country in the world. See Council of Economic Advisers 2011, 67 and Waverman, et al. 2011.

15. The National Broadband Map, a creation of the Department of Commerce's National Telecommunications and Information Administration (NTIA), depicts broadband availability for every community in the country; go to broadbandmap.gov.

16. Federal Communications Commission 2011b.

17. Among other projects, the Departments of Commerce and Agriculture invested about $7 billion in broadband projects under the American Recovery and Reinvestment Act. For more information, see BroadbandUSA at www2.ntia.doc.gov and Broadband Initiatives Program at www.rurdev.usda.gov/utp_bip.html.

18. National Telecommunications and Information Administration 2011.

19. For example, the Wireless Spectrum R&D (WSRD) Senior Steering Group coordinates spectrum-related R&D activities across the Federal government; for more information, see www.nitrd.gov/subcommittee/wireless spectrumrd.aspx

20. Brown et al. 2011.

21. Manyika and Roxburgh 2011, 6.

22. Manyika et al. 2011.

23. Manyika et al. 2011, 4–6 and 16.

24. Brynjolfsson et al. 2011, 1.

25. National Economic Council, *A Strategy for American Innovation,* 24.

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27. White House, *National Space Policy of the United States of America 2010,* 12.

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30. Reilly 2011.

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