Business Roundtable℠

Catalyst for Growth: America's Hybrid Infrastructure

Leveraging Technology and Information

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Business Roundtable

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Catalyst for Growth: America's Hybrid Infrastructure

Leveraging Technology and Information

Dear Business Leaders, Policymakers and Other Stakeholders:

We live in a world where physical and digital infrastructures are rapidly integrating into hybrid infrastructures, producing new and innovative ways of living and new opportunities for economic growth. For instance, mobile devices have evolved from simple communications tools to sophisticated computing platforms that enable businesses and consumers to conduct financial transactions with ease. Through smart grid innovations, our electricity system is becoming increasingly automated and providing consumers with an ability to monitor and manage electricity consumption.

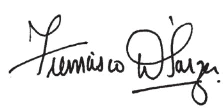
The CEOs of the Business Roundtable believe that building out hybrid infrastructures offers the nation an opportunity to spur long-term economic growth and generate substantial societal benefits, including the creation of new, innovative businesses; new public and private-sector services; new jobs; and improved quality of life.

Achieving these ends, however, will require all stakeholder groups — public and private-sector leaders, key policymakers, and individual citizens — to work together toward a functional framework for deploying hybrid infrastructures. Key considerations for such a framework include the minimization or removal of barriers such as costly and outdated regulatory policies; a lack of public support for investment; a scarce talent pool of individuals trained in science, technology, engineering and mathematics fields; and concerns about the privacy and security of data.

The CEOs of the Business Roundtable stand ready to work with all stakeholder groups to orchestrate the development of a functional framework. Accordingly, we hope that this paper initiates a dialogue on how public policy can encourage the large-scale deployment of hybrid infrastructures.

Sincerely,

Ajay Banga
President and CEO, MasterCard
Chair, Information and Technology Committee,
Business Roundtable



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Executive Summary

Infrastructure has always been important to our nation's economic growth and success, but the infrastructure needed for today's economy is rapidly changing with advances in information technology (IT). This new infrastructure — hybrid infrastructure — integrates both physical and digital qualities and is critical to delivering the next wave of innovation and economic growth in the United States.

Successfully building out hybrid infrastructure will unlock new economic opportunities, create jobs and improve quality of life. To illustrate this point, this paper explores five leading examples of hybrid infrastructure: cloud computing, mobile payment systems, sensor networks, the smart grid and the Next-Generation Air Transportation System (NextGen).

- **Cloud computing** is the practice of "renting" remotely located IT services, including computational devices, information storage and software applications, as a commercial service on an as-needed basis. Cloud computing turns fixed costs into variable costs and allows organizations to scale their computing resources to meet demand.

- **Mobile payment systems** involve using mobile phones or tablets for financial transactions and purchases, including contactless mobile payments, online purchases and mobile banking. Mobile payment systems automate and digitize many processes for both buyers and sellers and enable consumers to replace loyalty cards, IDs, credit cards, transit cards and cash with a single mobile device.

- **Sensor networks** monitor the physical characteristics of the environment and, in certain cases, respond to changes in those characteristics. These networks use wireless technology to collect, process and communicate data from multiple sensors either to electronic devices that can initiate an automatic response or to a central server for additional monitoring and analysis.

- **The smart grid** is a digitally enabled electrical grid that gathers, distributes and responds to information regarding the behavior of suppliers, consumers and the grid itself. It provides customers — residential, commercial and industrial — with additional information, such as the amount of electricity they have used, when it was used and how much it costs, to help customers better manage their electricity use. The smart grid also automatically responds to failures and disturbances, sustaining operations even under adverse conditions.

- **NextGen** is the transformation of national air traffic management from radar-based surveillance and analog communications to satellite-based surveillance and digital communications. This transformation also involves the development and adoption of new navigation procedures that take advantage of more precise navigation capabilities on aircraft, better surveillance technology, and improved communications and information management capabilities.

The deployment of hybrid infrastructure offers the United States an opportunity to spur long-term economic growth and generate substantial societal benefits. In addition, the nation also stands to benefit from hybrid infrastructure in the following areas:

- **Capacity expansion:** increasing use of both existing and new infrastructure;

- **Time savings and convenience:** reducing congestion in travel systems, simplifying routine operations and enabling more informed decisionmaking;

- **Cost savings:** minimizing waste, boosting efficiency and creating more flexibility in the provision of key services;

- **Improved reliability:** enhancing predictability and reducing interruptions in the provision of key services; and

- **Enhanced safety:** improving resiliency to outside threats and interruptions.

Unfortunately many barriers to deployment can stand in the way of realizing the economic and societal benefits of hybrid infrastructure. These barriers include costly and outdated regulatory policies; a lack of public support for investment; a scarce talent pool of individuals trained in science, technology, engineering and mathematics fields; and concerns about the privacy and security of data. Given these barriers, **the CEOs of the Business Roundtable recommend that the government and private sector work together to develop a comprehensive national strategy for hybrid infrastructure** to facilitate its immediate development and deployment and to maximize the potential economic and societal benefits. We also recommend promoting private-sector investment in hybrid infrastructure through public investments; reviewing and reforming regulatory policies to create a friendlier environment for hybrid infrastructure; ensuring domestic and global policies are aligned and support interoperability; developing the workforce needed to meet emerging needs; and promoting privacy and security.

As with traditional infrastructure, hybrid infrastructure affects everyone, creating multiple stakeholders with competing interests. All stakeholders — public and private industry leaders, key policymakers, and individual citizens — are essential to crafting a workable framework for the large-scale deployment of hybrid infrastructure. We hope this report launches the public-private dialogue that is needed to explore the benefits and opportunities offered by hybrid infrastructure as well as to discuss how barriers to deploying hybrid infrastructure can be reduced through thoughtful public policy initiatives. We are committed to working with policymakers to explore these recommendations and to advance legislative and policy solutions that rapidly promote the deployment and use of hybrid infrastructure.

I. Introduction

From the beginning, abundant natural resources, navigable waterways and extensive terrain have provided the backbone for commerce and community in the United States. The industrial age used these strengths and extended them through a rapid expansion of the nation's physical infrastructure, including the construction of the electrical, highway and rail systems. The development of telegraph, telephone, radio and television networks created critical communication infrastructure and contributed to a more connected society. And the information technology (IT) revolution during the latter half of the 20th century ushered in new digital infrastructure, such as the Internet, private information networks and robust wireless technologies, which led to another wave of innovation and economic growth in the nation. Throughout this development, physical and digital infrastructure were largely separate.

Today, the nation stands poised to benefit from another wave of growth based on **hybrid infrastructure** — the integration of IT with traditional physical infrastructure to deliver more efficient and effective capabilities. While many hybrid infrastructures are deployed today and are already transforming industries, significant barriers still must be overcome. To that end, this paper calls for policymakers to work with the private sector to develop a comprehensive strategic plan for hybrid infrastructure that aggressively invests in the development and deployment of these technologies, eliminates regulatory barriers to their use, and promotes the importance of hybrid infrastructure to the economic future of the country.

To start this dialogue, this paper examines benefits and opportunities associated with the deployment of five leading hybrid infrastructures: cloud computing, mobile payment systems, sensor networks, the smart grid and the Next-Generation Air Transportation System. The paper concludes with public policy recommendations designed to maximize the potential benefits of further deployment of hybrid infrastructures.

II. Hybrid Infrastructures

This paper explores five leading hybrid infrastructures and their associated economic and societal benefits. Successfully building out these infrastructures will unlock new economic opportunities, create jobs and improve quality of life.

Cloud Computing

Cloud computing is the practice of "renting" remotely located IT services, including computational devices, information storage and software applications, as a commercial service on an as-needed basis.[1] Because consumer usage dictates its costs, cloud computing is scalable to individual organizations' demands.[2]

Main Features and Applications

Cloud computing provides consumers and businesses access to scalable, on-demand computing resources. Many computing resources can be provided as cloud-based services, including software, development platforms, or computing resources such as storage or processing. In contrast to traditional computing investments, cloud computing users pay only for the resources they use, which allows them to scale their usage up or down according to demand. This capability allows organizations to reduce overhead costs while still retaining ownership and control of their data. Cloud computing also allows users to protect their information from localized threats, such as fires or power failures, by storing data on remote servers that can be accessed anywhere with an Internet connection. Because multiple clients can use cloud computing services at once, the overall server cost per user is reduced, making cloud computing especially efficient.[3]

Economic and Societal Impact

Cloud computing provides benefits for organizations (both public and private), consumers and society as a whole. The U.S. federal government has realized savings of between 25 and 50 percent of IT expenditure by going to the cloud, and the private sector has seen similar levels of savings.[4] These savings enable more organizations, including small and start-up organizations, to afford more computing resources. Individuals are able to obtain cheaper and more reliable storage options for data. Centralizing IT infrastructure provides a broader societal benefit as energy use declines and the need for initial capital investments declines with it. In short, cloud computing leads to more efficiency, lower costs and greater consumer convenience.

Mobile Payment Systems

Mobile payment systems involve using mobile phones or tablets for financial transactions, including contactless mobile payments, online purchases and mobile banking. The availability of mobile payment systems in turn enables the automation and digitization of many commercial processes for both buyers and sellers, resulting in innovation and cost reductions.

Main Features and Applications

Mobile devices have evolved from simple communications devices to sophisticated computing platforms. In addition to providing access to more than a million applications, mobile devices are increasingly being used to conduct financial transactions.[5]

First, traditional retail transactions can be conducted using "contactless" or proximity payments. Using a short-range wireless communication technology standard called near-field communication (NFC), mobile users can make contactless payments simply by waving their mobile phone directly in front of an NFC-enabled payment terminal. This capability allows consumers to use their phones as multifunctional electronic wallets to pay for public transit, taxis or parking; to make purchases from merchants, restaurants and convenience stores; to check in at airports and hotels; to enter apartment buildings, workplaces and schools; and for a host of other functions.[6]

Second, mobile devices can be used to purchase goods and services online. These purchases include digital content, such as applications, books, movies and music, as well as other purchases from online retailers.

Third, mobile banking allows consumers to reduce the time and expense of traveling to a branch office. For example, using a mobile phone, consumers can check their balances, remotely deposit a check (by simply sending a picture of the check over the wireless network) and transfer money from one bank account to another. These factors and the fact that mobile phone usage is common across socio-economic levels mean that mobile banking can expand access to financial services among currently underserved poor communities.[7]

Leveraging these technologies as repositories for both information and finances can help automate and streamline the exchange of personal and financial information, improve transaction efficiency, and expand access to existing services to underserved populations. Mobile payment systems create efficiencies that were not previously available to consumers and organizations. They enable consumers to replace loyalty cards, IDs, credit cards, transit cards and cash with a single mobile device, and they promise faster transaction processing speeds for a vast array of services.

Economic and Societal Impact

Because using cash costs society approximately 0.5 percent of a country's gross domestic product, mobile payment systems offer significant savings by increasing the proportion of retail payments that are conducted electronically.[8] In addition, mobile payment systems serve as a platform for businesses to develop new services, thereby contributing to economic growth. Finally, a secure solution that allows consumers to easily store and save an electronic record of transactions, relieving the need for paper receipts and financial statements, benefits both consumers and the environment.

Sensor Networks

The main function of sensor networks is to monitor the physical characteristics of the environment and, in certain cases, respond to changes in those characteristics. These networks use wireless technology to collect, process and communicate data from multiple sensors either to electronic devices that can initiate an automatic response or to a central server for additional monitoring and analysis.

Main Features and Applications

Sensors detect characteristics of the physical environment, such as movement, temperature, humidity, sound and light. Sensors can be placed on or in an object, regardless of whether it is traveling through the air, sitting stationary or immersed in water. Using sensors to automatically process data about the world around us is not a new idea — many homes and buildings have smoke alarms or carbon monoxide sensors. But while sensors in the past were mostly used only in limited, stand-alone solutions, now they can be deployed as fully networked systems that integrate data from multiple sources and provide feedback through various channels. These datasets are then analyzed to control, monitor and evaluate an entity or environment. For example, cities can use this information to improve public safety, and businesses can use this information to create better working conditions.

Sensor networks are used in a variety of applications, from bridges and buildings to farms and factories. Many applications of sensor networks are found in fields such as military operations, air traffic control, ground traffic surveillance, physical security and infrastructure security. For example, the bridge rebuilt over the Mississippi River in Minneapolis is embedded with sensors to report bridge conditions in real time.[9] Or to take another example, sensors may be used to monitor the air quality inside of a building or the structural integrity of the building.

One interesting application of sensors is to create "intelligent homes" that use sensors to monitor air, water quality, temperature and energy usage. All of this information will be available online to allow individuals to control their homes and the appliances in them remotely and more efficiently. Intelligent home services are starting to be offered to customers. They provide individuals with an integrated system to monitor home security, adjust the thermostats, and turn lights on and off. Individuals can access these features from an in-home touchscreen device, a laptop or even a smartphone.[10]

Economic and Societal Impact

Sensor networks benefit various industries and society at large. Sensors are able to ease business operations by collecting data that are more accurate, and they reduce costs caused by disturbances or failures. Sensor networks not only cut maintenance costs but also have the potential to streamline managerial responsibilities by automating processes of monitoring and measuring. The safety benefits of sensor networks are also significant. Sensors can obtain more accurate data analytics than an individual physically traveling to the location of the object of interest, which can be a dangerous endeavor (e.g., examining the condition of a bridge or building).

The Smart Grid

The smart grid is a digitally enabled electrical grid that gathers, distributes and responds to information regarding the behavior of suppliers, consumers and the grid itself. It provides customers — residential, commercial and industrial — with additional information, such as the amount of electricity they have used, when it was used and how much it costs, to help them better manage their electricity use. The smart grid also automatically responds to failures and disturbances, sustaining operations even under adverse conditions.

Main Features and Applications

By integrating IT into the electrical grid, the smart grid provides more reliable, responsive and resilient power services.[11] This capability is made possible through a number of technologies including smart meters, advanced control systems, communication networks, energy storage technologies and distributed power generators.

Smart meters allow utilities to monitor real-time power usage of consumers. They also allow consumers to manage their power usage based on price signals. For example, major appliances in homes — such as water heaters; clothes dryers; and heating, ventilation and air conditioning systems — can be programmed to run when power rates are lowest.

The smart grid also uses sensors, communication networks and other devices to monitor operations in real time and provide forensic analysis of power grid disturbances. This capability allows the smart grid to be more resilient than the traditional electrical grid infrastructure and respond to natural and manmade disasters. For example, the smart grid can quickly reroute power in the event of failures, mitigating the negative impacts of those disturbances.

Finally the smart grid enables other important technologies such as energy storage technologies, plug-in electric vehicles (PEVs) and renewable power generation. Energy storage technologies, such as pumped hydro, compressed air and chemical batteries, can play a major role in meeting peak demand requirements and can be better used in the smart grid because of enhanced two-way communication networks.

Similarly, PEVs, which are powered by batteries that store electricity from the grid, represent another form of energy storage that can help supply the grid. Utilities can offer incentives to promote use of the PEV energy storage capacity to improve overall grid efficiency or power quality. The smart grid will enable operators to incentivize vehicle charging at off-peak times of day, giving PEV owners an opportunity to profit by buying electricity at low rates and then selling it back to the grid for higher rates.

Finally, the ability for customers to sell electricity back to the utility facilitates the use of clean energy. Because of the intelligence in the smart grid, utilities can integrate distributed sources of energy such as solar panels on residential and commercial customers' rooftops and industrial combined heat and power units. Without the smart technologies needed to link these sources to the grid, electricity generated by customers that was not used or stored onsite would be wasted. The smart grid also better enables the deployment of other intermittent sources of electricity, such as the power generated on wind farms.

Economic and Societal Impact

Once fully operational, the smart grid will deliver significant cost savings to utilities and electricity end-users, in addition to increased efficiency, reliability and flexibility to the electrical grid.

The largest benefit of smart grid investments is likely to be improved grid efficiency. The Electric Power Research Institute estimates that dynamic pricing and other smart grid capabilities would have the potential to deliver average annual economic benefits of $31–50 billion over the next 20 years due to improved efficiency.[12] Dynamic pricing can incentivize customers to use power during off-peak rather than peak hours, helping to smooth the daily peaks and troughs of power demand. Moderating peaks in energy demand reduces the overall power generation capacity needed to serve a given population, lowering investment costs for utilities.

The smart grid will also enable the electricity sector to provide cleaner energy. By facilitating two-way electricity and information flows, smart grid technologies reduce barriers to investment in distributed power generation, smart appliances and PEVs. Furthermore, the smart grid encourages end-users to become more active consumers of electricity by providing dynamic electricity rates and information on usage and sources of waste, thereby allowing them to reduce their monthly bills by changing their behavior.

The smart grid will also deliver electricity more reliably to customers by monitoring, diagnosing and responding to failures in power services. Reliable power is critical to traffic management systems, security systems, hospitals, and homes of seniors and other vulnerable populations. Smart grid technologies not only improve reliability but can also immediately detect and locate outages, allowing utilities to alert police and other authorities. Preventing these failures saves money. The cost to companies due to power disturbances can reach $100 billion per year; the cost to the national economy ranges from $15 to $24 billion per year.[13]

Finally, the smart grid makes the electrical grid safer. The enhanced monitoring, mitigation methods and control functions of the smart grid provide more reliable and safer power transmission and distribution. The smart grid offers enhanced cyber security through continuous monitoring to identify vulnerabilities and by providing the ability to remedy vulnerabilities prior to an attack.[14]

Next-Generation Air Transportation System (NextGen)

NextGen is the transformation and overhaul of the National Airspace System (NAS) from a ground-based system of air traffic control that uses radar surveillance and analog communication to a satellite-based system of air traffic management that uses digital communication. It involves updating outdated weather monitoring systems and significantly improving safety, capacity and efficiency on runways and in the nation's skies while reducing fuel burn, carbon emissions and noise. The Federal Aviation Administration (FAA) is leveraging existing technologies and expanding their capabilities with the goal of delivering a more efficient and reliable travel experience.[15]

Main Features and Applications

The air traffic management system has relied on radar and ground beacons for surveillance and navigation and on analog voice messages for air-to-ground communication for more than six decades. Once fully deployed, NextGen will rely more heavily on satellite Global Positioning System (GPS) tools for surveillance and navigation and on digital signals and interconnected computer systems for communications. Major enhancements in surveillance, navigation, automation, weather monitoring and communication capabilities are highly interrelated and depend on coordinated investments across the aviation industry and the FAA.

Since the end of World War II, air traffic control systems have relied primarily on radar for surveillance. While this system has safely guided aircraft through the NAS for decades, a lack of precision and radar coverage have constrained airport and airspace capacity and prevented the adoption of more efficient flight procedures and paths. In contrast, NextGen uses GPS to greatly enhance the precision and accuracy of air traffic control surveillance systems. The surveillance technology that the FAA has adopted, called Automatic Dependent Surveillance-Broadcast, enables aircraft to determine their own location with a high level of accuracy and precision and then continuously broadcast that location along with the aircraft's identity, speed, altitude and course to other aircraft and ground stations. The ability to more easily, accurately and precisely identify aircraft flight data enables air traffic controllers to better manage aircraft in flight, including reducing the required distance between aircraft. This technology also improves collision avoidance capabilities and enhances safety over oceans and other areas that currently lack ground surveillance coverage.

NextGen is also leading to improvements in navigation. For decades, air traffic control has used ground beacons to guide aircraft along specific routes, restricting them more or less to slightly zigzagging routes from beacon to beacon as they traverse the country. Furthermore, aircraft departing from and arriving at airports have used a small number of flight paths, requiring them to wait in line for take-off clearances and in holding patterns near their destination for landing clearances. However, NextGen reduces congestion by using the greater surveillance and navigation precision to open up more flight paths that can be used simultaneously by different aircraft. These new flight paths allow aircraft to fly in a straight line from airport to airport, regardless of where ground beacons are located. They also allow aircraft to exit and enter the flight paths when they are closer to their departure and destination airports, reducing flight distances and time and fuel spent waiting for clearances.

NextGen also helps curb weather-related delays, which are currently the source of 70 percent of aircraft delays.[16] While some weather-related delays are unavoidable, many are due to failures and delays in processing or relaying weather data. The existing system includes multiple sources of weather information, none of which provide a holistic view of what aircraft are likely to encounter along their routes. The NextGen weather system collects data from all major federal and commercial weather databases, consolidates and filters those data, uses models to provide short- and long-term forecasts, and then transmits forecast information to aviation decisionmakers and system users on a single network.

Finally, NextGen helps improve the safety and efficiency of communications between aircraft and air traffic control centers. Current analog communications are labor and time intensive and rely on repetition of messages between pilots and controllers to minimize miscommunications. NextGen digital data communication, on the other hand, can eliminate these sources of error. Furthermore, it is less labor intensive, increasing controller productivity, and nearly instantaneous, enabling air traffic control to re-route aircraft much more quickly in response to changes in weather or traffic conditions. For example, the NextGen Voice Switch program creates a flexible voice communication system that does not require aircraft and controllers to be in close proximity.[17] This flexibility helps ensure that air traffic control centers in one location can call upon underused staff in another to help handle workload spikes, relieving what would otherwise have resulted in aircraft congestion and delays.

Economic and Societal Impact

NextGen provides cost savings for the U.S. economy. The FAA estimates that failure to implement NextGen would cost the U.S. economy $22 billion a year in lost economic activity by 2022 due to delays and reduced air traffic capacity.[18] NextGen deployment and implementation have begun across the nation, and as more airports and airlines adopt the system, net benefits will be greater. NextGen also increases the capacity of the current airway infrastructure by allowing more planes to travel at a closer proximity. All this means lower costs for flying passengers and freight.

III. Impact

Much like traditional infrastructures, hybrid infrastructures not only deliver a multitude of direct benefits to both the users and operators of the infrastructure, but they also offer a wide array of societal benefits that cut across sectors. To further demonstrate this point, this section summarizes both the economic and societal benefits that hybrid infrastructures will provide if deployed on a larger scale.

Economic Benefits

Hybrid infrastructures allow organizations (for-profit, nonprofit and government) to improve back-end services, such as cloud computing deployed to consolidate IT functions, and to improve the delivery of services to consumers and citizens alike, such as mobile payment systems offered to allow individuals to pay their bills. Hybrid infrastructures provide microeconomic benefits in several major areas (see Appendix for more details):

- **Capacity expansion:** increasing use of both existing and new infrastructures;
- **Time savings and convenience:** reducing congestion in travel systems, simplifying routine operations and enabling more informed decisionmaking;
- **Cost savings:** minimizing waste, boosting efficiency and creating more flexibility in the provision of key services;
- **Improved reliability:** enhancing predictability and reducing interruptions in the provision of key services; and
- **Enhanced safety:** improving resiliency to outside threats and interruptions.

Investing in and supporting hybrid infrastructures also creates macroeconomic benefits for the U.S. economy. The United States invests billions of dollars each year in infrastructure to enhance quality of life and expand economic capacity. Directing these investments toward hybrid infrastructure projects will generate both short- and long-term macroeconomic benefits.

In the short run, the deployment of hybrid infrastructures will require significant investment in IT. Although much of this investment will come from the private sector, public investment and support is also essential. If well coordinated, many of these investments will pay for themselves quickly — technologies such as cloud computing can have immediate returns, while others, such as NextGen, will take several years to generate positive returns. The upfront investments in technology development and deployment are likely to have immediate positive impacts on employment, especially over the next decade or so as the economy will likely continue to struggle with less than full employment. Furthermore, aggressive domestic deployment will increase the likelihood that technology and manufacturing firms located in the United States become or remain global leaders in developing and deploying the cutting-edge technologies used in hybrid infrastructures, allowing them to create jobs here at home to serve global hybrid infrastructure markets.

In the long run, these investments will increase U.S. productivity, raising standards of living and making the establishments in the United States more competitive internationally. Furthermore, these infrastructure enhancements will create efficiencies in the U.S. economy, such as lowering upfront computing investments and simplifying financial transactions, and encourage entrepreneurship.

Societal Benefits

In addition to economic benefits, investment in hybrid infrastructures is also likely to generate significant societal benefits, from convenience to safety to reduced energy use. For example, investments in the smart grid are critical for more efficient energy production and distribution, as well as for integrating technologies like PEVs and solar and wind power generation. The implementation of the NextGen infrastructure will generate new environmentally friendly procedures and technologies that will reduce fuel consumption, carbon emissions and noise pollution. Furthermore, the advancement of mobile payment systems will bring us closer to a paperless society. Hybrid infrastructures will also save consumers time by speeding up burdensome tasks and allowing them to complete transactions more efficiently. NextGen infrastructure will increase the reliability and effectiveness of air travel, improving the overall passenger experience and allowing individuals to get where they are going more quickly and efficiently.

IV. Recommendations

While hybrid infrastructures have many benefits, many barriers hinder deployment. These barriers include:

- **Antiquated and inadequate global and domestic regulatory and policy frameworks** (e.g., businesses must obtain regulatory approval before they are eligible to acquire smart grid data in some states; country-specific data server requirements create difficulties for deploying cloud computing);[19]

- **Multiple owners and stakeholders with competing interests** (e.g., the FAA and the aviation industry must coordinate the development and deployment of technologies to realize the benefits of NextGen);

- **Concerns about privacy and security** (e.g., consumer privacy groups have voiced concerns about specific technologies such as smart meters);[20] and

- **Lack of a skilled 21st century workforce** (e.g., workers are needed to develop, install and manage hybrid infrastructures).

If left unmanaged, these barriers will slow the expansion of hybrid infrastructures. To that end, policymakers should work with the private sector to create a comprehensive national strategy to maximize the benefits and address the barriers associated with hybrid infrastructures. Such an approach will require strategic government and private-sector investments, development of public-private partnerships for major infrastructure projects, and creation of an environment supportive of private-sector initiatives.

Create a National Strategy for Hybrid Infrastructure

Much of the nation's infrastructure is owned and operated by the private sector and by state and local governments. The federal government also owns and operates infrastructure, such as the NAS, and it has a vested interest in broadly protecting and enabling all infrastructure to support nationwide social and economic development, innovation, commerce, and security interests. Moreover, the federal government is uniquely able to respond to certain global challenges related to hybrid infrastructure by using its diplomatic, political and trade policies.[21]

The nation's infrastructure touches the lives of every citizen, creating multiple stakeholders with competing interests. The diverse and complex relationships among private-sector owners and operators of infrastructure; federal, state and local governments; and members of the public present unique challenges that affect the nation's ability to focus on infrastructure at a strategic level. However, the development of the nation's infrastructure should not be a haphazard process but rather a coordinated and strategic initiative led by both the public and private sectors. Top-level leadership from the public and private sectors is required to develop a national strategy for hybrid infrastructure that will optimize the expected economic and societal benefits. Developing such a strategy should be a multistakeholder effort that includes representatives of businesses, academia, national laboratories and citizens, as well as members of federal, state and local governments. A common vision and strategic investment plan should be jointly developed and put into action.

Promote Investment in Hybrid Infrastructure

The major overhaul and hybridization of infrastructure will require not only a common vision among multiple owners and stakeholders but also long-term investment. While state, local and national governments have cut their investment in all kinds of infrastructure, significant public capital investment will continue to be required for traditional public infrastructure projects and for research and development (R&D) from federal and state governments.

For private investment, the current environment often does not provide the requisite levels of predictability, financial security or incentives to attract enough long-term capital, which in turn creates an impediment to U.S. businesses that innovate and develop new hybrid infrastructures and related technologies. The private sector can partner with the public sector to continue to promote investments and R&D in hybrid infrastructure. Private investment decisions, however, should be supported by reinvigorated policies and programs that provide the predictability needed for long-term investment. Policymakers should ensure that tax reform initiatives recognize the importance of private-sector return on all capital investments in critical assets, including hybrid infrastructure.

In addition to enabling the private sector to commit to long-term investments, the public sector should strategically align R&D and infrastructure investments.

As with many emerging technologies, government investment in R&D is an important catalyst for continued innovation. For example, continuing to invest in research for sensor networks will be important to developing the next generation of technology and assisting in the deployment of this technology to new application areas. And without public funding for sensor networks to address public needs (e.g., transportation), hybrid infrastructures will be slow to emerge. Government should be a smart purchaser of hybrid infrastructures — for example, by moving to cloud computing and adopting mobile payment technology.

Smart Buildings

Buildings contain many different complex control and maintenance systems. These systems include heating and cooling, lighting, communications, security, and access control systems. In the United States, buildings consume approximately 40 percent of all energy and 70 percent of all electricity.[22] By 2025 buildings will be the largest emitters of greenhouse gases on our planet.[23] Given these facts, both the public and private sectors have a strong incentive to improve the efficiency with which we consume energy in buildings.[24]

One promising strategy for improving energy efficiency in buildings is the development of "smart buildings." Smart buildings are equipped with sensors that allow building operators to collect and analyze data on building performance in real time. This technology allows building operators to constantly monitor critical building systems, anticipate asset failure and quickly generate maintenance requests when systems malfunction. Timely actions to address service needs will reduce energy consumption, extend asset life and reduce costs.

The federal government has been at the forefront of these "data-driven" building efforts. In May 2012, the General Services Administration awarded a contract to develop and install advanced smart building technology in 50 of the federal government's highest energy-consuming buildings. The initiative, dubbed BuildingLink, will connect building management systems to a central cloud-based platform, improving efficiency and saving up to $15 million in taxpayer dollars annually.[25]

The BuildingLink team is deploying a system to monitor government building performance nationwide and stream data to a central facility, allowing faster analysis and more informed decisionmaking. This solution uses innovative building management technology to enable tenants to view building performance data on dashboards that provide real-time metrics on energy savings and recommendations on how to further increase efficiencies. After the initial 50 buildings are integrated into this system during the first year, additional buildings will be added as new facilities are built or upgraded.

Create "Hybrid-Friendly" Regulatory Policies Domestically

The robust deployment of hybrid infrastructure requires a smart and streamlined regulatory environment. Outdated and costly regulatory policies designed for the infrastructure of the 20th century may impair the development and deployment of the infrastructure of the 21st century. Moreover, excessively complex infrastructure permitting processes can delay delivery of new investments.

For example, among the most significant barriers to widespread smart grid deployment is the overall lack of a coherent and comprehensive national energy strategy aligned to existing policies and regulations. The current patchwork of policies and regulations is often characterized by overlapping mandates and conflicting goals.[26] In addition, while the deployment of smart meters has accelerated in recent years, the approval by public utility commissions of real-time or variable pricing has lagged dramatically — meaning that some key smart grid benefits are not being exploited by those who have the capability. This generates significant business uncertainties for smart grid investment projects, which delays investments that otherwise make financial sense.

For virtually every hybrid infrastructure existing regulations need to be modernized to reflect significant changes in technology and leading industry practices. Updating and improving the regulatory system will ensure that companies will continue to make significant investments in new hybrid infrastructures.

Promote Hybrid-Friendly Policies Globally

In establishing a national strategy, policymakers should take into consideration that U.S. businesses operate in a global ecosystem in which international organizations and national policies in other countries can work to optimize or constrain innovation and investment. For example, a number of countries have adopted barriers to the free flow of information, such as local data server laws requiring data infrastructure to be situated in that country. Country-specific policies like these hinder the deployment of interoperable and scalable hybrid infrastructure systems — especially in the area of cloud computing.

The United States has already taken important steps toward creating a global and domestic environment free of conflicting requirements by working bilaterally to develop policy positions such as the United States-European Union Trade Principles for Information and Communication Technology Services and supporting the Organisation for Economic Co-operation and Development "Principles for Internet Policy Making." The CEOs of the Business Roundtable encourage the Administration and Congress to practice what they preach by incorporating these important policies into domestic law and policy. Once U.S. law and policy is explicit, we encourage U.S. trade and diplomatic leadership to advocate for the international adoption of similar approaches in law, policy and best practices as well as in bilateral, multilateral and plurilateral agreements.

Build the Workforce Needed To Operate Hybrid Infrastructure

Implementation of hybrid infrastructures will require an advanced talent pool. The current rate of U.S. students focusing on the areas of science, technology, engineering and mathematics (STEM) is not sustainable to meet the needs of the growing technology market. Talent will be necessary to fuel innovation and create new solutions, implement hybrid infrastructure projects, and operate hybrid infrastructure.

For example, advances in building analytics and control system technologies have surpassed the skill level of many professional building operators. Leaders in the smarter buildings arena fear that significant investments made in advanced building systems management technologies will be rendered ineffective by people who are not prepared to use these new systems.[27] Similarly, too few security professionals are available to protect these hybrid infrastructures and manage the vast amounts of data these systems will generate.[28]

The private sector can help address these challenges. For example, some businesses are working with postsecondary institutions to recognize an individual's work experience after a rigorous assessment.[29] This recognition allows individuals to secure a credential more quickly while also meeting the needs of employers. However, policymakers should also craft policies that will spur the development of a larger and more talented STEM workforce to ensure that the human capital is available for the successful deployment and use of hybrid infrastructures.[30] For example, policymakers should support expanding the dual enrollment programs implemented in several states where students have an opportunity to pursue a high school diploma and recognized industry certificate and/or associate degree in a STEM field. Similarly, policymakers should support community college efforts to offer programs to recent high school graduates and adults to pursue high-skilled STEM careers.

Promote Privacy and Security

Realizing the promise of hybrid infrastructure need not require the sacrifice of privacy or security, even as hybrid infrastructure projects manage and manipulate large volumes of data. Policymakers should work in cooperation with the private sector to ensure that public policies support privacy and security in ways that enable competition and innovation and allow the data generated by hybrid infrastructures to be used to create value for society. Moreover, public and private-sector leadership should also educate the public about solutions that can be used to mitigate potential privacy and security risks.

Specifically, policymakers should work with all stakeholders to reform relevant existing laws, such as the Electronic Communications Privacy Act and the Computer Fraud and Abuse Act, to reflect new advances in technologies such as cloud computing and mobile payment systems; support the federal government in continuing its leadership role in the development of secure electronic identity management; encourage continued collaboration between the public and private sectors to facilitate the development of voluntary, risk-based standards and best practices to ensure the security of personal and commercial data; and examine policy solutions to enable consumers to have secure access to and use of their own data collected by hybrid infrastructure.

Conclusion

The United States has the opportunity to reap tremendous benefits from the development and deployment of the next wave of hybrid infrastructures that will touch every sector of the economy from health care to education to defense. The Business Roundtable welcomes an open dialogue with policymakers to create a roadmap for its success. We can offer insights about solutions, innovative technologies and new services that can advance the national infrastructure for years to come.

Appendix: Summary of Benefits

The table below demonstrates how the five leading hybrid infrastructures discussed in the previous section can create direct benefits to organizations.

Hybrid Infrastructures: Benefits and Examples

1. Capacity Expansion

- **Cloud computing** allows users to share computing power and applications, meaning that many more users can access the same computing services without investing in nearly as much computing infrastructure.
- **Mobile payment systems** enable retail and transit providers to serve more consumers with fewer checkout lines and turnstiles by speeding up transaction processing times.
- **Sensor networks** that monitor and disseminate real-time parking availability and cost information have helped cities facilitate greater use of their existing parking infrastructure.
- **The smart grid** enables a greater matching of electricity supply and demand as well as improved monitoring of transmission line use, minimizing the amount of new power production and transmission capacity needed to supply the nation.
- Improved aviation surveillance and navigation systems through **NextGen** deployment enable aircraft to safely fly closer to one another, increasing the capacity of airports and the air space around them.

2. Time Savings and Convenience

- **Cloud computing** puts digital information and computer applications at consumers' fingertips on any network-connected device, making information more accessible to its intended users and negating the need for consumers to transfer files among computers.
- **Mobile payment systems** enable users to replace cash and the multitude of cards that they have in their wallet (e.g., credit, debit, loyalty and transit) with one network-connected device, such as a smartphone.
- Real-time traffic information gathered by **sensor networks** helps travelers to make better decisions about routes to their destination, reducing congestion and saving time.
- **The smart grid** enables utilities to measure electricity usage and monitor grid disturbances from control centers, reducing the need for meter readers to go door to door or to physically inspect power delivery infrastructure to identify potential sources of power disruptions.
- **NextGen** facilitates more direct flight paths and better departure and arrival coordination, which can significantly reduce flight times and delays.

3. Cost Savings

- **Cloud computing** reduces upfront capital investments and ongoing operational costs for IT infrastructures.
- **Mobile payment systems** are less costly than face-to-face transactions for retailers, transit authorities and others.
- **Sensor networks** enable remote monitoring of the safety and integrity of infrastructure, such as pipeline networks, water supplies and bridges, reducing the need for more costly onsite inspections.
- **The smart grid** helps utilities reduce expenditures on new generation and electricity delivery infrastructure by increasing capacity utilization.
- **NextGen** infrastructure enables airlines to optimize flight paths and minimize in-flight delays, reducing two of their most expensive costs — fuel and labor.

4. Improved Reliability

- **Cloud computing** provides reliable backup of information and removes consumers' dependence on personal computer or server storage options that are often susceptible to failure.
- The use of **mobile payment systems** allows consumers to easily store and save an electronic record of transactions, relieving them from holding paper receipts.
- Monitoring the integrity of infrastructure using **sensor networks** can help identify defects before they create disruptions.
- **Smart grid** technologies can improve the situational awareness of grid operators, reduce grid congestion and help the grid fix itself when disturbances occur. These qualities help reduce the frequency, duration and geographical footprint of power interruptions.
- **NextGen** deployment reduces aircraft delays and cancellations through improvements in navigation, surveillance, communication and coordination.

5. Enhanced Safety

- **Cloud computing** service providers are able to deploy robust security measures to protect information at a fraction of the cost of securing traditional IT infrastructure.
- **Mobile payment systems** relieve the security risk of obtaining, carrying and using cash.
- **Sensor networks** can be used to identify infrastructure defects supporting life-sustaining services, such as air and water quality conditions.
- **The smart grid** can not only provide reliable power to traffic management systems, security systems, hospitals, and homes of seniors and other vulnerable populations, but it can also immediately detect and locate outages, allowing utilities to alert police and other authorities of their occurrence.
- **NextGen** improves information sharing, thereby providing greater awareness to both pilots and controllers and helping them anticipate and avoid dangerous situations.

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