WRITTEN STATEMENT

Disrupter Series: Smart Communities

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Disrupter Series: Smart Communities

Summary: Making Smart Communities: Streamlining Research, Development, and Deployment

Smart communities are critical to the future economic competitiveness of the United States. Smart communities are not just an opportunity to increase economic growth but they present a challenge as well: Does the U.S. invest in intelligent infrastructure to build the 21st century economy and plan for what's beyond?

The Federal Government has an important role to play in shaping the scope and scale of intelligent infrastructure investments going forward. In short, the Federal Government will decide the platform on which the national economy is built going forward and whether it meets 20th century standards or sets a new standard for the 21st century economy. Research universities have extensive experience partnering with industry and government on technology diffusion projects like smart communities. Research universities are built to test new technologies, evaluate alternatives, assess investments, evaluate economic impacts, measure distributional consequences, and certify processes, materials, products, and standards. As with any new enabling technology, research universities can play a role as a neutral third party with specialized technical expertise. Further, universities are embedded in local communities and have long-term working relationships with local and state governments and a vested interest in the presence of world class infrastructure in their own communities.

How to design and deploy intelligent infrastructure to efficiently and effectively support smart communities is one of the central questions going forward for the country as a whole and for local communities in specific. Building the replicable models and dissemination networks for the broad and sustained implementation of information and communication technologies into the next generation of national infrastructure is the opportunity and the challenge before us.

Introduction

"Smart communities" have captured the attention of popular audiences and experts alike. The "Smart City" concept promises access and opportunity as well as expanded services and increased efficiencies for local communities. The idea promises simultaneously to generate new revenue via new markets, products, and services and to save money through new efficiencies and systems optimization. Advocates argue that smart communities are more efficient, more sustainable, more profitable, and more inclusive.

Economic geographers have long studied innovation as part of the broader disciplinary project of mapping and analyzing the spatial distribution of economic activities within and across cities, regions, and countries. In recent years technology and innovation have gained privileged positions of prominence in these industry analyses. Researchers particularly focused on processes of technology diffusion and how regional economic ecosystems absorb new technologies and incorporate them into existing complexes of firms, industries, and industrial specializations. In other words, how incumbent systems incorporate new processes, products, materials, and actors.

Smart communities are a challenge and an opportunity for the U.S. The challenge is to proactively engage the declining, incumbent national infrastructure system and not merely repair it, but replace it, with an internationally competitive cyber-physical system which provides not only an opportunity for better services for citizens but a platform for a 21st century, high tech economy and beyond.

Smart Communities and US Economic Competitiveness

Smart communities are critical to the future economic competitiveness of the U.S. Over 90 percent of the country's GDP is generated in metropolitan economies --- in cities and their suburbs.[1] Smart communities are not just an opportunity to increase economic growth and opportunity but they present a challenge as well: Does the U.S. invest in intelligent infrastructure to build the 21st century economy and plan for what's beyond? Or, does the U.S. miss the moment when targeted investment in integrating information and communications technologies (ICT) into infrastructure systems could form the foundation of an "Industry 4.0" level cyber-physical systems. The state of U.S. infrastructure and amount of funding devoted to it undermines U.S. global leadership in smart communities innovation and implementation. The American Society of Civil Engineers' latest report card ranked America's infrastructure at a D+, requiring $3.6 trillion in investment.[2] The question is how can the U.S. plan a smart communities future, and the research and development necessary to support it, when there is such a critical gap in incumbent infrastructure systems?

The economic opportunity presented by smart communities is three-fold. First, the data produced by intelligent infrastructure promises to increase the reliability of local government services and performance of infrastructure systems. The data paves the way for building interoperable and cross platform systems that build efficiencies and ultimately allow localities to provide higher quality services at a lower cost. The result is the opportunity to expand services and maintain more reliable and efficient systems ranging from waste management to transportation.

[1] From the U.S. Metro Economies GMP and Employment Report (2015-17), the United States Conference of Mayors: "Metropolitan areas drove the US economy in 2015. They were home to 85.7% of the nation's population, 87.7% of total employment, 87.9% of total real income, 91.3% of wage income, and 90.8% of GDP."
[2] 2017 Infrastructure Report Card, American Society of Civil Engineers

The second opportunity is that smart communities data systems can enhance and inform the strategic planning capacities of local communities --- large and small --- with real world (continuous and real time) data on how infrastructure and infrastructure systems are used by citizens and businesses and how the infrastructure is performing. Local communities, businesses, and citizens will be able to see how their community is operating rather than model its functions based on past performance.

Further, the sharing of data amongst smart communities partners and participants helps to build networks for diffusing policy strategies and technology models. These strategic partnerships form the foundation for the third economic opportunity that flows from smart communities: entrepreneurship and market leadership. The data generated by and for smart communities systems (and the systems that produce that data) form the foundation of new enterprises and new products and services and, as a consequence, function as platforms for further economic development.

"Intelligent Infrastructure": Next Generation Services and Structures

The promise of "smart" or "intelligent" infrastructure is that it will increase resilience across domains of critical infrastructure systems by expanding capacities and building resiliency through increased interoperability. In other words, by moving from a collection of discrete infrastructure systems to truly interdependent infrastructure ecosystems, the efficient, effective, predictable, and adaptive delivery of services will increase as well.

Across disciplines ranging from engineering to computer science to innovation policy, intelligent infrastructures are increasingly seen as solutions to the "wicked" problems that face local governments.[3]

[3] See Patton, Carl V, David S. Sawicki, and Jennifer J. Clark (2012) Basic Methods of Policy Analysis and Planning. New York: Routledge. 3rd Edition.

These problems include how to respond to both long term and short term threats to resilience: 1) strained resources spread across ever growing urban populations, 2) aging infrastructures and public services systems, 3) competitiveness in the global economy, and 4) acute human and environmental stressors.

In recent years, governments ranging from dense urban environments to rural communities have made significant investments in smart and connected communities (SCCs), leveraging the capacity of information and communication technologies (ICTs) to improve existing operations and develop new services. The resulting "intelligent infrastructure" is dependent on a layer of new technologies to collect and store data, combine data from both fixed and mobile sensing devices, integrate existing data sets, and report the status of the city to user groups including businesses, governments, and communities. These new data streams come from connected, self-reporting, sensing devices (e.g. the Internet of Things, or IoT), citizen contributions (e.g. crowdsourcing), and municipal and official sources (e.g. open government data). These new capacities contribute to an increasingly complex system of users, platforms, interests, and information—with profound implications for systems design and governance.

This infrastructure presents particular challenges because it is integrated both into and across different critical infrastructures. From water and electricity systems and across built, natural, and socio-economic environments, robust intelligent infrastructure is increasingly required for the secure and resilient operations of government services and systems. As a consequence, this infrastructure-of-infrastructures presents a unique problem for critical infrastructure: how to integrate the capabilities and capacities of intelligent infrastructure into incumbent systems while mitigating interruptions, reducing exposure to threats, and ensuring continuity of service? In short, intelligent infrastructure requires attention in its own right as a new critical public infrastructure.

Intelligent infrastructure is quickly becoming central to the operations of critical infrastructure providing services ranging from water, to energy, to multi-modal transportation, to health, to communications. And, economic competitiveness is increasingly tied to the reliability and resilience of these critical infrastructure.[4] Simply put, places without robust intelligent infrastructure systems will be left behind in the global economy because their critical infrastructure systems — utilities, energy, transportation, health, and emergency services — will be not be competitive compared to places who made the investments in cyber-physical systems to support operations.

Intelligent infrastructure directly impacts the management of systems through manual and semi- and fully-autonomous interventions, such as allowing changes to traffic lights during a period of heavy vehicle throughput. Intelligent infrastructure also indirectly impacts existing systems by providing information important to design, maintenance, and decision-making from operations to city planning and administration. The products currently emerging in the context of smart communities are largely service-embedded goods built on a platform of critical infrastructure systems. In other words, smart communities cannot move forward without intelligent infrastructure. Smart communities require: 1) connectivity (reliable, predictable, interoperable, and upgradeable), 2) analytical services (expertise and assets to make data legible and useable), 3) data storage and management services (including security and privacy), and 4) open access to data through platforms and interfaces for citizens, entrepreneurs, and incumbent firms to build enterprises and expand engagement.

[4] See Clark, Jennifer (2013) Working Regions: Reconnecting Innovation and Production in the Knowledge Economy, London: Routledge. See also Clark, Jennifer, Hsin I. Huang, and John P. Walsh (2010) A *Typology of Innovation Districts: What it Means for Regional Resilience*. Cambridge Journal of Regions, Economy and Society. 3 (1): 121-137.

For example, a “smart cities object” — a trash can, a streetcar, a light pole, a traffic light — requires embedded sensors. Those sensors require connectivity (fiber, wireless, etc.). The object requires a service contract to maintain and manage that connectivity. Data analytics are required to manage the resulting data and perform analysis. Interfaces and visualization tools are required to make the data accessible to citizens and businesses. Smart communities are a market-making enterprise and failing to invest in intelligent infrastructure misses the opportunity to provide local communities with globally competitive roads, bridges, and transit but also abdicates the opportunity to build a new industry around the products, services, and systems developed on the platform of intelligent infrastructure.

Making Smart Communities: Streamlining Research, Development, and Deployment

The making of smart communities follows a model of technology diffusion familiar in the private sector context. This, however, is technology diffusion into a public-sector context where there is a necessary focus on the broad provisioning of reliable and efficient services and a consideration for building access to data for enterprise development. There are significant private sector participants in smart communities and some of these firms have created consortiums to offer communities integrated and interoperable packages of hardware, software, and connectivity services.

In the U.S., the national innovation system largely relies of publicly-funded basic research and development conducted within the network of world class research universities throughout the country. For decades, these universities have served as the research and development backbone of U.S. industry and of national

defense.[5] Research indicates that this national innovation has been effective in bringing forward new technologies and in facilitating the commercialization of new products, processes, and materials.

In the smart communities context, research universities are again serving an essential role in the research and development phase of smart communities innovation. At Georgia Tech, we are engaged in developing new policy models for smart communities as well as new technologies including data analytics, sensor networks, and operating systems. Through this research we have identified four key elements in smart communities technology projects: 1) Phased technical deployment to increase opportunities for in-action learning, community engagement and responsiveness, and integration of ongoing technical improvements, while simultaneously reducing the implementation burden on participating organizations, 2) Comprehensive administrative and technical strategies focused on interoperability that account for the necessary current and future need for systems to communicate and foster expansion over time, 3) Programmatic commitments to engaging the community at large, and to integrating concerns originating in everything from planning to technical specifications in meaningful ways and tailored to local conditions, 4) Established policies around open data and open innovation in order to ensure both continued access and local and regional economic development.[6]

Local governments are focused on managing growth and change in their communities and providing services to citizens. Rarely do local governments have internal research specializations. Although some larger local governments have made recent investments in innovation delivery teams, information management teams,

[5] Clark, Jennifer (2014) *Siting "Scientific Spaces" in the US: The Push and Pull of Regional Development Strategies and National Innovation Policies.* Environment and Planning C: Government and Policy. Pp.1-16

[6] For further information see the research project: MAPPD: Multi-Array Phased Participatory Deployment. MAPPD is a technical and strategic smart cities project developing a repeatable approach to scaling up a Smart City sensor network. MAPPD is a city-university partnership between the Georgia Institute of Technology and the City of Atlanta and a featured project of both the MetroLab Network and NIST's Global City Teams Challenge.

and resilience offices, these efforts remain focused on enhanced service delivery to citizens. Further, many of these efforts have been financed by philanthropic investments by leading national foundations interested in improving the quality of life and capacity for service delivery in local communities. In other words, even the exemplar smart communities programs are largely experiments with limited resources, limited timelines, and unclear scalability.

Research universities have extensive experience partnering with industry and government on technology diffusion projects. Research universities are built to test new technologies, evaluate alternatives, assess investments, evaluate economic impacts, measure distributional consequences, and certify processes, materials, products, and standards. As with any new enabling technology (biotechnology, nanotechnology, advanced manufacturing, photonics) research universities can play a role as a neutral third party with specialized technical expertise. Universities are also embedded in local communities and often have long-term working relationships with local and state governments. Research universities also have vested interest in the upgrading and maintenance of intelligent infrastructure in the cities and communities in which they are located. World class industry partners, star scientists, and the next generation of entrepreneurs all look for intelligent infrastructure to support their research and commercial enterprises. The absence of this infrastructure makes universities less globally competitive --- for talent and for capital. And, as stated before, such absences make local communities less globally competitive as well.

Rather than stand up research and development divisions in every local government in the country in order to assess and deploy smart communities technologies, it would be reasonable to again turn to the nation's network of world class universities, like Georgia Tech, to conduct the research and development work of smart communities and thus facilitate the path to deployment by local communities.

Finally, as research universities train the next generation of workers, citizens, and entrepreneurs, it is important to recognize that living and working in smart communities will be distinct from the built environment in which we live now. Whether the changes are immediately disruptive like autonomous vehicles or incremental adjustments to the skills required for living in and navigating the built environment (think automated grocery store check outs, smartphone based parking systems), investments in technical training for new and incumbent workers will be required to take advantage of the value-added these technologies bring to the labor market. Universities again will be critical partners in developing both these technologies and the skilled workforce required to capitalize on their contributions to national and regional growth.

Smart Communities Implementation and the Role of the Federal Government

In 2015 the U.S. Department of Transportation announced a Smart Cities Challenge for cities across the country. The competition was a "winner take all" grant which Columbus, Ohio won. But 77 other communities also applied for the grant. In other words, 77 local communities across the country pulled together strategic plans for implementing intelligent infrastructure systems in their own communities and tailored to their own needs. The Federal Government has long played an essential role in investing in infrastructure and in emerging technologies. Smart Communities combine both these roles. And communities across the country have demonstrated their readiness to move forward.[7]

The Federal Government has several key roles going forward. First, as noted above, smart communities involve technology diffusion into a complex private sector and public sector space --- and that space is also a place, a jurisdiction. The implementation of smart communities involves engaging real people in real places

[7] See the US Department of Transportation summary of the Smart Cities Challenge

in real time. Therefore, flexibility and policy tailoring will be essential to successful implementation. What works in New York City is unlikely to be exactly what works in Columbus or Savannah or Dallas. One size will not fit all.

Although the Federal Government should not set a standardized approach, the Federal Government should consider developing technical standards and platforms for data, connectivity, and integration of hard infrastructure and information and communication technologies to protect citizens and consumers from excessive experimentation. The National Transportation Safety Board's approach to guidance on autonomous vehicles is a good example of signaling to industry, local governments, and researchers about how to shape strategic planning and private investment while protecting consumers and citizens.[8] The National Institute of Standards and Technology's efforts to develop the global cities team challenge and convene industry, local governments, and universities to discuss and develop standards is an important start as well.[9]

Because smart communities technologies cut across domains they also do not fit neatly under a specific federal agency. Many of the efforts to consider and support smart communities have been partial and ad hoc. The recent call for public comments by the Networking and Information Technology Research and Development (NITRD) Program on the "Smart Cities and Communities Federal Strategic Plan: Exploring Innovation Together" is a start at coordinating planning across the Federal Government.[10]

[8] See US Department of Transportation Autonomous Vehicle Policy
[9] See US Department of Commerce, NIST Global Cities Team Challenge
[10] See the Networking and Information Technology Research and Development Program's Smart Cities and Communities Task Force

Georgia Tech and the City of Atlanta are partners in a national network designed for developing smart communities policies and technologies with the scalability of those models to other local governments in mind.[11] The MetroLab Network is a network of 38 cities, 4 counties, and 51 universities, organized into "city (or county) – university partnerships" focused on "research, development, and deployment" (RD&D) projects that offer technologically- and analytically-based solutions for challenges facing communities: mobility, security and opportunity, aging infrastructure, and economic development. One role for the Federal Government is in resourcing and institutionalizing these networked partnerships to support policy diffusion across communities and information exchange about how smart communities investments (programs, projects, and objects) perform as implemented. These networks allow local governments to achieve some economies of scale, build capacity, and avoid replicating mistakes or reinventing the wheel.

The Federal Government has an important role to play in shaping the scope and scale of intelligent infrastructure investments going forward. Simply put, the Federal Government will decide the platform on which the national economy is built going forward and whether it meets 20th century standards or sets the standard for the 21st century. There is a significant amount of basic research required to ascertain how to achieve the promise of smart communities. Some of that research can be resourced through programs like the Smart and Connected Communities program or the Critical Resilient Interdependent Infrastructure Systems and Processes (CRISP) program of the National Science Foundation. However, the current resources are modest investments in basic research and not of a sufficient scale to support the broad, national technology deployments necessary.[12]

[11] For more information about the national MetroLab Network's activities in supporting city and community partnerships please see their website.
[12] See NSF CRISP Program and the NSF SCC Program

There is also a significant amount of applied research required to move smart communities technologies from design to development to deployment. There is a growing need for education and training. In research universities like Georgia Tech we are developing new curriculum to integrate teaching and learning about innovation and communities, technology and cities and regions. We are also investing in research centers, like the Center for Urban Innovation and the Institute for People and Technology, that take an interdisciplinary approach to moving innovations in engineering, sciences, and computing into a complex real world context of communities, entrepreneurs, and industries.[13] How to design and deploy intelligent infrastructure to efficiently and effectively support smart communities is one of the central questions going forward for the country as a whole and for local communities in specific. Building the replicable models and dissemination networks for the broad and sustained implementation of information and communication technologies into the next generation of national infrastructure is the opportunity and the challenge before us.

[13] For more on Georgia Tech's Center for Urban Innovation and Institute for People and Technology's smart cities research and partnerships please see the websites.