CRA
Computing Research Association

Intelligent Infrastructure Research

Our infrastructure touches the day-to-day life of each of our fellow citizens, and its health is crucial to the overall competitiveness and prosperity of our country. While our immediate infrastructure needs are critical, it would be shortsighted to simply replicate more of what we have. By doing so, we miss the opportunity to create ***Intelligent Infrastructure*** that will provide a foundation for increased safety and resilience, improved efficiencies and civic services, and broader economic opportunities and job growth.

Intelligent infrastructure is the deep embedding of sensing, computing, and communications capabilities into traditional urban and rural physical infrastructures such as roads, buildings, bridges, pipelines, water and electric distribution systems for the purpose of increasing efficiency, resiliency, and safety. Intelligent infrastructure has a wide range of applications, including transportation, energy management, public safety and security, disaster response, agriculture, and health. (See table 1) Intelligent infrastructure is likely to have an impact on society comparable to the establishment of the interstate highway system in the 1950s and the Internet in the 1960s. Indeed, intelligent infrastructure can be viewed as the convergence of these two very powerful ideas. The vision is compelling, but we lack some vitally important components to make it real.

Key to reaching those goals is identifying critical gaps and barriers to successful deployments in four foundational areas:

- **Resiliency and Adaptability** - The ability of the intelligent infrastructure to cope with extreme or unexpected circumstances -- for example, wireless communications in the face of a natural disaster where human lives are on the line, demand on the network is high, and time is of the essence.
- **Robustness and Interoperability** - Bringing together data from large numbers of independent sensing systems owned or controlled by different stakeholders, public and private, to achieve shared common goals.
- **Security, Trustworthiness and Privacy** - Ensuring that systems are protected from breaches, that they perform as expected, and that the data and information collected is used as advertised with clear policy definitions for algorithmic accountability.
- **Accessibility and Usability** - Creating infrastructures that meet the needs of rural and urban communities, and creating tools and training capabilities to ensure that regional leaders can manage and utilize these key services and that regional workforces are capable of working with and on these new infrastructures.

Key Recommendations

- There is a need to understand how to integrate these “systems of systems.” Intelligent infrastructure is by necessity not a system of silos -- these are interconnected, interoperable, interdependent systems that require research, new ways of modeling and testing, and a workforce trained to work with them.
- The value of these systems increases with the use of shared data -- research on open data models will help increase the value of these infrastructures to communities and create opportunities for entrepreneurship and greater understanding.
- Open research testbeds and open data will also lead to intelligent infrastructures that are more integrated, cost-efficient, resilient, adaptive and effective.
- It is vital for the research and policy community to work together to ensure that policy innovation informs technology and that technology innovation informs policy.
- There is a rich set of research problems that require solving to truly realize the benefits of intelligent infrastructures, federal efforts are already underway which merit highlighting and bolstering, and university researchers and national labs are well-positioned to carry out this cross-disciplinary, convergent work.

For more, see: http://link.cra.org/intelligentinfrastructure

Table 1 - The Potential of Intelligent Infrastructure Across Multiple Domains

Descriptive: Provides an accurate and timely characterization of current state, e.g., water level in a storm drain or traffic congestion.
Prescriptive: Recommends immediate and near-term actions, e.g., re-routing traffic or dispatching onsite service personnel.
Predictive: Anticipate future challenges and opportunities, based on assessment of the current state, patterns of past activity and available resources and capabilities, e.g., street-level flooding by incorporating water sensors, weather patterns and runoff capabilities.
Proactive: Guides complex decision making and scenario planning, incorporating economic data, to inform future investment.

	Descriptive	**Prescriptive**	**Predictive**	**Proactive**
Intelligent Transportation	Real time traffic congestion information	Reroute traffic; Adjust dynamic lane configuration (direction, HOV)	Anticipate rush hour / large event congestion; Anticipate weather related accidents	Suggest traffic patterns w/ intelligent stoplights; road diet plan
Intelligent Energy Management	Real time energy demand information	Improve asset utilization and management across transmission and distribution system	Anticipate demand response required to ensure grid reliability	Suggest new market approaches to integrate production and distribution capabilities
Intelligent Public Safety and Security	Real time crowd analysis	Threat detection; Dispatch public safety officers	Anticipate vulnerable settings and events	Suggest new communication and coordination response approaches
Intelligent Disaster Response	Real time water levels in flood prone areas	Timely levee management and evacuations as needed	Anticipate flood inundation with low-cost digital terrain maps	Inform National Flood Insurance Program; Inform vulnerable populations
Intelligent City Systems	Describe mobility patterns (pedestrian, cycling, automobile, trucking, electric and autonomous vehicles)	Adjust mobility management to improve safety; reduce energy usage	Anticipate changing needs for parking, charging stations, bike and ride share programs.	Inform future mobility capabilities to drive economic development and reduce barriers to employment
Intelligent Agriculture	Characterize spatial and temporal variability in soil, crop, and weather.	Advise based on environmental stressors and crop traits	Forecast crop yield; Anticipate seasonal water needs	Customize management practices and seed selection to local conditions
Intelligent Health	Block – level assessment of current allergens / air pollutant levels	Inform asthma action plans based on local conditions	Anticipate peak seasonal spikes in allergen and air pollutant levels	Inform transportation plans to shift road use away from "asthma corridors"

From "A National Research Agenda for Intelligent Infrastructure" – http://link.cra.org/research_agenda_for_intelligent_infrastructure