

Vision for an Integrated and Active Digital Pavement Management System

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Workshop on “Roads of the Future”



What is a ‘Smart City?’

“A smart city is an urban development vision to integrate multiple information and communication technology (ICT) solutions in a secure fashion to manage a city’s asset, including: schools, libraries, transportation systems, hospitals, power plants, water supply networks, waste management, law enforcement, and other community services.



<http://www.wsj.com/articles/singapore-is-taking-the-smart-city-to-a-whole-new-level-1461550026>



<http://www.barcinno.com/smart-city-barcelona/>

The goal of building a smart city is to improve quality of life by **using technology to improve the efficiency of services and meet residents’ needs**. ICT allows city officials to interact directly with the community and the city infrastructure and to monitor what is happening in the city, how the city is evolving, and how to **enable a better quality of life.**”

en.wikipedia.org/wiki/Smart_city





What is a 'Smart Service System?'

Service systems are socio-technical configurations of people, technologies, organizations, and information [1] designed to create value by fulfilling the needs of those participating in the system....



[1] Spohrer, J., Maglio, P., Bailey, J., Gruhl, D. (2007). Steps towards a science of service systems. *Computer* 40(1):71-77. doi:10.1109/MC.2007.33

[2] Ng, I. (2015). The Internet of Everything and the Future of Service. Speech, 2015 Frontiers in Service Conf, San Jose, CA. <http://hubofallthings.com/hat-in-the-usa/>

A **"smart" service system** is a system that amplifies or augments human capabilities [2] to identify, learn, adapt, monitor and make decisions. The system utilizes data received, transmitted, or processed in a timely manner, thus improving its response to future situations. These capabilities are the result of the incorporation of technologies for sensing, actuation, coordination, communication, control, etc.



Motivation Towards Smarter Ways to Monitor and Manage Pavements



Expensive and infrequent assessment



Rough pavements = more environmental harm



User delay, safety, low-tech/blue-collar image problem



Potholes develop quickly; very damaging



Technological disruption will happen; ... our community should lead it



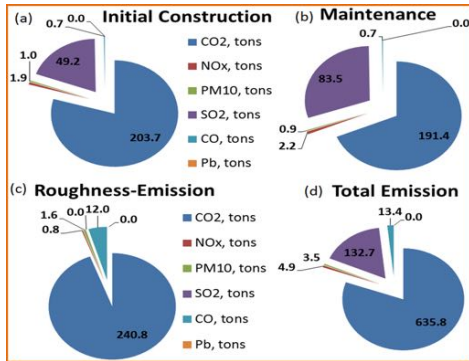
Dangerous and inefficient field data collection; disparate data sources



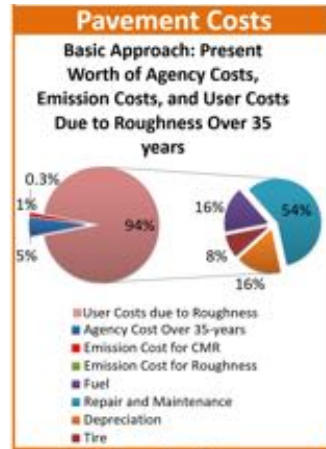


Return-on-Investment for Keeping Pavements Smooth

48-to-1 Return on Investment for Smoothing Rough Pavement!!!



Life-Cycle Analysis



Islam, M.S., and W.G. Buttlar, "Effect of Pavement Roughness on User Costs," *Journal of the Transportation Research Board*, Vol 2285, Issue 1, pp. 47-55, 2012.

Islam, M.S., and W.G. Buttlar, "Assessment of Emission Costs due to Maintenance and Rehabilitations to Reduce Pavement Roughness," *Journal of the Transportation Research Board*, Issue: 13-5084, 2013.



Pavement Roughness

- Defined in engineering practice as surface unevenness which adversely affects ride comfort
- Expressed by a numerical scale called the International Roughness Index (IRI)



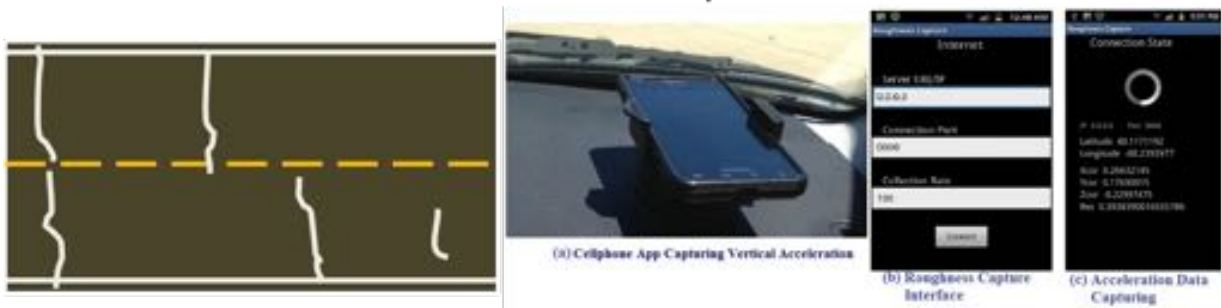
Quarter-car Model

Inertial Profiler

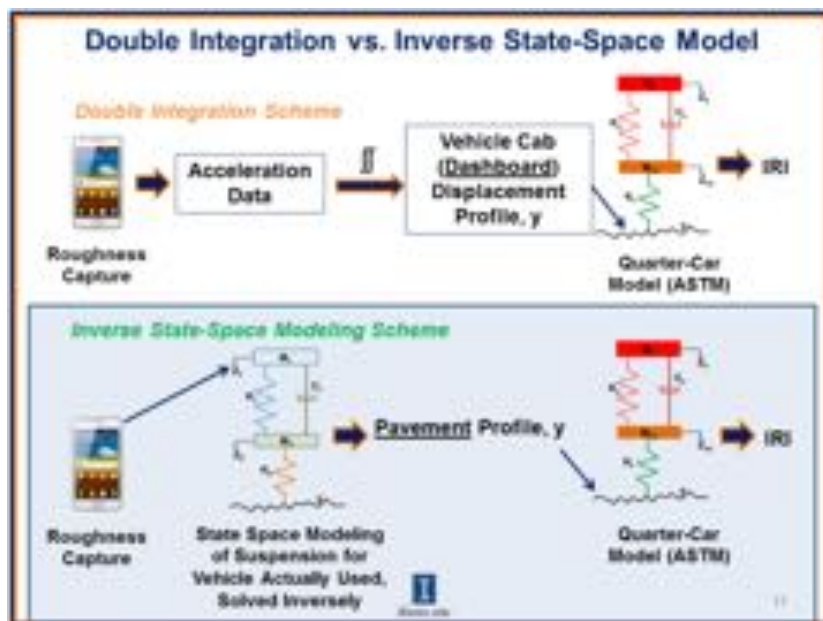


Roughness Capture App

- Pavement surface irregularities causes the vehicle wheels to move up and down with respect to the road surface, causing the vehicle cab to accelerate (although cab movement is dampened by suspension)
- "Roughness Capture" has been used to collect vertical acceleration data in the vehicle cab - It is hypothesized that vehicle cab acceleration measured with smart phones can be combined with vehicle dynamics models to arrive at accurate measures of pavement IRI

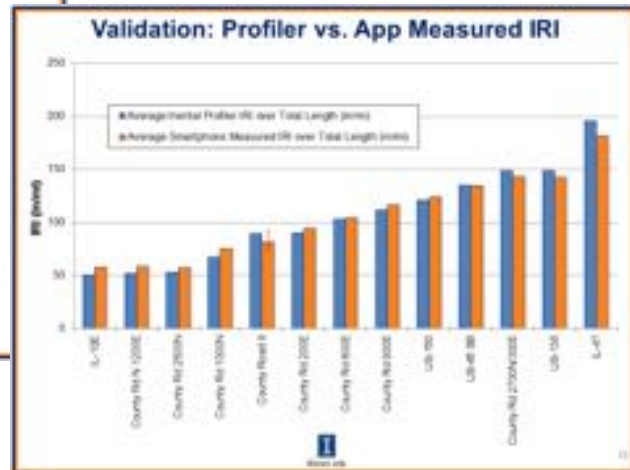
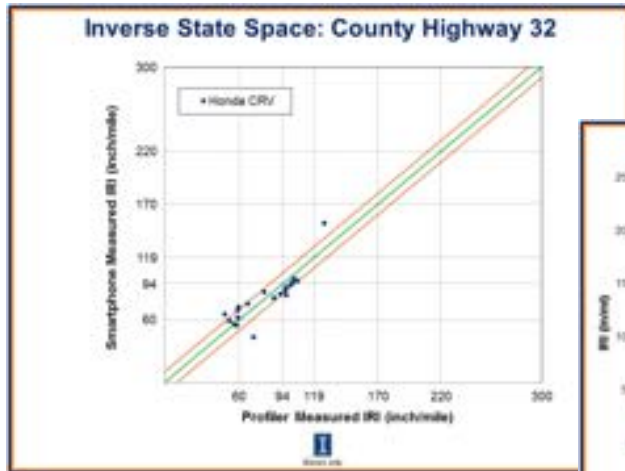


Roughness Capture App

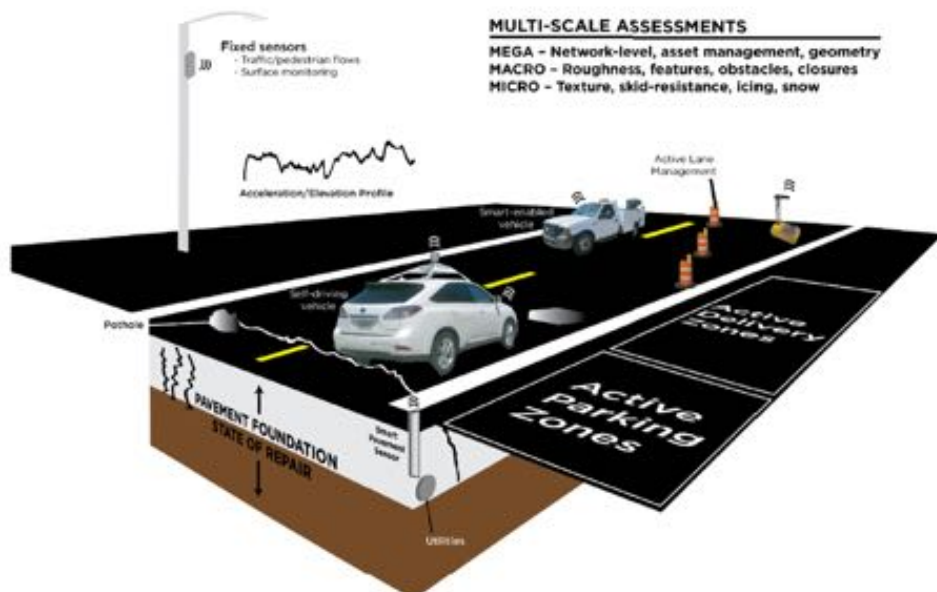




Roughness Capture App

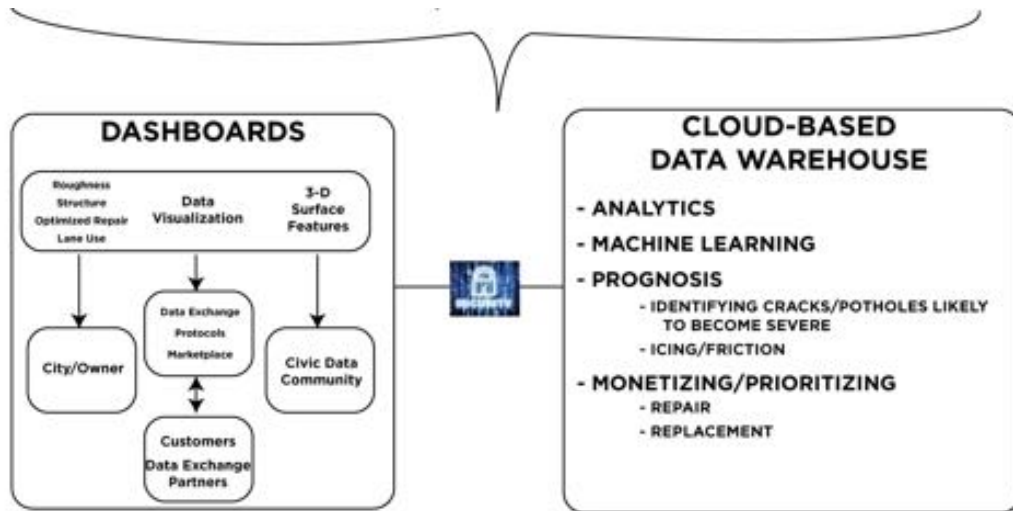


Vision: Active Digital Asset Management System (1/2)





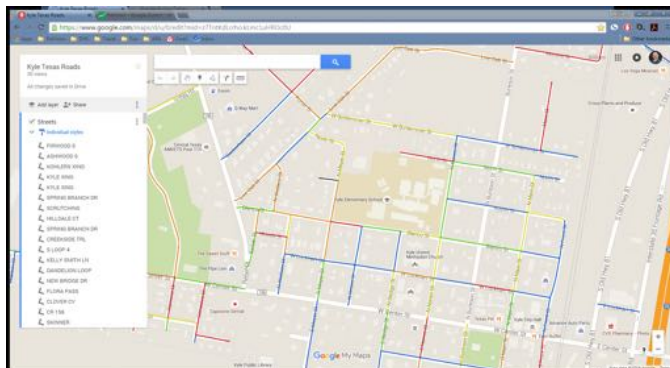
Vision: Active Digital Asset Management System (2/2)



Imagine a City Where...

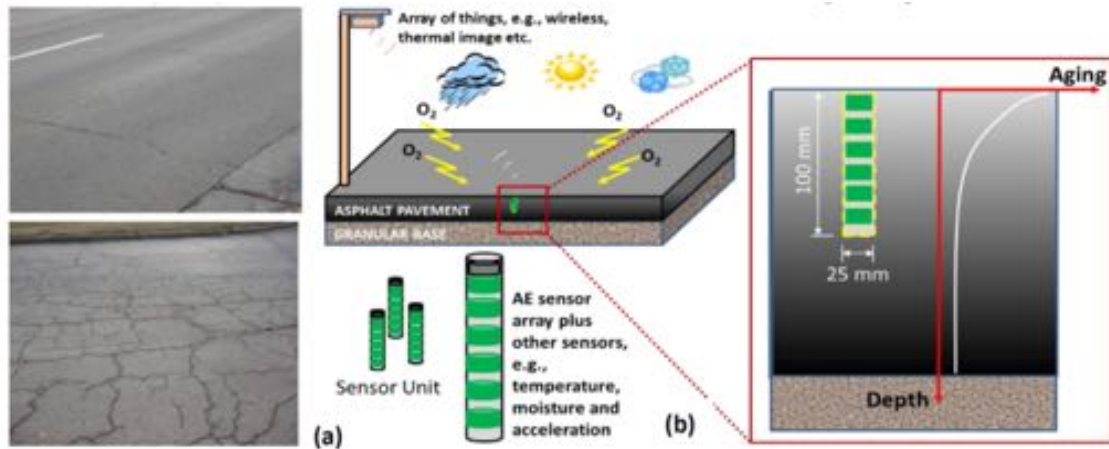
Transportation engineers use PCs, tablets and smartphones to collect and view roadway information in an intuitive, graphical format, anywhere, anytime:

- To view roughness/feature 'hot spots' (potholes, blowups...) in **real time** from varied data sources (acceleration from fleet vehicles and apps, image feeds, 311 reports...), to dispatch maintenance crews, and to assess/monitor road repairs.
- To view data geographically and temporally, i.e., similar to online weather maps, where pavement condition can be scrolled between past-present-future, where future condition is predicted using an ever-evolving, intelligent pavement prognosis system fueled by data fusion, advanced analytics and machine learning.





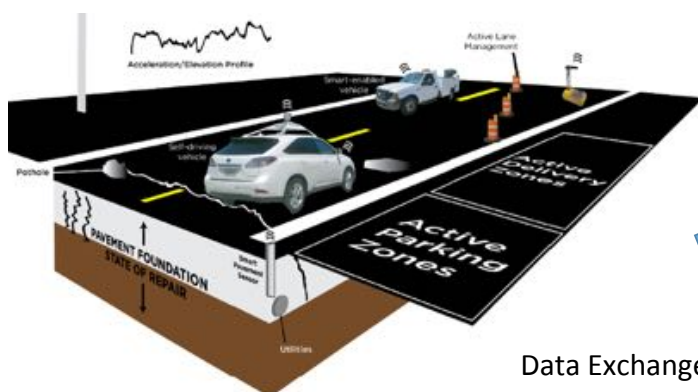
Smart Instruments



...Imagine a City Where...

Auto makers and navigation apps can access 3D roadway profile and feature data, and purchase/exchange data regarding precise pavement geometry and profile, roughness features and obstacles, lane closures, and dynamically-assigned parking and loading zone locations

- Navigation-aided and autonomous vehicles can then safely navigate around rough routes, dangerous/damaging pavement features, and request/reserve special digital-only lanes, parking, and loading zones in urban centers



Smart Vehicle



Self-Driving Vehicle

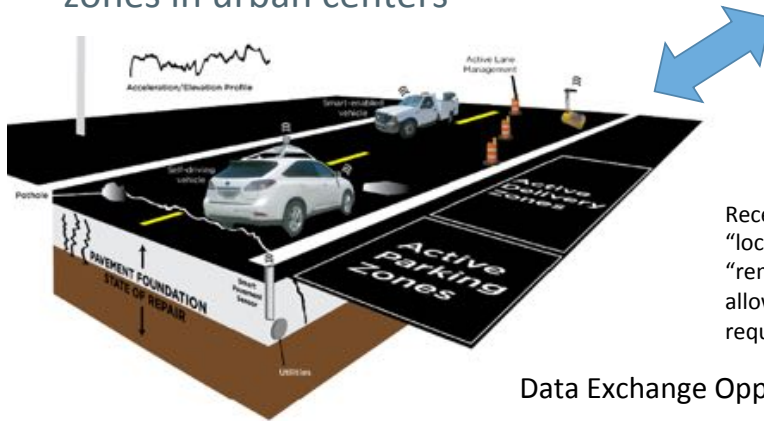
Data Exchange Opportunities



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Recent software upgrade in Tesla Model S gives it a "location-based air suspension," allowing it to "remember" potholes, rough routes, etc. It also allows the car to automatically re-adjust as required to minimize damage to the vehicle.

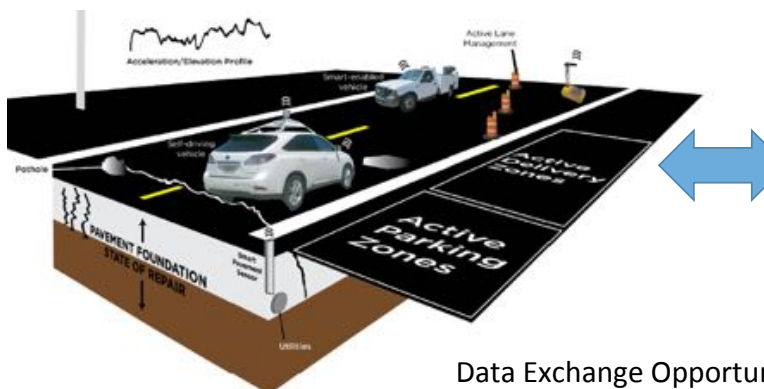
Data Exchange Opportunities



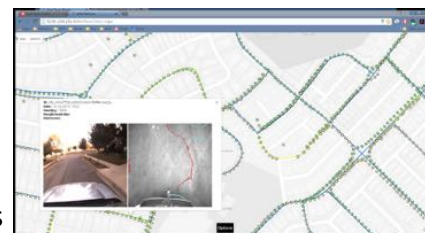
...Imagine a City Where...

Transportation engineering firms can lower the cost of pavement evaluation and management, by:

- Using the smart pavement service system as a complement to their existing pavement assessment and management systems.
- Exchanging high-resolution and high-accuracy pavement profile and feature data in the digital marketplace for access to high-volume, multi-source data feeds and pavement condition prognosis tools. This will also enable calibration of algorithms and sensors in the smart service system.



www.ara.com/projects/PaVision-automated-pavement-condition-assessment-system



Data Exchange Opportunities

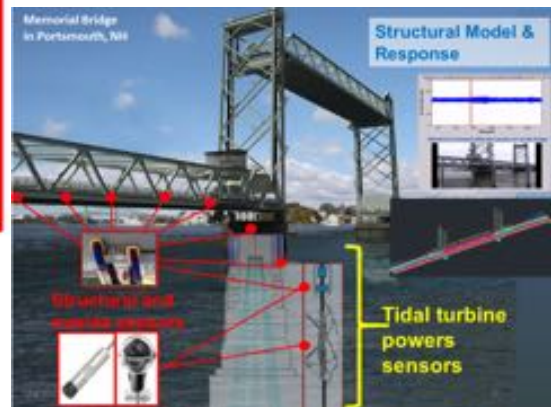
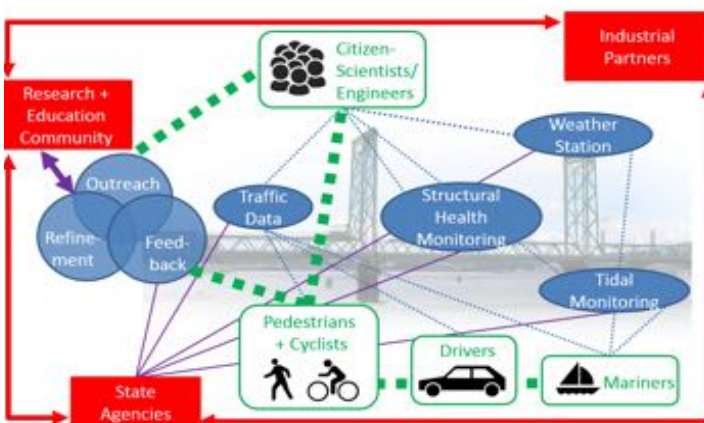


City Digital at UI Labs



The Living Bridge Project @ UNH

“The Future of Smart, Sustainable, User-Centered Transportation Infrastructure”



Acknowledgement: Dr. Erin Bell,
University of New Hampshire

memorialbridgeproject.com



Road 2 Tomorrow. Missouri DOT

www.modot.org/road2tomorrow/

ROAD TO TOMORROW

HOME MEET THE TEAM

OUR MISSION

Missouri has always been at the vanguard of America's transportation system. From the earliest days of the nation's westward expansion to the first length of the nation's interstate highway network, the Show-Me State has led the way. And now it's time to lead again.

Road To Tomorrow Update

Internet of Things

www.modot.org/road2tomorrow/

ROAD TO TOMORROW

HOME MEET THE TEAM

BECOME PART OF THE FUTURE

Do you have the innovation that will build and fund the transportation system of the future?

[SUBMIT YOUR IDEAS](#)

OUR GOALS

The Missouri Highways and Transportation Commission launched Road to Tomorrow as an innovative way to help create financing for the restoration of Interstate 70 and to deliver a 21st Century transportation system.

MoDOT Director Patrick McKenna said Interstate 70 from Kansas City to St. Louis is being offered as a laboratory for innovation. To date we've received approximately 300 ideas. MoDOT is still aggressively seeking partners, grants and other tools to transform this project from a conceptual design into a reality.

<h4>SMART HIGHWAYS</h4> <p>The use of technology to offer optional, premium services via the roadway.</p>	<h4>TRUCK PLATOONING</h4> <p>The use of proprietary technology to increase fuel efficiency and reduce accidents among long-haul trucks.</p>	<h4>TRUCK FERRIES</h4> <p>The use of trucks transferring trains during mandated downtime to increase overall efficiency and reduce damage to roadways.</p>	<h4>DATA/COMMUNICATION</h4> <p>Allowing the use of MoDOT infrastructure to host Data and Communications equipment.</p>
<h4>FUNDING</h4> <p>Varieties of new tolling structures, HOV-lanes, and user taxes all requiring statutory or constitutional changes.</p>	<h4>ALTERNATE TRAVEL</h4> <p>Supplementing the current corridor with efforts outside of the current transportation infrastructure.</p>	<h4>ENERGY</h4> <p>Using a public private partnership to finance, construct, and maintain renewable energy along the corridor.</p>	<h4>ADVERTISING</h4> <p>Selling the right to advertise on the public right of way.</p>

8th RILEM International Conference on Mechanisms of Cracking and Debonding in Pavements (MCD2016)

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Kansas City, Missouri

kcmo.gov/smartcity/

CITY OF KANSAS CITY HOME CITY OFFICIALS DEPARTMENTS CAREERS 311 PAY TAX

KCMO.GOV

City of Kansas City, Mo.

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KCMO = the world's most connected Smart City

Kansas City is now the **world's most connected Smart City** thanks to the installation of cutting-edge technologies which will improve everyday experiences for residents. The more than \$15 million public-private partnership is one of the first economic development projects credited to the City's modern **streetcar**, which will open to the public on May 6. The Smart City corridor follows the 2-mile-long streetcar route.

Smart City initiatives will help the City of Kansas City use real-time data to deliver basic services more efficiently and will attract economic development & entrepreneurs. With interactive kiosks ([see locations](#)), free public WiFi, smart streetlights and sensors, it is the start of a new experience for those who live, work and play in Kansas City.

Downtown Kiosk Installation

Overall quality of SERVICES provided by KCMO

13.8%	1.8%
25.9%	51.8%
+4%	

8th RILEM International Conference on Mechanisms of Cracking and Debonding in Pavements (MCD2016)

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Moving Forward...

- Disruption wave – don't run, ride!
 - In addition, will attract new talent to our field
- Need to standardize:
 - New roughness, pavement condition, user cost and sustainability parameters/indices from active data streams
 - Cloud storage data structures
- Get industry and citizenry involved
 - Crowd sourcing – 311 reporting, social media sentiments, repair funding ('GoFundMe' pothole repair funding)
 - Data exchange marketplace standards and business model

