Proposal Title: Transform Rutgers New Brunswick Campus into an Urban Sustainability Laboratory and Classroom

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Primary Strategic Priority/Foundational Element/Integrating Theme Addressed:

__ Envision Tomorrow's University
__ Build Faculty Excellence
__ Transform the Student Experience
__ Enhance Our Public Prominence
__ Strong Core of Sciences and Humanities
__ Inclusive, Diverse, and Cohesive Culture
__ Effective and Efficient Infrastructure and Staff
__ Financial Resources Sufficient to Fund Our Aspirations
__ Robust Shared Governance, Academic Freedom, and Effective Communication
__ Cultures, Diversity, and Inequality—Local and Global
__ Improving the Health and Wellness of Individuals and Populations
_x_ Creating a Sustainable World through Innovation, Engineering, and Technology
__ Educating Involved Citizens and Effective Leaders for a Dynamic World
__ Creative Expression and the Human Experience
__ Measuring Progress and Defining Success

Proposal Abstract:

We propose to transform the New Brunswick campus into a living laboratory and classroom for studying the contemporary issues facing a typical U.S. city: aging infrastructure, old buildings, rising energy cost, reduced operation budget, increased population, traffic congestion, increasingly aggressive climate system, shifting in social behavior, and rising demand for more productive, healthy, efficient, and equitable built environment. The initiative leverages existing capabilities in infrastructure and building condition assessment, large-scale geospatial sensing, urban environment modeling and informatics, cyber-physical systems, agent-based simulation, energy audits and simulation, user behavior, traffic engineering, social media, big data analytics, and industry ecology to collect data and use the data to better understand how a complex environment, such as the New Brunswick campus works, and how its operations can be improved.

We envision that this collaborative effort will bring exciting streams of data into the heart of our daily education and research activities. This will allow the education and training of the next generation of students and researchers. Those will be better positioned to remedy a wide range of issues affecting the everyday lives of citizens, the long-term health and efficiency of cities, and the sustainability of our built and natural environments. Our immediate goal is to make the campus more productive, livable, equitable, and resilient through the development of a virtual laboratory for resource and data sharing, advanced analytics, and a suite of educational modules that cross cut several disciplines. The virtual laboratory will build its data base from actual measurements and monitoring across New Brunswick campus, data mining, numerical simulations, modeling and analyses.

What is Being Proposed?

The New Brunswick campus embodies many of the contemporary issues facing a typical U.S. city: aging infrastructures, old buildings, rising energy cost, reduced operation budget, increased population, traffic congestion, increasingly aggressive climate system, shifting in social behavior, and rising demand for more productive, healthy, efficient, and equitable built environment. This provides a precious opportunity to transform the New Brunswick campus into a living laboratory and classroom for studying these contemporary issues. As a first step towards this goal, we propose to leverage our existing capabilities in infrastructure and building condition assessment, large-scale geospatial sensing, urban environment modeling and informatics, cyber-physical systems, agent-based simulation, energy audits and simulation, user behavior, traffic engineering, social media, big data analytics, and industry ecology to collect data and use the data to better understand how a complex environment like the New Brunswick campus works, and how its operations can be improved.

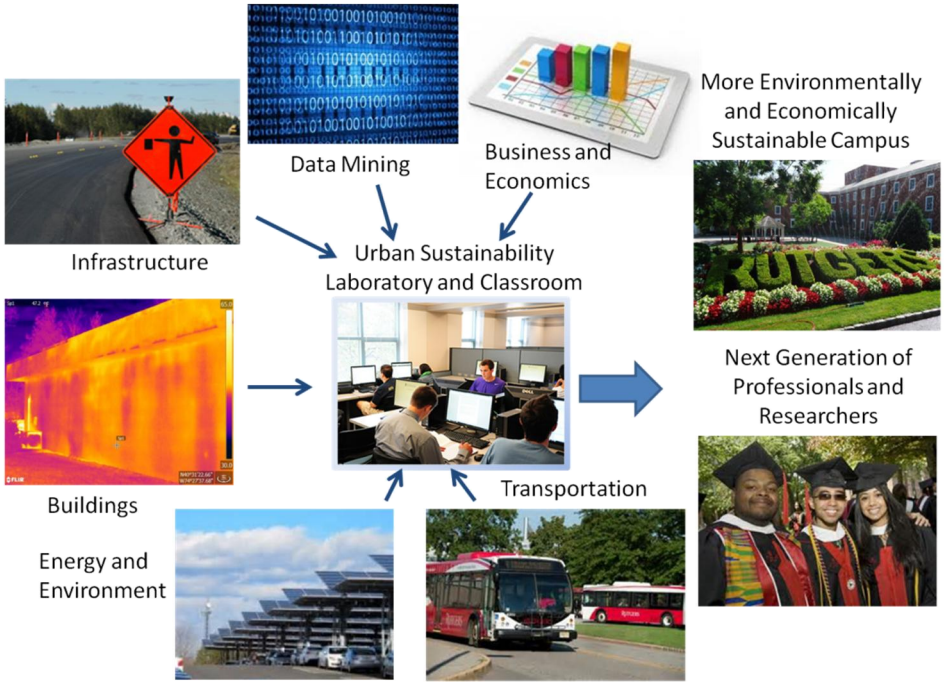

Figure 1 A Framework for Urban Sustainability Laboratory and Classroom

We envision the data and our collaborative effort in bring these data to the heart of our daily education and research activities can educate and train a new generation of students and researchers who will be better positioned to remedy a wide range of issues affecting the everyday lives of citizens, the long-term health and efficiency of cities, and the sustainability of our built and natural environments. Our immediate goal is to make the campus more productive, livable, equitable, and resilient through the development of a virtual laboratory for resource and data sharing, advanced analytics, and a suite of educational modules that cross cut several disciplines. The virtual laboratory will build its resources from actual measurements and monitoring across New Brunswick campuses, data mining, numerical simulations, modeling and analyses. Our philosophy is: many school units or even individual faculty members have their own laboratories; instead of building a new lab, we focus on the concept of a virtual sustainability laboratory that collects and creates essential campus sustainability data using resources from existing laboratories and integrate these networks of laboratories for data sharing and collaboration in the cyberspace. We deeply believe in open research such that we will make (non-confidential) data, the developed tools, and education materials available to researchers and students across our institution.

Scope of Activities

Infrastructure Condition Assessment and Asset Management: The actual building and infrastructure measurements across campuses will be conducted for condition assessment, energy efficiency, asset documentation, and other purposes. The measurements will provide a multitude of opportunities for research and education, including: technology application, development of new approaches and automation of data collection, including robotics, advanced analytical procedures, data integration, fusion and visualization, and interfacing with asset management systems. Existing resources within the participating units will be utilized in all data collection. As illustrated below (Figure 2), geophysical and nondestructive evaluation technologies will be utilized to characterize assess campus road network condition and identify potential utility issues. The information collected, in many cases periodically, will facilitate multi-disciplinary research and instructional activities, and be a resource to the University in better management of its infrastructure assets. The goal of this living laboratory is to collect and assess condition data, but more importantly to develop realistic deterioration and predictive models, and ultimately life-cycle-cost models for optimum maintenance and improvement strategies.

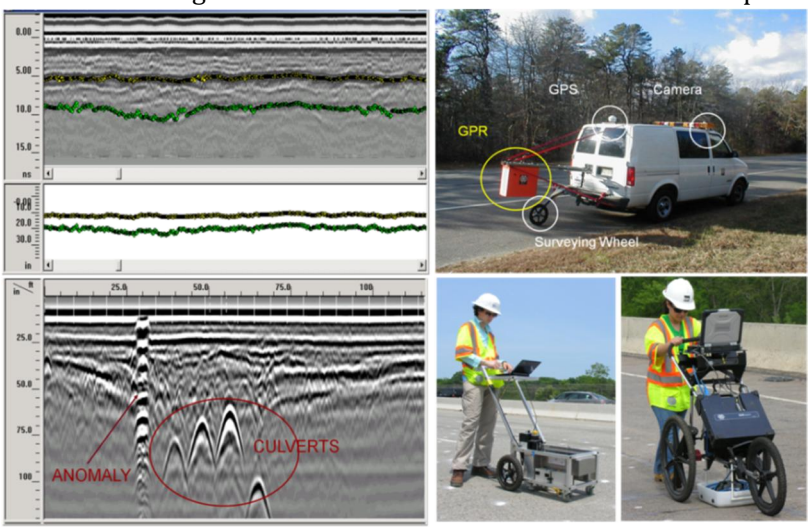

Figure 2 Underground Infrastructure Condition Assessment

There is a broad societal need for the development of efficient asset management tools for resource allocation, decision-making and long-term planning (Figure 3). Specifically, the laboratory will provide expertise and resources related to campus asset management, with multiple potential benefits. The instructional component will provide education to the students and training for campus staff in the concepts of inventory, condition assessment, performance modeling, and economic analysis that can be used for all the campus assets including roads, traffic signals, lighting, storm and sanitary sewers, water distribution, building facilities, etc. The research component will further enhance already nationally and internationally recognized Rutgers' strengths in infrastructure, transportation and environment. Finally, the laboratory will be a resource to campus administrators in long-term strategic decision making for facility and property management. Among others, the research activities will lead to identification of options in utilizing available resources and technologies for the development of a green infrastructure network that will benefit campus users and improve human health.

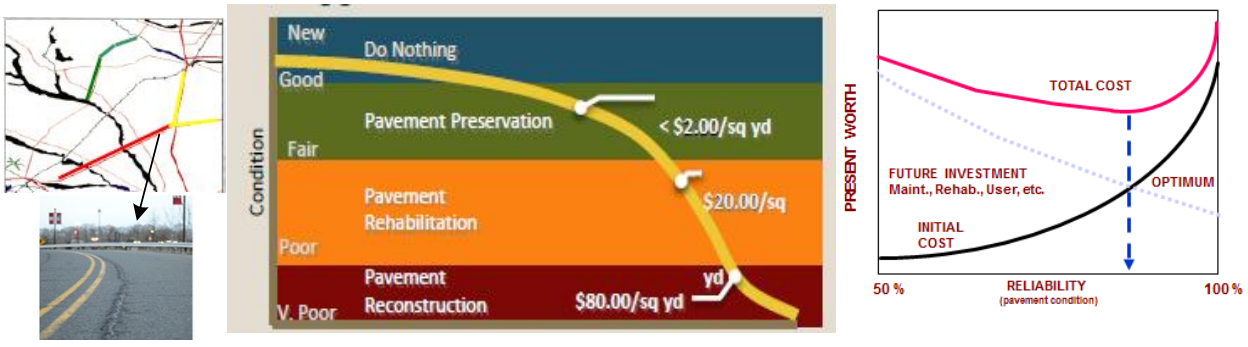

Figure 3 Development of Campus Pavement Management System

Campus-Scale Facility and Infrastructure Modeling: To provide a platform for integrating infrastructure and building measurement data, we will leverage our existing resources (LiDAR mapping, computational facilities for large-scale building and infrastructure modeling, infrared sensing), existing data (post-Sandy LiDAR data set for Busch and College Avenue campus – Figure 4), capabilities in building data modeling and visualization as well as modeling of infrastructure system interdependencies to develop a robust and intelligent facility data platform for campus-scale applications (Figure 5). Once the platform is created from laser and infrared sensing data, it will result in a campus-level integrated GIS/Building Information Model system, which can be used to support a variety of campus facility management functions to reduce New Brunswick campus's environmental footprint while making it safer and more productive. This research component dovetails one of our ongoing federal grants on building advance sensing systems for urban-scale geospatial and thermal mapping.

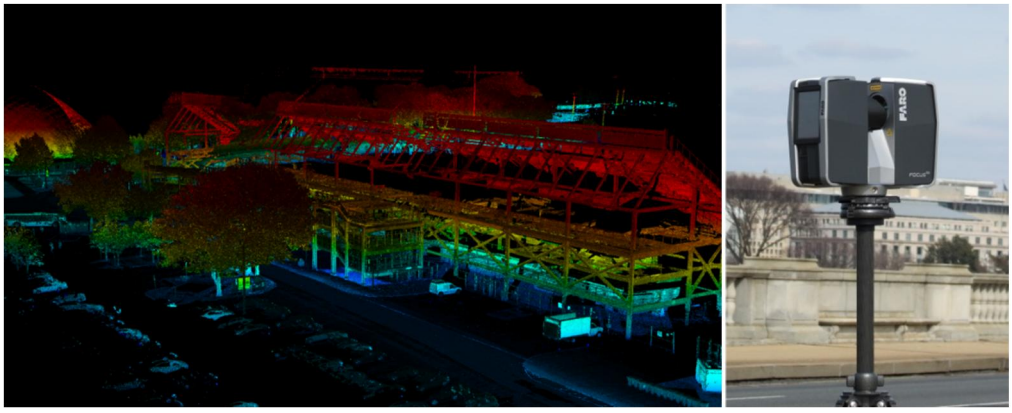

Figure 4 A LiDAR Image of High Point Solution Stadium (colored by elevation)

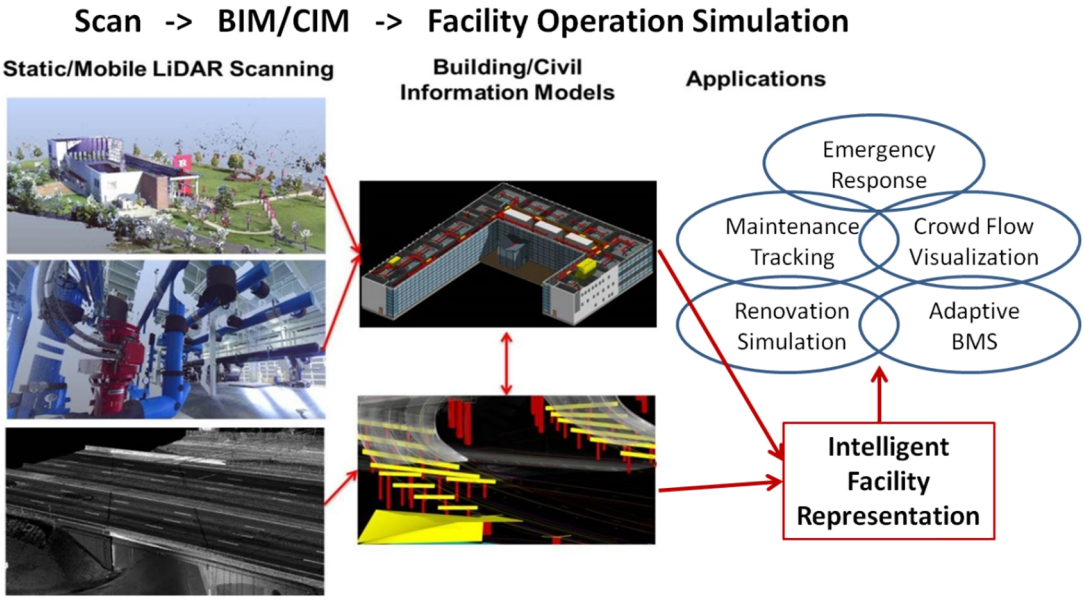

Figure 5 Developing a Campus-Level GIS/BIM System

Transportation and Activity System Modeling: The unique layout of the New Brunswick campus resulted in a complicated transit and transportation systems that is tightly integrated with the local street and highway systems. In the meantime, the intensive daily activities across the campus, including regular classes, sports, and recreational events also generate unique recurrent and non-recurrent traffic patterns (Figure 6). We will collect traffic data, transit schedule and operations data, and campus travel demand data. The data will be used to establish the simulation platform for the multi-modal transportation systems. The platform will be used to identify bottlenecks in all modes of

campus transportation systems including buses, automobiles, bicycles, and pedestrians, understand the interactions among transportation systems, infrastructure, and social activity systems, provide guidelines for campus activity scheduling, and evaluate new solutions designed to improve the productivity and sustainability of the New Brunswick campus.

Figure 6 Campus Transportation and Activity Simulation Platform

Big Data Analytics, Urban Dynamics, and Simulation: The emphasis of this component is on building analytic tools for turning our observations of the living laboratory campus into actionable information. This direction closely relates to the paradigm of "Internet of Things", where multiple systems are networked to provide an accurate view of a physical infrastructure, and will help the research team to establish its presence in this research domain. Data analytics, behavior modeling, and physics and agent-based simulations will play a critical role in understanding how the physical systems intermingle with human behavior. We believe the multitude of data generated in this research is a legitimate big data problem. The GIS/BIM system provides a cyber-environment for students and researchers in computer science, data science, and urban planning to conduct simulations to support high-level campus planning and to understand the impact of operational decisions. Leveraging techniques, such as agent-based simulation, will provide insights into emerging behaviors. Our team has strong credentials and prior federal-level support in the areas of cyber-physical systems, urban planning, human behavior, big data, and market dynamics, is built around these analyses and modeling needs. The developed algorithms and software tools will be shared through the virtual sustainability laboratory portal.

Education and Outreach: Students from various disciplines will collaborate to observe, analyze, and model the campus-infrastructure and human processes. To expand the reach of this program, we will conduct workshops and summer camps to engage more undergraduate students. The outcome of this initiative will be organized into courses and training materials for students as well as for facility personnel.

Alignment of the Initiative with the University Strategic Plan

The initiative with its activities contributes to the overarching aspiration to be broadly recognized as among the nation's leading public universities: preeminent in research, excellent in teaching, and committed to community. While in its core the initiative's theme is sustainability, its related themes are improving the health and wellness of individuals and populations, educating the next generation of effective leaders and involved citizens, and improving human experience.

The initiative is also fully in line with the University's strategic priorities, in the sense that it builds faculty excellence through this highly interdisciplinary activity, that it transforms student experience by exposing them to a wide range of real world challenges, and to them solution approaches and implementations, and that it enhances our public prominence by deriving solutions common to any urban environment. By being an integral part of the New Brunswick campus and University, the laboratory will be also contributing to envisioning its more sustainable future.

Who Will Be Involved?

The laboratory and classroom initiators are listed below. However, the team is confident that upon its initiation, the laboratory and classroom will involve many more units and individuals across the campus, and that the extent of activities with time will go far beyond those outlined in the proposal.

- Nenad Gucunski, SOE, Civil and Environmental Engineering (Infrastructure Systems, Geosystems, Condition Assessment)
- Jie Gong, SOE, Civil and Environmental Engineering (Building Science, Energy Simulation, Geospatial Mapping, Resilience)
- Hao Wang, SOE, Civil and Environmental Engineering (Infrastructure Management Systems, Sustainable Material, Life Cycle Assessment)
- Peter Jin, SOE, Civil and Environmental Engineering (Traffic Engineering, Social Media, Safety)
- Jingang Yi, SOE, Mechanical and Aerospace Engineering, (Robotics, Automation)
- Kostas Bekris, SAS, Computer Science (Cyber-physical Systems, Agent-based Simulations)
- Clint Andrews, Bloustein (Green Building, Energy Policy, User Behavior, Industry Ecology)
- Hui Xiong, Business School, Mgmt. Science and Information Systems (Big data, market dynamics)

Desired Outcomes

There are three main desired outcomes:

1. Integration of multidisciplinary research talent to address issues of urban sustainability issues, which are complex and can be solved only through participation of a broad range of disciplines.
2. Establishment of an educational specialty area on urban infrastructure and operations sustainability. The current education concentrates on the design and development of new systems. Educating the next generation of professionals and researchers regarding the management of existing systems opens huge new opportunities. Participation of diverse student groups on both educational and research sides will be stimulated.
3. Building of campus infrastructure, building and operations resource program. The laboratory aims becoming a resource to the Campus administration and services by providing data, conducting analyses, and offering recommendations.

Anticipated Resources

There are three main support items requested for the proposed activity with the budget over a period of three years. The first is computing hardware needed to create virtual campus sustainability laboratory. It involves servers, computers, storage devices and minor items. This is a one-time expense budgeted in the first year at $115K. The second item is graduate and undergraduate student support for a period of three years. It will cover two graduate assistantships for a period of three years and hourly undergraduate student support. The annual student support is estimated to be $150K. The third item is support for workshops for University and industry dissemination that will be conducted in years 2 and 3 of the program and is estimated at $5K per year. The breakdown by years of the needed resources is the following: $265K - Year 1, $160K - Year 2, $160K - Year 3.

Proposed Measures to Mark Progress or Determine Success

The progress and success of the established laboratory will be measured using five criteria:

1. Number and diversity of students utilizing the virtual laboratory for research and enrollment in the developed new courses.
2. Attraction of research funding related to issues of infrastructure and operations sustainability in urban environment from external sources.
3. Number of faculty and research staff members joining and/or using the virtual laboratory.
4. Generation of support or interest from industry for collaborative efforts.
5. Contribution to university operations, University facilities management feedback, and cost savings to the University.