Center for Smart Streetscape (CS3)

Columbia University (lead institution)

Innovation built through partnerships to improve life on the streetscape for all

CENTER FOR SMART STREETSCAPES

A National Science Foundation Engineering Research Center since 2022

Partner Institutions:

- ***Florida Atlantic University***
- ***Lehman College***
- ***Rutgers University***
- ***University of Central Florida***

The Center for Smart Streetscapes (CS3) will forge livable, safe, and inclusive communities through real-time, hyper-local streetscape applications built on advancements in edge-cloud technology, wireless-optical engineering, visual analytics, privacy preservation and data security, and social science.

More than 80% of Americans and over half the world's population live in urban areas. High-density cities are transforming how people live, work, travel, and manage urban infrastructure. With the nation's urban areas facing emerging challenges threatening livability, safety, and inclusion, it is the streetscape–neighborhood streets, sidewalks, and public spaces–that marks the nexus of public and commercial activities, where rich, spatially and temporarily dense data can be harnessed for the public good.

The NSF Engineering Research Center for Smart Streetscapes, led by Columbia University, together with Florida Atlantic University, Rutgers University, University of Central Florida, and Lehman College, will develop a rich ecosystem of streetscape applications built upon real-time, hyper-local intelligence to advance livable, safe, and inclusive communities. CS3 will adopt a fundamentally new approach to engineering research, leveraging a diverse cohort of non-academic stakeholders–industry partners, community organizations, municipalities, and K-12 schools–as collaborative co-producers of knowledge and auditors of technology research and development, built on a culture of inclusion that bridges the "digital divide" that starkly demarcates stakeholdership. With an extensive network of partners, CS3 will explore five application themes: road safety and traffic efficiency, public safety, assistive technologies for people with disabilities, the future of outdoor work, and hyper-local sensing and modeling.

CS3's engineering process will begin with the study of community-specific application requirements, constraints, and sensitivities. The resulting community-inspired applications will be piloted within three distinct urban testbeds–in New York City (NY), West Palm Beach (FL), and New Brunswick (NJ)–leveraging prior federal and municipal investments. Outcomes from these pilots will catalyze a novel innovation ecosystem, drawing upon CS3's broad network of aspiring entrepreneurs, emerging start-ups, and established companies. Realizing and sustaining this vision requires a next-generation workforce that cross-cuts engineering, data science, social science, and policy. CS3 will leverage shared, day-to-day streetscape experiences to attract students from diverse disciplines and backgrounds to engage in the emerging discipline of smart cities. Built on the four closely integrated foundational elements of NSF's ERC program–Research, Engineering Workforce Development, Diversity

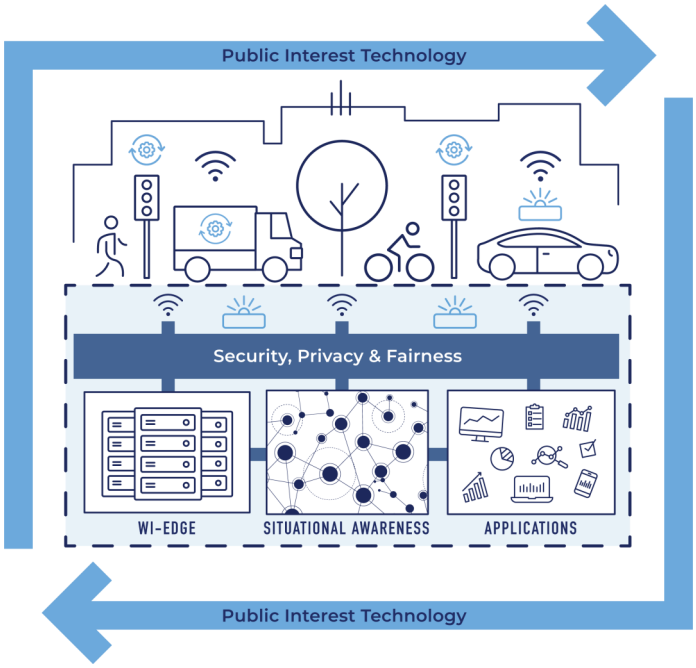
COSMOS educational platform and accompanying toolkit for K-12 students to learn STEM subjects including experiments related to wireless networks. Frederick Douglas Academy I, Harlem, NY. (Credit: Jane Nisselson, Columbia Engineering)

and Culture of Inclusion, and Innovation Ecosystem–CS3's work has the potential to redefine America's streetscapes by applying a digital layer over physical urban infrastructure, ensuring that America's cities meet the needs of local communities and that the technologies being adopted take into account critical questions regarding safety, equity, privacy, and security.

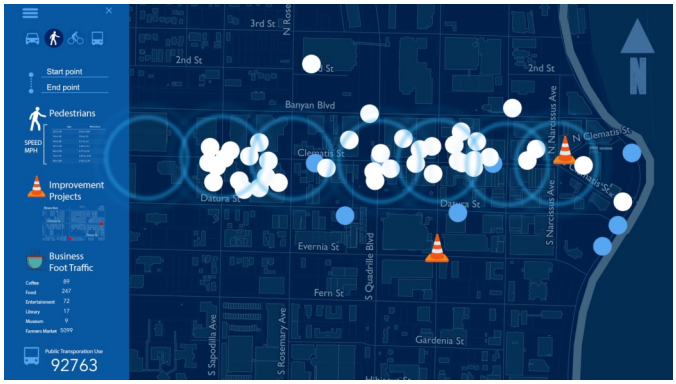
RESEARCH

CS3 will advance fundamental knowledge in civil and urban systems engineering, electrical and network engineering, visual analytics and sensor fusion, computer privacy and security, and public trust and technology–catalyzing and coalescing the emerging discipline of smart cities. CS3 will unite diverse research communities through a convergent research model that delivers innovations across five engineering and scientific areas:

- Research Thrust 1: Wi-Edge – the integration of high-speed wireless-optical networking, high-performance edge-cloud computing, and software-defined radios and networking, collectively termed "Wi-Edge." The work is motivated by Thrust 2-5 requirements for ultra-low latency and ultra-high bandwidth data streaming from high data-rate sensors to high-performance analytics infrastructure, in ways that protect personal privacy and community trust.



At CAIT's Visualization Lab, researchers analyze mobility data collected from roadside sensors. Center for Advanced Infrastructure and Transportation (CAIT) at Rutgers, The State University of New Jersey. (Credit: CS3)



West Palm Beach Mobility Intelligence Testbed smart streetscape technologies. (Credit: Florida Atlantic University's Institute for Sensing and Embedded Network Systems Engineering (I-SENSE) and College of Engineering and Computer Science)

- Research Thrust 2: Situational Awareness – fine-scale, real-time observation, modeling, and forecasting of human behavior over variable time horizons at streetscape scales. Focus on overcoming fundamental knowledge gaps in visual analytics, including advances in multi-object detection and tracking, relationship detection, multi-scale activity detection, and object re-identification.
- Research Thrust 3: Security, Privacy & Fairness – addressing socio-technical barriers of privacy and security within locally intelligent streetscapes, yielding a software pipeline for streetscape applications that gives community-configurable guarantees of privacy, fairness, and transparency. This is motivated by the recognition that although emerging technologies enable unprecedented public-space data collection and automation, they also pose fundamentally new privacy, security, and fairness challenges that may compromise social equity, endanger lives, or reduce the livability of our streetscapes.
- Research Thrust 4: Public Interest Technology – understanding through community participation how CS3 technologies, applications, and security/privacy policies impact the social landscape and promote regional economic development. Shaping novel social scientific research methods that can be integrated into the engineering and design of streetscape applications.
- Research Thrust 5: Streetscape Applications – focusing on the design of an application services architecture that will enable the exploration of cross-layer/thrust optimizations and support novel streetscape applications. The specific applications to be realized within our testbed cities will be identified and codified through CS3's unique co-production model, mediated by security, privacy, and fairness concerns (Thrust 3) and the goals of public interest technology (Thrust 4).

EDUCATION

CS3's engineering workforce development (EWD) objectives are to (1) develop a diverse smart streetscapes workforce by integrating convergent research with educational activities and assets, (2) broaden program participation through community engagement, and (3) create opportunities for collaborative problem-solving across disciplines.

The ERC does this by employing five main strategies. The first strategy is convergent curriculum development,

Columbia Engineering students take millimeter wave channel measurements for the COSMOS advanced wireless research testbed in West Harlem. COSMOS is a cloud-enhanced open software defined mobile wireless testbed for city-scale deployment. (Credit: Columbia Engineering)

which brings smart streetscape research into graduate and undergraduate courses across CS3 institutional partners. The second strategy is course-based undergraduate research experiences (CURE), which brings undergraduates into CS3 research by providing access to data and tools in the context of their course work. The third strategy is Research Experiences for Undergraduates (REU), including Summer Undergraduate Research Experiences (SURE), which provide undergraduates with opportunities to engage with CS3's cross-disciplinary research teams in further depth outside of their coursework. The fourth strategy, Research Experiences for Teachers (RET), engages local K-12 teachers in our testbed communities to expand pathways into smart streetscapes research. The final strategy is creating micro-credential programs, which offer a condensed educational track for students and professionals to master smart streetscape technology.

DIVERSITY AND CULTURE OF INCLUSION

CS3's diversity and culture of inclusion (DCI) objectives are to (1) create and maintain an organizational culture in which individuals representing diverse experiences, backgrounds, and communities have the opportunity to contribute their full potential to accomplish CS3's mission, and (2) ensure CS3 programs adhere to its guiding principles of developing technology to serve the public good, using community engagement for direct use-inspiration, and addressing the "digital divide."

Smart City Intersection. Vehicle and pedestrian object detection at COSMOS pilot site located at the corner of 120th street and Amsterdam Avenue, New York City. (Credit: Zoran Kostic, Columbia Engineering)

CS3's DCI program employs four main strategies. First is the development of a Code of Conduct and Equity Resource Team, which assists leadership and participants in adhering to CS3's values. The second strategy is having a robust diversity and inclusion assessment as part of the evaluation process, which helps identify areas of opportunity for training and knowledge sharing. CS3's third strategy is diversity seed funding, which allows testbed community members to fund selected research, education, and innovation projects that support CS3's mission. The fourth strategy is community outreach and engagement to help set the agenda for all CS3 research, education, and innovation activities. Finally, CS3 has a youth researcher engagement program to broaden participation by funding K-12 and undergraduate students within our testbed communities to participate in our research programs.

INNOVATION ECOSYSTEM

CS3's innovation ecosystem (IE) objectives are to (1) build a robust IE allowing development and commercialization of smart city innovations by diverse stakeholders (communities, academic, industry, public sector), and (2) accelerate transition of smart city innovations from academic environment to the marketplace in a way that positively impacts communities.

The IE program employs four main strategies, starting with training and cohort formation in an accelerator program. This accelerator program creates validation and venture tracks for teams to facilitate smart streetscapes

technology translation. The second strategy is awarding innovation seed grants to attract a broad array of teams to participate in the accelerator program. The third strategy is to partner across our institutions and industry members to organize innovation summits, which highlight the work of teams completing the accelerator program. The fourth strategy is integrating diversity and inclusion into commercialization and entrepreneurship programs through mentoring and internships for students representing a diverse set of backgrounds and disciplines. CS3 will develop and implement these strategies with its broad network of large and small private, public, nonprofit, and international stakeholders.

FACILITIES

In addition to the laboratory and testing facilities across the core partner institutions, CS3 leverages three notable recent investments in real-world urban testbed infrastructure. These testbeds are in very different, yet complementary, urban settings and emphasize different core technologies and application areas being explored.

1. **West Harlem, New York – Beyond-5G urban wireless communications testbed (COSMOS)** NSF and industry consortium funded. An FCC Innovation Zone.
2. **West Palm Beach, Florida – Pedestrian and micromobility intelligence testbed** City of Palm Beach, Knight Foundation, and Community Foundation of Palm Beach and Martin Counties.
3. **New Brunswick, New Jersey – Connected & automated vehicle proving ground (Smart Mobility Testing Ground)** New Jersey DOT (prime: USDOT) funded.

CS3 is headquartered in a recently renovated space at the Columbia Innovation Hub in West Harlem, opposite Columbia's new Manhattanville Campus and immediately adjacent to the COSMOS testbed. The space includes a 70-person capacity reconfigurable workshop and meeting space.

CENTER CONFIGURATION, LEADERSHIP, TEAM STRUCTURE

The Leadership Team (LT), chaired by the Director, includes the two Deputy Directors and the Managing Director (MD) and is responsible for the Center's visioning, demonstrating, and fostering a culture of inclusion, budgeting and overall decision-making. The LT consults with the Executive Committee (ExCom) on a monthly basis to review, develop and approve Center-wide activities, project plans, milestones, and objectives over near and long-term time horizons. The ExCom evaluates progress and operations and provides feedback and recommendations to the LT. The LT interacts directly, primarily through the Director, with NSF ERC Staff in their management and oversight capacity and with a Director's Council in their advisory capacity. The Executive Committee also periodically includes the Student Leadership Council Chair in its meetings. CS3 contains several subcommittees and boards. Their activities are driven by priorities set by the Leadership Team and the Executive Committee, and they also continuously provide feedback to facilitate the management of convergence.

CENTER HEADQUARTERS

Columbia Engineering Innovation Hub
2276 12th Ave, New York, NY 10027

https://cs3-erc.org/

streetscapes@columbia.edu

Key Contacts:

Center Director: Andrew Smyth

Managing Director: Olivia Moore

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