UF DCP Research Agenda-Setting White Paper

Developing Digital Twin Methodologies For Smart Cities

Executive Summary:

This white paper proposes developing a scalable methodology for implementing Digital Twin (DT) technologies as a foundational infrastructure for Smart Cities. While Digital Twins—real-time, data-connected virtual representations of physical systems—are rapidly transforming industries such as manufacturing and aerospace, their application in the built environment remains fragmented and underdeveloped. By leveraging BIM, GIS, IoT technologies, and Machine Learning (ML), this project aims to establish an integrated framework to transition from BIM or GIS 3D to full Digital Twin deployment. Through case studies including the DCP Collaboratory, the University of Florida Campus and the City of Jasonville—we will test data-driven protocols that enable predictive analytics, real-time monitoring, and user-responsive management of urban infrastructure. This research will produce a replicable methodology for Smart Cities that supports sustainable planning, efficient operations, and human-centered services. Outputs will include the development of data harmonization protocols, ML-based predictive tools, and open guidelines for scalable DT adoption in Smart Cities.

WG Members:

Name	Title	Affiliation	Academia/ Industry/ Government
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Description of the Problem

As cities become increasingly complex and data-driven, the need for real-time monitoring, predictive analysis, and cross-system integration is paramount. However, current implementations of Digital Twins in the built environment lack scalability, data interoperability, and standardized methodologies.

Key Research Areas / Priorities

- Transitioning from BIM to DT frameworks for city-scale infrastructure
- Integration of IoT for real-time data flow and environmental sensing
- ML-based forecasting for energy efficiency and operational performance
- Digital platforms for urban-scale simulation and decision-making

Primary Research Question

1. What data and modeling protocols are necessary to scale DTs from individual buildings to city-wide applications?
2. How can real-time data streams (from sensors, occupancy, energy, etc.) be efficiently integrated and visualized?
3. What platform architectures support secure, interoperable, and user-friendly Smart City DTs?
4. How can predictive ML algorithms be customized for urban-scale energy, O&M, and climate resilience?

Solutions and Methodological Considerations

This project will begin with a comparative review of Digital Twin platforms and their capacity to scale from building-level applications to smart city systems. We will characterize and prioritize critical urban data—from energy use to occupancy, infrastructure condition, and environmental monitoring—by developing a comprehensive Data Management Plan and architecture. Using real-world case studies, we will build DT prototypes and test their ability to support decision-making in building operations, maintenance, and energy performance and emergency response. Open-source ML algorithms will be trained to simulate and predict building behavior, with use cases informing smart urban responses. A platform selection matrix will guide stakeholders in choosing the most appropriate DT tools for their context. Usability testing and stakeholder feedback will help refine these tools and create a final set of DT guidelines, focusing on integration, interoperability, and human-centered design.

WG's Strengths, Weaknesses, Opportunities, and Challenges:

Strengths	• Interdisciplinary expertise across AI, urban design, BIM, and systems engineering • Strong institutional and industry partnerships (NVIDIA, Siemens, Autodesk) • Access to active construction and remodeling projects on campus	• Limited current real-world examples of full-scale DT implementation in academia • Limited precedent for fully integrated Smart City DTs in academic contexts • Managing integration across different platform standards and legacy systems	Weakness
Opportunities	• Develop a pioneering, scalable DT protocol for university campuses • Inform national standards and guidelines for DT implementation • Use DTs for proactive maintenance, energy optimization, and smart campus strategies	• Harmonizing city-scale data standards, regulations, and privacy constraints • Ensuring privacy, security, and ethical data use within a campus-wide system • Long-term sustainability and maintenance of digital twin systems	Challenges