As we emerge from a tragic pandemic, let's catalyze action among professionals in the fields that shape the physical housing and communities where we live. This series of case studies shares innovations that are advancing a set of **guiding principles** for built environment professionals–from creative ways to redress inequities and engage the public in participatory planning, to unique housing and community models that enable every resident to thrive.

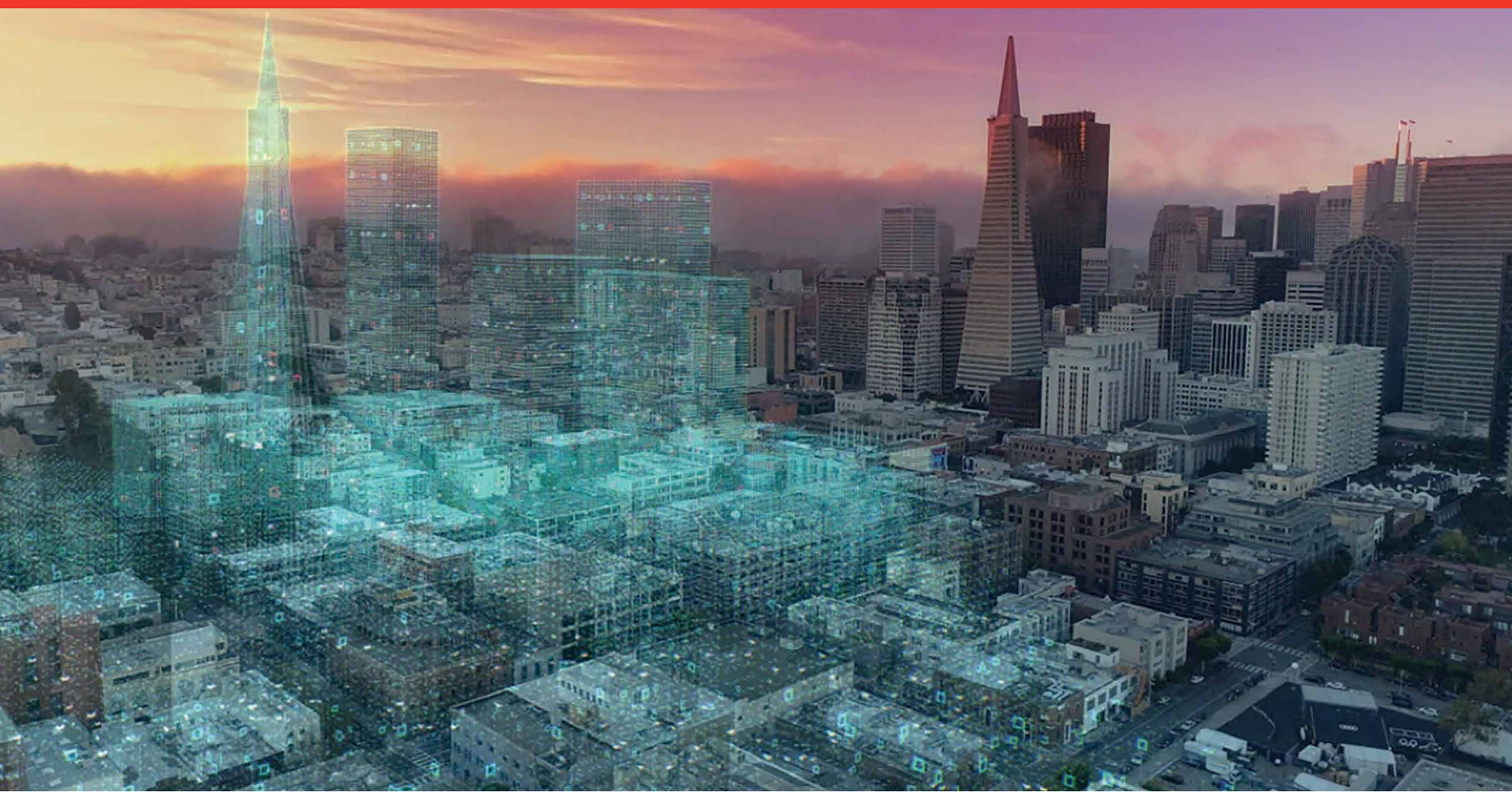


Photo: Integrated Environmental Solutions

Digital Twin Cities for All: Inclusive Virtual City Planning

By Stephanie Firestone and Anita Weaver

"Digital twin cities" (DTC), which use a variety of technologies including artificial intelligence (AI) to create real-time models of cities, are poised to revolutionize the way cities are planned. By utilizing the exponentially growing availability of real-time data, DTC models can guide city growth and development. Yet, practitioners advancing DTC projects must take active measures to include populations that have traditionally been excluded and often harmed through city planning models and their execution in the real world. This includes addressing the needs of older people in both the product and its development process, to ensure that DTC models reflect equitable visions of what cities can provide their diverse constituents.

Needs/Challenges

"**Digital twins**" are virtual representations of objects, processes, or systems in the physical world and have become popular in sectors from manufacturing to health and urban planning. In recent years, the concept of "digital twin cities" (DTC) has been framed as a transformative advance in city planning.

Humans have a long **history of constructing models of cities** in order to better understand, manage, and engage with complex physical environments. From meticulously crafted scale replicas to early 3D computer simulations, models have often served to represent idealized visions of a bright future as well as to function as practical tools for analyzing and modifying the urban built environment. In the digital era, DTCs are a recent and technologically advanced tool for modeling cities. DTC projects create accurate, real-time, authentic virtual replicas of urban environments, promising to revolutionize the way that cities are managed, experienced, and evolve into the future.

Still, there are challenges that must be met to ensure DTCs are used in a responsible, equitable manner that avoids repeating past mistakes and perpetuating discriminatory practices. It is critical to ensure that groups of people discriminated against are included in discussions about a DTC project's vision and goals so that their data are included, concerns about surveillance and the weaponization of data are addressed, and needs are met. Historical models of cities often reflected the goals and visions of elite stakeholders and decision-makers, excluding the needs and desires of a diverse populace and resulting in great disparities. For example, during the urban renewal era of the mid-20th century, scale models of cities were frequently promoted as visions of a future free of "blight" (often referencing the places where low-income people or people of color lived); decisions based on these models displaced many residents and razed neighborhoods or split them through highways, leaving them isolated from the broader urban fabric.

As populations age, it is also critical to ensure older adults are fully represented in city modeling projects. This includes avoiding the representation of older people as a homogenous group. Statistical data collection frequently enforces an "age cap" and excludes individuals aged 65 and over, or alternatively aggregates data into a singular, overly generalized "age 65 and older" category.[1] Silvia Urra Uriarte of Tecnalia, who was interviewed for this case study, stresses that disaggregating the data into multiple age ranges allows for more precise insights and addresses the varied needs within each age group. For example, DTCs must consider the mobility limitations that some older adults experience while walking in urban settings, challenges of cognition in the physical realm, and even heightened concerns about safety and privacy. Additionally, in order to develop inclusive, user-centric, and empathic solutions, DTCs must also overcome access and digital skills gaps in the model-development process. Ultimately, Digital Twin Cities must center the needs of people of all ages and abilities, such that their interactions are used to inform the urban built environment.

Innovations

The DTC market is booming. The **2022 World Economic Forum's Digital Twin Cities: Framework and Global Practices Insight Report**, a comprehensive study on the concept, value, practice, and challenges of digital twin cities, reports that the DTC market has a projected global value of $48.2 billion. Furthermore, the technology market research firm ABI predicts that by **2025 DTC deployments will exceed 500**.

[1] The United Nations Statistical Commission created the **Titchfield Group on Aging-related Statistics and Age-Disaggregated Data** to address these issues.

DTCs for Built Environment Professions

DTCs enable built environment professionals to work with an integrated model to drive better decision-making, improve operational efficiency and resource allocation, and potentially drive down costs. Through tools including AI-powered internet-connected sensors, advanced video analytics and satellite data, and smart technologies, DTCs use continually analyzed and calibrated real-time data to virtually model cities and their complex, dynamic ecosystems. By recreating real-life situations, DTCs are a tool for guiding the growth and development of cities. DTCs are used to identify and solve urban problems and shape the physical urban fabric by simulating intricate, what-if scenarios and predicting future outcomes.

Artificial Intelligence (AI) must be deployed responsibly to ensure that it brings significant and equitable benefits while ensuring fairness, transparency, and accountability. Algorithmic decision tools should be tested to ensure that they produce unbiased, accurate and reliable results. Data and documentation should be retained to allow for meaningful review of decisions. Processes and results should be transparent and accountable to consumers, with strong data privacy and security safeguards.

Some DTC Use Cases for Built Environment Professionals

Architecture, Engineering, Construction Professionals

- Complex designs & models
- Smart sensor integration
- Enhanced material selection
- Data-driven decision making

Urban Planners

- Dynamic & sustainable land use practices
- Streamlined planning workflows
- Enhanced infrastructure management & maintenance
- Improved community outreach & participation

Transportation Planners

- Mobility network analysis & optimization
- Emissions monitoring
- Enhance road safety

Developers

- Complex site & impact analysis
- Virtual tours
- Enhanced stakeholder participation

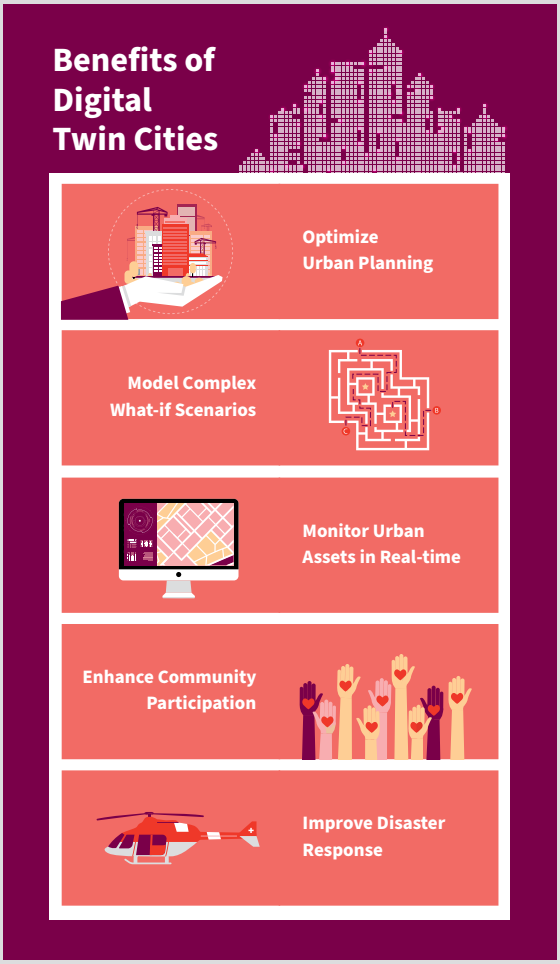
Community

- Enhanced local decision-making
- Improved outreach & engagement
- Access to real-time data & issue reporting
- Enables enhanced oversight of planning decisions

DTCs also simulate the interactions between people and public spaces, such as how pedestrians use streets and crosswalks. And the technology also enhances citizen participation, for example, by allowing people to report city infrastructure maintenance issues. By harnessing the power of real-time data collection, predictive analytics, and AI-driven machine learning, DTCs offer a potential sea change in long-term planning from the traditional static modeling to a nimble, dynamic system that better informs decision-making.

The nomenclatures "Smart City" and "Digital Twin City" are often used interchangeably, but while there is a lack of standardization regarding the definition and use of either phrase, they are not the same. One way to conceptualize the difference is to think of smart city technologies–such as AI-powered sensors, satellite data, and video analytics–as components that integrate with and supply data to digital twin cities. DTCs, on the other hand, are integrated, real-time, comprehensive virtual "copies" of a city. DTCs can show how traffic moves along roads, how much electricity is being used, how clean (or polluted) the air is, and even how noisy or hot an area might be.

With the recent surge of DTC projects and the surrounding excitement, it's critical that these technologically driven models that inform city planning do not perpetuate historical biases. DTCs must intentionally and thoughtfully include and address the needs of older people and other groups that have not been sufficiently represented, so that they can equitably benefit from the unprecedented insights and innovative urban planning actions and interventions that the technology promises.



Inclusive Models

URBANAGE

Launched in 2021, the **URBANAGE project** is a European consortium composed of cities and experts from technology, academia, and civil society. Funded through the European Union's **Horizon 2020** research and innovation programme, URBANAGE is developing a digital ecosystem to help urban planners and city managers adapt to increasingly aging populations while involving older people in the decision-making process.

Through the participation of organizations such as **AGE Platform Europe** and **Tecnalia**, URBANAGE embarked on three pilot cases focused on developing new, data-driven technologies–utilizing a combination of digital twins, big data analytics, and AI-powered modeling and simulation–to help cities become more inclusive and age-friendly. URBANAGE's **Digital Twin City** platform implements a virtual replica as a means to model and plan cities and their infrastructure in ways that support older people to age well in their cities, promoting healthy and active aging. Each of the three pilot city cases involved a collaborative, workshop-based participatory approach that included older adults, urban planners, and city officials.

In the Helsinki, Finland pilot, older adults identified hidden accessibility issues that impacted their ability to navigate their neighborhoods with ease. URBANAGE equipped older adults with wearable **Internet of Things** (IoT) devices for using a virtual, browser-based map service which allowed them to report barriers. The collected data was integrated into a mapping layer and a dashboard, allowing users who access the platform to identify where there are specific built environment challenges in particular neighborhoods.

URBANAGE's goals for the Flanders region of Belgium included developing a Green Comfort Index and accompanying visualization map. This AI-powered project helps older adults who want to find comfortable areas of the city to help escape the urban heat island effect. It also notifies them about the locations of nearby accessible restrooms outside the home, which is key to supporting older persons' going out and participating in their communities.

In the city of Santander, located along Spain's northern coast, URBANAGE developed an Age Friendliness Neighborhood Index. Variables such as street infrastructure condition, obstacles, the availability of urban furniture, and noise and temperature levels were integrated with an **Open Street Map**-based mapping layer to provide a visualization of the age-friendliness of each of the city's neighborhoods through a Digital Twin (DT). The DT also includes a simulation tool that can be used to predict how changes in the variables will impact an area's age-friendliness.

URBANAGE has developed a detailed roadmap with practical advice on how to better understand and identify the needs and challenges faced by older adults to ensure that technology projects such as digital twins are inclusive of their needs. These **guidelines** provide advice on creating citizen engagement strategies that foster the inclusion of older adults.

Photo: Flanders

Photo: Santander

Informative Models from Around the World

An **innovative, small-sample study in Sweden** demonstrated that the digital twin environment was a useful model for evaluating older people's emotional experiences to physical environments. The study explored how older adults could emotionally connect with these virtual urban landscapes, in order to realize the full potential of DTCs in the context of developing empathetic, inclusive, and user-centric solutions. Researchers compared older adults' reactions to a digital model of a care home, to their reactions to a brick-and-mortar care facility and found the emotional reactions of the participants were virtually identical. This result holds promise for the design and development of more age-inclusive and emotionally responsive Digital Twin Cities.

Another innovative study focused on the intersection of digital twins and age employed the Digital Twin City model of Dublin to examine how curb heights affect walkability, particularly for older adults. Using simulations powered by the Unity game engine and heatmaps categorized by different demographic groups, the research identified areas where curb heights pose a risk of falls. The findings confirmed that the Dublin DTC could be used to effectively evaluate factors that negatively impact walkability.

As part of the **Cooling Singapore Digital Urban Climate Twin (DUCT) project**, **Prof. Winston Chow and his team set off on a "heat walk"** of downtown Singapore, since older people are especially vulnerable to high heat and humidity. The research team was joined by a group of volunteers outfitted with wearable biometric devices to capture their heart rates and skin temperatures. The project's goal is to help policymakers analyze and model heat mitigation methods before committing financial and human resources to developing solutions that might not be effective.

In another example of how digital twins can enhance extreme weather event planning, **RUNWITHIT Synthetics (RWI)**, in collaboration with the Tennessee Valley Authority (TVA) and the Electric Power Research Institute (EPRI), the City of Nashville, and Nashville Electric Service (NES) recently studied community impacts from hypothetical, high-risk cold snap events. The Synthetic Nashville project digitally simulated cold snaps (and related intermittent power outages) by modeling the city's energy infrastructure, built environment and population. According to RWI's CEO and Founder Myrna Bittner, the focus was on vulnerable populations including older people, who are often more susceptible to the cold, have greater mobility challenges that limit access to community warming centers, and are more energy-dependent for medical needs such as refrigeration of medications. The aim is for Synthetic Nashville to help the city identify vulnerable areas in order to mitigate risks, improve community resilience, and inform future planning.

Photo: Sythetic Nashville

Finally, the City of Long Beach, California is integrating the needs and concerns of older adults into its leading-edge **Smart City Initiative**. While not explicitly part of a broader digital twin city project at this time, the smart city technologies adopted by Long Beach also aim to enhance urban infrastructures and services. Long Beach's **Smart City Initiative Strategic Plan** emphasizes equity, accessibility, and inclusivity, ensuring technology benefits all, especially people of color, immigrants, low-income households, and older adults. The city has collaborated with the **Long Beach Gray Panthers** and conducted focus groups at senior centers to gather feedback about Smart City programs. This feedback highlighted the importance of digital inclusion and the desire for older adults to benefit from smart technologies. Older residents have also voiced a need for guidance on digital privacy and cybersecurity, especially concerning data collected by the city. The city is documenting its pilot Smart City projects and plans to showcase them on a dedicated website dashboard in the future. Some of the projects in development include an AI chatbot for the city's website and implementing safety features in Silverado Park such as smart lighting and emergency call buttons.

Replicability

As growing numbers of built environment professionals are actively participating in the design, development, and implementation of DTC projects, it is critical that virtual urban systems reflect the diverse needs of all their inhabitants. Some ways that DTC project development can ensure the participation of older adults in its various phases include:

- Incorporate strong data privacy and security protections.
- Create opportunities for open, inclusive, accessible, and meaningful citizen participation in planning and designing DTC outreach and public engagement to support the inclusion of older adult voices and their lived experiences.
- Design interactive technologies (e.g., wearable sensors, mixed reality interfaces, virtual simulations) that integrate physically and cognitively accessible user interfaces and are accessible to older adults of differing abilities and socioeconomic backgrounds.
- Support heterogeneity within the older adult population, considering the nuanced distinctions, unique experiences, and diverse needs within this demographic.
- Ensure predictive and algorithmic analytics are deployed responsibly to ensure fairness, transparency, and accountability for all populations, including by testing the data and algorithm for potential bias.
- Provide stakeholder access to collected data and models.

It is important to stress that built environment professionals managing a DTC process employ tools that are intentionally age-inclusive, i.e., through focus groups, training sessions and workshops, maps, surveys, interviews, and neighborhood walks. Partnering with trusted community organizations such as senior centers and local community groups that center older adults can be instrumental in driving engagement for DTC projects and provide comfortable, familiar, and supportive settings for participatory activities. It is equally important that this engagement extends beyond the initial phases of a DTC project and that it integrates regular feedback loops post-implementation, allowing older adults to provide comments, ask questions, and receive prompt responses.

In this era of breathtakingly rapid change in which the digital world is increasingly merging with the physical one, we cannot risk repeating the mistakes of the past that often resulted in unsafe conditions, leaving older adults socially isolated from their communities and society. Built environment professionals should tap the invaluable insights, wisdom, creativity, and lived experiences of the diverse older adult population. Full representation of older adults must extend beyond simply capturing older adults' demographic statistical data; this must include providing older adults with the agency and knowledge to participate collaboratively and effectively in the design, testing and validation, and evaluation phases of these innovative and complex digital initiatives. Including diverse older adults and their perspectives in this way will create inclusive, innovative, and successful Digital Twin Cities that lead to positive and uplifting transformations in their real-world counterparts.

