Synthesis Memo: specific public services urban digital twin use cases

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Research Synthesis Memo: Urban Digital Twin Use Cases in Public Services

Overview

Urban Digital Twins (UDTs) represent a transformative technological advancement, offering dynamic, virtual replicas of urban environments that integrate real-time data to support a wide array of public services and city management functions (Apeldoorn2025, chunk_97), (WEF2022, chunk_69). These digital counterparts of physical cities enable enhanced planning, operation, and maintenance across various domains (WEF2022, chunk_95), (WEF2022, chunk_96). Among the collected cases, public services or management stands out as the foremost application scenario in digital twin city construction, accounting for 55.6% of implementations (WEF2022, chunk_70). Other significant application areas include community development (44.4%) and intelligent buildings (40.7%) (WEF2022, chunk_70). The diverse landscape of UDT applications spans critical areas such as transportation, environmental management, disaster response, urban planning, and governance (Wu2024, chunk_27). This memo synthesizes the specific public service use cases identified in the provided evidence, highlighting their practical implications and outlining areas requiring further investigation.

Key Findings

Urban Digital Twins are actively being deployed across numerous public service sectors, demonstrating their utility in improving efficiency, sustainability, and citizen welfare. The specific use cases supported by the evidence can be categorized as follows:

1. Comprehensive City Management and Planning:

Urban Digital Twins serve as foundational platforms for holistic city management and strategic planning. They enable the digital supervision of the entire life cycle of a city, encompassing planning, construction, management, use, and maintenance (WEF2022, chunk_95), (WEF2022, chunk_96). This comprehensive oversight is exemplified by the Xiong'an New Area in China, which utilizes a Building Information Modeling (BIM) management platform for this purpose (WEF2022, chunk_95), (WEF2022, chunk_96). Furthermore, UDTs facilitate comprehensive and systematic advance planning and design, which helps prevent costly and disruptive demolitions that often result from problematic construction (WEF2022, chunk_69). A core function of UDTs in this domain is the provision of a 3-Dimensional visualization of the city or region, which aids in understanding complex urban dynamics (Apeldoorn2025, chunk_97).

2. Infrastructure and Transportation Management:

A significant portion of digital twin practices, particularly in China, is related to smart transportation, accounting for 54% of such applications (WEF2022, chunk_70). Specific examples include the use of digital twin technology in metro planning and construction in Rennes, France, which has led to significant reductions in construction costs (WEF2022, chunk_96), (WEF2022, chunk_95). UDTs also support infrastructure builders in New South Wales, Australia, by enabling sound digital planning decisions before project implementation, thereby promoting regional economic development (WEF2022, chunk_96). For ongoing urban operations, digital twins are applied in urban traffic management, as demonstrated by Kunming, China, which leverages traffic databases for this purpose (WEF2022, chunk_96). Beyond traditional infrastructure, digital twin technology has been applied to specialized facilities like the Mawan Smart Port in Shenzhen, China, indicating its role in managing critical logistical hubs (WEF2022, chunk_96).

3. Environmental Management and Sustainability:

Globally, over 40% of digital twin practices focus on environmental and low-carbon development, highlighting a strong emphasis on sustainability (WEF2022, chunk_70). Cities such as Orlando, New York City, and Sydney utilize digital twin technology to monitor energy consumption and economic returns, directly supporting low-carbon development initiatives (WEF2022, chunk_70). UDTs contribute to the low-carbon transformation and liveability of cities by simulating light and shadow intensity, optimizing urban lighting to achieve a balance between safety requirements and energy-saving targets (WEF2022, chunk_69). Urban planners can further refine the use, operation, and maintenance of energy systems, record the city’s carbon trajectory, and actively promote carbon neutrality using these technologies (WEF2022, chunk_69). The city of New Mexico, USA, for instance, has leveraged its digital twin to work towards a cleaner city and reduce carbon emissions (WEF2022, chunk_95).

4. Public Safety and Urban Resilience:

Urban Digital Twins play a crucial role in enhancing the resilience of urban areas against various adversities, including natural disasters and pandemics (Apeldoorn2025, chunk_97). This capability was demonstrated in Georgetown, Malaysia, where a digital twin city was used to mitigate the impact of the COVID-19 pandemic and support urban economic recovery (WEF2022, chunk_95). More broadly, digital twin technology is capable of protecting citizens’ personal safety (WEF2022, chunk_41) and can monitor and predict the movement of people, places, and objects within the city, enabling proactive and comprehensive advance planning (WEF2022, chunk_69).

5. Social Services and Community Development:

Digital twin technology extends its reach into community development, representing 44.4% of digital twin city construction scenarios (WEF2022, chunk_70). In China, 31% of digital twin practices are related to smart communities (WEF2022, chunk_70). Beyond infrastructure, UDTs enhance the quality of life for residents by enabling customized services in key social sectors (WEF2022, chunk_41). Digital twin hospitals, classrooms, and nursing homes are envisioned to provide full-range, full-time, customized, and follow-up services for individuals, thereby optimizing their experiences and contributing to citizens' sense of happiness (WEF2022, chunk_41).

Where Sources Disagree

The provided sources generally complement each other by offering different perspectives on UDT use cases, ranging from broad classifications to specific city examples. There are no direct factual disagreements regarding the existence or application of specific public service use cases. However, one source highlights a pertinent challenge related to the organization and communication of these use cases: the need for standardized terminology (Wu2024, chunk_27). Wu et al. (2024) note that various studies delineate unique use cases for different domains, such as transportation, environment & energy, disaster response, planning & design, management & operation, urban operations, governance, urban design, and architecture, construction, and engineering (ACE) (Wu2024, chunk_27). While these categories are broadly consistent with the more specific examples provided by WEF2022, the lack of a uniform set of use cases or standardized terminology across different research and implementation efforts underscores a challenge for cross-domain communication and collaboration (Wu2024, chunk_27). This suggests that while UDTs are being applied in similar areas, the way these applications are named, classified, and communicated can vary.

Practical Implications

The widespread adoption of Urban Digital Twins in public services carries several significant practical implications for urban governance and citizen welfare. Primarily, UDTs significantly enhance the efficiency and rationality of resource use within cities (WEF2022, chunk_41). By facilitating sound digital planning decisions and enabling comprehensive supervision throughout the city's life cycle, they can reduce construction costs and prevent problematic developments, thereby optimizing public spending (WEF2022, chunk_96), (WEF2022, chunk_69).

Furthermore, UDTs are instrumental in advancing urban sustainability goals. They allow for precise monitoring of energy consumption, optimization of urban systems like lighting for energy efficiency, and detailed tracking of carbon trajectories, directly contributing to low-carbon transformation and carbon neutrality efforts (WEF2022, chunk_70), (WEF2022, chunk_69), (WEF2022, chunk_95). This capability supports environmental protection and helps cities meet ambitious climate targets.

From a public safety and resilience perspective, UDTs offer critical tools for mitigating the impact of various crises, including natural disasters and pandemics (Apeldoorn2025, chunk_97), (WEF2022, chunk_95). Their ability to monitor and predict urban phenomena helps protect citizens' personal safety through proactive planning and response mechanisms (WEF2022, chunk_69), (WEF2022, chunk_41).

Finally, UDTs have the potential to profoundly improve the quality of life for residents by enhancing the inclusiveness of cities and citizens' sense of happiness (WEF2022, chunk_41). Through customized and integrated services in areas like healthcare, education, and elder care, UDTs can provide personalized experiences and support, fostering a more responsive and citizen-centric urban environment (WEF2022, chunk_41).

However, the effective realization of these implications faces challenges. A significant hurdle is the lack of coordination between public and private organizations, alongside a lack of transparency and openness to non-experts, which can impede broader adoption and collaboration (Apeldoorn2025, chunk_97). Moreover, the absence of widely adopted best practices and use cases, coupled with difficulties in determining costs and benefits for financing, remain severe non-technical challenges that require concerted efforts (Lei2023, chunk_84).

Remaining Gaps and Next Retrieval Steps

While the evidence provides a strong foundation for understanding specific public service UDT use cases, several gaps remain that warrant further investigation to fully grasp their potential and overcome existing challenges.

1. Detailed Implementation Specifics and Success Metrics: The current evidence lists various use cases and cities, but often lacks granular details on *how* these UDTs are implemented, the specific technologies employed, and quantitative measures of their success or impact (e.g., precise cost savings, efficiency gains, environmental improvements). For instance, while metro planning in

Rennes is cited for cost reduction (WEF2022, chunk_96), specific figures or methodologies are not provided.

• Next Retrieval Step: Seek detailed case studies, technical reports, or white papers that elaborate on the implementation architectures, data sources, analytical models, and measurable outcomes (KPIs) for each public service use case.

2. Standardized Use Case Taxonomies: The observation that disparate approaches exist for classifying use cases and the highlighted need for standardized terminology (Wu2024, chunk_27) indicates a practical gap in harmonizing understanding across different initiatives.

• Next Retrieval Step: Look for research focusing on developing or evaluating standardized UDT use case taxonomies, frameworks, or best practice guides that can facilitate consistent classification and reporting.

3. Specifics of Community Development and Smart Communities: While "community development" and "smart communities" are identified as significant application scenarios (WEF2022, chunk_70), the evidence provides only high-level statements or examples related to specific facilities like hospitals or classrooms (WEF2022, chunk_41). More direct and diverse examples of how UDTs contribute to broader community engagement, local service delivery, or grassroots initiatives are less apparent.

• Next Retrieval Step: Search for case studies or reports specifically detailing UDT applications in broader community development contexts, beyond individual buildings or specialized services.

4. Financial Analysis and Cost-Benefit Studies: The challenge of "determining costs and benefits" for financing UDT projects is explicitly mentioned (Lei2023, chunk_84). The current evidence indicates benefits like cost reduction (WEF2022, chunk_96) but does not provide comprehensive financial analyses for specific public service use cases.

• Next Retrieval Step: Prioritize retrieving financial analyses, cost-benefit studies, or return-on-investment (ROI) reports related to public service UDT implementations to inform investment decisions and justify funding.

5. User Interaction and Citizen Engagement: While "user interaction is as easy as in a computer game" is highlighted as a characteristic (Apeldoorn2025, chunk_97), the evidence lacks specific examples or studies on how this ease of interaction translates into improved citizen engagement or direct public service delivery for various use cases. The mention of lack of transparency and openness to non-experts also points to a need for better understanding user interaction (Apeldoorn2025, chunk_97).

• Next Retrieval Step: Look for studies on citizen engagement platforms built on UDTs, user experience research for public services accessed via digital twins, and strategies for improving transparency and accessibility for non-expert users.

Addressing these gaps through targeted retrieval will provide a more comprehensive, actionable understanding of Urban Digital Twin applications in public services, supporting stakeholders in overcoming current implementation challenges and maximizing their transformative potential.

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