

The potential and challenges of digital twins for 15-minute cities

Lucas Van der Meer^{1,6}, Lukas Esterle², Fariya Sharmeen³, Gustav Friis⁴, Sofie Malm⁵, Christopher Stelzmüller⁶, Philip Amaral⁷, Goran Lepen⁷, Martin Loidl¹, Mario Cools^{8,9,10}

¹University of Salzburg, ²Aarhus University, ³KTH Royal Institute of Technology, ⁴Aarhus Municipality, ⁵Eskilstuna Municipality, ⁶Triply GmbH, ⁷European Cyclists' Federation, ⁸University of Liège, ⁹Hasselt University, ¹⁰KU Leuven Campus Brussels

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In recent years the 15-minute city (15mC) has received increasing attention from both researchers and practitioners as a planning paradigm that emphasises the importance of accessibility, sustainability, and human-centred urban environments. It aims to ensure citizens can access essential services within a 15-minute walk or bike ride, leading not only to a reduced dependency on motorised vehicles, but also shaping the required conditions for dense, diverse and vibrant public spaces that stimulate senses of community and belonging and benefit both the mental and physical health of inhabitants. This is a fundamentally different view than that of the smart city paradigm, in which technological innovations are seen as the core of efficient and performant urban systems. Although the 15mC differs from the smart city in being a human-centred rather than a technology-centred concept, it has been stressed that certain smart city technologies can be used as a tool to facilitate the realisation of the 15mC in real-world settings.

One of the promising technologies in this regard is the digital twin. Digital twins are dynamic virtual representations of a physical system, updated continuously through real-time data exchange. They originate from the manufacturing industry but have gained popularity in urban planning as a way to mirror the complex dynamics of a city in a virtual model. Such urban digital twins enable (semi-)automated decision making based on real-time information, as well as the simulation and evaluation of different planning scenarios.

However, urban digital twins face many challenges regarding standards and interoperability, and there are still doubts if the technology is mature enough for practical use. Furthermore, the concepts and techniques developed in the smart city context cannot simply be copied to the 15mC context, given the fundamental differences between the two. Whereas in smart cities interventions can be evaluated by predominantly objective indicators based on physical laws, the 15mC requires a socio-technical perspective with workflows that explicitly take subjective factors into account, such as the perceptions of people that move through the urban space and have all kinds of different experiences along the way. Therefore, there is a need to develop human-centred assessment frameworks (e.g. for accessibility, walkability and bikeability) inside the digital twin that align with the specific goals and characteristics of the 15mC. The 15mC also puts strong emphasis on citizen engagement and participatory planning. The digital twin framework should facilitate this by interactively involving multiple stakeholders in all phases, including data collection, scenario formulation, and evaluation.

In this paper, we explore in more detail the potential of digital twin technology for the 15mC. We provide an overview of the state-of-the-art, describe how the technology could be tailored to the specific goals

and characteristics of the 15mC, list important challenges that need to be addressed, and formulate general directions for future research.

This work is part of the DUT-funded CITWIN project that aims to develop a generic digital twin framework tailored to the 15mC. The digital twin will replicate the urban transport environment and allow for the design, simulation and evaluation of sustainable transport policies within the 15mC context. The project takes an interdisciplinary approach combining data science, engineering, planning, and social sciences. It will integrate data from various sources, including big quantitative sensory data and qualitative human perception assessments. Two middle-size European cities, Aarhus in Denmark and Eskilstuna in Sweden, serve as urban living labs, providing real-world contexts for the digital twin prototypes. Both cities emphasise citizen engagement, aligning with the 15mC's participatory planning approach. Besides that, the focus is on ensuring generalisability, flexibility, and compliance with existing 15mC planning practices.

All in all, we describe a promising approach to support the practical implementation of the 15mC, leveraging the potential of digital twins in urban planning. We underpin the importance of human-centred assessment frameworks, participatory planning approaches, and interdisciplinary research, on the way to more sustainable, accessible, and liveable urban environments for the future.

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