Integrating Walkability, Dependability, and Cybersecurity for Inclusive Smart Cities

Maurizio Giacobbe[†], Salvatore Distefano[†‡], Antonio Puliafito[*‡]

[*]Department of Engineering, University of Messina, Messina, Italy

[†]Dept. of Math., Computer, Physical and Earth Sciences, University of Messina, Messina, Italy

[‡]Consorzio Interuniversitario Nazionale per l'Informatica (CINI), Rome, Italy

{mgiacobbe, sdistefano, apuliafito}@unime.it
ORCID: 0000-0001-6178-7132 (Giacobbe), 0000-0002-2752-626X (Distefano), 0000-0003-0385-2711 (Puliafito)

***Abstract*—This paper offers a concise overview of how secure and dependable Cyber-Physical Systems (CPSs) can enhance accessibility in smart cities for people with disabilities. By ensuring reliability and protection against cyber threats, such systems support inclusive mobility and interaction with urban environments. The discussion highlights core challenges and outlines key enablers, with the aim of educating the design of equitable and inclusive smart city infrastructures.**

***Index Terms*—accessibility, cyber-physical systems (CPSs), cybersecurity, dependability, resiliency, smart cities, walkability**

I. Introduction

The integration of walkability, dependability, and cybersecurity can improve accessibility and inclusion within smart cities, particularly for people with disabilities. As urban environments increasingly rely on Cyber-Physical Systems (CPSs), ensuring these systems are both reliable and secure becomes essential for fostering accessible mobility solutions. This overview emphasizes the critical role of reliable and secure systems in supporting inclusive urban spaces, highlighting the significance of digital infrastructure in modern walkability. Although walkability has traditionally been a measure of physical infrastructure, in smart cities it is closely tied to the reliability of digital systems such as smart crosswalks, real-time navigation apps, and sensor-driven safety measures. Dependable systems ensure the consistent performance of these technologies, while cybersecurity is fundamental to protect them from external threats that could compromise their function and public trust.

II. Scenario and Related Work

A. Walkability and its importance

Walkability is essential for sustainable and healthy cities, reflecting how well an area supports walking through infrastructure, connectivity, and access to services [1], [2]. It is especially important for **older adults** and people with **disabilities**, promoting physical activity, social engagement, and independence. Assessing walkability is key to designing inclusive and resilient urban spaces [3].

A *walkable* urban system should be based on smart infrastructures (e.g., traffic lights that adjust according to the flow of pedestrian). Such systems must be dependable (never fail) and cybersecure (never be manipulated). For example, an attack on a traffic light or smart signal system can make a city less walkable and less safe. Dependability and cybersecurity therefore become technical prerequisites for digital walkability, therefore incentivizing inclusive accessability.

B. Secure and Dependable CPSs

Secure CPSs refer to integrated systems which physical processes are monitored and controlled by computer-based algorithms. Containers are essential elements for developing applications based on the microservices paradigm [4]. Dependability is the ability to deliver service that can justifiably be trusted [5], [6]. Table I synthesizes the main CPSs for visual and hearing impairments in smart cities, with dependability and cybersecurity metrics. Without cybersecurity, dependability cannot be fully achieved. Likewise, without dependable systems, walkability enhancements powered by digital infrastructure risk failure or loss of public trust.

AI-based optical sensors have been included in both visual and hearing impairment contexts due to their capability to analyze environmental factors such as crowd density and traffic flow in real time. These systems enhance situational awareness through visual interpretation and can complement traditional CPSs by improving responsiveness and safety in complex urban settings.

III. Interrelation between Walkability, Dependability, and Cybersecurity

Walkability in smart cities is only as strong as the dependability and cybersecurity of the systems that support it. The relationship between walkability, dependability, and

This work was partially supported by the European Union - Next Generation EU under the Italian National Recovery and Resilience Plan (NRRP), Mission 4, Component 2, Investment 1.3, project SecCO, CUP D33C22001300002, and project 3D-SEECSDE, CUP J33C22002810001, partnership on "SEcurity and RIghts in the CyberSpace" (PE00000014 - program "SERICS").

TABLE I
CPSs for Visual and Hearing Impairments in Smart Cities with Dependability and Cybersecurity Metrics

CPSs for Visual Impairments	**Dependability Metrics**	**Cybersecurity Metrics**
Beacon and Bluetooth Tags	High availability, resilience in real-time	Secure communication protocols (e.g., encryption)
Smart Audio Traffic Signals	Fault tolerance, reliability in signal transmission	Protection against spoofing, secure signal transmission
Tactile Pathways with Embedded Sensors	Robustness against sensor failures, fault detection	Secure sensor data communication, authentication of devices
Smart Wearable Glasses or Devices	High availability, user-friendly interface for real-time use	Secure data collection and transmission, device integrity
CPS-Based Navigation Apps for Blind	Continuous service availability, system uptime	Data privacy protection, secure location data sharing
AI-Based Optical Sensors for Crowd and Traffic Detection	Real-time environmental awareness, redundancy, responsiveness	Privacy-aware image processing, secure edge/cloud communication
CPSs for Hearing Impairments	**Dependability Metrics**	**Cybersecurity Metrics**
Smart Traffic Lights with Visual Alerts	Availability, real-time response, failover systems	Secure traffic data, protection from cyber manipulation of traffic flow
Intelligent Informational Panels	High reliability for real-time data display, availability	Protection against hacking and tampering with information content
Silent Urban Alert Systems	Redundancy, robustness in emergency situations	Secure communication channels, resilience to cyber threats
Communication Support Apps	High system availability, scalability for large user bases	Data encryption, secure app communication, user authentication
AI-Based Optical Sensors for Crowd and Traffic Detection	Visual analysis of dynamic environments, robustness to occlusions	Secure image data, anomaly detection, tamper-resistant models

cybersecurity is characterized by mutual dependencies and reinforcing feedback loops (see Figure 1).

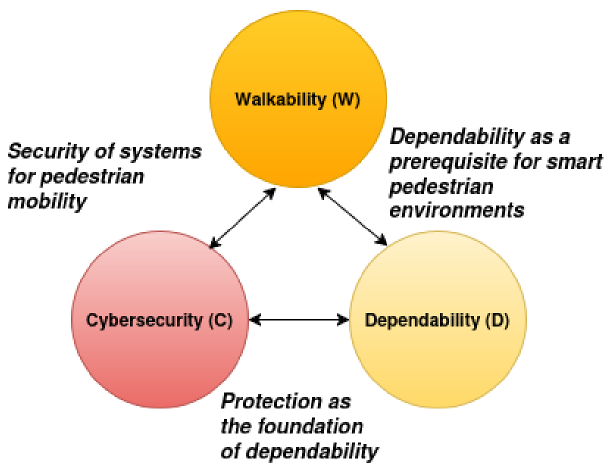

Fig. 1. Conceptual relationship between walkability, dependability, and cybersecurity.

A failure in cybersecurity (e.g., a breach or attack) can undermine the dependability of urban technologies, compromising pedestrian systems' reliability and eroding walkability. If systems lack dependability, users may lose trust, reducing the effectiveness of walkability-enhancing technologies, as public engagement is crucial. Moreover, when walkability goals are unmet (e.g., unsafe urban spaces), the perceived value of smart technologies declines, leading to reduced political and financial support, and underinvestment in both cybersecurity and dependability. This highlights the need for integrated design strategies in smart urban systems (see Algorithm 1).

Data: States of Cybersecurity (C), Dependability (D), Walkability (W)
Result: Dynamic behavior of systems in an urban environment
while C *and* D *are high* **do**
    $W \leftarrow$ Optimized;
end
if C *is compromised* **then**
    $D \leftarrow$ Reduced;
    $W \leftarrow$ Negatively Affected;
end
if D *is low* **then**
    $W \leftarrow$ Negatively Affected;
end
if C *is high and* D *is low* **then**
    $W \leftarrow$ Reduced;
end

Algorithm 1: Evolution of the conceptual model between Walkability, Dependability, and Cybersecurity

IV. Conclusion and Future Work

Secure and reliable cyberphysical systems are crucial to incentivize vulnerable populations, especially people with disabilities. In this work, we highlighted the importance of walkability as a key factor in the design of healthy and sustainable urban environments. Dependability acts as the bridge between cybersecurity and walkability. To foster inclusive, accessible, and resilient urban environments, all three elements must be co-designed. This contribution aims to provide a foundation for future research and development in the area of smart cities, focusing on how walkability, dependability, and cybersecurity can work together to create more inclusive urban environments.

References

[1] A. Rao, R. D. Nandineni, R. S. Shetty, K. Mallaiah, and G. B. Kamath, "Enhancing walkability for older adults: The role of government policies and urban design," Infrastructures, vol. 10, no. 4, p. 77, 2025. [Online]. Available: https://doi.org/10.3390/infrastructures10040077

[2] Porębska, A., Rizzi, P., Otsuki, S., and Shirotsuki, M., "Walkability and Resilience: A Qualitative Approach to Design for Risk Reduction," Sustainability, vol. 11, no. 10, p. 2878, 2019. doi: 10.3390/su11102878.

[3] A. Ramírez-Saiz, L. Baquero Larriva, D. Jiménez Martín, and A. Alonso, "Enhancing urban mobility for all: The role of universal design in supporting social inclusion for older adults and people with disabilities," Urban Science, vol. 9, no. 2, p. 46, 2025. [Online]. Available: https://doi.org/10.3390/urbansci9020046

[4] M. Giacobbe, S. Zanafi, J. A. Olana, and A. Puliafito, "SecCO-OC: Security strategies for containerized microservices architecture," in Advanced Information Networking and Applications, L. Barolli, Ed. Cham: Springer, 2025, vol. 250, Lecture Notes on Data Engineering and Communications Technologies, pp. 177–188, doi: 10.1007/978-3-031-87778-0_17

[5] J.-C. Laprie, Dependability: Basic Concepts and Terminology. Vienna, Austria: Springer, 1992

[6] L. Xing and S. Distefano, "Reliability and performance of cyber-physical systems," Reliability Engineering & System Safety, vol. 225, p. 108642, 2022, doi: 10.1016/j.ress.2022.108642.