Bridging the Normative Gap:
Standardization for Sidewalk Robots in a World of Self-Driving Cars,
Personal Robots and Automated Industrial Vehicles*

Marko Thiel¹, Noel Blunder¹, Justin Ziegenbein¹, Philipp Braun¹ and Jochen Kreutzfeldt¹

Abstract—Sidewalks are increasingly being shared by autonomous mobile robots, creating a safety-sensitive environment that lacks explicit safety-focused standards. Establishing such standards is an essential prerequisite for progressing these vehicles from the laboratory to large-scale, widespread use. This ongoing research presented here aims to fill this gap by exploring standards in related areas, assessing their applicability, and examining possible derived specifications adapted to mobile robots operating on sidewalks and similar traffic environments. As part of our methodology, we draw upon findings from the development of two delivery robot prototype vehicles and a literature review. By establishing a foundation for the design and assessment of future standard drafts, our research supports the broader adoption of mobile robots and contributes to safer urban sidewalks.

I. INTRODUCTION

Sidewalk-based mobile robots, depending on context also referred to as Sidewalk Autonomous Delivery Robots (SADR) [1] or Public Mobile Robots (PMR) [2], hold great potential to automate various aspects of public life, including last-mile transportation, food delivery, and cleaning tasks [3]–[5]. These robots navigate sidewalks, pedestrian zones, and public squares, effectively operating within public spaces and on public roads. As such, they occupy a unique position: On one hand, they resemble automated robots widely employed for industrial indoor transportation tasks such as automated guided vehicles (AGV) and autonomous mobile robots (AMR); on the other, their application environment resembles the conditions encountered by autonomous passenger cars. Furthermore, their proximity to people reveals distinct parallels to service robots and personal care robots.

Given these complexities, the use of sidewalk robots requires stringent safety measures for the vehicles, their operation, and their development processes, including verification and validation. Standards frequently serve to harmonize the representation of state-of-the-art practices across various domains [6]. This holds true for safety-related subjects as well, making such standards essential for the future widespread deployment of robots in public spaces, both from the perspectives of manufacturers as well as regulatory authorities. In addition, the establishment of clear standards would also benefit research institutions seeking to evaluate robot systems within real-world environments.

To date, only a few publications have addressed the topic of safety standards for mobile robots operating on sidewalks. Salvini, Paez-Granados, and Billard [7] examine hazards from mobile robots, providing crucial groundwork for developing necessary safety specifications. In our own previous work [8], [9], we briefly discuss the application of automotive standards to a mobile delivery robot operating on sidewalks in Germany. However, machine safety standards have also been used for similar vehicles, see for example the transport robot by SEW Eurodrive [10]. Again Salvini, Paez-Granados, and Billard [11] address a related question by examining the extent to which the ISO 13482 [12] standard for personal care robots sufficiently covers safety for bystanders and in public spaces and suggests the need for extensions in this area. Beyond that, efforts are underway to develop a standard for sidewalk vehicles that encompasses not only space management but also a part on safety considerations (ISO 4448 [44]). However, as the standard remains in the development stage, detailed information concerning the specific safety topics it addresses is not yet accessible to the public.

As a result, it is important to determine the extent to which sidewalk robots are already covered by existing standards and identify areas where further standardization may be required. Additionally, it is crucial to determine the specific adaptations or novel requirements that would be advisable for these vehicles. In the context of this contribution, we aim to offer a preliminary overview of our work on this subject, focusing on identifying standardization gaps and highlighting similarities or comparable existing regulations.

II. METHODS

Our preliminary findings originate from a practical case study (see [9], [45]) and a literature review. The case study centered on the development of two delivery robot prototypes for deployment on sidewalks in public spaces in the city of Lauenburg/Elbe, Germany. During this process, a technical inspection association (TÜV Nord Mobility) was consulted to provide guidance on the development and validation stages, utilizing automotive standards deemed most appropriate for the task at hand. The supporting literature...
environments. This applies, for example, to the design of the systems in mobile industrial robots (AGV/AMRs) provide a solid foundation for tackling safety concerns, they do not consider safety scenarios in distinct environments. Operating sidewalk robots. This is particularly important when considering safety scenarios in distinct environments. Operating vehicles (ISO 26262). In addition, there are standards featuring cybersecurity and safety of the intended functionality, emphasizing autonomous driving features in road traffic. Here a critical examination is warranted to determine if the focus on classical road vehicles, which can be significantly larger and faster, is appropriately suited for compact robots that operate at pedestrian speeds and solely transport goods. However, it appears reasonable to take into account the hazards that may arise from misuse or potentially dangerous system behavior, as described in ISO 21448.

Furthermore, initial standards explicitly addressing service and personal care robots fall short in adequately considering the unique context of sidewalks, where robots interact with pedestrians and other road users.

### IV. Summary and Outlook

It becomes evident that sidewalk mobile robots are not sufficiently addressed by current safety standards for autonomous robots or cars. The distinct application context of compact robots operating in close proximity to people and navigating within public traffic areas is not considered. Nevertheless, general methodologies for development processes and specific requirements can be derived from standards in related fields. These approaches should be incorporated into ongoing standardization efforts or employed as evaluation criteria for assessing draft standards.

### References


Intelligent transport systems - Low-speed automated driving (LSAD) systems for predefined routes - Performance requirements, system requirements and performance test procedures, ISO 22737:2021(E), 2021.
