講演番号	130

Design Approach and Structural and Functional Design for a Small Last-Mile Delivery Mobility

Mizuki Takehara [1)]

1) TOYOTA MOTOR CORPORATION Tokyo Design Laboratory
2-3 Ishikawamachi, Hachioji, Tokyo, 192-0032, Japan (E-mail: mizuki_takehara@mail.toyota.co.jp)

KEY WORDS: **other means of mobility, personal mobility, logistic robot** [F3]

This paper presents the design approach and development process of a small-scale last-mile delivery mobility proposed as a partner robot for urban residential logistics. The study was conducted within an advanced design division of a major automotive manufacturer transitioning toward a mobility-oriented enterprise. With increasing parcel demand driven by e-commerce and the labor shortage known as the “2024 logistics problem” in Japan, improving working conditions and operational efficiency in last-mile delivery has become increasingly urgent.

To address these challenges, a core concept of “ease and enjoyment” was established to reduce physical burden while enhancing the attractiveness of logistics work. Based on this concept, a logistics ecosystem named “Buddies” was proposed, in which electric commercial vehicles, delivery workers, and autonomous robots collaboratively optimize overall efficiency. The mobility functions as a complementary partner rather than a replacement for human labor.

This study focuses on a design methodology integrating functional performance and social acceptance. Analysis of robot perception in Japan identified three characteristics for acceptance: robots are seen as cooperative rather than perfect substitutes, positioned between tools and companions, and associated with emotional expression. Residential environments further require designs that minimize intimidation and harmonize with surroundings.

Based on these insights, the mobility adopts a quadruped walking mechanism for uneven terrain and narrow pathways, while reducing psychological pressure on pedestrians. The payload platform size was determined through parcel distribution analysis, enabling efficient handling of approximately 80% of deliveries, with larger items managed through human-robot collaboration. A vacuum-based suction mechanism secures cargo while maintaining a clean appearance, covered by an iris-like shutter when not in use.

The leg structure was developed using reinforcement learning simulations, followed by physical validation. A communication lighting system conveys operational status and emotional cues, enhancing intuitive interaction. The exterior design emphasizes soft, organic forms to create a friendly presence in public spaces.

The development process highlights early integration of design thinking and close collaboration with engineering. An agile approach enabled a functional mock-up within approximately one year, significantly shorter than conventional development cycles, though with limitations in long-term validation and durability testing.

Finally, while still a conceptual model, challenges remain for real-world implementation, including stable locomotion, legal and infrastructural constraints, and societal acceptance. Nevertheless, this study demonstrates a design-driven approach to next-generation last-mile delivery systems integrating functionality, human factors, and social context.

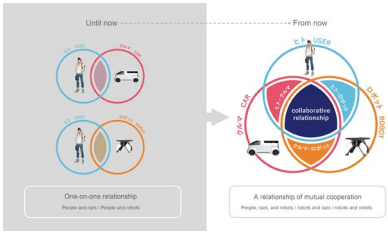

Fig.1 “Buddies” ecosystem

Fig.2 Initial sketch

Fig.3 Final design with cargo loaded