E-BOOK OF EXTENDED ABSTRACT

THE 14TH INTERNATIONAL INVENTION, INNOVATION & DESIGN COMPETITION 2025

14TH INDES 2025

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DEV (DIFABEL ELECTRIC VEHICLE) FOR WHEELCHAIR USER

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ABSTRACT

Mobility for wheelchair users remains constrained by inadequate assistive technologies and infrastructure, limiting independence and quality of life. This study presents the development of a three-wheeled electric vehicle tailored for wheelchair users, featuring an integrated foldable rear ramp (10–15° incline), a secure wheelchair locking system, and ergonomically positioned handrails for balance support. The vehicle uses a 72 V, 3 kW BLDC hub motor powered by a 72 V, 40 Ah lithium-ion battery, supported by dual braking systems and a Battery Management System (BMS). Tests showed safe operation on slopes up to 15°, a top speed of 38–40 km/h, and a range of approximately 90 km per charge and boarding time was under 60 seconds. User feedback reported high satisfaction in comfort, control, and safety. The vehicle demonstrates strong potential as an inclusive mobility solution for urban environments.

Keyword: Electric Vehicle, Disability, Wheelchair Accessibility, BLDC Motor, Inclusive Mobility

1. INTRODUCTION

The global population of individuals with disabilities has reached a significant figure, both worldwide and in Indonesia. In Indonesia, the Central Bureau of Statistics (BPS) reported that the number of persons with disabilities reached 22.5 million in 2022[1]. Among them, wheelchair users face major challenges in daily mobility due to inadequate accessibility and infrastructure that are not disability-friendly. Mobility is a crucial aspect for supporting independence and active participation in daily activities, such as commuting, shopping, or social interaction[2]. The lack of effective mobility support often leads to dependency on others and significantly reduces their independence and productivity. These limitations also have a psychological impact, including feelings of helplessness and social isolation[3]. Current conventional assistive technologies still fall short in providing full autonomy for users, highlighting the urgent need for innovative and inclusive mobility solutions.

2. METHODOLOGY

2.1 Design Specifications

The proposed electric vehicle main specifications are categorized as follows:

1. Independent Access System
   a) The rear ramp is designed with an optimal inclination (approximately 10–15°) to ensure safe and independent access for wheelchair users.
   b) Hand grips and a pull-strap mechanism are installed on the rear ramp to allow users to open and close it without assistance.

2. Propulsion and Power System
   a) Powered by a 72V, 3kW BLDC hub motor (160–300 Nm torque) with direct rear-wheel drive via throttle.
   b) Uses mechanical disc brakes and regenerative braking.
   c) 72V 40Ah lithium-ion battery supports urban range and efficient energy use.

3. Safety and Control Features
   a) Integrated BMS for thermal protection, overcurrent safety, and cell balancing, while MCB installed for short-circuit protection.
   b) Wheelchair foot-locks prevent movement during operation.
   c) Soft Start Enable feature minimizes sudden torque on start, while Speed Limit Enable caps the maximum speed at 40 km/h.
   d) Features include reverse mode and 3-speed level control.

4. Design and Ergonomics
   a) Reinforced frame supports stability on various terrains
   b) Interior optimized for 1-2 hour use with ergonomic throttle and control access
   c) Wide front and side visibility enhances user awareness

2.2 System Design

The designed system is illustrated in Figure 1 and Figure 2, which shows a detailed view of the electric vehicle prototype specifically developed for wheelchair users. The system integrates several essential components: (1) a rear-access ramp, (2) a wheelchair holder with a locking mechanism, (3) a BLDC hub motor for propulsion, and (4) a 72V lithium-ion battery for power supply. The vehicle allows wheelchair users to enter the cabin independently via the foldable ramp located at the rear. Once inside, the wheelchair is secured using a locking system to ensure stability during travel. The cabin includes side holders that provide added support for maintaining body balance.

Control components such as the electric throttle and dual braking system are positioned ergonomically and designed to be easily accessible from the seated position. This enables users to operate the vehicle directly from their wheelchair, without the need to transfer seats. The entire operation process is designed for independence. The user begins by entering the vehicle through the ramp with minimal physical effort. After securing the wheelchair, the user can immediately assume the driving position, supported by stabilizing handrails. With all controls within reach, including acceleration and braking, the vehicle can be operated intuitively and safely. This design empowers users to complete the full sequence without assistance, promoting autonomy and accessibility.

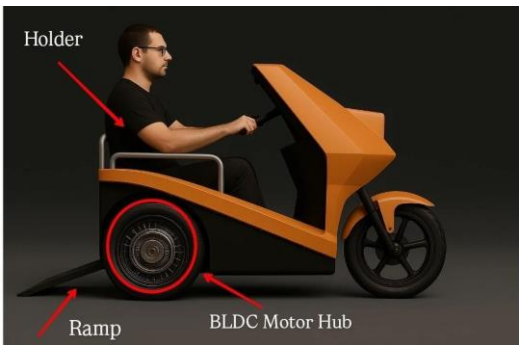

Figure 1. Vehicle side view showing ramp, holder, and hub motor

Figure 2. A view of 72 V lithium-ion battery pack from entry side

3. FINDINGS

The electric vehicle prototype designed for wheelchair users was tested to evaluate its performance in terms of accessibility, stability, user comfort, and energy efficiency. Accessibility trials showed in Figure 3 that users could enter and exit the vehicle in under 60 seconds using the integrated rear ramp, significantly reducing the need for external assistance. Stability testing on inclined surfaces confirmed the vehicle remained balanced up to 10° slope without tipping. As shown in Figure 4, speed tests on flat roads revealed a maximum velocity of 38–40 km/h. Battery efficiency testing indicated a single charge could sustain a range of 90 km under normal load conditions. User feedback from real-world trials highlighted improved independence, ease of use, and perceived safety. Participants noted that the throttle control system and seat-locking mechanism allowed for confident operation even by users with limited upper-body strength. The system met most of the intended specifications, including safety features such as dual braking systems and energy protection via a Battery Management System (BMS), although limitations in terrain versatility and charging infrastructure were acknowledged for future improvement.

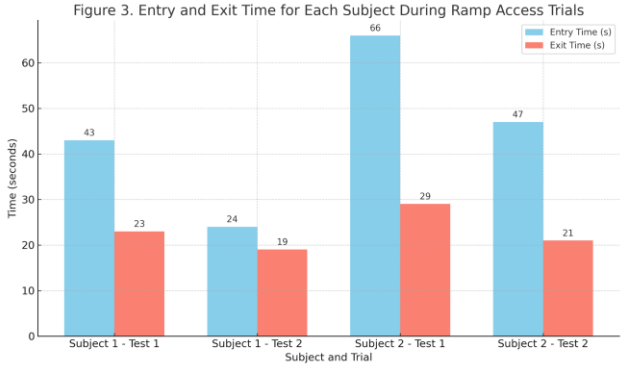

Figure 3. Ramp access entry and exit times recorded for two subjects across two trials.

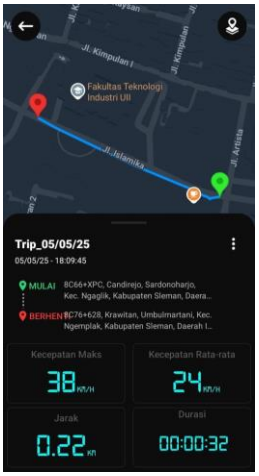

Figure 4. GPS-based test showing a peak speed of 38 km/h over a 0.22 km straight path.

4. CONCLUSION

Based on the analysis of a various of tests conducted on the Difabel Electric Vehicle, several conclusions were drawn as follows; the prototype electric vehicle successfully enables independent wheelchair access via a rear ramp and secure locking mechanism, with boarding completed in under 60 s; stability tests confirmed safe operation on slopes up to 15°; performance trials demonstrated a top speed of 38–40 km/h and a real-world range of approximately 90 km on a single 72 V 40 Ah charge; and user feedback highlighted ease of control, perceived safety, and enhanced autonomy, validating the vehicle's design for urban mobility of persons with disabilities.

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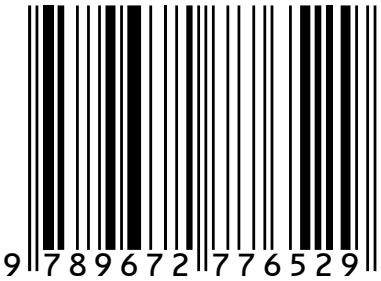

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