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ELECTRIC PLATFORM FOR TRANSPORTING SMALL OBJECTS ON SUSTAINABLE CONSTRUCTION SITES

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Abstract: *The paper presents the development of an electric platform for the transportation of small objects in the logistic activities of supplying various components for electrical and plumbing works in a sustainable construction site. The transportation platform was developed, in the first stage, in the laboratory at the concept level and the results were used in the design of the electrical transportation platform presented in this paper. The use of stand-alone electric transportation systems on construction sites is a necessity at the present time when the reduction of greenhouse gas emissions is desired. The mobile platform is powered from renewable sources and allows use in both outdoor and indoor areas of construction sites. A pair of rubber tracks was used as a propulsion system to ensure easy moving in difficult terrain specific to construction sites. The test results recommend this type of transportation for the construction sites of the future to be as environmentally friendly as possible.*

Keywords: *Electric transportation, construction logistics, sustainable construction site*

1. Introduction

The field of construction has introduced innovative automated electric platforms for the transportation of small objects in the transportation of various objects, addressing the efficiency, safety and sustainability of these solutions to ensure logistics.
One solution for the integration of modular electric platforms for the transportation of objects is the modular integrated construction (MiC) technology. In paper [1], the integration of electrically powered transportation systems with digital tools such as Building Information Modeling (BIM) and IoT sensors is highlighted. These systems enable just-in-time component delivery and real-time monitoring, increasing construction site efficiency and operator safety. Another solution for the transportation of small objects on construction sites is the use of drones and artificial intelligence: drones, combined with artificial intelligence, are increasingly being used for material transportation and site monitoring. Although mainly used for surveillance, these platforms represent a step towards automating the transportation of objects on construction sites [2,3].
Electric transportation platforms equipped with sensors and AI algorithms help to safely move materials in a construction site, reducing the risk of accidents. These technologies help to proactively identify and mitigate risks in dynamic work environments [2]. Semi-autonomous electric-powered platforms are being adopted to help move materials, with an evolution towards fully autonomous systems for controlled environments such as warehouses and prefabricated construction sites. However, on typical construction sites, semi-automated systems currently dominate due to the variability and complexity of these environments. Advances in artificial intelligence and remote control systems are paving the way for wider deployment [4,5]. Automated platforms are part of broader trends in smart construction, driven by digitization and automation specific to sustainable construction sites.
The solutions proposed by developers of platforms for material transportation on construction sites can be: the WestonRobot platform that can transport 60 kg for logistic transportation on construction sites with a power of 120 W [6]; Robotnik Automation has developed RB-VOGUI, a modular, autonomous and collaborative ground robot designed for autonomous material transportation in the industrial and construction sectors. The platform consists of a modular, all-terrain mobile base suitable for transporting loads up to 200 kg [7]. The Cross-country XC-30 crawler transporter is a heavy-duty transporter that combines power and versatility. With a carrying capacity of up to 2200

kg on flat surfaces, this compact, electric-powered equipment can be used for transporting objects on construction sites [8].

2. Implementation

Construction sites require efficient logistics for moving tools, materials and equipment. With the increasing importance of sustainability goals, traditional fuel-based transportation systems are being replaced by environmentally friendly alternatives. This study presents the development of an electric transport platform to streamline logistics on construction sites while minimizing environmental impacts. The study pursues the efficient conversion of transportation equipment equipped with heat engine to autonomous electric equipment. In developing a small object transportation platform we aimed to: Reducing carbon emissions and noise pollution; increasing worker safety and ergonomics; Integrating renewable energy systems for charging; compactness and maneuverability average payload capacity 100-300 kg, sufficient for tools, small equipment or materials; use of lithium-ion batteries for energy density or lithium-iron-phosphate for safety and longevity; renewable charging options (solar panels) and fast-charging compatibility; high-efficiency brushless DC motors; options for remote control or autonomous navigation ; use of weatherproof and dust-resistant materials.
The development of an electric platform for transporting small objects on sustainable construction sites is an innovative approach to improving efficiency while maintaining environmentally friendly practices. The considerations and features considered in the development of the electric platform for small object transportation were as follows:

- Compact dimensions optimized for movement in narrow spaces on construction sites.
- Electric undercarriage use of zero-emission electric motors powered by rechargeable batteries.
- Durable construction use of materials that can withstand harsh conditions such as dust, water.
- Configurable, modular compartments or adjustable shelves to carry tools, materials or small equipment.
- Renewable charging use of solar panels or compatibility with on-site renewable energy sources.
- Recycled materials use of recycled or low-impact materials.
- Energy efficiency: intelligent systems to optimize battery use.
- Autonomous or semi-autonomous capabilities: GPS-guided navigation or remote control options.
- Optimized charging capacity: Designed to carry loads efficiently without excessive energy consumption.
- Safety Sensors: Equipped with obstacle detection sensors, anti-collision systems and emergency stop functions.
- Smart connectivity: Integration with site management software to track usage, optimize routes and monitor battery status.
- Reduced noise level by using electric motors.
- Tool transportation use: moving small hand tools or power tools to large sites; material delivery: transporting small quantities of materials such as bricks, screws or pipes; collecting recyclable waste from different areas of the site.

The development of the electric transportation platform was aimed at converting an existing thermal engine powered equipment into an equipment usable in the sustainable construction sites of the future. To this end we converted the GeoPorter 330 D [10] motorized platform with a useful transport capacity of 330 kg. Its transportation system is powered by a Briggs and Stratton 6.5 HP [11] gasoline engine with a capacity of 280 cm3 with a maximum power of 6.5 hp and a maximum torque of 2800 rpm coupled, through a belt transmission, to a gearbox with three forward and one reverse gear. The GeoPorter 330 D platform is equipped with a travel system with two rubber tracks with a width of 190

mm and a diameter of the drive stellate wheel of 150 mm, as in fig 2. The design of the platform consisted of the survey and subsequent modeling of the GeoPorter 330 D motorized platform in the 3D SolidWorks virtual environment, see Fig 1. The modeler was made in order to implement modifications to the transmission and actuation to ensure the initial transport performance.

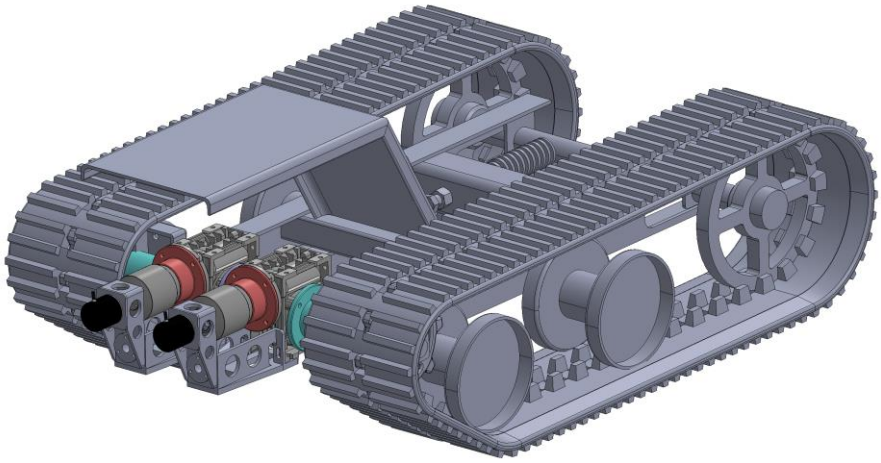

Fig. 1. 3D model of the electric powered transportation platform

The modification of the platform travel system has taken into account the following parameters of the kinematic chain for thermal engine and speed reducer actuation: maximum moment speed of the thermal engine 2600 rpm; total transmission ratio in first gear is 70. 95; in gear II it is 36.55; in gear III it is 30.10 in reverse R 94.6. The travel speed of the heat engine driven platform is 0.091 m/sec in gear I; 0.177 m/sec in gear II; 0.215 m/sec in gear III; 0.073 m/sec in gear R.

Fig. 2. Actual model of the electric powered transportation platform

The kinematic chain of the electric transportation platform, fig.3, consists of the following components: brushless electric motor 6374 170 kV [12] with a maximum power of 2800 W, a maximum power of 1700 W, a speed range of 4080 - 7920 rpm; a gearbox with a transmission ratio of 100. Under these conditions the speed at the level of the stellate wheel driving the track is between 41 - 79.2 rpm which corresponds to a speed range of 0.102 - 0.198 m/sec. The practical realization of the modified kinematic chain of the electric transportation platform is shown in fig.4.

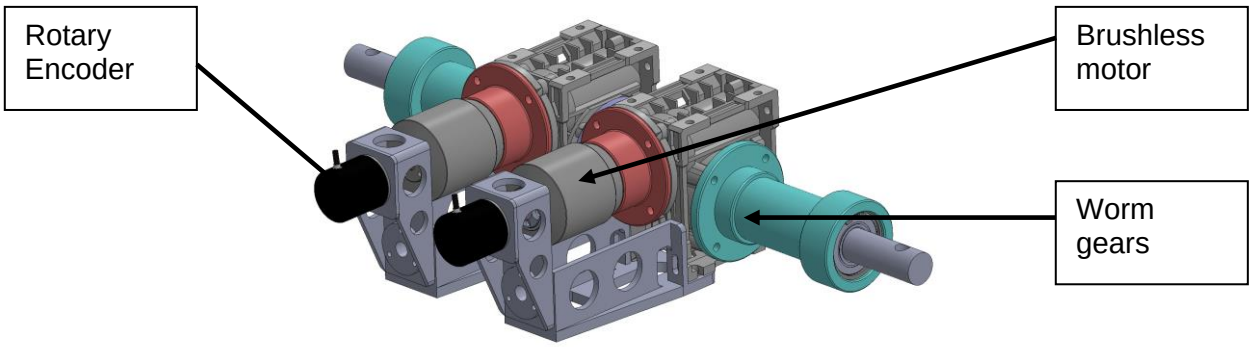

Fig. 3. 3D modeled mechanical transmission of electrically powered transport platform

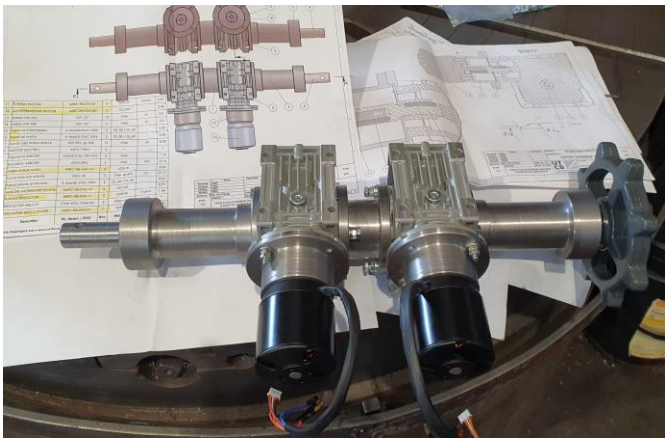

Fig. 4. Practical realization of the transmission of the electric powered transport platform

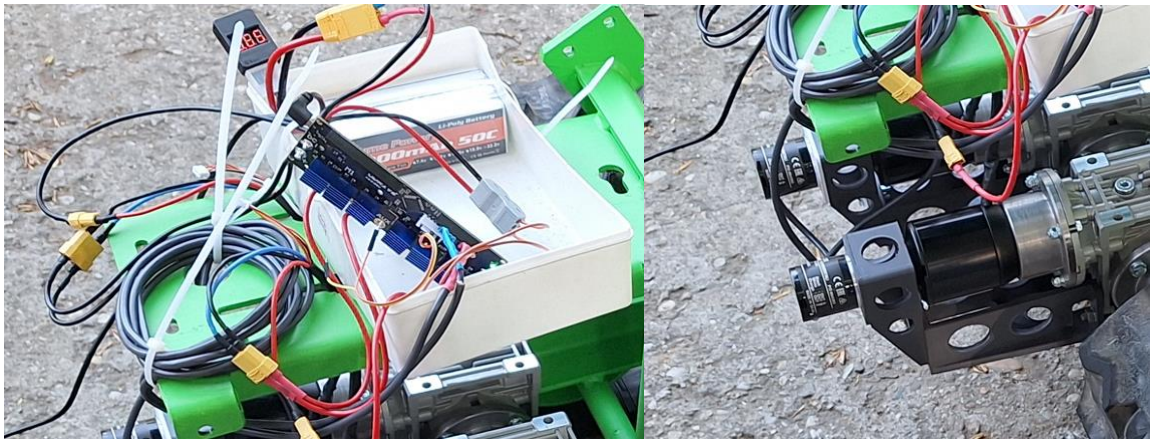

Fig. 5. Command and control module of the electric powered transportation platform

To drive the electric transport platform, Fig. 5, we used the ODrive v3.6 driver [9] which allows: position, speed and current control; Automatic identification of motor parameters (Inductance, Resistance); Real-time USB communication with the Python host program; Information for many variables including position, speed, current, control effort: extensible to expose your own variables. The command and control scheme is shown in Fig 6. For motion control we used YUMO type E6B2 -CWZ3E [13] rotary encoder with 1024P/R resolution.

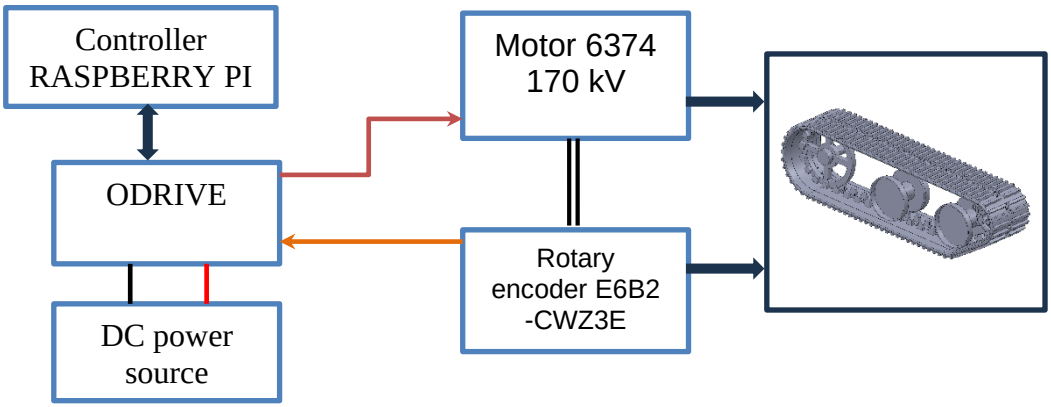

Fig. 6. Command and control scheme of the electric powered transportation platform.

The conversion from a heat engine powered transportation platform to an electric powered transportation platform fulfils the requirements for the travel speed on a construction site of about 1.0m/s as shown in the tests performed and presented in fig. 7.

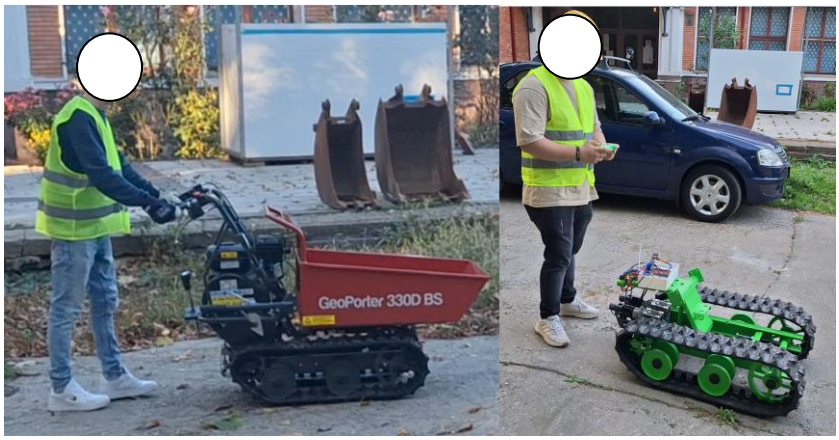

Fig. 7. Conversion of the transportation platform from thermal to electric motor drive

3. Conclusions

The electric platform for small object transportation featured in the article aligns with the future of sustainable construction. By efficiently addressing on-site logistics and minimizing environmental impact, this solution promotes sustainable practices while providing practical benefits in on-site transportation of small objects. With the right design and strategy, this platform could become a standard tool on sustainable construction sites. Electric transportation platforms align with global goals to reduce greenhouse gas emissions; reduce the time and effort required to move small objects, allowing workers to focus on important tasks; use of autonomous platforms help with repetitive tasks and reduce manual handling; reduce the risk of on-site work accidents; electric platforms are particularly well suited for urban construction sites, where noise ordinances often restrict traditional machinery.

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