# Design and Development of a Motorized Mobility Retrofit for a Ballistic-Resistant Podium (MAPS)

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***Abstract***

Ballistic-resistant podiums deployed in public-facing security environments provide effective static protection, but their mass makes them difficult to reposition quickly. This paper presents the Motorized Anti-Ballistic Podium System (MAPS), a motorized, operator-controlled mobility base retrofitted to an existing bullet-resistant podium. The system integrates a 2,000 W brushless DC motor, a 48 V/30 Ah lithium-ion battery pack, an electronic motor controller, a pre-assembled tracked front-axle drive unit, and rear 360° swivel casters, operated through a combined throttle and three-speed-switch interface. The complete unit weighs approximately 1,200 lb and is rated to carry up to 1,800 lb. Functional testing at the UTSA Engineering Senior Design Symposium showed that the platform moved its full rated load unassisted at speeds exceeding 2 mph over grass and rocky terrain, with a measured battery runtime of approximately 30 minutes at full power; steering was functional but difficult. Finite element analysis of the drive shaft under a 1,500 lb load case returned a maximum von Mises stress of 314 MPa against a 310 MPa yield strength for the free-cutting brass shaft material — a safety factor slightly below unity, reported here as a design limitation rather than a validated margin. The work demonstrates a functional proof of concept and identifies drive-shaft strength, maneuverability, and quantitative validation as priorities for future design iterations.

***Index Terms***—*motorized platform, ballistic-resistant podium, tracked drive, finite element analysis.*

## I. INTRODUCTION

Bullet-resistant podiums are engineered for structural protection, not mobility. In fast-changing security situations — press briefings, public ceremonies, event staging — staff may need to reposition cover quickly, yet a fully assembled ballistic podium can exceed half a ton, making manual repositioning impractical. The Motorized Anti-Ballistic Podium System (MAPS) project designed, built, and tested a motorized, operator-controlled mobility base that attaches to an existing bullet-resistant podium so it can be repositioned without the operator pushing or dragging the structure.

This paper documents the MAPS platform, covering its system architecture, the hybrid mechanical drive layout, the electric propulsion and power system, the engineering analyses used to size and verify critical components, the operator control interface, functional test results, and operational safety provisions.

## II. SYSTEM OVERVIEW AND DESIGN REQUIREMENTS

The completed platform comprises four major sub-assemblies: (1) the ballistic-resistant podium structure itself; (2) the electrical/electronic package, consisting of the motor controller, battery, and user interface; (3) a pre-assembled tracked front-axle drive unit; and (4) an oak-wood enclosure that protects the electronics from environmental exposure and mechanical impact. Fig. 1 shows the completed assembly, Fig. 2 the protective electronics enclosure, and Fig. 3 the CAD design studies used to develop the mobility base and structural framing.

Fig. 1. Completed MAPS assembly: podium structure with tracked front-axle base and rear swivel casters.

Fig. 2. Oak-wood protective enclosure for the onboard electronics.


Fig. 3. CAD design studies of the tracked mobility base and structural framing.

The principal design requirements and estimated characteristics of the unit are summarized in Table I.

**TABLE I**
Estimated Dimensions, Mass, and Rated Capacity

| Parameter | Value |
|---|---|
| Length | 32 ± 0.5 in |
| Width | 32 ± 0.5 in |
| Height | 80 ± 0.5 in |
| Mass (complete unit) | ≈ 1,200 lb |
| Rated payload / carry capacity | up to 1,800 lb |
| Design travel speed | ≈ 2 mph |

## III. MECHANICAL DESIGN

### *A. Hybrid Locomotion Concept*

The chassis uses a hybrid locomotion layout: a tracked drive axle at the front, pre-assembled and providing increased ground-contact area and traction for the unit's mass, and free-swivelling caster wheels at the rear, allowing 360° rotation for tight-space maneuvering. The split between the powered track and the passive casters followed a mid-project sponsor change from an indoor concept to an all-terrain, rubber-tracked concept; no ground-pressure or turning-radius sizing of that split is documented in the project manual or the symposium poster, and this is identified as a gap in Section IX. Symposium testing found that the platform could traverse grass and rocky surfaces and move its full 1,800 lb rated load unassisted at over 2 mph, though steering, while functional, was difficult.

### *B. Drive Transmission*

Rotational force from the drive motor is transmitted to the tracked axle through a single drive shaft. The tracked front-axle assembly is shown in Fig. 4. Because the shaft is the sole load path between the motor and the tracks, its structural adequacy was examined by finite element analysis, reported in Section V-C.

Fig. 4. Front tracked-axle drive assembly.

## IV. ELECTRICAL PROPULSION AND POWER SYSTEM

### *A. Motor*

The primary drive is a 2,000 W brushless DC motor rated to a maximum of 4,300 RPM, with a copper-wound stator core (VEVOR) (Fig. 5). Brushless DC machines were selected for their high power density and simple electronic commutation, consistent with established practice in battery-powered mobile platforms [3], [4].


Fig. 5. Drive motor.

### B. Motor Controller

A single electronic motor controller manages current flow between the battery and motor, motor-phase switching for forward/reverse operation, the braking circuit, the three-speed input, and a charge-status indicator light. It is the only populated printed circuit board (PCB) in the electrical system (Fig. 6).

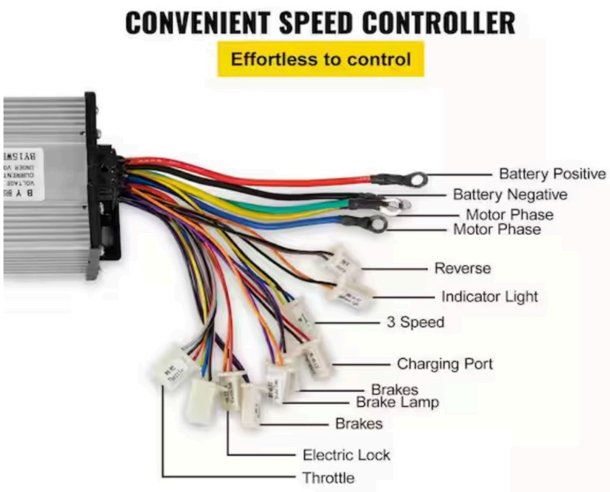


Fig. 6. Motor controller and wiring harness.

### C. Battery

Power is supplied by a single 48 V, 30,000 mAh (30 Ah) lithium-ion battery pack connected through quick-connect terminals to allow swap-out or bench charging (Fig. 7). Lithium-ion chemistry was chosen for its higher specific energy relative to lead-acid alternatives [7].


Fig. 7. 48 V/30 Ah lithium-ion battery pack and charger.

The bill of materials for the principal purchased components is given in Table II.

**TABLE II**
Bill of Materials

| Component | Cost (USD) | Function |
|---|---|---|
| Battery | 400 | 48 V/30 Ah power supply |
| Oak protective cover | 50 | Environmental/impact protection |
| Track assembly | 95 | Front-axle traction and load support |
| Electrical assembly | 168 | Motor controller, wiring, interface |
| Total | 713 | — |

## V. ENGINEERING ANALYSIS

### A. Motor Sizing

Motor sizing was based on the torque required to accelerate the 1,200 lb podium at 1 mph per second from rest, combined with the rolling resistance of the track on the target surfaces. The required power came out to just under 1 kW; a design factor of 1.5, applied to cover drivetrain losses, surface irregularities, and gradeability margin, yielded a rating of approximately 1.5 kW, and a 2 kW motor was selected on that basis. This follows the vehicle traction and gradeability sizing methodology in Wong [5] and the mobile-robot powertrain treatment in Siegwart et al. [6].

### B. Battery Runtime

Battery runtime was determined by bench test rather than by calculation from the nameplate rating alone: the team measured approximately 30 minutes of runtime at full power draw. For context, the pack's nominal energy content is 48 V × 30 Ah ≈ 1.44 kWh, corresponding to a theoretical endurance of roughly 43 minutes at a continuous 2 kW draw. The measured 30-minute figure is consistent with the motor operating at or near its peak rating during loaded acceleration, together with drivetrain and controller losses, and indicates that the battery is sized at the margin for sustained full-power operation. Range-extension options are discussed in Section IX.

### C. Drive-Shaft Finite Element Analysis

The drive shaft was analyzed under a 1,500 lb load case using finite element analysis. The shaft material, free-cutting brass, has a yield strength of approximately 310 MPa. The analysis returned a maximum von Mises stress of 314 MPa under the load case — marginally above the material's yield strength, corresponding to a safety factor of approximately 0.99. The shaft cannot be considered structurally adequate for the analyzed load case; this is reported as a design limitation rather than a validated margin, and it drove the redesign recommendations in Section IX.

## VI. CONTROL INTERFACE

The operator controls the platform through a two-part interface (Fig. 8): a three-speed selector switch, which sets the maximum operating speed range, and a throttle grip, which provides continuous speed adjustment within that range. Pushing the throttle up commands forward movement; pushing it down commands reverse. Turning is performed manually — the operator grips both handles and swivels the podium toward the desired heading while the platform is moving, using the 360° rear casters. This arrangement keeps the electronic interface simple but places the steering burden on the operator, a trade-off examined further in Section IX.


Fig. 8. Three-speed control switch.

## VII. TESTING AND VALIDATION

Functional testing was carried out as part of the UTSA Engineering Senior Design Symposium (Spring 2024). The results are summarized in Table III.

**TABLE III**
Functional Test Results

| Test subject | Result |
|---|---|
| Motor control | Motor was successfully controlled and secured in place |
| Battery life | Significant runtime; ~30 minutes at full power |
| Chain and sprocket strength | Remained attached and engaged even under load |
| Steering | Able to be steered; however, difficult |
| Multi-terrain capability | Traveled grass and rocky surfaces without issue |
| Movement with load | Moved the full 1,800 lb rated load unassisted at over 2 mph |

The results indicate that the core integration objective was met at the functional proof-of-concept level: a roughly 1,200 lb ballistic-resistant podium could be motorized with commodity components at low cost (approximately USD 713 in purchased parts) and could move its full rated payload unassisted over unprepared surfaces. No formal trial count, pass/fail threshold, or statistical success rate (for example, an obstacle-navigation success percentage) was documented for these tests; the results are qualitative functional outcomes rather than measured trial statistics. A quantitative validation protocol — measured turning radius, a standardized obstacle course with a defined success rate, endurance runs under a defined duty cycle, and instrumented shaft strain-gauge testing — is recommended for the next design iteration (Section IX).

## VIII. OPERATIONAL SAFETY AND TROUBLESHOOTING

Standard operating procedure requires the user to remain behind the podium while it is in motion and to disengage and move to a safe location if the drive system becomes compromised (for example, visible battery smoke or track damage). Documented failure modes and the corresponding checks are listed in Table IV.

**TABLE IV**
Documented Failure Modes and Corrective Actions

| Failure mode | Corrective action |
|---|---|
| Will not start | Check battery charge, connection security, ignition key, battery voltage, wiring |
| Wobbling/unstable driving | Check tracks for damage; verify track-nut tightness; inspect chain/sprocket engagement |
| Starts but will not move | Check battery charge, chain connection, throttle condition, motor and axle integrity |
| Battery overheating | Disconnect from motor or halt charging; increase airflow around the battery |
| Internal fire | Do not remove the battery; unplug and use a fire extinguisher from outside the enclosure; evacuate if the fire worsens |

## IX. LIMITATIONS AND FUTURE WORK

The team's own conclusion, stated on the symposium poster, was that MAPS adapted to a shifting sponsor scope and produced a functional proof of concept, but that maneuverability and structural load-bearing capacity remain open problems. The specific items requiring a design reassessment are:

- ***Drive-shaft strength.*** The FEA result of Section V-C indicates that the free-cutting brass shaft yields under the 1,500 lb load case (safety factor ≈ 0.99). The shaft should be re-specified in a higher-strength material — for example, an alloy steel such as AISI 4140, with a yield strength of roughly 655 MPa, would raise the theoretical safety factor to approximately 2 — and/or resized in diameter, then re-verified by FEA and a physical proof-load test.
- ***Steering effort.*** Steering was reported as difficult because turning relies on the operator swivelling the whole platform against the lateral resistance of the front tracks. Candidate improvements include braked or lockable swivel casters, a caster-offset geometry that generates a self-aligning moment, or a two-track differential-drive layout enabling true skid steering.
- ***Quantitative validation.*** Future testing should adopt defined trial counts and pass/fail criteria, and should measure turning radius, obstacle-course success rate, runtime under a specified duty cycle, and drive-shaft strain under load.
- ***Battery margin and thermal management.*** The measured 30-minute endurance at full power leaves little reserve relative to the theoretical 43-minute figure (Section V-B). A higher-capacity pack, regenerative braking, or a battery management system with thermal monitoring would extend both range and the safe operating envelope.
- ***Environmental protection.*** The oak enclosure provides mechanical and splash protection, but its ingress-protection rating, UV resistance, and durability

have not been characterized; a sealed metal or composite enclosure with gasketed access panels is recommended for outdoor service.

## X. CONCLUSION

This paper has documented the design, construction, and validation of MAPS, a motorized mobility system retrofitted to a ballistic-resistant podium. Using a 2 kW brushless DC motor, a 48 V/30 Ah lithium-ion battery, a single electronic controller, a tracked front axle, and rear swivel casters, the platform moved its full 1,800 lb rated load unassisted at over 2 mph across grass and rocky terrain during functional testing, with approximately 30 minutes of runtime at full power. The engineering analysis also exposed a critical limitation: the drive shaft, machined from free-cutting brass, has a safety factor slightly below unity under the analyzed 1,500 lb load case and must be redesigned before the platform can be considered structurally adequate. Steering effort and the absence of quantitative validation metrics are further items for the next iteration. The project demonstrates that mobility can be added to a heavy protective podium using commercially available components, at a reported purchased-component cost of approximately USD 713, and provides a functional engineering basis for further development and validation of the mobility retrofit.

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