



Team Name: Rover Works
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Abstract:
Rover Works is a Modular Automated Guided Vehicle that targets a retail price near two thousand dollars to bring flexible warehouse automation to small facilities that handle light loads. The base unit carries a payload of thirty pounds at speeds between three and four miles per hour for at least two hours on a twelve-volt system and can drive interchangeable top modules, including a height docking unit and a conveyor module. Power sizing, structural analysis, and subsystem testing confirm adequate torque, stability, and safety margins, showing that low-cost modular warehouse automation is both practical and economically attractive.

Introduction

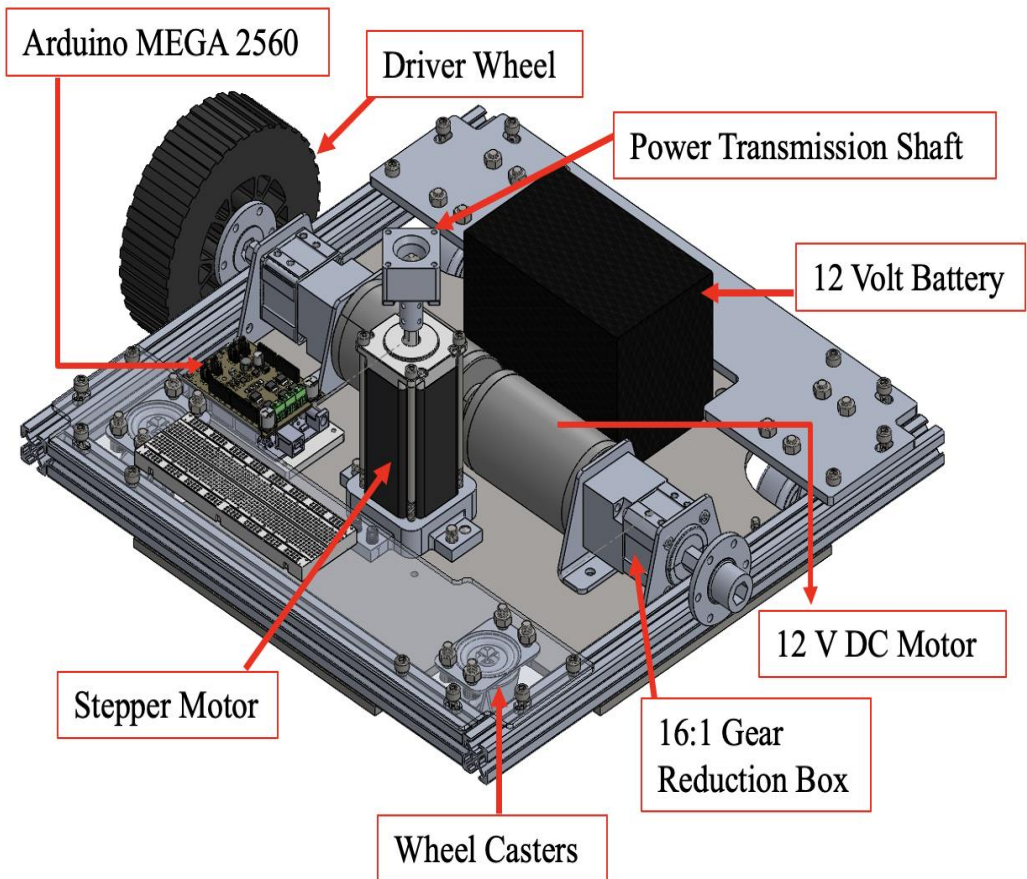
- Many small warehouses still rely on manual carts and labor
- Existing automation is often too expensive, too complex, and designed for very large facilities
- Rover Works introduces a modular automated guided vehicle (MAGV) that is affordable, easy to reconfigure, and simple to integrate into existing warehouse layouts
- This project demonstrates a low-cost base vehicle with two plug in modules (a conveyor and a height docking unit) as a proof of concept for scalable modular automation

Mechanical Design and Methods

Note: CAD models were created in SolidWorks. Parts were manufactured in the Purdue ME machine shop using water-jet and laser cutting, lathe, milling, and basic hand tools, then assembled with fasteners.

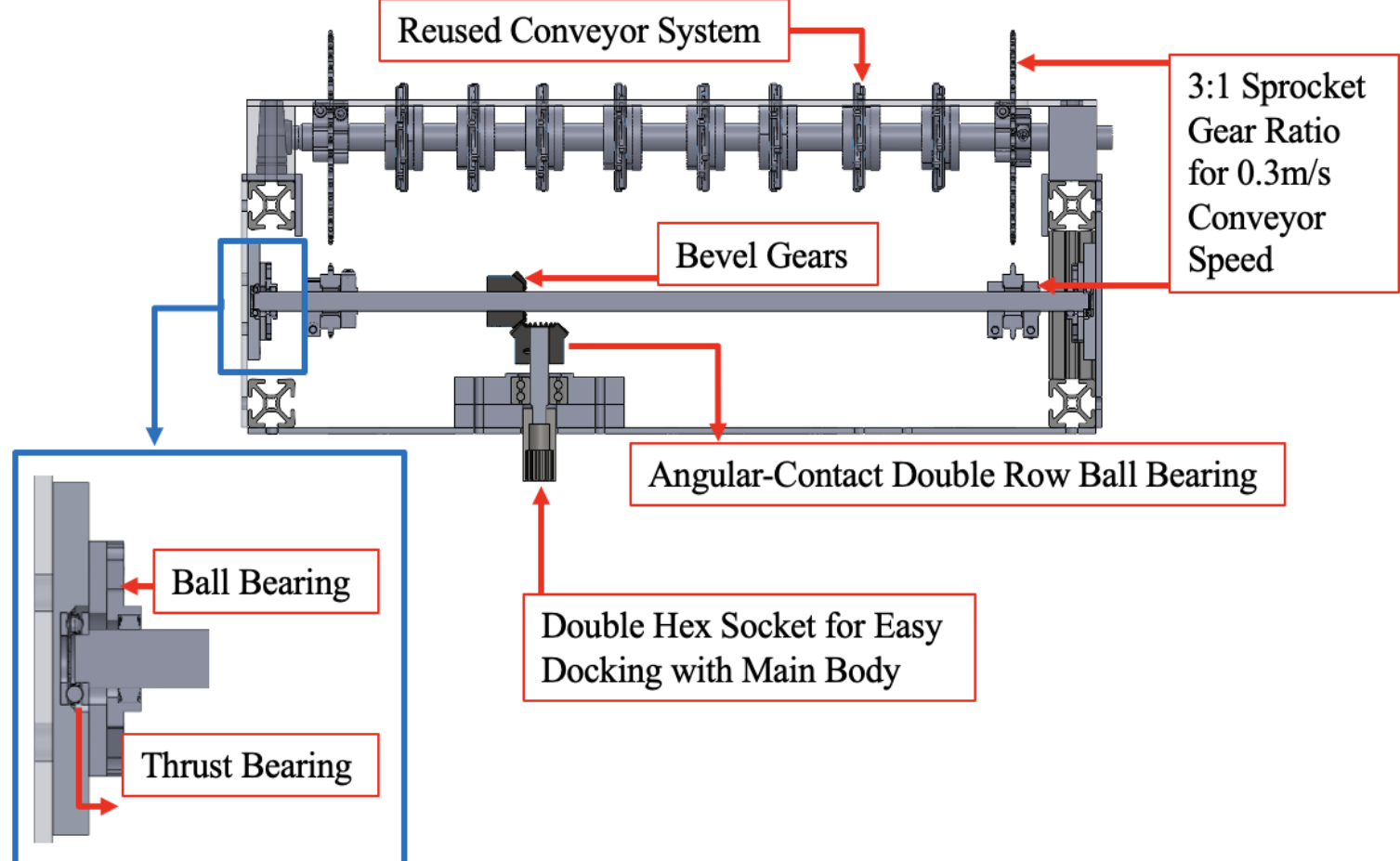
Main Body and Drive Train:

- 0.25-in hot-rolled steel baseplate for stiffness and easy fixturing of components.
- 80/20 extrusion frame for fast assembly, reuse of existing stock, and easy maintenance.
- Two 12-V DC motors with 16:1 gearboxes drive the rear wheels; supported by four casters.
- A NEMA-23 stepper motor drives a hexagonal modular shaft that sends mechanical power to the top modules.
- Arduino Mega 2560 with motor drivers controls drive motors and stepper.
- Five IR line-following sensors and four ultrasonic sensors provide navigation and obstacle detection.



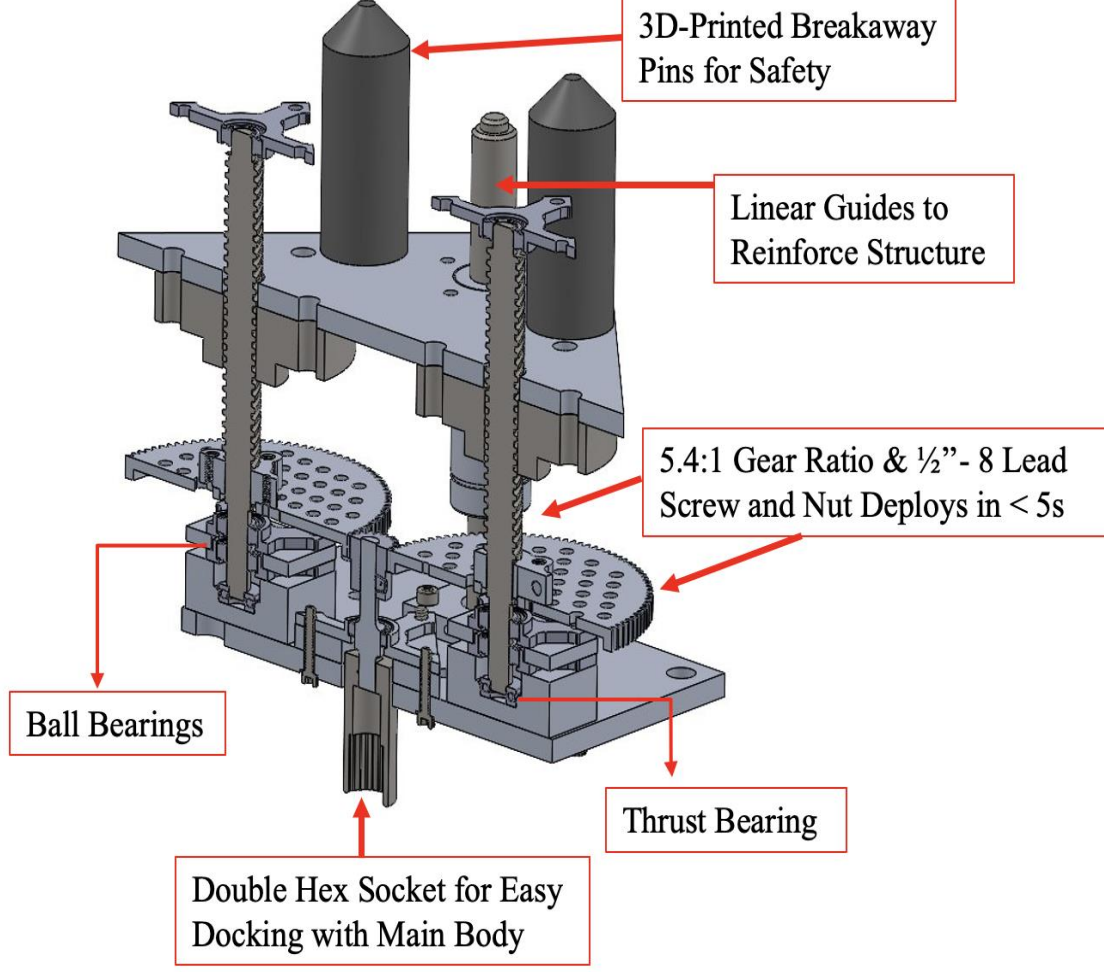
Conveyor Module:

- Reuses an existing roller/belt conveyor to reduce cost and fabrication time.
- Uses a chain and 3:1 sprocket reduction from the modular shaft to the conveyor shaft, setting belt speed to 0.3 m/s.
- Supports the shaft with angular-contact and deep-groove ball bearings plus a thrust-bearing stack to carry combined radial and axial loads.



Height Docking Module:

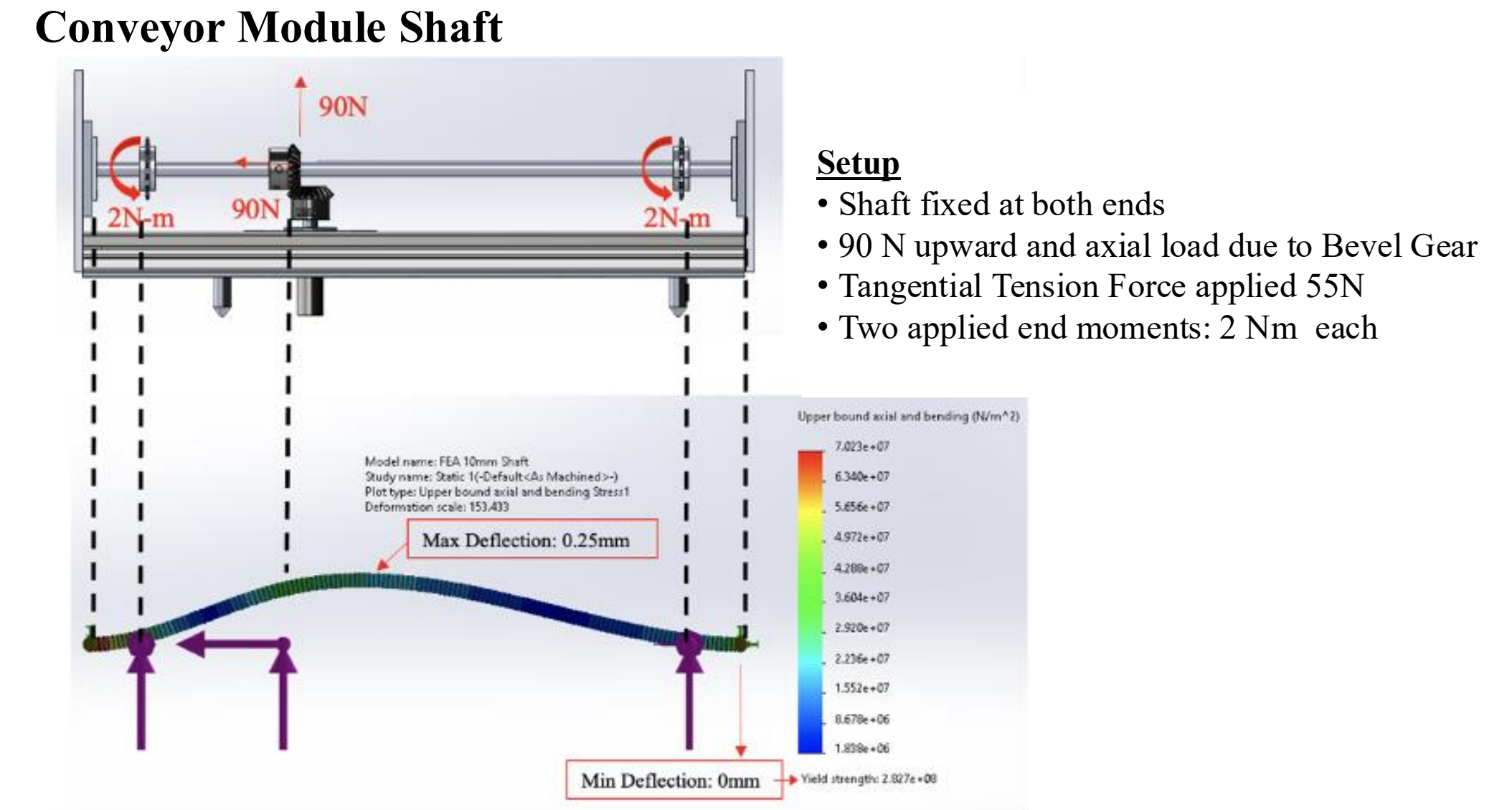
- Four docking pins actuated by 5.4:1 gear ratio and 1/2"-8 lead screws, achieving 55 mm stroke in < 5 s.
- Linear guide shafts, ball bearings, thrust bearings, and 3D-printed breakaway pins maintain alignment and protect the structure.



Results

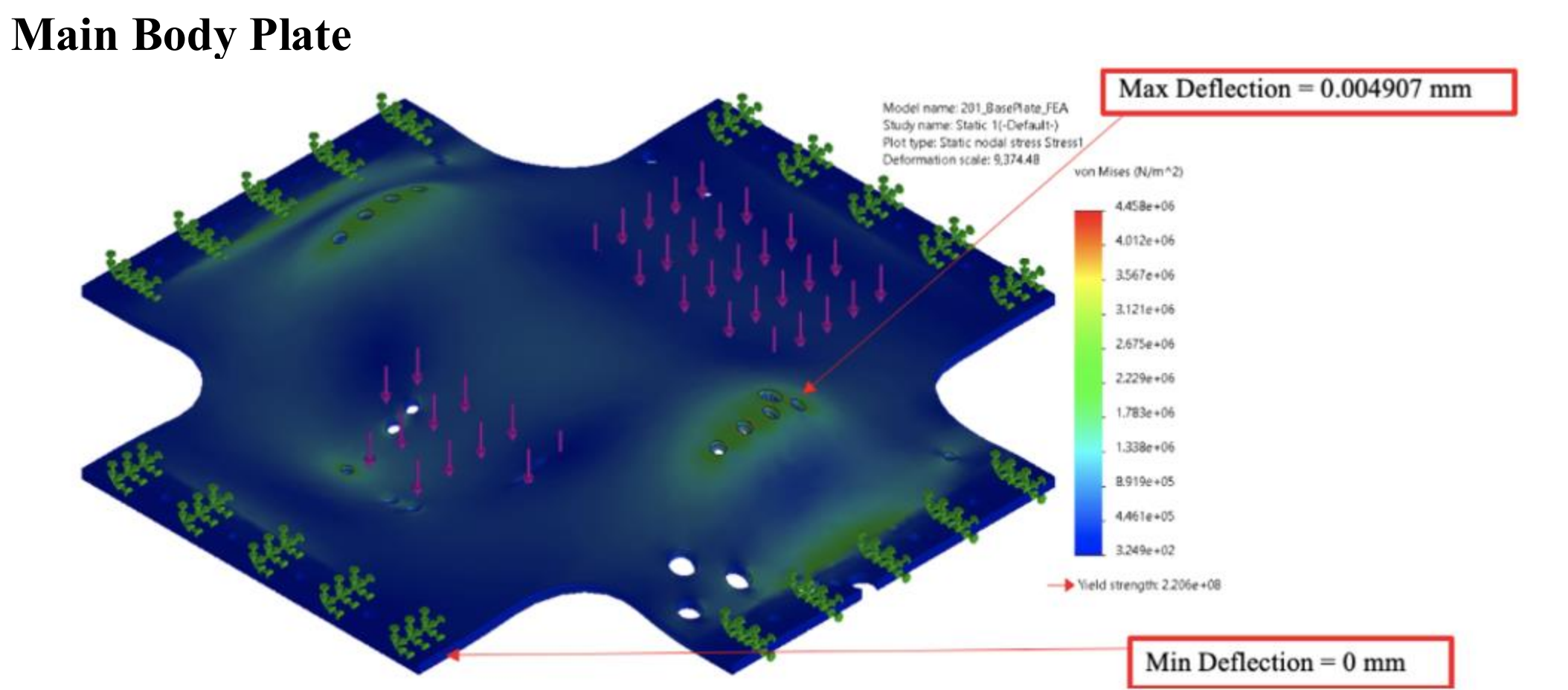
- 59 kg vehicle reaches 3–4 mph with a 30 lb payload using a 12 V dual-motor drive
- Battery provides ≈2 hours of runtime per charge under typical loading
- Baseplate, conveyor shaft, and lift show low stress/deflection with large safety margins
- Conveyor and height-docking modules achieve required travel and speeds
- Electrical architecture uses a single 12 V bus with a buck-converted 5 V logic rail and an Arduino Mega–motor driver–sensor stack, keeping all components within voltage and current limits

Structural Finite Element Analysis:



Results:

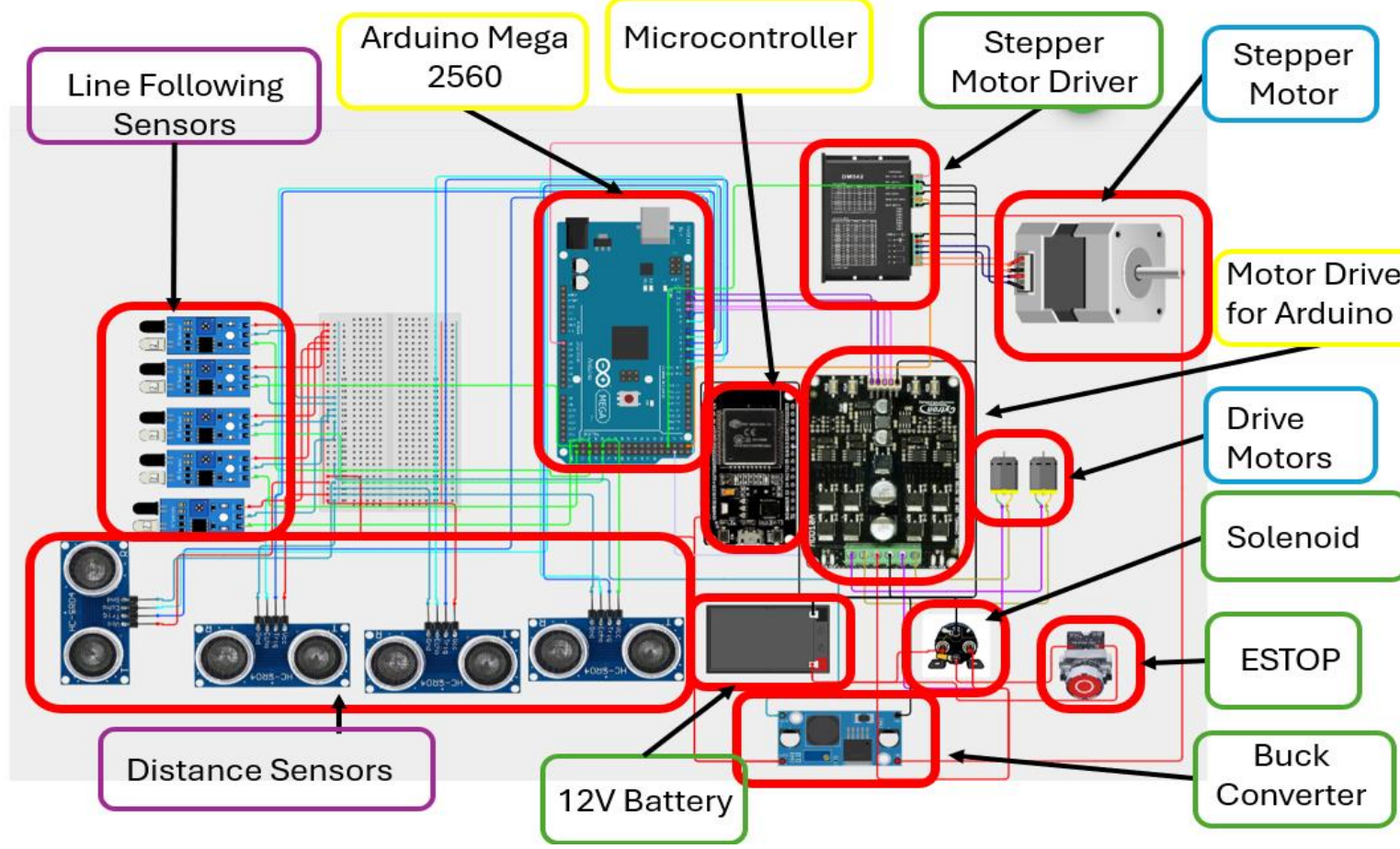
- Max stress: 70.23 MPa
- Yield strength: 283 MPa (4130 Steel)
- Factor of Safety (FOS) = 4
- Peak deflection 0.25 mm → meets strength and stiffness targets



Results

- Max stress: 4.6 MPa
- Yield strength: 220 MPa (4130 Steel)
- Factor of Safety (FOS) = 47

Electrical Design:



Conclusion

Performance and Requirements Met

- The specifications set out at the outset of the project have been met by the Rover Works MAGV, which moves reliably at walking speed while carrying a thirty-pound payload on a twelve volt system
- Battery sizing was validated to provide at least two hours of operation
- Finite element analysis showed that the baseplate and conveyor shaft stay within safe stress limits with high safety factors
- Kinematic checks also demonstrated that both the conveyor module and height docking module achieve the required travel range and speeds in warehouse applications

Engineering Validation

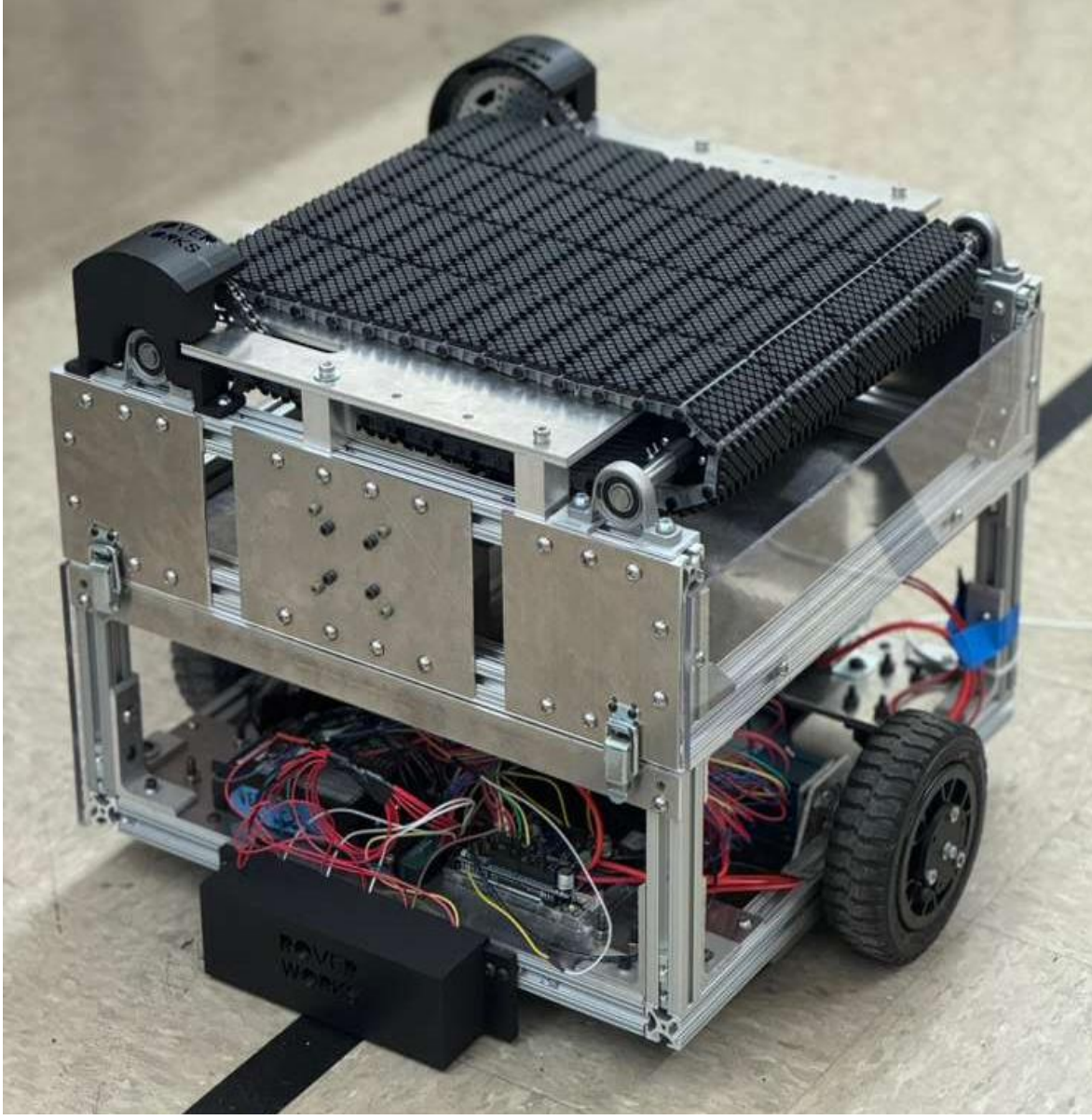
- These results confirm that a modular automated guided vehicle can be constructed using low-cost materials while still meeting strength, stability, safety, and performance requirements
- Successful electronics, drivetrain, sensors, and plug-in modules integration proves that modular automation can cope with real warehouse environments instead of needing large, purpose-engineered systems

Industry Impact

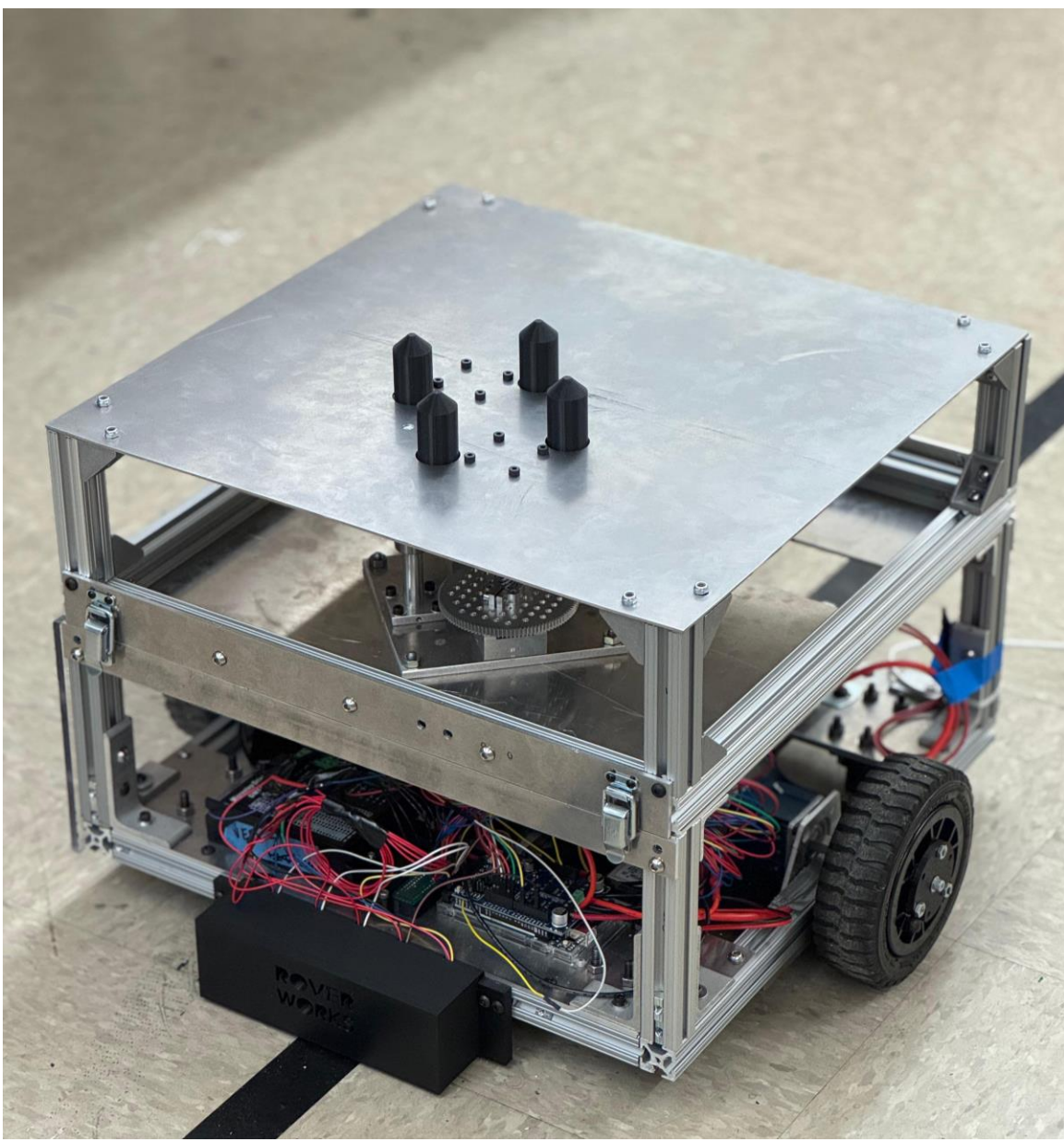
- Showcases a practical migration pathway for small facilities from manual carts toward scalable automation based on a flexible platform that can evolve over time by means of additional modules and improved navigation systems

Industry 4.0 Adoption

- The Rover Works MAGV proves that small warehouses can commence the adoption of Industry 4.0 technology through accessible engineering solutions, rather than through high-cost traditional automation

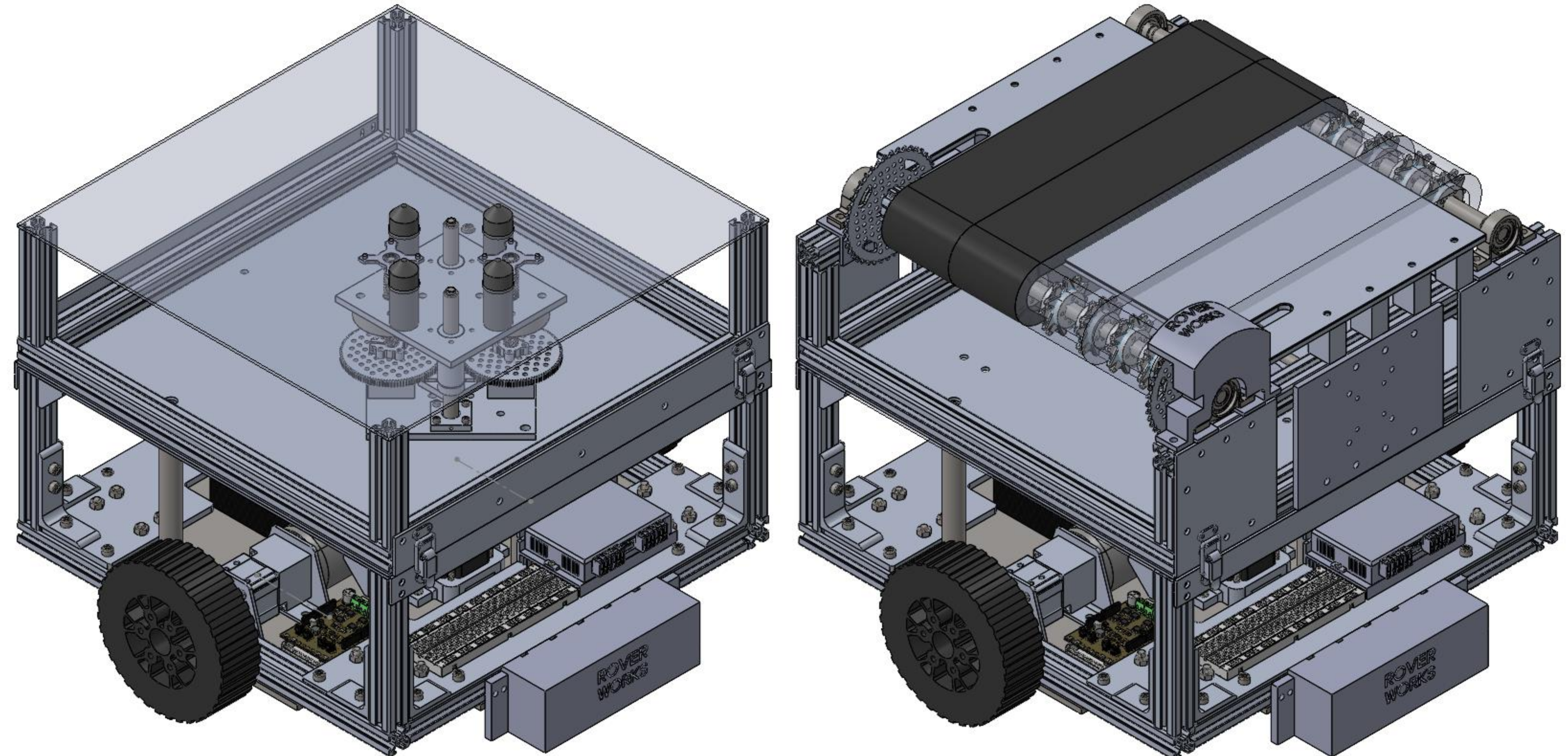


Assembly of the MAGV with Conveyor Module



Assembly of the MAGV with Height Docking Module

Modular Affordable Robot That Never Gets Tired Of Moving Boxes.



Complete CAD Assembly of the MAGV with Height Docking Module (Left) and Conveyor Module (Right)