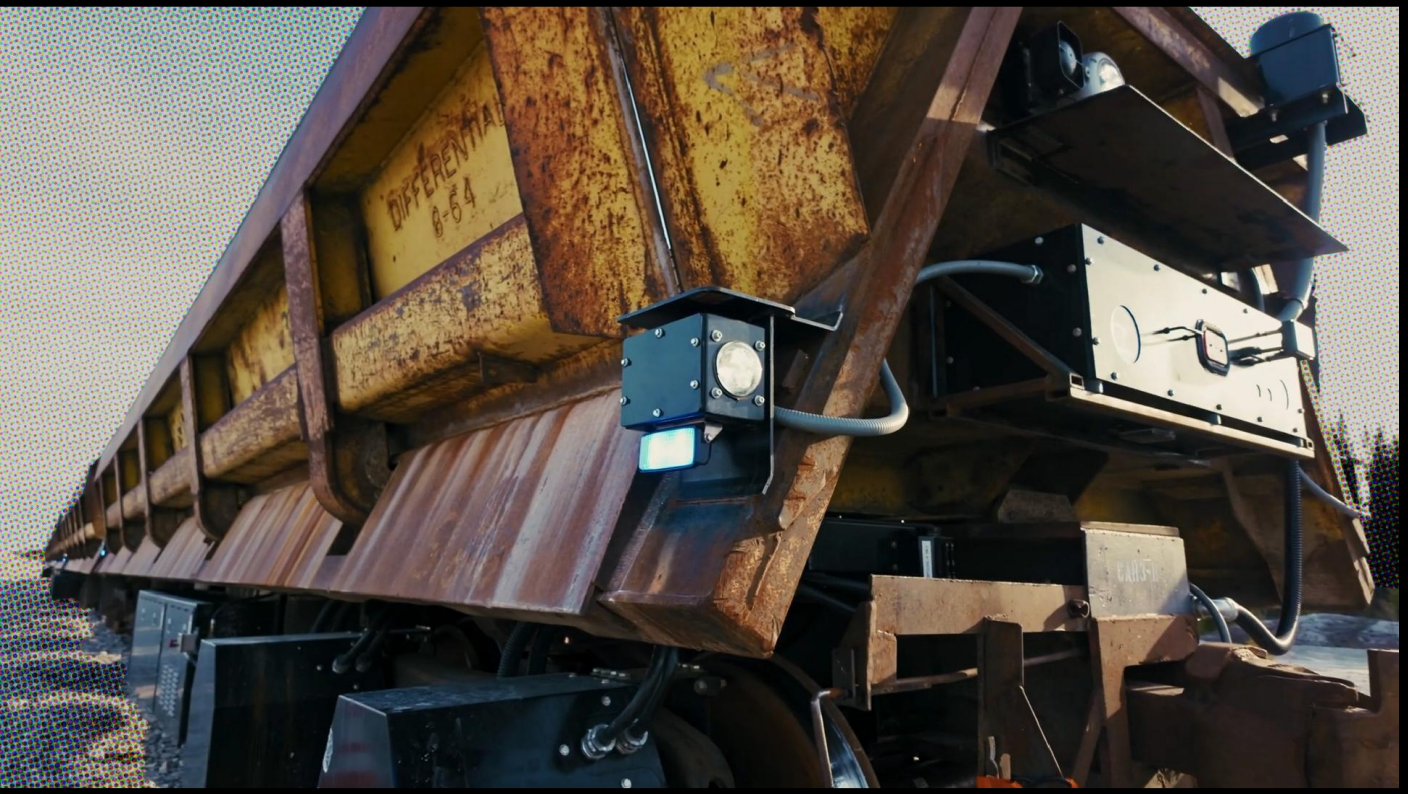
TUGVOLT AUTONOMOUS RAILCARS

AN UNPRECEDENTED TOOL FOR EFFICIENCY AND GROWTH

INTRAMOTEV

Freight cars, brought to life

Autonomous, battery-electric freight railcar retrofits to make railroads more competitive



Backwards-compatible, future-capable

- Intramotev adds batteries, motors, and perception systems to any freight railcar to move any commodity independently
- Enables three movement modes:
  - Independent point-to-point
  - Switching traditional railcars
  - Cooperating with locomotives in traditional trains as DP

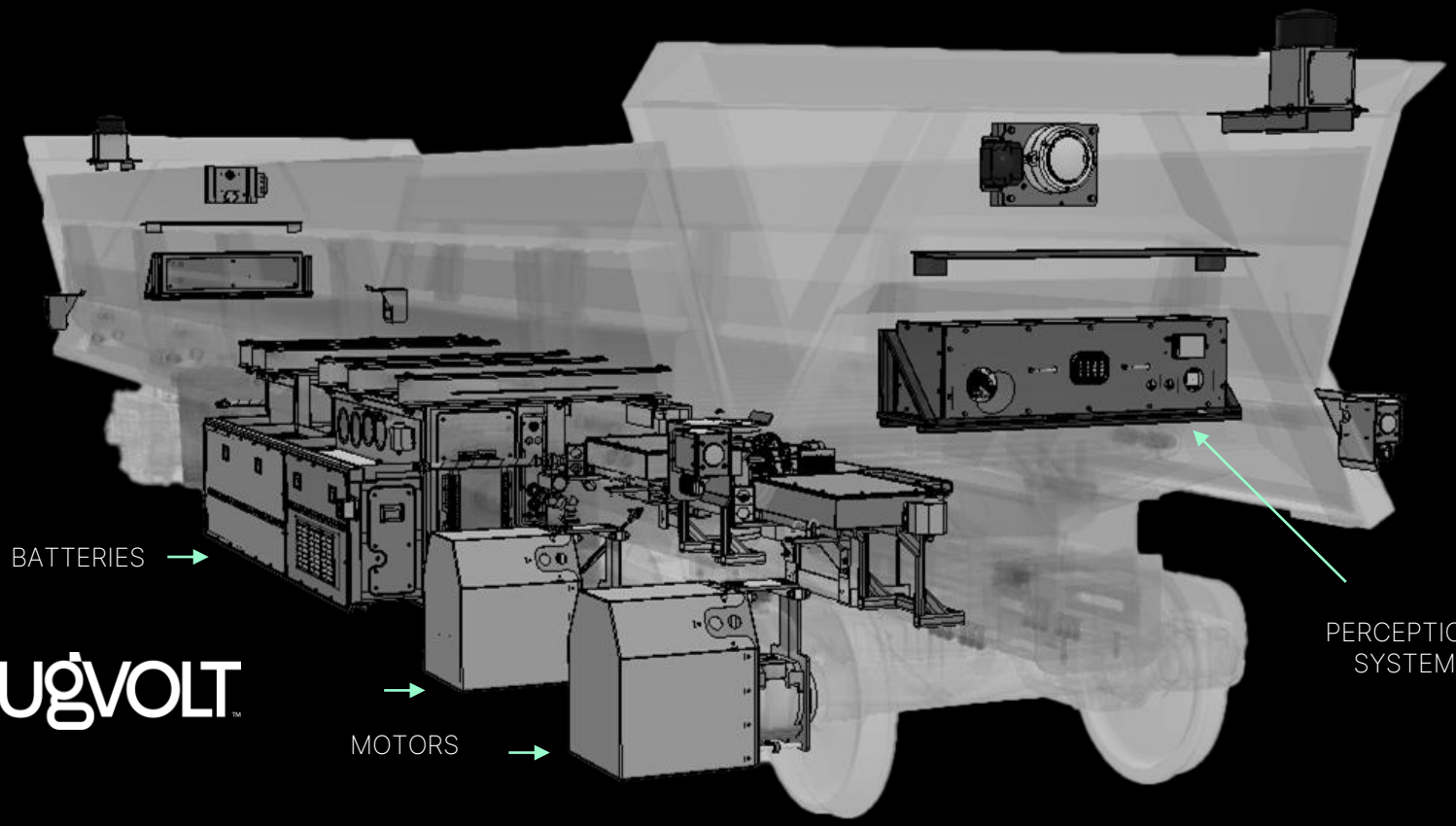
Making rail the no-brainer choice for your customers

- Operating cost reduction up to 80% compared to trucking or legacy rail
- Independent movement enables truck-like shipment times via rail
- Improves efficiency and cost of existing legacy rail operations

TECHNOLOGY OVERVIEW

Autonomy for any commodity

Leading-edge and durable technology fit to any freight car type



TUGVOLT FEATURES AND BENEFITS

A robust and innovative solution for freight movement

Remote or autonomous

Remote controlled via tablet interface with live feeds, or dispatched on pre-built mission sets and routes

Backward-Compatible

Keeps traditional railcar appliances including couplers and air brakes, utilizes existing infrastructure

Integrations and accessories

Seamless integration with physical and digital infrastructure, gate and hatch automation available

Advanced sensory perception

A sensor suite with cameras and machine vision, lidar, radar. Full connectivity and GPS location tracking.

Resilient and reliable

Built for extreme conditions and rough operating environments, fully thermally managed power systems

Sustainable and safe

Zero-emissions at the vehicle level to protect the climate, short stopping distances and intelligence to protect your workers and community

Safety

An integrated safety approach combining intelligent systems, rigorous processes, and human-first design

Frequently Asked Questions and Answers

What safety warning systems exist in the control interface and on the vehicle itself?

- Real time operating systems running built in tests, system health & diagnostics, and enacting fail safe protocols to command a full brake application.
- Ruggedized tablet with vigilance and drop detection capabilities.
- Onboard horn to alert at crossings and bells for general movement awareness.
- Headlight, Auxiliary, and indicator lights to provide vehicle visibility and operational state information.

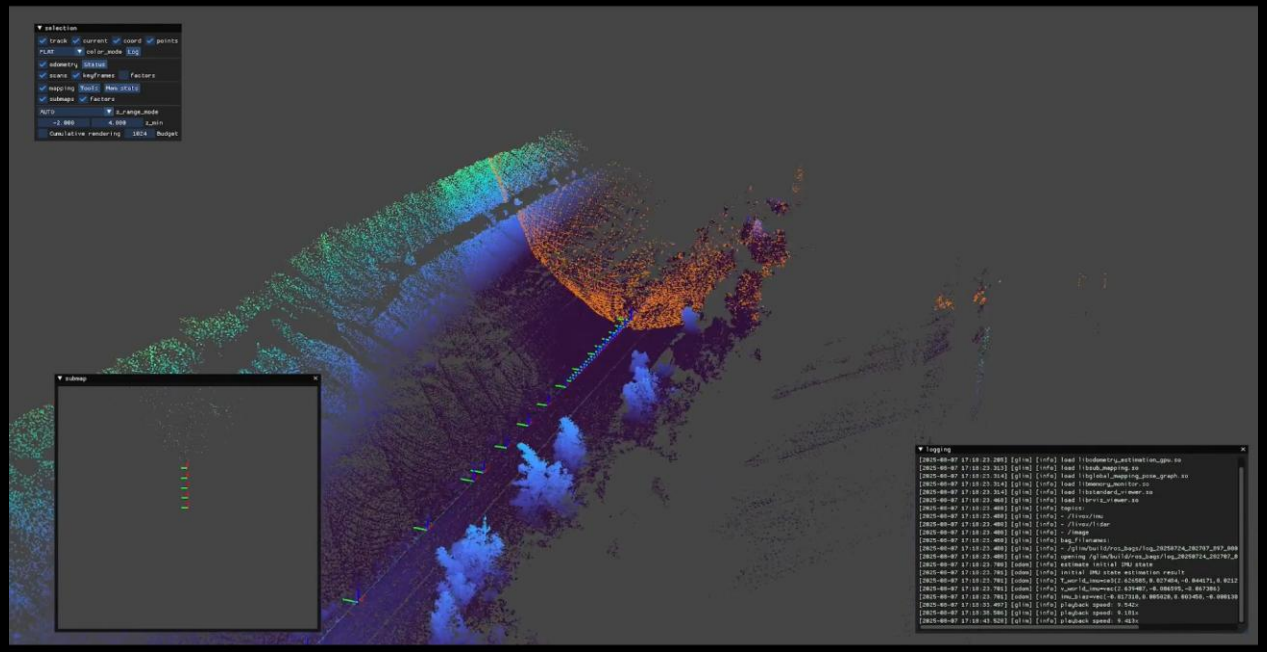
What redundancies and fail-safes exist in the TugVolt system?

- Heartbeat and watchdog functions to monitor vehicle health and enable/disable movement.
- Networking redundancy with network failover protocols. Connection timeouts trigger fail-safe actions.
- Remote E-Stop: Loading crews and others have the ability to Pause/Re-enable TugVolt units during operations if necessary.
- Dynamic stopping distance is calculated not just based on train makeup and speed, but also safe viewing distance. If the perception system can only safely see 250 meters, speed will be reduced accordingly.

Perception & object detection

Advanced sensors and intelligence to keep workers and community members safe

Frequently Asked Questions and Answers



How does the perception system work?

- In order to safely operate autonomously we have designed, built, and tested a system of multiple sensors, fused with one another and the vehicle to fully map the environment around the TugVolt. Lidar emits light “sees” the reflection of objects, Radar uses radio waves, and cameras capture video track objects in their field of view.
- An object moving into the field of view of a sensor becomes a tracked object once it meets criteria of persistence and confidence. Tracked objects that move into a defined area of interest (position relative to track) can be declared as a hazard, the distance the hazard is downrange governs the response, in some case it will be a speed reduction, in others it may result in a pneumatic emergency brake application.

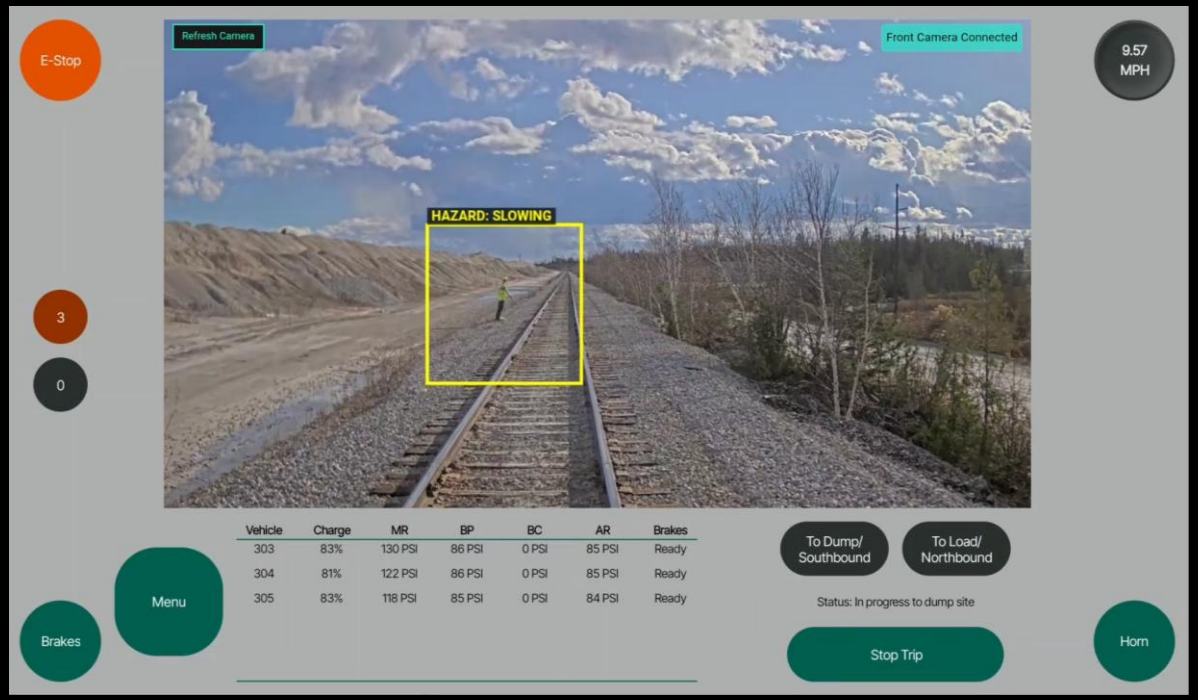
Does weather or adverse visual conditions affect the perception system?

- Fusion of Lidar, Radar, and Cameras protects against different adverse visual conditions such as rain, low light, and fog. Each sensor type specializes in different distances, lighting conditions, and weather conditions.

Vehicle control and autonomy

Advanced control systems and interfaces for effortless operation and efficiency

Frequently Asked Questions and Answers



What operating modes does the TugVolt feature?

- Operating modes range from manual remote control via tablet interface with live feeds, all the way to remote dispatch on pre-built mission sets and routes.

What does autonomous operation consist of?

- There are different levels of autonomy, the most advanced consists of users commanding a TugVolt to a waypoint, then only interfacing with the TugVolt again once it has reached its destination or needs support with an obstacle. In this mode the TugVolt will accelerate according to track speed limits, stop in the event of any onboard issues, make perception detections and adjust speed accordingly, then upon arrival, notify the operator.

Can operating modes and features be customized?

- Yes, every rail operation has unique needs that can typically be easily accommodated in our software setup. Changing things like GPS waypoints, perception distance vs. speed responses, and vigilance timers are highly customizable, to name a few.

Battery and charging

Intelligently managed battery and charging health, standard EV components for minimal infrastructure needs

Frequently Asked Questions and Answers

What electrical infrastructure and charging equipment is required?

- Charging infrastructure typically only requires class 1 or 2 chargers utilizing 240VAC and CCS/SAE J1772 protocols. Level 3 DC charging can be utilized as well but is often unnecessary.

How does cold weather affect operating performance and charging?

- Batteries along with the rest of the temperature sensitive components are thermally managed, we have the ability to heat the batteries to an ideal temperature in even the coldest environments (while running or charging). Dead batteries in hot or cold environments is undesirable for getting maximum life out of the cells.

General Information	
Chemistry	Lithium Iron Phosphate (LFP)
Capacity	Scalable (105-352kWh)
Nominal Voltage	630V
Life	5000+ Discharges
Range	Variable based on duty cycle (up to 200mi)
Charging	240/480VAC options available, target 2hr recharge

Drivetrain and vehicle performance

Electric drivetrains for efficient and capable performance

Frequently Asked Questions and Answers

General Information	
Tractive Effort	Up to 22klbf
Max Speed	Up to 45mph
Carloads*	Up to 16
Max Grade**	Up to 6%

*Dry track, 0% grade, 286klbs/railcar

** Dry track, TugVolt only, loaded to 286klbs gross

How many loaded railcars can I pull?

- The intent of the TugVolt platform is to be highly scalable, we can tailor the number of motors, type of motors, and number of TugVolts to be right sized for any operation moving anywhere from just a few railcars at a time to up to (16)* railcars per Tugvolt.

How does grade/slope affect performance?

- Just as with any other rail-based vehicle grade plays a major role in determining tractive effort needs. The difference in pulling capacity drops from 100% at 0% grade to ~40% at 1% and 20% at 2% grades.

How does braking work? Does it power pneumatics when pulling traditional railcars?

- Yes, we have onboard compressors, reservoirs, and pneumatic controls to supply and control air for all pulled railcars.

Vehicle maintenance and service

Electric drivetrains for efficient and capable performance

Frequently Asked Questions and Answers

Does the Intramotev equipment impede inspection and maintenance of the underlying traditional railcar?

- All standard rail equipment is easily visible/accessible outside of the bearings/adapters with drivetrain equipment mounted on them. These components are part of the TugVolt kit and can instead be continuously monitored for defects.

What are maintenance and part replacement schedules like?

- The timing of each component replacement is highly variable depending on the amount of use, but generally batteries (5000 discharges) drivetrains (20,000 drive hours), power distribution and perception modules (50,000 hours), are the largest cost items.

Are there ongoing connectivity and software updates needed?

- Yes, annual software upgrades, connectivity services, and data analytics and are included in all of the maintenance tiers. Custom analytics and software features can be captured with one-time costs.

What maintenance does the customer team do and what is left to Intramotev?

- Intramotev supports three tiers of maintenance support to match different operational and risk preferences:
- Tier 1 – Comprehensive Coverage functions as an extended warranty, where customers prepay for covered maintenance and repairs and we assume full responsibility for diagnosing issues, supplying parts, and performing all corrective and preventive work to keep vehicles in service.
- Tier 2 – Service On-Demand provides access to our qualified technicians to perform repairs and maintenance as needed, with labor and parts supplied and billed per service event, offering professional support without full prepayment.
- Tier 3 – Parts & Virtual Technical Support is designed for operators with in-house maintenance capabilities; the customer performs all physical work while we supply approved parts and provide remote technical assistance for troubleshooting and repair guidance.

INTRAMOTEV

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