RoboZET: Autonomous Tram Initiative

Astro Synapse, Zagreb, October 2026

Summary

RoboZET is building an AI system that can drive a tram, starting on Zagreb's network. The project runs in three phases: a proof of concept on a single tram bogie, a prototype integrated into a real tram, and an MVP running in beta on one city line.

The first step is already working in software: recorded cab footage from ZET line 2 is turned into structured scene data, and an AI decision model chooses how the tram should respond. Phase 1 takes this onto real hardware, a decommissioned tram bogie driven by the AI on a closed track, for an estimated €350,000. The same bogie then becomes a scout robot that maps the network and delivers live daily scans of every line for traffic jams, accidents and roadworks.

Why trams

Trams are the most realistic place to put autonomous driving on public streets. A tram follows fixed rails, so it never steers; the only decisions are when to accelerate, coast, brake or stop. That turns a hard open-world problem into a narrower one: understand the scene ahead and control speed safely.

- **Fixed, known routes.** Every line can be mapped and recorded in advance, stop by stop.
- **One control axis.** Speed only, with no lane changes, parking or steering.
- **Existing infrastructure.** Zagreb runs 15 day lines on about 116 km of metre-gauge track (Wikipedia), and hundreds of European cities have similar networks.

Operators also have real pressure to modernise. ZET reported that only 57.47% of its trams were technically available in 2023 (tportal), and it is now replacing its oldest Tatra trams with new Končar vehicles. AI assistance and, later, autonomy can make better use of every vehicle and driver an operator has.

How it works

The system splits driving into four stages, each with its own output, so every stage can be tested and replaced on its own.

1. **See.** Cameras at the front of the vehicle capture the track and street ahead.
2. **Understand.** A local vision system detects people, cars, bikes and traffic lights, and works out whether each one is on the track, how close it is, and whether it is moving toward the rails.
3. **Decide.** The scene is sent as structured data to a decision model, which returns a driving action (accelerate, hold, coast, brake or emergency brake) with a probability for each option.
4. **Act.** A controller turns the chosen action into motor and brake commands. A hardware emergency stop works independently of the AI at all times.

The decision model is Jev by TypeSafe AI, a model built for fast, typed decisions with calibrated probabilities. Because the decision step is pluggable, it can be compared against or replaced by other models, including ones that run fully on board.

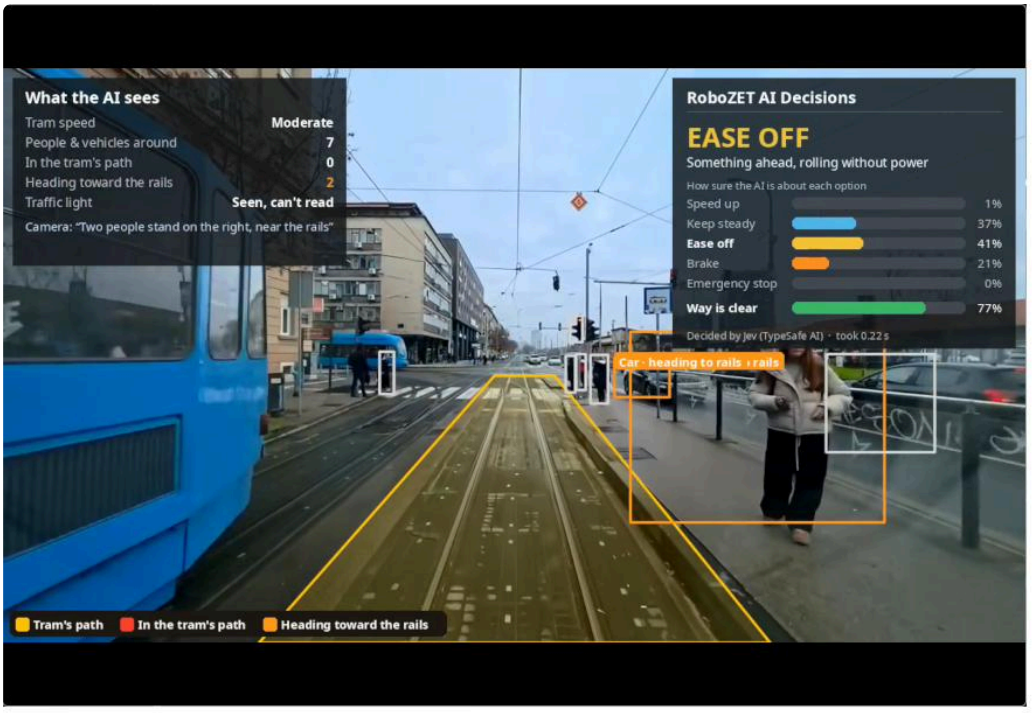
Phase 1: Proof of concept

Phase 1 proves that the AI can see, decide and physically control real tram hardware, and then turns that hardware into a robot that collects training data and monitors lines every day. It has three parts.

The AI vision system (working today)

A first version already runs on recorded cab footage of ZET line 2. It processes the video at about five frames per second and produces one structured scene description per frame.

- **Detection and tracking:** YOLO11 with ByteTrack identifies people, cars, bikes, buses, trucks and traffic lights, and follows each one over time.
- **Track awareness:** a calibrated track corridor marks which objects are on the rails, left or right of them, and moving toward them.
- **Distance and motion:** object proximity is estimated from position in the image, and the tram's own speed (stopped, slow, medium, fast) from optical flow.
- **Signals and context:** traffic light colour is read from each detection, and a local vision-language model adds a short scene note every few seconds.
- **Decisions:** each scene description goes to Jev, which returns the driving action and its confidence. The result is rendered as an overlay video showing detections, the track corridor and the AI's decision.



The first version running on ZET line 2 footage. Left: what the AI sees. Right: Jev's decision (here "ease off", 41%) with its confidence for each option. A full demo video is available on request.

The bogie

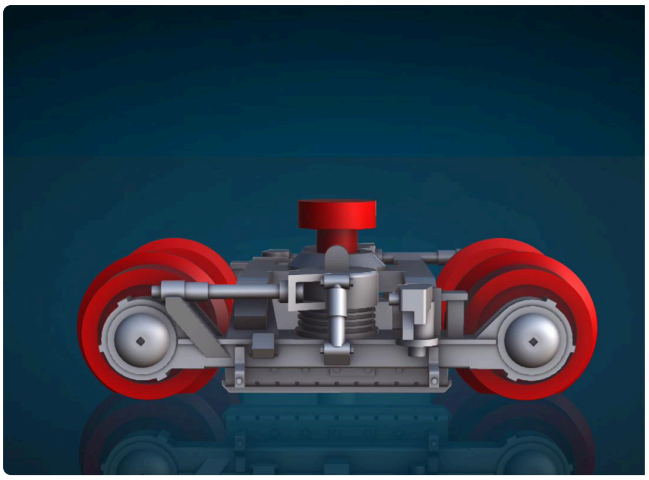
The physical platform is a single motor bogie from a decommissioned Tatra T4 tram, the type ZET runs as TMK 401. ZET is gradually retiring these trams as new TMK 2400 vehicles arrive (Bauštela), which makes bogies available that would otherwise be scrapped. Re-using Tatra bogies under a new vehicle has precedent: Dresden's CarGoTram runs on bogies from retired Tatra T4D trams.



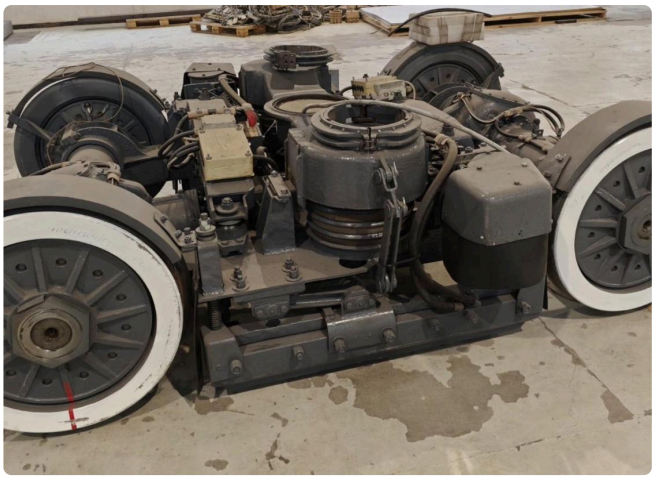
A Tatra T3-family tram. ZET's T4 (TMK 401) shares the same bogie design: two motor bogies under a single car body.

- **Fits Zagreb's track:** metre gauge, the same wheels and brakes that run on ZET lines today.
- **Drive:** two original TE 022 B DC traction motors, each rated 40 kW (Wikipedia).
- **Power:** a 72–96 V LiFePO4 battery pack instead of the 600 V overhead supply, giving slow, safe test speeds, through an industrial DC motor controller the AI commands over CAN bus.

- **Safety:** a main contactor, fusing and a physical emergency stop that cuts power regardless of the AI.
- **Compute and sensors:** an onboard GPU computer runs the vision system; cameras, radar or lidar, and GNSS/IMU sit on a frame above the bogie.



Model of the Tatra T3/T4 bogie for 1000 mm gauge.



A refurbished motor bogie of the kind Phase 1 would reuse.

First runs take place on a closed metre-gauge test track, with no public traffic.

The scout robot: mapping, then daily line monitoring

Once the bogie drives reliably under AI control, it is upgraded into a self-propelled scout robot. Its first job is to record one complete ZET line: synchronised camera, depth and position data of the track, stops, junctions, signals and traffic. That builds the dataset needed to train and validate the driving AI for Phase 2.

The robot is not a one-off mapping tool. After the initial scan it keeps working every day as a scout across the network, running ahead of or between service trams and reporting live, continuously updated scans of each line:

- **Traffic jams and blockages:** cars parked on the rails, congestion at junctions, stalled vehicles.
- **Accidents and incidents:** collisions or obstructions on or near the track, reported as they are detected.
- **Roadworks and track condition:** new construction zones, temporary signals, damaged or obstructed track.
- **Change detection:** anything that differs from the last scan of the same stretch, flagged for the operator.

For the operator, this means a live picture of every line, updated many times a day, alongside the training data the autonomous system needs. The same platform carries forward into every later phase and every new city.

Runs on live lines would happen with ZET's approval, starting outside service hours. If that is not possible early on, the same sensor pack can be mounted on a regular tram to collect the first data.

Budget and timeline

Phase 1 is estimated at **€350,000 over about 12 months**.

Item	Budget (€)
Engineering team (AI and mechatronics, ~12 months)	160,000
Sensors (cameras, radar or lidar, GNSS/IMU)	45,000
Bogie acquisition, transport and refurbishment	40,000
Mechanical platform, brake integration and safety systems	30,000
Battery, motor controller and power electronics	25,000
Test track access, insurance and regulatory advice	25,000
Onboard compute	10,000
Contingency	15,000
Total	**350,000**

Phases 2 and 3: Prototype and MVP

Phase 2, prototype. The AI system moves from the bogie into a real, road-legal tram, working with the operator. It first runs in shadow mode, making decisions alongside a human driver without control, then drives under supervision on test runs. The data recorded in Phase 1 is used to train and validate it on the real line.

Phase 3, MVP. Training is completed and the system is integrated as a traffic-ready autonomous driving system. It enters beta testing in real traffic on a single line, with a safety driver on board, under the approvals required by the city and the technical inspection authorities.

Scale-up

After a successful single-line beta, the system expands in two steps.

- **Level 1:** all tram lines in Zagreb, then other Croatian cities with tram networks.
- **Level 2:** tram operators in other countries, starting with Central and Eastern European cities that run similar metre-gauge networks and Tatra-family vehicles.

The scout robot built in Phase 1 scales with the system. Each new line or city starts with a recorded, mapped dataset before any AI driving begins, and a fleet of scouts then provides operators with daily, live monitoring of their whole network: a service with value on its own, well before full autonomy.

Funding options

The €350,000 for Phase 1 can come from one source or a combination of several.

- **Grants:** EU and Croatian innovation and smart-mobility programmes suited to applied AI and transport research.

- **Partnerships:** co-development with the operator, the City of Zagreb, research institutions or rail-industry companies, contributing funding, hardware, track access or expertise.
- **Venture capital:** equity investment from investors interested in autonomous mobility and applied AI. Early investors would back a company with a clear path from a working proof of concept to a product that can be sold to tram operators across Europe.

Who is behind it

RoboZET is developed by Astro Synapse, a Croatian company working on applied AI systems and infrastructure. The team brings hands-on experience in AI agents, machine-learning pipelines and production software, and has built the first working version of the vision and decision system.

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