Public Summary

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Project Title: Twin-Guided Robotic Pavement Overlays (T-GRO): Safer, Faster, Cleaner Resurfacing
Challenge Area: Optimization

America depends on pavement overlays to maintain highway performance, safety, and freight mobility. Yet today's resurfacing is slow, disruptive, and risky. Lane closures cascade into queues, missed deliveries, and Hours-of-Service (HOS) timeouts, while rural detours overload restricted bridges and urban lane drops create shockwaves that immobilize traffic. Strict construction windows compound the problem: hot-mix asphalt (HMA) must be placed and compacted before cooling, with rollers achieving 92–96% density and joint quality under tight temperature and timing limits. Quality assurance remains after-the-fact, relying on sporadic cores and smoothness checks. Work zones elevate crash exposure, generate excess idling emissions, and strain limited labor forces. Even where advanced tools—3D mills, automatic pavers, intelligent compaction rollers—are deployed, they function in isolation, not as coordinated, data-sharing fleets.

T-GRO closes this gap. The project delivers a twin-guided, semi-autonomous resurfacing platform that orchestrates robotic paving fleets (milling, paving, rolling, striping, and Auto Truck-Mounted Attenuators (ATMA)/TMA protection vehicles) under digital twin supervision. The twin integrates traffic, plant output, truck dispatch cycles, and live Quality Assurance (QA) telemetry to continuously generate and evaluate feasible overlay portfolios. Guardrails encode construction standards such as Manual on Uniform Traffic Control Devices (MUTCD) closure charts, density and smoothness requirements, taper rules, and crew safety constraints. A graph-based generative planner samples thousands of candidate nightly plans, while physics-in-the-loop surrogates score them for delay, worker exposure, quality risk, and CO_2e. A receding-horizon Model Predictive Control (MPC) layer dynamically retimes convoy pace, roller sequences, and detour assignments during execution.

Stage-1 demonstrations will include two pilots: (1) an urban arterial night overlay with limited detours and (2) an interstate mainline overlay carrying heavy truck volumes. For each, T-GRO will generate hundreds of constructible nightly plans, benchmark them against agency baselines, run shadow operations on live data, and validate supervised robotic trials with ATMA-protected overlay cells.

Target outcomes include:

- ≥50% fewer lane-closure hours
- ≥30% reduction in user delay
- ≥40% fewer worker exposure hours
- ≥20% lower CO_2e from idling and haul cycles
- ≥2 pay-factor grade improvements in density and smoothness

Transition and impact. T-GRO will be piloted with the Idaho Transportation Department (ITD) and contractor/OEM partners to validate manufacturability, refine playbooks, and prepare procurement templates. Deliverables include containerized software, integration adapters, robot-ready overlay playbooks, and operator training materials. Longer term, T-GRO will scale through an open-core plus Software-as-a-Service (SaaS) model, a certified marketplace of "T-GRO-ready" devices, and a multi-state consortium that shares overlay libraries and benchmarks. By embedding digital twins, robotics, and real-time QA into one coordinated workflow, T-GRO enables agencies to deliver overlays that are faster, safer, cleaner, and higher quality—transforming resurfacing from a disruptive necessity into a precise, reliable, and sustainable process.