piper®

STANDCLEAR™

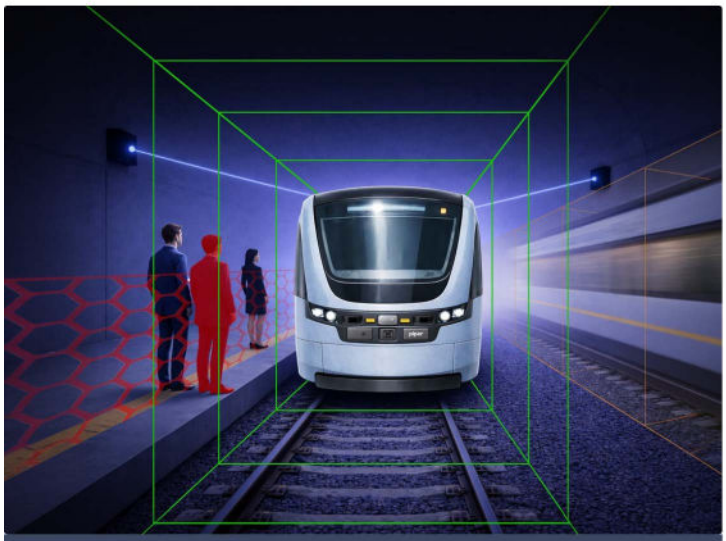
TRACK INTRUSION DETECTION SYSTEM (TIDS)

Deterministic Track Intrusion Detection using Solid-State LIDAR and Time of Flight (ToF) Sensors

THE CHALLENGE

Every day, passengers at rail and transit stations face a risk that is difficult to eliminate through signage, barriers, or staff presence alone — the risk of falling, being pushed, or walking onto the track. For train operators, the challenge is equally serious: by the time a hazard in the fouling area is visible from the cab, stopping distance is often insufficient.

Traditional approaches — CCTV monitored by staff, basic proximity sensors, and platform screen doors — each have significant limitations. Camera-based systems that rely on AI or machine learning require extensive training periods, are vulnerable to lighting and environmental conditions, and cannot currently be certified to the safety integrity levels that vital rail applications demand. Piper's StandClear™ takes a different approach — deterministic, safety-certifiable, and operational from day one with no training period required.



StandClear™ in operation — sensor fields detecting platform encroachment in real-time.

HOW STANDCLEAR™ WORKS

TrackSight™ LiDAR

Platform-end mounted · detects a 1m³ object at 100m

Piper's patented solid-state TrackSight™ LiDAR sensors are positioned at the ends of platforms, facing down the tunnels and along station tracks. Not susceptible to degradation from headlights, darkness, or other visual spectrum interferences.

Time of Flight (ToF) Cameras

Ceiling-mounted · up to 16m — detects between berthed trains

Piper's proprietary ToF cameras measure the distance to objects by calculating the round-trip time of reflected light signals. Ceiling-mounted above platform edges, they are fully operational in low-light and no-light conditions, eliminate sun glare, and can see between berthed trains.

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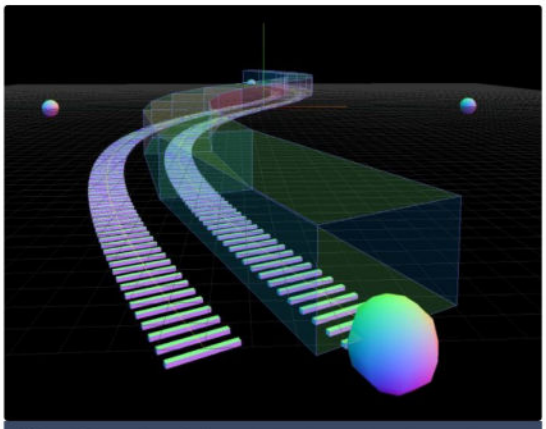
VIRTUAL TUNNELS

Digital clearance envelope · geometry-driven alerting · no image processing latency

Both sensor systems operate within Piper's proprietary Virtual Tunnel framework — a digital model of the track's dynamic clearance envelope built from a survey of the station geometry. Virtual Tunnels are constructed as strings of polyhedrons along the centerline spline of the track, calibrated to the operator's requirements. They define precisely where intrusion alerts should and should not be generated, ensuring the system responds only to genuine hazards within the fouling area — with no latency from image processing.

The system operates with a duty cycle of 100 milliseconds, with any latency confined to the communications channel — not the detection logic itself. Detection performance is consistent and predictable from commissioning day.



Virtual Tunnel model — polyhedrons along the track centerline spline define the dynamic clearance envelope.

DETECTION SCENARIOS

StandClear™ detects and responds to the full range of guideway intrusion scenarios at passenger stations:

Platform edge approach
Passengers getting too close to or crossing the platform edge.

Platform falls
Accidental falls from the platform onto the track, detected immediately.

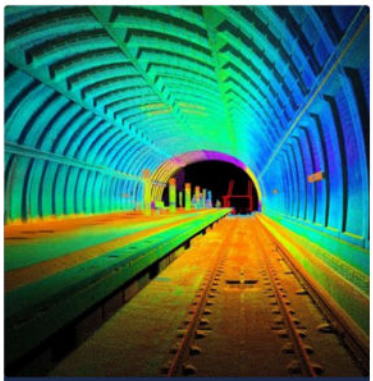
Deliberate intrusions
Malicious or deliberate track intrusions triggering immediate operator alert.

Object detection
Luggage, equipment, and debris left in the fouling area — flagged with sufficient stopping distance.

Tunnel entrance
Intrusions into tunnel entrances from platform edges — covered by TrackSight™ LiDAR.

Animate/inanimate discrimination
The system reliably distinguishes people and animals from objects, enabling proportionate alert responses.

DETERMINISTIC DETECTION — NOT ARTIFICIAL INTELLIGENCE



TrackSight™ LiDAR scan — real-time point cloud imaging inside a rail tunnel.

The fundamental limitation of AI and machine learning-based intrusion detection systems is that their performance depends on the quality and breadth of their training data. They require extended training periods before deployment, their accuracy degrades in conditions not represented in their training set, and they cannot currently be certified to the safety integrity levels that vital rail applications demand.

StandClear™ is a fully deterministic system.
It does not learn, and it does not infer. It is founded on the principle that relying on a database of learned objects cannot fulfill the safety requirements of higher-level systems. StandClear™ compares real-time sensor data against the Virtual Tunnel geometric model and generates an alert when that boundary is breached. This approach is inherently auditable, predictable, and SIL-4 certifiable. **There is no training data period. Performance on day one is identical to performance on day one thousand.**

ALERTS AND INTEGRATION

When StandClear™ detects a hazard, it communicates through multiple channels simultaneously to ensure the appropriate parties are notified with sufficient time to act:

TRAIN OPERATOR
Direct alerts to the Piper Vehicle Operator Display (VOD) in the approaching train cab.

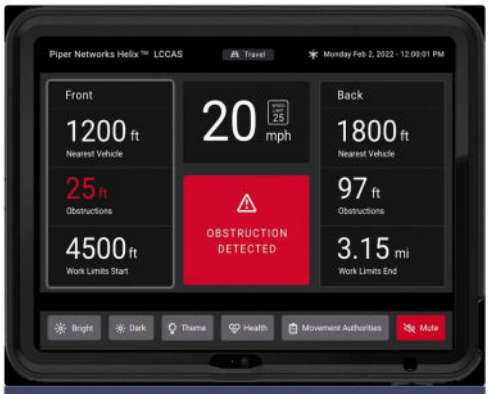
RIGHT OF WAY
Visible signals and strobes from the right of way, visible to the train operator on approach.

TRACK LIGHTING
Integration with track lighting systems for platform-wide visual warnings.

PASSENGER ALERTS
Targeted audible warnings and LED light pipe alerts to passengers in encroaching areas.

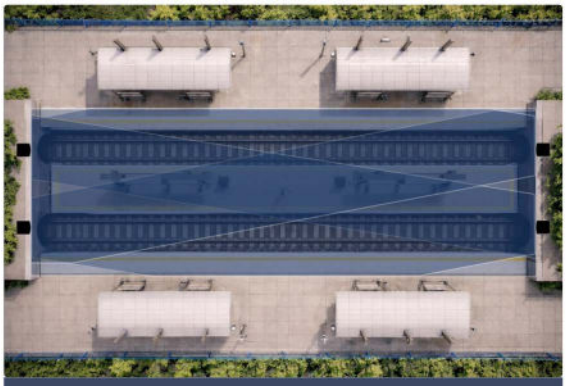
TRAIN CONTROL
Communication link into the train control system for automated responses.

DATA & ANALYTICS
All video and telemetric data stored securely for forensic analysis and incident review.



Piper Vehicle Operator Display (VOD) — obstruction detected alert in the train cab.

INSTALLATION AND INTEGRATION



StandClear™ sensor coverage — ToF cameras and LiDAR provide complete platform edge and tunnel entrance detection.

StandClear™ is designed for straightforward installation into existing station infrastructure. ToF sensors mount on ceilings above platform edges with standard wayside power — typically 110 volts or 277 VAC. LiDAR sensors are positioned at platform ends with an effective detection range of 100 meters for a 1m³ object. A station survey is required to build the Virtual Tunnel database prior to commissioning.

Communication between sensor devices and the operator network is facilitated via Ethernet, LTE, or Wi-Fi, with an option for an on-premises secure closed copper connection. An API for OCC integration is also included. Piper is an experienced systems integrator and can adapt the installation to the specific layout and existing infrastructure of each station.

STANDALONE OR INTEGRATED
The system can operate as a standalone solution or integrate directly into existing train control and station management systems.

REMOTE MANAGEMENT
A cloud-based systems administration platform monitors all components, with Over-the-Air (OTA) remote management for maintenance and updates.

PERFORMANCE AND RELIABILITY

All-Condition Operation
TrackSight™ LiDAR is inherently immune to headlights, darkness, and visual spectrum interference , and ceiling-mounted ToF sensors eliminate sun glare entirely by virtue of their downward-facing installation geometry. For conditions where environmental factors affect optical performance — heavy fog, tunnel dust, or precipitation — Piper has developed proprietary software mitigation methods that maintain detection reliability.

Proven Track Record
No anomalous failures have been reported across 600 railbound vehicles operating for 3.5 years in the Northeast Corridor. Piper's FRACAS process — Failure Reporting, Analysis, and Corrective Action System — ensures ongoing maintenance tracking and systematic extraction of performance data across all deployed installations.

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BENEFITS OF STANDCLEAR™

Deterministic, safety-certifiable
No training data period, no AI inference. Performance is predictable, auditable, and certifiable to the highest rail safety standards from day one.

Operational in all conditions
Effective in total darkness and low light. Piper has developed mitigation methods for fog, dust, snow, and rain. LiDAR is not susceptible to headlights, darkness, or other visual spectrum interferences.

Comprehensive platform coverage
Combined ToF and LiDAR coverage addresses the full platform edge, fouling area, and tunnel entrance with no detection gaps. ToF cameras also see between berthed trains.

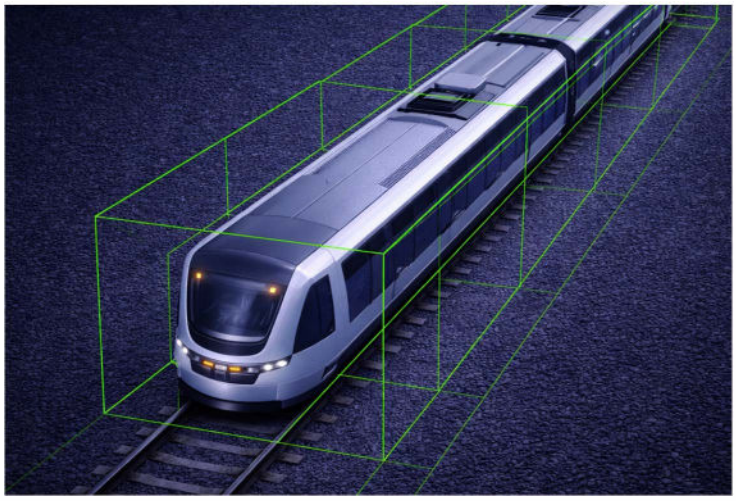
Animate and inanimate object discrimination
Reliably distinguishes people and animals from objects, enabling appropriate and proportionate alert responses, even in low-light conditions.

Multi-channel alerting
Simultaneous alerts to train operators, passengers, and control systems through the right channels with sufficient time to act.

Zero nuisance alarms by design
Geometry-only detection means alerts are generated only when the fouling area boundary is genuinely breached — never from pattern mismatches or unfamiliar objects.

Meets stringent rail standards
Compliant with CENELEC, AREMA, and IEEE standards. Piper's LiDAR is AEC-Q100 certified for transit and automotive applications.

Remote management
OTA software for health monitoring and updates. FRACAS reporting facilitates ongoing maintenance tracking across all installed locations.



STANDARDS & CERTIFICATIONS

CENELEC SIL-4
System components certified or in the process of achieving Safety Integrity Level 4 — the highest standard in the rail industry.

AEC-Q100
Piper's LiDAR sensors are AEC-Q100 certified for use in transit and automotive applications.

AREMA / IEEE
Compliant with AREMA and IEEE standards for railway signaling and safety systems.

Part of the Piper Platform

StandClear™ uses the same **TrackSight™ LiDAR** hardware deployed across Piper's Vital Train Positioning platform — proven in revenue service at Amtrak, MTA New York City, and other major US operators. No anomalous failures reported across **600 railbound vehicles operating for 3.5 years** in the Northeast Corridor. The same sensing technology that keeps trains positioned with centimeter accuracy keeps passengers safe at platform edges.

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