

Rail Crossing Information Systems vs Commercial Off-the-Shelf (COTS) Technologies for Train Detection

A head-to-head comparison between video, radar, and LiDAR devices with a Rail Crossing Information System to determine which approach can meet the needs for rail crossing safety.

Commercial off-the-shelf (COTS) technologies like video, radar, and LiDAR work well for roadways – but fall short at rail crossings. This is where a Rail Crossing Information System (RCIS) that’s purpose-built for rail environments comes in. RCIS was independently tested and found to deliver:

- ✓ 100% detection accuracy vs. 40–80% for COTS systems
- ✓ Predictive alerts up to 10 minutes in advance vs. no prediction for COTS
- ✓ Seamless integration with emergency platforms vs. manual setup and limited compatibility for COTS
- ✓ Operational in 3 days vs. 4–6 weeks for COTS

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EXECUTIVE SUMMARY

As cities across North America seek modern solutions to reduce delays, improve safety, and increase situational awareness at rail crossings, many turn to familiar tools like video cameras, radar, or LiDAR. While these commercial off-the-shelf (COTS) technologies are well-suited for vehicle detection and traffic monitoring, they fall short when adapted for rail-specific applications.

However, rail crossings introduce a fundamentally different set of technical and safety challenges. Train movements are less frequent but far more consequential than general traffic events. Missed detections are not minor inaccuracies — they represent complete failures to capture long-duration, high-impact events. Unlike roadway traffic data, which is continuous and redundant, train detection is binary: either the system catches the train or it doesn't.

A year-long pilot project in Houston, Texas provided a direct comparison between TRAINFO's purpose-built Rail Crossing Information System (RCIS) and COTS-based detection technologies. The results were conclusive:

- **TRAINFO achieved 100% detection accuracy under normal conditions**
- **COTS systems ranged from 40% to 80% accuracy**, depending on the site and environmental conditions
- **TRAINFO was fully deployed and operational in just 3 days**; COTS systems required months for installation, calibration, and logic development
- **TRAINFO provided predictive alerts, real-time dashboards, and emergency system integration out of the box**

These findings confirm that while COTS technologies may be suitable for traffic applications, they do not meet the performance, reliability, and deployment needs required for rail-grade crossing detection.

TRAINFO's RCIS was purpose-built by transportation engineers to detect and communicate train activity with near-perfect accuracy in real time. This whitepaper outlines the engineering rationale, real-world testing results, and performance benchmarks that show why an RCIS is the clear choice for modern rail crossing management.

THE MISCONCEPTION: CAN COTS TECHNOLOGIES DETECT TRAINS RELIABLY?

Video analytics, radar, and LiDAR have become common in transportation and surveillance applications. Cities use them to count vehicles, identify incidents, and enforce traffic rules. Understandably, public agencies ask:

“If we already use video and radar for traffic detection, why not use them for train detection too?”

The answer lies in purpose and precision.

COTS technologies are optimized for vehicle movements on road networks where 90–95% detection accuracy is often sufficient for flow monitoring. In contrast, train detection at rail crossings demands near-perfect accuracy, precise event timing, and predictive insight — capabilities COTS systems were never designed to deliver. These systems also lack built-in analytics tailored to rail events, often requiring custom logic to be developed just to recognize a blocked crossing. Dashboards, alerts, and trend metrics must also be created from scratch. **Adapting COTS technologies to rail environments requires extensive customization, calibration, validation, and sometimes additional hardware** — just to approach the performance RCIS delivers out of the box.



OVERVIEW OF COTS DETECTION TECHNOLOGIES

To better understand the performance differences observed in the Houston pilot, it's useful to examine how commercial off-the-shelf (COTS) technologies — particularly video, radar, and LiDAR — operate, and what their respective strengths and weaknesses are in the context of train detection.

Video

Video systems use image processing and object recognition algorithms to detect motion and classify objects. They are cost-effective and widely deployed for general traffic surveillance.

- **Pros:** Already installed in many cities; useful for real-time visual monitoring; capable of detecting moving objects with reasonable accuracy in controlled conditions.
- **Cons:** Sightlines can be obstructed by gates, poles, fencing, or other rail-specific infrastructure. Performance is highly sensitive to lighting and weather, and stopped trains may be misclassified as background.

Radar

Radar systems measure the reflection of radio waves to detect motion and object presence. They perform well in poor lighting or weather conditions.

- **Pros:** Less affected by visibility conditions; good for detecting motion and presence.
- **Cons:** Struggles with identifying stationary trains and classifying objects. Detection depends heavily on mounting angles, which can be constrained at crossings.

LiDAR

LiDAR emits laser pulses to create 3D point clouds of the surrounding environment. It is commonly used in autonomous vehicle testing and high-precision mapping.

- **Pros:** Offers detailed spatial resolution and can detect and track objects with precision.
- **Cons:** High cost, especially for multi-crossing deployments. Performance is degraded by fog, dust, or precipitation, and the system is highly dependent on clear sightlines.

Limitations Common to All

Even when these technologies succeed in detecting physical presence, they do not inherently understand *rail crossing behavior*. The primary limitations of COTS systems are:

- **No rail-specific logic:** Most don't know the difference between a passing train and a stationary one, or a gate malfunction versus a train arrival.
- **No built-in user interface or workflows:** Cities must build custom dashboards, alerts, and reporting from scratch.
- **Extensive calibration and validation:** Agencies must invest heavily in testing, tuning, and analyzing outputs before these systems can be trusted.

TRAINFO'S RCIS: BUILT FOR RAIL, PROVEN IN THE FIELD

TRAINFO's Rail Crossing Information System uses **proprietary acoustic sensors** specifically engineered for the rail environment. These sensors detect the unique sound signatures generated by approaching, passing, and stopped trains — enabling accurate classification and real-time response.

The system features **edge computing** at each crossing to perform initial quality control and validation before data is sent to the cloud. Once in the cloud, **machine learning algorithms** analyze sound patterns to determine train speed, direction, type (e.g., freight vs. passenger), and movement type (e.g., through movement vs. shunting or switching). Unlike video, radar, or LiDAR systems, TRAINFO's sensors are **unaffected by visibility, glare, weather, or mounting angle constraints**.

TRAINFO's sensors also detect crossing bells and can identify malfunctions in audible warning devices. All events can be validated using raw audio files, which provide a high level of transparency — it's obvious when a train is present.

While the system does not natively provide visual data (such as train type or operator), camera modules can be added to the RCIS platform. These optional modules offer visual verification, vehicle and pedestrian movement tracking, and automated detection of trespassing, warning device violations, and near-misses.

TRAINFO's acoustic-based approach is not only reliable and predictive — it's engineered from the ground up to handle the realities of rail crossings, giving transportation agencies actionable data with minimal installation, rapid deployment, and built-in scalability.

A major differentiator is TRAINFO's **patented predictive capability**. Our system can forecast train arrivals and clearance times with **±1 minute accuracy 90% of the time** — a level of precision unmatched by COTS systems. This capability is powered by a machine learning engine trained on over 1 million historical train movements and continuously improving with each new event captured. This level of predictive accuracy enables smarter emergency routing, signal preemption, and driver alerting — well before a train becomes visible or audible to roadside observers. Its proprietary acoustic sensors, predictive machine learning algorithms, and cloud-native architecture are designed to function in the unique acoustic and environmental conditions of rail infrastructure.

Unlike systems that attempt to detect trains by interpreting visual or reflected signals, TRAINFO's sensors *hear* the train—and know what it means.

Key capabilities include:

- ✓ 100% train detection accuracy under normal conditions
- ✓ Rapid deployment in as little as three days
- ✓ Predictive alerts up to 10 minutes before train arrival
- ✓ Railroad approval for installation is not required
- ✓ Seamless integration into third-party systems for traffic management and emergency response



WHY TRAIN DETECTION DEMANDS A HIGHER STANDARD

Train detection is fundamentally different from vehicle detection — not just in terms of technology, but in the consequences of failure. A 90% detection rate may sound high, but when applied to rail crossings, it means **missing 1 in 10 trains** — a rate that is simply unacceptable given the risks involved. The stakes at rail crossings are significantly higher than at traditional road intersections: lives are at risk, delays are longer, and the consequences of failure are more severe.

Here are 5 reasons why traditional COTS traffic technologies fall short and why rail-specific detection systems must meet a much higher standard of performance and reliability.

1. Train Detection Errors Carry Disproportionate Consequences

Missing 10% of vehicles in traffic monitoring still allows engineers to model flows, identify trends, and make operational decisions with minimal impact. But **missing 10% of trains can mean missing the entire event** — a train that blocks a crossing for 15 minutes, cuts off emergency access, or creates safety risks for pedestrians. This isn't just a data gap — it's a failure to detect the most consequential events in the system. Unlike vehicle flow data, which is continuous and redundant, **train events are infrequent but highly impactful. Failing to capture even a single event severely limits the system's usefulness for emergency response, traffic diversion, and public reporting.**

2. Rail Infrastructure Presents Unique Detection Challenges

Rail crossings feature a wider variety of physical infrastructure than standard roadways — including gates, signal arms, fencing, and ballast — all of which can confuse detection algorithms not designed for these conditions. COTS traffic sensors, such as video and LiDAR, are typically trained on typical road environments. **When exposed to rail-specific elements, COTS technologies can misclassify common objects or behaviors, leading to false negatives or false positives.**

Scientific studies and field tests have shown that visual and reflective sensors struggle with inconsistent lighting, obstructed views, and unique features at crossings. These challenges make it clear that train detection requires purpose-built sensing logic, rather than adaptations of roadway systems that were never intended for rail applications.

3. Rail Events Need Accurate Clearance Windows

Emergency response systems depend on precise timing: when a train arrives, how long it blocks the road, and when it clears. A late detection—even by a minute—can result in dangerous and avoidable decisions by motorists or delayed responses by first responders.

4. Trains Kill More Often Than Cars

Rail crossing collisions are **far deadlier** than road collisions. According to Federal Railroad Administration data, highway-rail grade crossing collisions result in a fatality approximately **1 in every 10 incidents**, whereas motor vehicle crashes on roadways result in a fatality in roughly **1 out of every 140 incidents** (based on NHTSA data). That means **rail collisions are** over 10 times more likely **to result in death.**

This dramatic difference highlights why train detection requires far higher standards. Any failure to detect a train—especially during peak pedestrian or emergency response periods—can result in **life-threatening consequences.**

5. Rail Crossing Events Are Binary, Not Incremental

In road traffic monitoring, capturing 90% of vehicles can still give reliable flow data. But with trains, **either the train is detected or it's not.** There's no such thing as "partial detection" of a train. COTS tools designed for traffic flow simply aren't built for binary event detection with zero margin for error.



REAL-WORLD EVALUATION: THE HOUSTON PILOT TEST

To evaluate TRAINFO's RCIS against commercial off-the-shelf (COTS) detection technologies, the City of Houston conducted a year-long project from late 2022 through 2023. The project focused on testing and validating each technology's ability to detect and report train activity at high-impact locations.

Test Environment

Location: Houston's East End — one of the city's most active and congested rail corridors, where frequent and extended blockages cause significant delays for emergency responders and motorists.

Duration: Approximately 12 months of installation, calibration, monitoring, and validation.

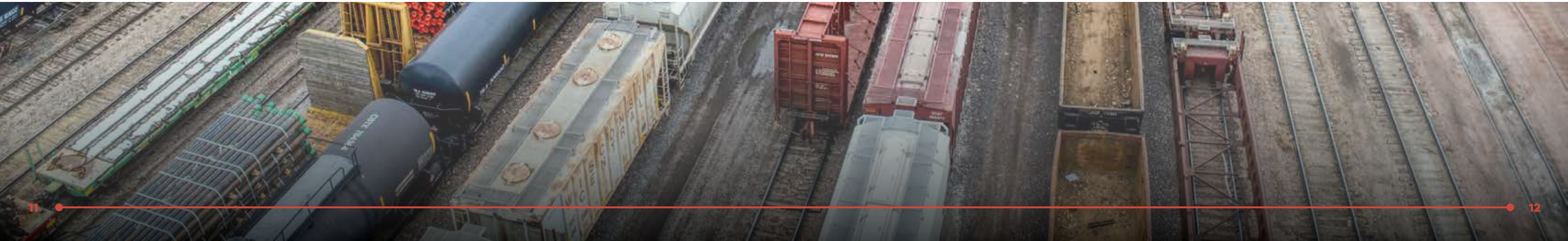
Crossings Tested: Six grade crossings were selected, with three used for direct side-by-side comparisons between technologies.

Technology Setup: Each site was outfitted with different combinations of sensors including video, LiDAR, and TRAINFO's proprietary acoustic sensors, depending on technical feasibility and line-of-sight constraints.

Evaluation Methodology

The pilot team used a structured audit process, reviewing 10 randomly selected alerts per week from each system. Video validation was used to confirm accuracy, and all results were compiled in weekly reports. Systems were evaluated based on:

- **Accuracy** of detecting train arrivals, departures, and stopped trains
- System responsiveness and **reliability** in different weather and visibility conditions
- **Usability** of dashboards, data reporting, and integration with platforms like Haystax
- **Ease** and speed of deployment
- Ability to provide **predictive** alerts for upcoming train activity



● KEY FINDINGS

TRAINFO achieved near-perfect detection accuracy under normal conditions and was fully operational within three days. The system’s data matched independent video review audits and was integrated into emergency response tools from day one. In contrast, the COTS-based system required extensive setup, custom logic development, and still produced inconsistent results, with detection accuracy ranging from 40% to 80% depending on the site.

Performance Metric	TRAINFO (RCIS Solution)	Video & LiDAR (COTS Solution)
Detection Accuracy	100% under normal conditions	Varied from 40% to 80% depending on conditions
Environmental Reliability	Stable across all tested weather and lighting conditions	Performance dropped significantly in poor lighting and with visual obstructions
Deployment Speed	3 days (plug-and-play sensor installation)	Up to 6 weeks (including site prep and calibration)
Usability	Intuitive dashboard; minimal training needed	Required technical training and manual video review
Emergency System Integration	Fully integrated with Haystax for first responder use	Not integrated with emergency dashboards
Predictive Alerts	Alerts issued up to 10 minutes before train arrival	Not available

Source: City of Houston Smart Railroad Crossings Pilot, 2023–2024

RCIS BY TRAINFO: DESIGNED FOR RAIL CROSSINGS

An RCIS is not just a train detection tool — it's a fully operational transportation system, built from the ground up to work out of the box. Unlike commercial video or sensor platforms that require extensive customization to detect trains and build out dashboards, TRAINFO's RCIS comes ready with:

- **Real-time alerting dashboards**
- **Historical reporting and CSV export tools**
- **Trend analysis and heatmaps**
- **Built-in integrations with 911 and ATMS platforms**

This means cities can move from installation to operation in days — not months. In contrast, COTS sensors like video and LiDAR require cities to build detection logic, event triggers, interfaces, and integrations from scratch — a process that often involves multiple vendors and prolonged trial-and-error cycles.

Moreover, before COTS solutions can be trusted, agencies must often conduct extensive testing, fine-tuning, and outlier analysis to understand where and why detection errors occur. TRAINFO's RCIS has already undergone this rigorous process, including independent field evaluations in complex environments like Houston and Florida. This means agencies can deploy TRAINFO's RCIS with immediate confidence in its performance, rather than spending months validating a system that was never designed for rail applications.

TRAINFO's RCIS delivered not only better detection but more usable data—real-time alerts, incident reporting, trend analysis, and agency coordination tools tailored to the workflows of traffic engineers, planners, and emergency response teams.

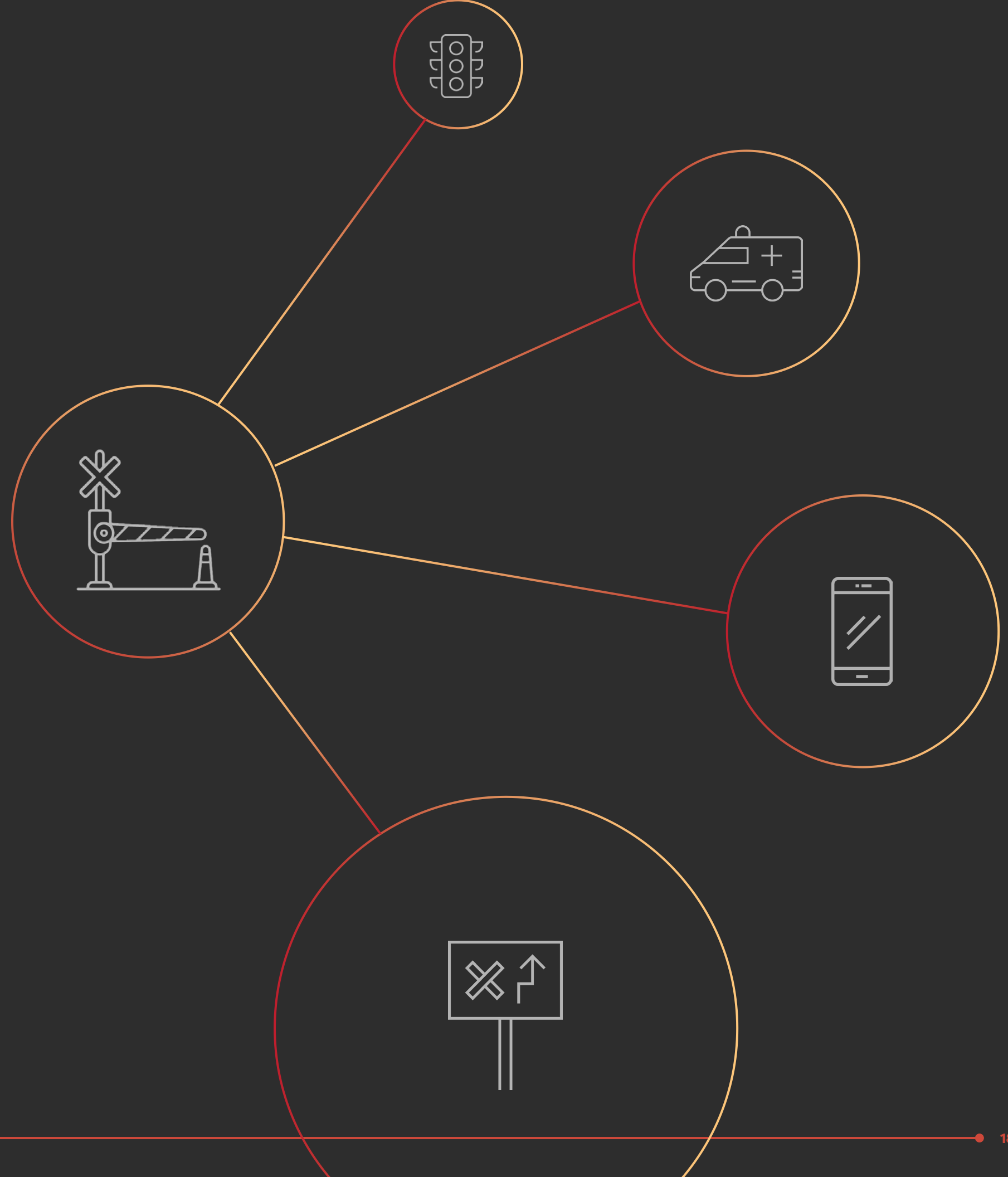


CONCLUSION

COTS technologies may appear to offer a cheaper or more familiar option, but the evidence is clear: when it comes to train detection, they cannot match the accuracy, speed, or reliability of an RCIS.

RCIS isn't just a better tool—it's a necessary one. Cities that want to reduce delays, enhance safety, and improve coordination around rail crossings need a solution built for the task.

RCIS is the new standard for train detection.



ABOUT TRAINFO

TRAINFO is the only company in North America dedicated exclusively to solving blocked rail crossings and is the world's leading provider of RCIS. Our RCIS is deployed in cities across the U.S. and Canada and backed by years of transportation research and real-world testing.

Learn more at www.trainfo.ca or contact us at info@trainfo.ca

