By the mid-1990s, Indian Railways had completed the full computerization of its reservation system, marking one of the earliest milestones in the digitization of railway operations.

Around the same period, India’s first metro rail service was introduced in Kolkata, symbolizing a move toward urban rapid-transit modernization.

**TCAS**

In 2012, the Indian Railways implemented a major safety innovation—the Train Collision Avoidance System (TCAS), which was first tested in Hyderabad. TCAS was designed to automatically control train movement and prevent collisions by alerting drivers and activating brakes when two trains occupy the same section of track.

However, its deployment has remained limited to a few premium services such as the Shatabdi and Rajdhani trains, leaving a large portion of the network dependent on manual signaling systems.

The continuing use of manual signaling has contributed to several incidents, including the 2012 derailment of a Gwalior-bound narrow-gauge train that struck a tractor and the Brahmaputra Mail collision with a stationary goods train the same year.

These accidents demonstrate that while technological progress has begun, India’s safety systems have yet to achieve full automation and comprehensive coverage.

Therefore, the transition toward real-time, sensor-based obstacle detection and alert systems is essential to strengthen railway safety beyond current signaling and collision-avoidance measures.

**Problems with the Current System**

The current railway transportation system possesses the following issues:

1. Derailing of trains. Since the loco pilot could not view the tracks clearly, therefore

There is always a chance of a train getting derailed, which can cause huge destruction

to lives.

2. Collision of trains. Since the loco pilot could not predict the presence of other

train on the same track (no device is there that can help him to do so),

Therefore, train collisions do take place [4].

3. Delay in winters Due to bad weather, the loco pilot becomes unable to view

tracks; for this reason, to avoid any mishappening, he drives the train at a

very slow speed. Every year in winter, it is now a common scenario that the

The train got delayed by 20–24 hours, which caused huge inconvenience to passengers.

4. TCAS technology. With this technology, a huge amount is required to be

invested; that is, for running a train 1 km, about 1–2 lakhs rupees are required,

which means the cost of implementing it in trains would be very high [4]. This poses

a great expenditure on Indian railways. Perhaps this huge investment may be

one reason that, in spite of the introduction of TCAS in India in December,

In 2012, it has not been able to be implemented yet  
  
  
**Description of the Proposed System**

Through the installation of thermographic cameras on the engine, the proposed solution seeks to address the main safety and visibility concerns that Indian Railways faces.

Even in inclement weather, such as intense rain or thick fog, loco pilots can see track conditions and nearby objects, including people, animals, and obstructions, thanks to their cameras.

The thermographic feed and the coordinates of neighboring trains are shown on a dashboard screen, enabling the pilot to keep an eye on several trains and avert possible collisions or derailments.

In times of crisis, this real-time depiction of the track and train environment improves situational awareness and reaction time.

**System Components**

The system integrates multiple subsystems to achieve continuous safety monitoring:

GPS Device: Tracks the train’s exact location relative to nearby stations and displays the data on the onboard screen.

IC Sensors on Engine and Last Coach: Allow the pilot to view the complete length of the train and ensure alignment across all carriages.

FLIR HRC-Series Thermographic Camera: Provides high-resolution imaging up to 4–5 km ahead of the locomotive, ensuring clear vision during all seasons and weather conditions.

The total estimated cost of implementation ranges from ₹65,000–₹75,000, making it significantly more economical than TCAS technology, while offering broader visibility and simpler installation.

**Issues Resolved by the Proposed System**

The proposed setup aims to resolve several operational challenges currently faced by Indian Railways:

* **Prevention of Derailments:** Continuous track visualization helps the loco pilot maintain train alignment and detect anomalies before derailment occurs.
* **Avoidance of Collisions:** Integration with TCAS ensures that trains on the same track are detected early, minimizing collision risks.
* **Reduced Winter Delays:** The thermographic camera enables visibility through fog and low-light conditions, maintaining regular train speeds even during winter months.
* **Lower Implementation Cost:** Compared to TCAS, the system provides better visual results at a fraction of the cost, thereby improving safety while reducing expenditure.

## **Limitations and Implementation Challenges**

Although the system enhances visibility and train safety, it remains **driver-dependent**, requiring active monitoring and interpretation by the loco pilot.  
 Major implementation challenges include **initial setup expenses**, **regular maintenance**, and **the need for specialized training** for train operators.  
 Because the system depends on human response, it does not completely eliminate risks associated with human error or delayed reaction times.  
  
 **Although the thermographic camera-based system provides enhanced visibility and cost benefits, it lacks automation and intelligent obstacle recognition. This creates a gap for the development of an advanced, AI-driven Obstacle Detection and Alert System (ODAS) that can function autonomously and minimize human dependency**

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