SAFETY

MAKING UNMANNED RAILWAY CROSSINGS SAFE

All the safety measures adopted by Indian Railways have failed to prevent accidents on unmanned railway crossings. Here is a practical suggestion for a simple and economical automated sensor-based alarm that could reduce the number of train accidents every year.

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Some years back there was a horrendous accident near Pune where a school bus was rammed by a train, leading to ghastly death of 58 small children. This is not an isolated happening on Indian railway networks. Every year, several hundred people die a gruesome death in India, in collision of road vehicles with trains on unmanned railway crossings in rural and remote areas. The problem is particularly severe on crossings near curved/sloped tracks or hills, at nights and during rainy and misty seasons, as the oncoming train cannot be seen.

The best way to protect the road travellers, of course, is to convert every unmanned railway crossing into a manned one—involving barriers and round-the-clock gatekeepers. Since the number of unmanned railway crossings in India is very large, this option will cost much and we must adopt some other system to make unmanned railway crossings safe.

One of the simplest precautions to prevent accidents on unmanned railway crossings is to put up signboards along the track indicating to the train driver that there is an unmanned railway crossing ahead. On seeing such a signboard, the train driver can repeatedly sound the horn to warn the road travellers or slow down the train. Such a system is already in place but the number of accidents is still significant.

To increase safety, we need to augment the measures like signboards and reduce dependence on human factors, e.g. on train drivers, for complying with mandatory actions like sounding horns. Simple technology can be brought to bear on this task.

The automated alarm system

What is needed is a simple, economical automated alarm system designed to help in preventing such accidents as far as possible. Ideally, to diminish bureaucratic resistance, such a system should not depend on any existing railway facilities like track power, signalling systems, and track circuits (occupancy sensors). That is, it should be largely independent of the infrastructure of Indian railways and should be usable on tracks of any kind and gauge.

Also, installation and operation of the system should not require too much intrusion on the existing tracks and trains, and should not require substantial changes to be made by the railway personnel. The system should be fault-tolerant, fail-safe, easy to maintain, and configure to many different situations.

Essentially, in the simplest configuration, such a system (shown in the figure on next page) will detect a moving train approaching an unmanned gate and then sound an alarm as well as flash a red light at the site of the crossing. Once the train departs, the alarm and the light would switch off.

The train detection sensors will report the arrival and departure of a train on the track using radio frequency (RF) to the alarm controller at the crossing. Use of RF will avoid cabling, improve reliability, and reduce maintenance problems. Communication between the sensors and the controllers should not depend on the line-of-sight; repeaters may be used, if necessary. Also, the train may arrive from either side towards the gate.

Some drivers of road vehicles make a fateful dash across the track, despite the flashing red light, when they are ‘speeding’, and see the light only when they are too near the gate and don’t have enough time to apply brakes. So the drivers need to be warned much before they reach the gate—by placing additional flashing red lights, say, 25-50 metres before the gate. Both the light at the gate and these secondary red lights down the road would be...

Distance radar for automatic rendezvous
controlled by the system.

The system should be configurable for the distance of sensors from the crossing, number of tracks at the crossing, additional sensors for fault-tolerance, additional alarm devices (displays at the crossing, replay of pre-recorded voice messages in local language and/or Hindi, etc), preset schedules for operating the alarms, etc.

If trains pass the unmanned crossing at up to 120 km/hour, the train detection sensor should be placed about 2 km away from the crossing, to provide at least one minute of warning to the road vehicle drivers. Since the peak speeds may vary in different areas, the distance of sensors should be calculated separately for each crossing, so as to provide warning to the road travellers for the optimum time.

A barrier may be added which, along with other alarms, could be closed or opened by the system. This barrier operation has to be carefully designed so as to avoid trapping of a vehicle on the track, which can be very dangerous as there is no gatekeeper to help occupants of the trapped vehicle. One solution is to provide a prominent button that can be pressed by the people to quickly lift the barrier and rescue the vehicle.

A simple panel may be provided for manual checking, re-setting, and start or shutdown of the controller and alarms. The system should be housed in a protective enclosure to prevent theft and damage from rain, heat, and cold. It should be powered by a low-cost, long-life, maintenance-free battery, with an optional back-up battery. Solar power could also be used.

The system should provide an event logging capability that will record the arrival and departure of every train, along with a timestamp. This data could be stored in, say, an EEPROM for about 30 days, and the system should have the facility to send the data via a serial port to a PC. The logged data may also include train’s direction and speed of arrival, temperature, status of the sensors, alarms, power sources, and other system components, etc.

The minimal system should cost less than Rs 10,000. An added advantage would be to build the system entirely from Indian components including RF transmitters and receivers. As imported train detection sensors may cost more, we need to manufacture economical and reliable train detection sensors within the country.

**Train detection sensors**

The train detection sensor should not only detect the arrival of a train but it should also, ideally, be designed to report the direction of arrival and speed so that the controller can compute the estimated time of arrival of the train at the gate.

Several options are possible to design a train detection sensor: a pressure sensor for a passing train, a small electrical circuit closed by the metal wheels of the train, an RF noise generator fitted on each locomotive, interfacing and making use of railway signaling or the track circuit system, an infrared ray broken by two wheels simultaneously, use of lasers or radars, detection of changes in magnetic fields, etc. The sensor should be reliable, fail-safe, and able to withstand heat, humidity, rain, light, etc.

It is crucial to correctly define the expected behaviour of train arrival (and departure) sensors. For instance, since the length of a typical train can vary from a single engine to a long goods train, the simplest wheel-based sensors would provide multiple signals to the control (one for each wheel), resulting in ‘chatter’. A simple strategy is to avoid sending multiple signals to the controller if after detecting the first wheel there are multiple wheels at a regular interval.

However, such a system should carefully handle the situation where the train stops after the first wheel is detected but before the last wheel is detected. In such a case, once the train starts moving, it might be detected as arrival of a new train. This will confuse the system because only one train departure will be detected.

Another possible confusing situation could arise if the sensors are too far from the controller. In that case there may be more than one train in the control zone, i.e. the track between the arrival and departure sensors. This situation can be handled by counting the numbers of arrival and departures and maintaining them to be the same. For instance, if a train arrives before the first train departs, two train departures should be detected before the alarms are switched off.

Also, the sensor should be able to distinguish between a train (or an engine) and small vehicles like the small track-inspection trolleys that cause no harm to the road traffic.

The sensor (or the controller) should be robust enough to minimise spurious detection of trains (due to people on the track, etc) and should be intelligent enough to reset or shutdown itself in situations when the train arrival sensor has tripped but the train departure sensor has not tripped for 30 minutes, etc.

The train detection sensor should be very small, with its own power source and RF transceiver, so that it could be placed unobtrusively on the track. It should be housed in a tough casing that withstands vibrations, shocks, heat, cold, and rain. It should be firmly fitted to the track, without obstructing train movement. It should be calibrated for speeds from 5 km/hour to 120 km/hour with a resolution of 1 km/hour. It should also be calibrated for various distances from 100 m to 3 km at a resolution of 50 m.

**An alternative to train detection sensors**

Instead of placing train detection sensors along the track, the locomotives can be
equipped with a small RF transmitter that constantly emits a fixed signal, which can be received and used by the gate controller to indicate the arrival of the train. Since the number of gates is likely to be much larger than the number of locomotives, and each gate needs at least two train detection sensors, this option is much more economical and avoids the pitfalls of a physical train detection sensor.

The RF transmitter should be such that the corresponding RF receiver at the gate controller is not limited by line-of-sight transmission. Issues like interference with other systems need to be tackled.

**Fault tolerance and reliability**

The automated alarm system must be designed to handle most common faults by means of appropriate fault-tolerance techniques. The mean time between failure (MTBF) should be 3-4 years.

The most serious fault is the failure of the train arrival sensor. To tackle this problem, one simple strategy would be to replicate the train detection sensors and setting off the alarm when even one of the sensors trips.

The red lamp and the horn for alarm must be reliable and have a long life. Simple replication (back-up lights and horns) may be used to handle the failure of alarms (the red lamp and the horn).

Failure of RF communication links between the sensors and the controller can be detected by the controller by means of simple periodic self-tests and a default yellow light may be switched on to warn the road travellers in case the controller cannot communicate with any of the train sensors (from either the arrival side or from the departure side).

Failure of the power to the controller or the sensors can pose another major problem. Simple replication (back-up battery) may be used to handle this situation, with an option of using either the mains supply, if available, or the power supply from railways.

The controller should have a self-test ability to detect failures of components (controller components, RF communication links, sensors, and alarms) and then resort to a default yellow light to indicate that the system is not working.

**Conclusion**

The RF-based controller system for unmanned railway crossings opens up new trade opportunities as it could be exported to under-developed countries. Corporate sponsorships may be invited in order to cover the cost of some installations of the systems (say, in the vicinity of the factories).

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