NextGen ATP for Automatic Train Operations

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Abstract

Automatic Train Protection(ATP) system ia s control system used by railways to help avoid collisions by automatically controlling the maximum permissable speed (MPS) that a train can travel at in at any given time relative to its movement authority. The MPS can vary from 0 MPH to the track/loco/formation's MPS. Constant communication between train onboard computer and wayside Equipment help determine MPS. ATP controls only deceleration of the train and Automatic Train Operation (ATO) controls all phases of train operation - from acceleration to precise stopping. The article disscusses the reasons for provision of automatic train operations on Indian Railways mixed traffic network and how the indigenous automatic train protection system being developed by RDSO can be transformed to fully automatic train operation (FATO) system

1 Indigenous Train Protection System

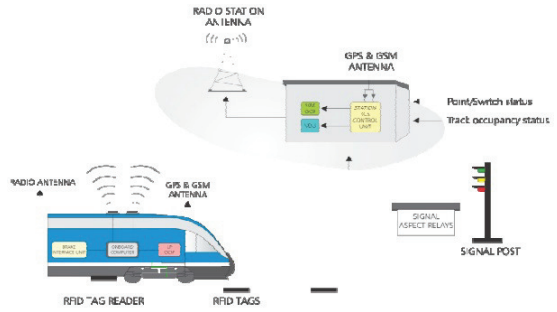

Figure 1: Indigenous Train Protection System of RDSO

The signalling interlocking status (Signal aspects, Point indications and berthing tracks) are ready by the vital computer in the stationary system and is converted into radio packets. The on board vital computer after ensuring radio security then processes the regular radio packets. The on board vital computer sends its location and its status in every cycle which will be monitored by the stationary units present in the territory of ATP.The location is corrected for its odometric error accumulated with the help of passive RFID markers located at one kilometer interval all along the track. The time synchronization between stationary and on board system is ensured through GPS in redundant manner.Redundancy is provided for radio modems, GSM modems (alert/fault messages), GPS Modems and RFID readers.

1.1 Advantages of indigenous ATP

- Detection and Prevention of SPAD
- User friendly On Board Display of Signal Aspect.
- Maximum Section Speed Supervision and Control
- Maximum Loco Speed Supervision and Control
- Permanent Speed Restriction Supervision and Control
- Multi-vendor interoperability free from monopoly
- Helpful in Foggy Weather
- Helpful at high speeds
- Centralized live monitoring of Train Movement
- Head On Collision Prevention
- Rear End Collision Prevention
- Side Collision Prevention
- Manual SoS from Loco and Station
- Blowing horn while approaching Level Crossing Gate.

2 Automatic Operations in Loco for ATP

- Normal brake command for ceiling speed monitoring.
- Loco brake command when only light engine is moving.

Figure 2: Loco Pilot Machine Interface

- Full service brake command for speed supervision.
- Emergency brakes command in case the above brake commands become ineffective.
- Traction cut off command while braking.
- Automatic whistling in case of level crossing gates.

Hence, it is obvious that some operations inside locomotives are controlled as a part of ATP.

2.1 Necessity for Automatic Train Operations

The various factors determining the throughput are:

- Running Speed.
- Block section length.
- Block overlap.
- Train length.
- Station section.
- Sighting distance.
- Running time in block section
- Time taken for the train length to clear block overlap
- Time to release the route
- Time to take line clear
- Time to set the route for the next train
- Time to cover Sighting distance
- Time to cover distant signal and advanced starter

There is certain belief in the industry that speed increase will increase in throughput. A detailed analysis was done on this issue based on UIC 406 leaflet. It was found that if the same signalling is retained and speeds are increased upto 350 KMPH the resultant increase in throughput is not at the same rate due to various constraints. The best results are achieved when moving block is maintained as the main signalling system with fall back of auto signalling. Thus, the need is strongly felt for automatic train operations.

The results are shown in the Figure 3.

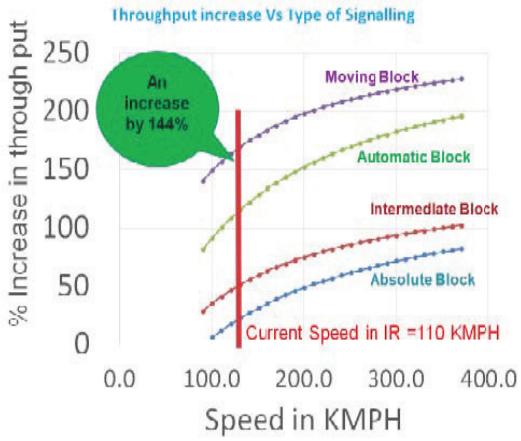

Figure 3: % Increase in Through-put with advanced Signalling Systems

But, it is challenging issue to bring moving block signalling systems on Indian Railways where traffic with various different loads (freight and passenger) but nevertheless the solutions do exist.

3 Proposed Solution for ATP on IR

The automatic train operation shall be able to command the loco controlling computer (LCC) by verifying the following:

1. Automatic Train Supervision (ATS).
2. Taking input of movement authority and static speed profile from the automatic train protection system.
3. Ensuring Train Integrity.

4. Ensuring Loco to Loco communication meet SIL-4 standards through the stationary TCAS.

5. Ensuring Rail Integrity (as a future option).

The Automatic Train Operation shall be developed in two phases:

- Phase-I: Guidance Mode.
- Phase-II: Auto Pilot Mode

3.1 Implementation of Guidance Mode ATO

Motive power directorate has developed specification for in cab advice system that helps Loco Pilots of both freight & coaching trains to save fuel and stay on time i.e. keep to the sectional running times as per the intended schedule(Specification NO. MP.0.2402.24 (Rev. 01)). Guidance for Optimized Loco Driving (GOLD) shall use optimization techniques to determine speed profiles that minimize fuel consumption subject to completing the journey within the specified time. The aim of this specification was not to override Loco Pilots, but to provide them with information that will help them drive more efficiently.

3.2 Drawbacks of Specification

- GOLD cannot take into account signal aspects in train-handling requirements.
- GOLD requires train, track and timetable data, including Temporary Speed Restrictions (TSRs). As such, being complex data the timetable data and the TSR data are planned to be uploaded to server using standardized input process.
- Downloads Route profile data from the central server.

The above drawbacks can be eliminated by integrating the GOLD with indigenous ATP developed by RDSO. The indigenous ATP developed by RDSO provides the train handling requirements on account of signalling and route profile data at the entry of each and every station dynamically. The time table manager is developed as per GOLD specification. TSR entry can be digitized through indigenous ATP developed by RDSO. This would actually constitute the Guidance Mode ATO based on way side interlocking.

4 Auto Pilot Mode based on Train-to-Train Communication:

Automatic train operation in this mode requires assurance of train integrity an SIL-4 communication between Loco to Loco in addition to the above. This system developed shall also include machines deployed for maintenance of OHE and track.

4.1 Train Integrity

The End of Train Telemetry (EoTT) equipment is used to establish communication between the locomotive driver and the last wagon of the train to ensure that the train is running with all coaches/wagons as a complete unit. EoTT system comprises two units: one unit called cab display unit (CDU) fitted on the locomotive and the other is sense and brake unit (SBU) fitted on the last coach or wagon of the train.

Both the units are fitted with radio transmitter which communicates with each other. In case of a train parting, the system is designed to indicate to the loco pilot the parting of the train and to apply brakes to the rear unit, thus averting collision of the rear portion with the front portion of the train. The indigenous ATP developed by RDSO has facility to read this parting input to be read in conjunction with EoTT. This would facilitate in ensuring train integrity part of Auto Pilot mode.

5 Train Traffic Control

The train traffic shall be controlled by the ATS to be developed and the indigenous ATO shall control the way side station points/level crossing gates. The way side interlocking shall be controlled through ATO and shall have two modes:

- **Fleet mode:** In fleet mode, the way side signals are ignored rather they display a distinct aspect. The trains control the movement of the traffic duly considering various factors deciding the occupancy time in the block, possession time of block, release time of block and time required to exit the block for the full length of the train. The blocks are to be dynamically managed.
- **Fallback mode:** In the fall back mode, the way side interlocking shall take care of train traffic control.

- **Shunt Manager Mode:** In this mode, the locos shall shunt for formation at the originating or terminating stations.

6 Conclusion

The above will be the complete solution for the safe and automated train traffic control on Indian Railways. However, the ATP shall also have provision for detecting rail integrity (for future use). The ATP, ATS and ATO being developed shall be designed for speeds of at least 240 KMPH keeping the utility in future for fully automatic train operations (FATO) on Indian Railways.

The information / views expressed in this paper is of the authors and are based on their experience. Comments / observations may be sent to the author at dsig5rdso@gmail.com.

G Pavan Kumar, currently working as Director(Signal), RDSO, is a seasoned professional with 15+ years rich experience in Research, Design, Development, Standardization, Project Management (installation, testing commissioning) of Train Collision Avoidance System (An indigenous Automatic Protection System for Indian Railways), Train Protection Warning Systems, FogPASS, Electronic interlocking system, MSDAC of Thales Make, Panel Interlocking, Electrically Operated Lifting Barriers, Approach warning to LC Gates,Optical Fibre system. He has also been associated with several innovations such as OFC based IBS, PPTC fuses, GPS based GSM Signal Strength Measurement, Remote Work Site Management System, Centralized voice logging for LC Gate communication, Centralized train information display and announcement system etc., that ahve are inducted into Indian Railways.