TITLE OF PRESENTATION : **GPS BASED CAB-SIGNALLING FOR INDIAN RAILWAYS – A CONCEPT**

NAME OF PRESENTER: ***S.K.BISWAS***
JOB TITLE: ***Professor-Telecom.***
COMPANY NAME: ***Indian Railways Institute of Signal Engg. & Telecomm Secunderabad. India.***

Introduction :

Indian Railways work on traditional land based fixed signalling system. It has two aspects (Red & Green), three aspects (Red, Yellow and Green) as well as four aspects (Red, Yellow, double Yellow and Green).

The train drivers are required to :

- Watch out for Signal Sighting Boards (SSB) while driving.
- From the point of SSB the concerned signal shall be visible clearly along with its aspect.
- Control his train as per the aspect seen till he reaches / passes the signal.

The entire train operation is regulated in terms of the General and Subsidiary Rules (GSR) of Indian Railways, which stipulates various instructions to be observed by both ground staff as well as train crew concerned.

Drawbacks of the present Signalling system :

The existing signalling system (Fixed signals) are very robust and time tested. It does not require any kind of on-board equipment to work on the railroad. Since all types of trains (freight and passenger) operate with a range of permissible maximum speed, this system serves its purpose quite well and fully safe.

The system has, however, the following drawbacks :

- The train driver has to look for the fixed signals and correctly read the aspect in all weather and day & night.
- Possibilities of reading aspect of any adjacent signal not meant for his route may lead to accidents.
- The signals cannot convey any temporary speed restriction imposed on account of any reasons. For this purpose train crew are advised in writing from the previous station.

Cab Signalling :

Almost all the advanced rail roads are having cab-signalling systems. There are various types of systems based on different concepts of design. All the types used as of now use some kind or the other type of track mounted / side equipments and on-board train equipments.

Track-side equipments will be vulnerable to miscreant activities and vandalism. Hence, in this paper a concept is outlined to have a cab signalling system fully free from any track side equipments with fail safe design and operation. This concept is based on Global Positioning System (GPS).

GPS based Cab Signalling :

Global position system (GPS) is a satellite based system available round the clock throughout the world. This system utilises a constellation of 24 satellites covering the entire globe. With the help of this system any one equipped with a suitable receiver can know his location on the globe, namely, longitude, latitude and altitude from the ground level when atleast 4 satellites are visible by his receiver. Initially when the system was introduced by US Government, it was mainly for its defence applications, common man also could use it with less accuracy of position data. Now, mainly because of its popularity amongst civilian users also – US Government has relaxed the restriction of accuracy of position data and now the position data is available with an accuracy of 10 mtrs. The position data is available in WGS – 84 format. The GPS satellite also give accurate time information which many users are using for other land based systems for synchronisation purpose commonly known as GPS clock system.

The entire system will comprise of three subsystems as follows :-

1. Locomotive Subsystem

In the GPS based cab signal system, the locomotives will be equipped with the following

- GPS receiver with roof mounted antenna.
- On Board processor.
- Residend data base for all the events like, stations, signals, bridges, level crossings etc.
- Suitable application oriented software.
- A full duplex VHF trans-receiver.

2. Station Subsystem

All the stations to be equipped with their subsystems comprising the following :-

- Power Interlocking System (Existing)
- Station Radio
- Station GPS (As reference GPS)

3. Signal Sub system

All the fixed signal posts to have their own subsystem comprising the following :-

- Colour light signal (Existing)
- full duplex VHF trans-receiver
- GPS receiver (As reference GPS)
- Processor

System Concept :-

The GPS receiver on-board the locomotive will be of robust type, which will work on power supply from the locomotive itself and shall remain continuously on to record its current location data. The current location data as recorded by the GPS receiver will be fed to the on-board processor. The processor will search from its resident database the nearest Railway station and its name as well as calculate its distance from the current location of the locomotive. An optional intelligent feature can be incorporated by which the system will simultaneously verify the station from the programmed route of the designated train.

As the locomotive moves closer to the approaching station, depending on its speed and priority, it will start sending a call request to the approaching station through its on-board radio. This distance can be little more than the normal breaking distance say 2 km. On receipt of the call signal from the locomotive, the station subsystem will sent acknowledgement signal through its radio equipment installed in the station building. It will also have a fixed GPS receiver. The location data of the station as recorded by the station GPS fixed receiver will be used to create the correction data on a continuous basis. Thus, this GPS receiver will form the reference receiver for all the loco mounted GPS receivers of allthe approaching trains to work as a differential GPS system (DGPS). The loco mounted processor will use this correction data and immediately correct its location data with improved accuracy, may be within a meter.

Now onwards the system on-board will be able to calculate more precisely, its distance from the approaching signal posts from the location coordinates of the signal posts already available in the database. It can also assist the driver to control its train in the event of a possible overshooting of a signal without appropriate authority from traffic controller or station master.. The station interlocking system will simultaneously transmit the signaling information, (may be the signal aspect, permissible / recommended speed, movement authority etc) along with adequate security bytes as well as parity bytes.

This information will be received by all the approaching trains of that station and will be used by intended train with the help of a proper exchange of protocol. The respective locomotive after receipt of this signal will decode the signal aspect, movement authority etc. or any other information and display on the dashboard of its CAB.

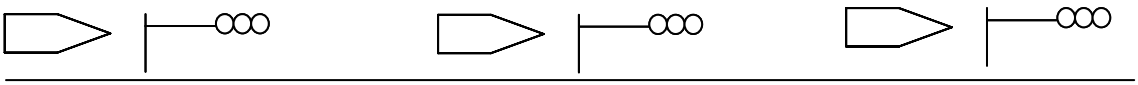
As the train further approaches to the fixed signal, which most commonly will have an aspect control interlocking with the occupation of the train by means of track circuits laid on the foot of the signal. Normally on touching the track circuit on the foot of the signal, the signal aspect turn to danger position. At this instant of time, the station interlocking system will immediately send this signal aspect through train radio to the CAB and display the change of aspect instantly. The service of DGPS system for accurately determining its position will help the train Driver continuously to know its position with respect to the concerned signal. Without this correction feature, some times inaccuracy of position location up to 100 mtrs. can cause the train bound system to wrongly understand about its position, precisely whether it has crossed the signal post or not.

The situation when multiple trains approach any station, it can be handled in the following way :

The situation of two or more trains simultaneously start sending call requests, causing interference at the station radio receiver, can be avoided by introducing a suitable protocol. Each train before sending its call request will ensure that there are no other radios which are simultaneously on. In such an event it will have to wait for getting the space free from any radio signal. Only after ensuring this, the loco subsystem will actually switch on its radio transmission and it will broadcast its identity and other information and switch off transmission. Then, this radio channel can be used by other trains and so on , as a shared radio channel. A station radio can however broadcast the replies to all trains with proper address code for various trains at a time .

In the event of trains entering into shadow region like tunnel, dense tree cover, the on-board GPS receiver may temporarily lose its fix. This problem can be adequately overcome with the help of a dead reckoning arrangement. In this arrangement, the train database can continue to feed the location data to the system taking the input from the on-board conventional Odometer. Simultaneously a message can be displayed like ***Poor GPS coverage*** or ***weak signal*** etc. Once a fix is re-obtained, the system can again relock and get actual GPS data.

Operation In Automatic Block Signal Territory



In the automatic signal territory, all the fixed signals will be provided with a Radio-Transreceiver and a small processor in it. As in the non-automatic block section, the train bound GPS based system will continuously calculate its distance from the next signal en-route for it and initiate call request when it comes within a specified distance. On receipt of call request the signal post mounted system will respond and transmit its identity and aspect. The train radio will receive the same and decode it. If found relevant for it, it will display the aspect in the Cab. At a regular interval of say 5 km or so a signal post can be provided with a GPS receiver to serve as a reference receiver for broadcasting the correction data for the train GPS(s) when coming in that particular area. With this correction data the train mounted system will correct is location with reference to the fixed signals within ± 1 meter and have full control on the movement as decided by the aspects of concerned signals.

Situations of non functioning of the system :-

In the event of no response comes from the expected station subsystem or signal subsystem , the system will initiate an alarm for the Driver to indicate that the signal information has not been received. Hence, Driver is to attempt to see the signal aspect physically as done at present. Similarly, in the event of on-board GPS receiver not functioning, an alarm will be raised by system to draw the attention of the Driver. It can also be extended to automatically apply emergency brakes in such events when the Driver fails to acknowledge the alarm and or take necessary action in time.

This will be protected by suitable protocols to take care of the authenticity of data exchange between locomotive and ground systems.

As the train approaches the signal post, and when eventually it crosses the signal, the loco system will look for aspects of the next signal relevant for its route in the similar manner.

The location data about other permanent type of track features or events namely, gradient, temporary speed restrictions, level crossing gates etc can be permanently stored in the data base and from the location data generated by GPS receiver to be continuously used for calculating the distance of those fixed features. These features can be displayed inside the loco, either by graphical symbols and or through pre-recorded voice. This will help the Driver to know before hand that which are the spots he is approaching and at what moment of time. This can however be extended to take decisions of running speed as per the data stored for the respective section of the route. It will be possible to keep a continuous log of the events based on what speed, what time, automatically by on-board system.

A schematic diagram of the system concept is enclosed.

Initially, this concept may be used for an aid of the Driver and after a thorough trial, the system can be used for regular cab signalling and other signalling applications.

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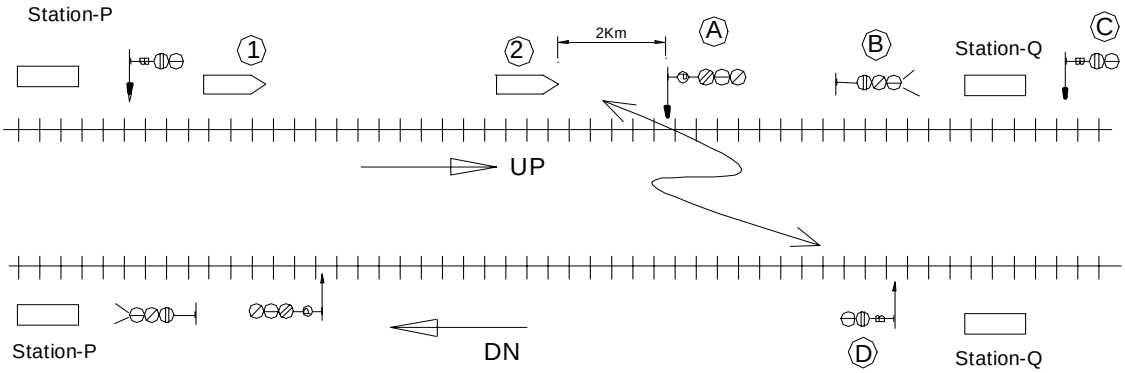

NOTE:
Response from Signal A for train 2 is relevant whereas from signal D is not relevant. This will be filtered by suitable protocol depending on direction of train movement as well as route etc.

LEGEND:
1 and 2 are train locations A, B, C, D, etc. are fixed signals with VHF Transreceivers (Intelligent Signals) P & Q are two stations in the route

GPS Based Cab Signalling