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Optimising Headway using Communication Based Train Control system

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***Abstract*- In most of the previous researches the grade of automation 3 i.e. (GOA 3) has been analyzed for Direct Train Operation i.e. DTO mode while the focus of this proposed is to analyze the feasibility for the Grade of Automation 4 i.e GOA 4 which implements the Unattended train operation i.e. UTO Mode. In this specification the current Headway used by most of the Metro Rails is 120 sec. The comparison of signaling system of conventional Railways and the CBTC system in Metro Railways is also been included in this work and how the upgraded version have affected the capacity and efficiency of the mass transit system.**

***Keywords*- Communication based train control system (CBTC), Headway, EMC, Signal, Power.**

I. INTRODUCTION

Communication based train control system (CBTC) is a technology of train detection and control in Metro Rail using Moving Block technique while Headway is the time difference between two trains at a station. CBTC is the preference for mass transit railway operators these days, with more then a hundred systems have already been installed worldwide. The time critical, safety related, applications such as train control impose more reliability and availability requirements on the used radio communication technology.

The Research includes analysis of various factors effecting Headway and calculation measures in order to optimize the Headway.It is not enough for the CBTC system to be able to determine the train location accurately but it also should protect the train from all the types of failures. listing out vital functions that CBTC system should perform. By analyzing the section, it is apparent that the vital functions may be placed in three categories which are avoiding collision, protection from overs peed and other miscellaneous protection.

Collision protection defines the ability in our CBTC system in order to mantain train safely separates from each other and also from other obstacle on guideway. Over speed avoidance is the ability in our CBTC system to determine speed of train accurately and control the speed in the tight tolerance.

II. MODES OF OPERATION

The Signalling and Train Control System shall provide the following modes of Train operation;

- Automatic Train Operation Mode (ATO)
- Automatic Train Protection Mode (ATP) or Supervised Manual Mode
- Restricted Manual Mode (RM)
- Running on Sight mode (ROS)
- Cut-out mode
- Unattended Train Operation Mode (UTO)

In ATO mode, the Train should operate without intervention by the Train operator except when starting from a station stop. It should be the normal mode of operation in the event of failure of UTO or as stated otherwise in operation requirement. In ATO mode, the ATO function of the train, controls the Train braking and traction systems under the supervision of ATP.

In ATP Mode, the Train Operator, obeying cab signals, will drive the Train. ATP mode should be normal mode of operation in the event of failure of ATO or as stated otherwise in operation requirement [14]. In ATP Mode, the Signaling and Train Control System should Provide Cab Signals and all other indications necessary to operate the Train including current speed, Determine continuously the Maximum Safe Speed and LOMA, Prevent Train operation in excess of the Maximum Safe Speed or LOMA, Provide audible and visual warning if the Train speed exceeds the Maximum Safe Speed.

The Signaling and Train Control System shall allow for call-on or push-out to be safely performed in the event of operational need to rescue a failed train using a functional train.

RM Mode remains in operation, until sufficient conditions have been met to allow for a transfer to the Automatic Train Protection Mode.In Restricted Manual Mode the Train speed shall be limited to a configurable speed of 25 Kmph. The Train Operator shall be given a warning, both audio and visual when the speed is above RM threshold but below 25 Kmph.

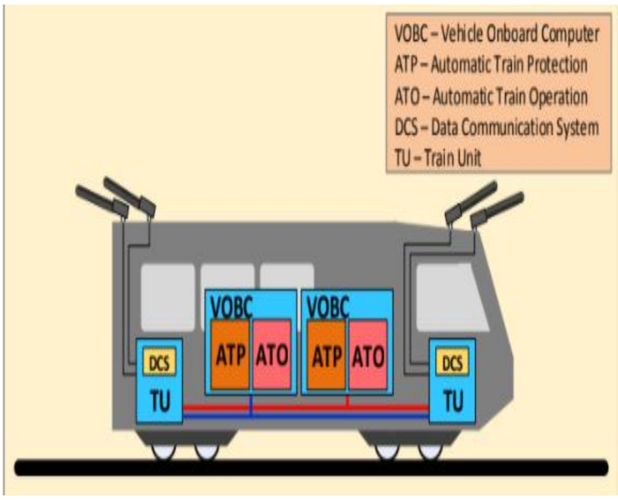

Fig 1. Various Operating modes.

In Cut-Out Mode, the TrainOperator in accordance with line-side signals and verbal instructions from the Controller shall operate the Train. Cut-Out Mode is intended for use in case of complete failure of Train borneSignaling and Train Control System preventing release of the emergency brake. The Train shall hold off the emergency brake.

The Signaling and Train Control System shall allow for call-on or push-out to be safely performed in the event of operational need to rescue a failed train using a functional train.

In UTO mode, the Train shall operate with crew member on-boardfor emergency situations and taking care of the passengers. UTOmode shall operate under the supervision & control of ATP functions. This mode shall be available everywhere on the line and the depot except the designated workshop/Maintenance lines.

UTO mode shall be the normal mode of operation, to make Unattended Train operation fully functional, the Signaling with Rolling Stock shall provide other associated modes of operation viz Stand-by mode (ready, dozing, sleeping), Immobilized mode etc. The details shall be finalized during interface and design finalization.

Initialization of UTOoperation after system start-up must be possible without any manual intervention in the Train, or any OCC operator command.Initialization of UTO operation after a global system failure should not be possible without manual intervention in each Train, nor shall require OCC operator command to be made for each Train. Transition between UTO and ATO/ATP/RM/ROS modes, must be possible continuously and anywhere on the running line and in the yards.

III. SIGNALLED HEADWAY

The Signaling and Train Control System Should achieve a minimum designed headway of 90 sec and should achieve an operational headway of 120 sec using 5 Car Trains with 30 sec dwelling at intermediate stations with minima of 2 min overlay at the terminal stations (minimum 30 sec layover when front crossover is used), the headway calculation will include PSD operation time.

We are doing this research for a 5 car train soa as to achieve all performance and operational parameters mentioned below.

Due consideration should be given to the above factors when deciding the station dwell time used for the designed headway and operational headway so that the actual time allowed for boarding and alighting of passengers is optimized. A station stops braking profile of 08 ms to 2 ms shall be used for design of signaled headway

IV. RECOVERABILITY

In the event of failure of one operating mode, there shall be graceful degradation to another mode, which shall optimize service capacity while maintaining safety. In the event of total UTOsystem failure under UTOmode of operation on Mainline, the Train shall be controlled by a remote command from OCC / SCR under the protection of ATP to nearest station, however it will befinalised during design stage, during the on-site test and commissioning period that the Automatic Train Supervision (ATS) shall recover a delay to service by utilising all available margin obtained from the difference between 5% and maximum performance for all inter-station runs and the difference between the nominal and minimum values for all station dwells.

Also that the Signalling and Train Control System can recover delays to scheduled Train service. and that the Signalling and Train Control System can recover Train service to constant service headway. For the purposes of this demonstration, a delay to a single Train at any station of 2 minutes, with full Train service of constant required headway, shall be recovered within 20 minutes. Recovery, in this context, shall be defined as all Trains operating to a constant required headway, within the configurable tolerance.During Failure of UTO mode, The Train can be driven in creepto the nearest station for the attendant (driver) to board the train after which train can be driven in ATO/ATP mode of Operation.

If ATO mode fails, the train shall operate in ATP mode with driver on-board and driving the train under protection of ATP. In the Event of ATP Failure, ATP Mode degrades to ROS mode after stopping of Train and conscious action of the Train Operator of pressing the ROS Button.An alarm indication shall be provided within the Train operator cab/console and OCC/BCC/SCR to indicate degraded mode of operation.

The degraded operation performance requirements shall be demonstrated as specified

1. Ride Quality: The Signalling and Train Control System shall control the movement of following Trains to avoid frequent occurrences of acceleration and braking. This function shall not compromise the headway and capacity requirements.

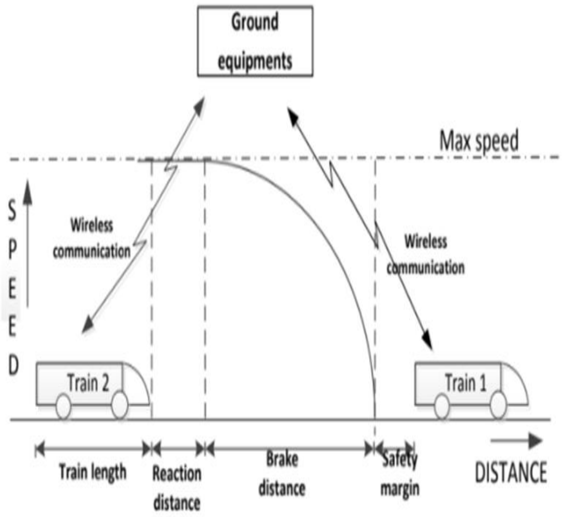

Fig 2. Signaled Headway.

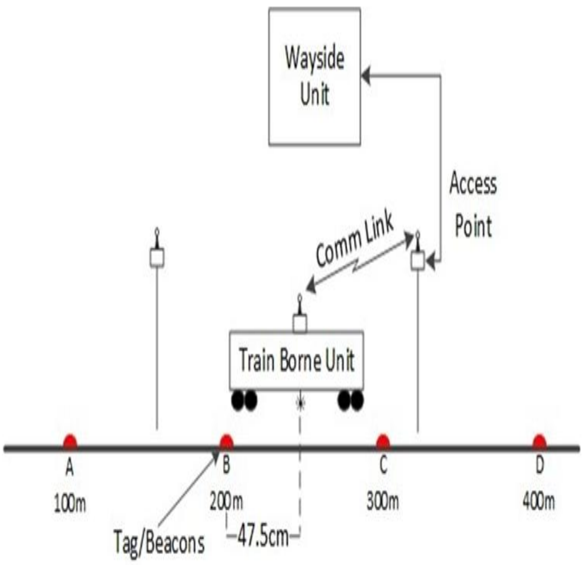

Fig 3. Interlocking.

2. The S&TC System: Shall ensure that the Jerk limit specified for the Train Consist is not exceeded.

3. Transition between Modes:

The Train Control and Signaling System shall allow the train to transfer from ROS to ATP mode automatically without stopping the train while it should be possible to select the ROS mode only at standstill.

The Train Control and Signaling System shall allow the train operator to transfer from ATO/UTO to ATP modes and vice versa. Transfer from ATP to ATO/UTO mode and vice versa shall also be possible remotely.In case of failure of ATP, the degradation to Cut-out Mode shall not be automatic. The Train will automatically come to stop and the Train operator shall change over to Cut-out mode by a manual switch (SCS).

In the event that the Train is above the Maximum Safe Speed (MSS) of the requested mode of operation, the SignallingandTrain Control System shall adopt the requested mode of operation but shall break the Train to within the new Maximum Safe Speed (MSS).

4. Effects of Equipment Failure: Minimizing the effects of failure so that the Train service may continue during times of equipment failure is of paramount importance. Consequently, the area of railway affected by the failure of an item of Wayside ATC equipment, which causes the use of RM/ROS mode of operation, shall not be greater than the area between two adjacent stations or between the halfway points on either side of the station. In any case this RM/ ROS operation area or shall not be longer than 200m in the normal direction of travel.

V. SPEED CONSTRAINTS

1. Operating Envelope: TheSignalling and Train Control System shall ensure safe movement of all Trains under all operating conditions by continuously generating a safe operating envelope defined by the LOMA and the Maximum Safe Speed.

The LOMA shall be the furthest point to which the Train may safely proceed taking into account margins for error in speed and distance measurement, calculating braking distances and equipment reaction times.

The Maximum Safe Speed shall be the maximum speed at which the Train is permitted to travel without intervention by the Signaling and Train Control System. It shall be continuously calculated such that:

- Civil Speed Limits are never exceeded;
- The speed limits for the type of Train are never exceeded;
- Temporary Speed Restrictions are never exceeded; and
- The Train can always stop without passing the LOMA.

Where the new Maximum Safe Speed is lower than the current Maximum Safe Speed, the Target Speed shall be calculated and displayed to the Train Operator in advance, such that the Train may be braked to the new Maximum Safe Speed with a normal service brake application.

Where the new MSS is higher than the current MSS, the Target Speed shall reflect this change immediately. The Signalling and Train Control System shall ensure minimum safe Train separation. Braking distance shall be derived from a safe braking model that shall consider worst case system response times and failure conditions, consistent with railway industry practice. The safe braking model shall be submitted as part of safe braking calculations. The Speed Measurement Apparatus to be installed on rolling Stock should be provided. A Target Speed shall be calculated for display to the Train Operator to provide advance warning of changes in MSS in ATP operation.

VI. TRACTION SUPPLY NEUTRAL ZONE

The Signalling and Train Control System shall ensure that no Train or part of the Train stops within the neutral zones (or air gap). The Line side Signals and Train detection system/interlocking boundary shall also be located suitably. The Signalling and Train Control System shall ensure that under Normal Circumstances the Train does not apply brake/traction through neutral zones (Air gap) when in ATO / UTOMode.The train will run in Coasting Mode of TBC in Air Gap Zone.

In UTO/ATO/ATP mode of train operation, S&TC system shall be suitably interfaced with SCADA system to ensure that whenever there is power failure in a particular section, no train enters that section or if already entered it shall be ensured that the train leaves that section with coasting as far as possible.

VII. IMPLEMENTATION AND RESULT

As discussed in the methodology, analysing a sample of some of the various parameters effecting the calculation aspects of signaling headway were implemented for different variables is as follows. The variable a and b in the below fig2 are the speeed constraints so declaring the variables as described.

As discussed in the methodology, analysing a sample of some of the various parameters effecting the calculation aspects of signaling headway were implemented for different variables is as follows.

4.1 The variable a and b in the below fig.4.1 are the speeed constraints so declaring the variables as described;
The above declared variables with values are now been put into function in order to calculate the cumulative effect of the average speed are considered as to observe its effect on the defined Headway.

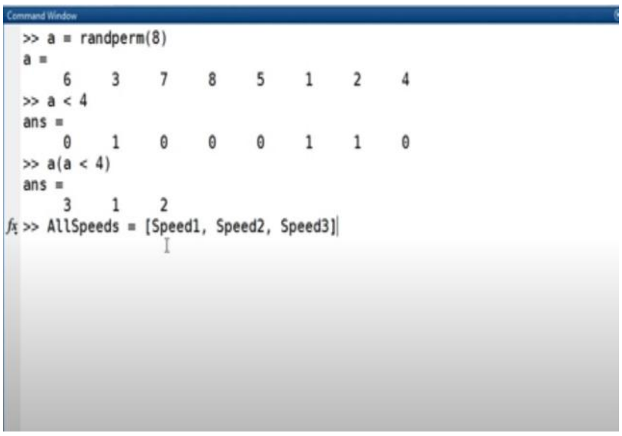

Fig 4. Variable Declaration.

The fig 3 above illustrates the above calculation.ehile fig 6 shows the implementation through image processing for time speed and temperature constraints.

Table 1. Comparative analyses of variables.

Time	Speed 1	Speed 2	Speed 3	Temp
00:00	6.9738	7.3491	8.268	-11
01:00	5.4315	6.0273	5.8522	-11
02:00	5.4315	4.1967	5.8323	-11
03:00	6.1692	5.0666	6.7605	-11

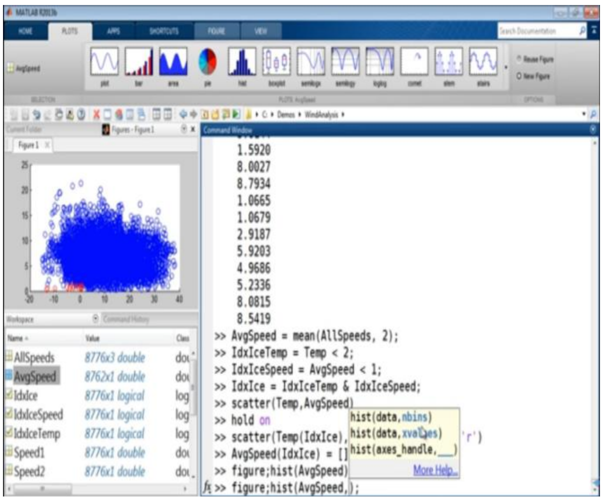

Fig 5. Matlab Programming for Implementataion.

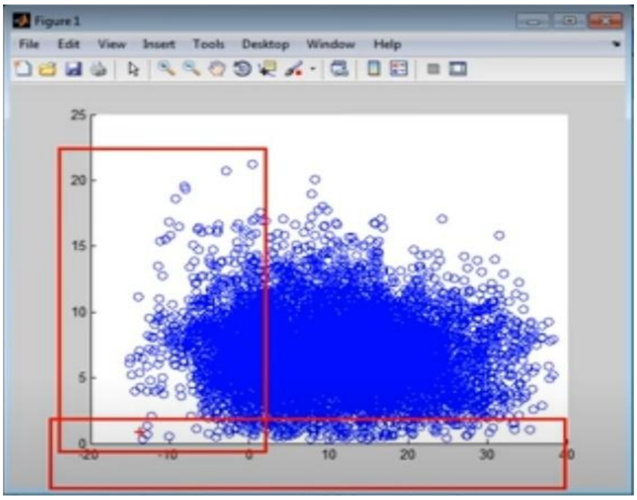

Fig 6. Image processing for speed time and temperature constraints.

As the mean calculated above is to be analyzed in a graph in order to show the scattering effect of the defined constraints of speed as well as temperature parameters is shown in the fig 4.

This mechanism allows the signaling system to test itself as it can generate the patterns based on a variety of algorithms, each focused on the particular type of circuitry or fault type. Comparison function has a lot of unique implementations including signal analyzer.

VIII. CONCLUSION

The optimal train speed rises up from 50.8km/h (Case 1) to 74.3km/h (Case 2). It is noted that this speed is hard to be achieved in the practical situation because of the speed limits of the subway line and the ATP (Automatic Train Protection), so the headway of the practical situation is bigger.

This work suggests the implementation constraints and feasibility of headway of 90 sec which can be achieved if the parameters effecting it can be tuned to the suggested specifications and the details of all such parameters has been discussed and analyzed and how it is effecting the proposed constraints are implemented and compiled in the conclusion.

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