CHAPTER 2
Block

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Unit 9 Communications Based Train Control

- Introduction
- Background and Origin
- Main features
- Main Benefits

Introduction

- Communications Based Train Control (CBTC) is a railway signaling system that makes use of the telecommunications between the train and track equipment for the traffic management and infrastructure control.
  - By means of the CBTC systems, the exact position of a train is known more accurately than with the traditional signaling systems.
  - This results in a more efficient and safe way to manage the railway traffic.
  - Metros (and other railway systems) are able to improve headways while maintaining or even improving safety.

Introduction

- A CBTC system is a "continuous, automatic train control system" utilizing high-resolution train location determination, *independent of track circuits*; continuous, high-capacity, bidirectional train-to-wayside data communications; and train borne and wayside processors *capable of implementing ATP functions, as well as optional ATO and ATS functions, as defined in the IEEE 1474 standard*.

9.1 Background and Origin

- City and population growth increases the need for mass transit transport and signaling systems need to *evolve and adapt* to safely meet this increase in demand and traffic capacity.
- As a result of this operators are now focused on maximizing train line capacity.
- The main objective of CBTC is to increase capacity by safely reducing the time interval (headway) between trains traveling along the line.

9.1 Background and Origin

- Traditional legacy signaling systems are historically based in the detection of the trains in discrete sections of the track called “blocks”.
- Each block is protected by signals that prevent a train entering an occupied block.
- Since every block is fixed by the infrastructure, these systems are referred to as fixed block systems.

9.1 Background and Origin

- Unlike the traditional fixed block systems, in the modern moving block CBTC systems the protected section for each train is not statically defined by the infrastructure (except for the virtual block technology, with operating appearance of a moving block but still constrained by physical blocks).
- Besides, the trains themselves are continuously communicating their exact position to the equipment in the track by means of a bidirectional link, either inductive loop or radio communication.

9.1 Background and Origin

- The advent of digital radio communication technology during the early 90s, encouraged the signaling industry *on both sides of the Atlantic* to explore using radio communication as a viable means of track to train communication, mainly due to its increased capacity and reduced costs compared to the existing transmission loop-based systems, and this is how CBTC systems started to evolve.

9.2 Main features

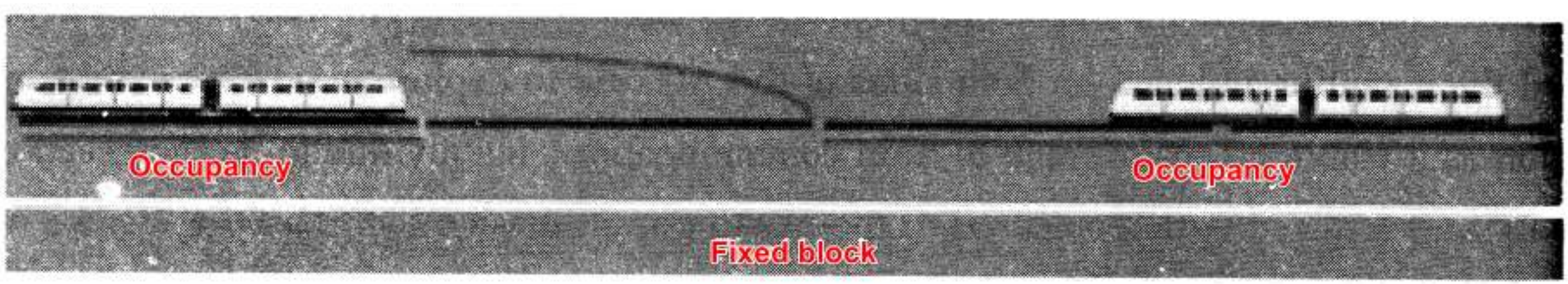
- CBTC systems are modern railway signaling systems that can mainly be used in urban railway lines (either light or heavy) and APMs (Automated People Mover System, 自动旅客捷运系统), although it could also be deployed on commuter lines.
  - For main lines, a similar system might be the European Railway Traffic Management System (ERTMS) Level 3 (not yet fully defined).

9.2 Main features

- CBTC systems are modern railway signaling systems that can mainly be used in urban railway lines (either light or heavy) and APMs (Automated People Mover System), although it could also be deployed on commuter lines.
  - In the modern CBTC systems the trains continuously calculate and communicate their status via radio to the wayside equipment distributed along the line.
  - This status includes among other parameters, the exact position, speed, travel direction and braking distance. This information allows calculation of the area potentially occupied by the train on the track.
  - It also enables the wayside equipment to define the points *on the line* that must never be passed by the other trains on the same track. These points are communicated to make the trains automatically and continuously adjust their speed while maintaining the safety and comfort (jerk) requirements.
  - So the trains continuously receive information regarding the distance to the preceding train and are then able to adjust their safety distance accordingly.

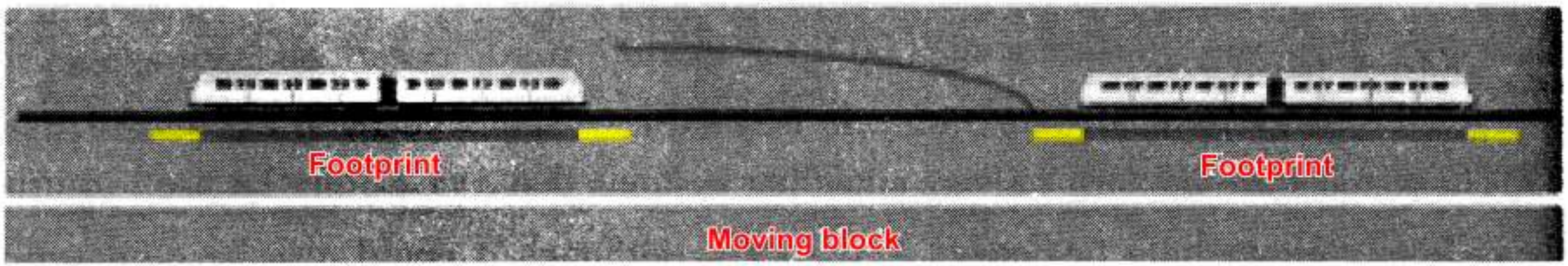
9.2 Main features

- From the signaling system perspective, the first Fig. shows the total occupancy of the leading train by including the whole blocks which the train is located on.
  - This is due to the fact that it is impossible for the system to know exactly where the train actually is within these blocks.
  - Therefore, the fixed block system only allows the following train to move up to the last unoccupied block's border.



9.2 Main features

- In a moving block system as shown in the second figure, the train position and its to braking curve is continuously calculated by the trains, and then communicated via radio to the wayside equipment.
- Thus, the wayside equipment is able to establish protected areas, each one called Limit of Movement Authority (LMA), up to the nearest obstacle (in the Fig. the tail of the train in front).



9.2 Main features

- It is important to mention that the occupancy calculated in these systems must include a safety margin for location uncertainty (in yellow in the Fig.9.1) added to the length of the train. Both of them form what is usually called “Footprint”. This safety margin depends on the accuracy of the odometry system in the train.

- CBTC systems based on moving block allow the reduction of the safety distance between two consecutive trains.
  - This distance is varying according to the continuous updates of the train location and speed, maintaining the safety requirements.
  - This results in a reduced headway between consecutive trains and an increased transport capacity.

9.3 Main Benefits

- The evolution of the technology and the experience gained in operation over the last 30 years *means that* modern CBTC systems are more reliable and less prone to failure than older train control systems.

- CBTC systems normally have less wayside equipment and their diagnostic and monitoring tools have been improved, which makes them easier to implement and, more importantly, easier to maintain.

9.3 Main Benefits

- CBTC technology is evolving, making use of the latest techniques and components to more compact systems and simpler architectures.
  - For instance, with the advent of modern electronics it has been possible to build in redundancy so that single failures do not adversely impact operational availability.

- Moreover, these systems offer complete flexibility in terms of operational schedules or timetables, enabling urban rail operators to respond to the *specific traffic demand* more swiftly and efficiently and to solve traffic congestion problems.
  - In fact, automatic operation systems have the potential to significantly reduce the headway and improve the capacity compared to manual driving systems.

9.3 Main Benefits

- Finally, it is important to mention that the CBTC systems have proven to be more energy efficient than traditional manually driven systems. The use of new functionalities, such as automatic driving strategies or a better adaptation of the transport offer to the actual demand, allows significant energy savings reducing the power consumption.

Homework

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