Conventional vs CABS vs CBTC Signalling & their Impact to Capacity
AGENDA
Agenda

- Introduction
- Conventional Signalling
- CABS Signalling
- CBTC Signalling
INTRODUCTION
Introduction

• Capacity definition
  • The maximum number of trains that can pass a given location during a given time period at a specified level of reliability.
Introduction

• Several Factors that affect capacity
  • Dwell time – Time spent serving a station
  • Signal system - Minimum safety distance between trains
  • Operating margin - Allowance for longer dwells
  • Minimum headway - Minimum operational distance between trains
  • Junctions
  • Turnbacks – Points at which a train changes direction
  • Traction Power Limits – Number of trains supported in a track section
Introduction

- Focus of this presentation is on “signalling systems” and their impact on capacity
  - Conventional Signalling
  - CABS Signalling
  - CBTC Signalling
CONVENTIONAL SIGNALLING

Traditional Fixed Block Signalling
Conventional Signalling

• Drivers use trackside signals to determine:
  • If the train can proceed forward (aspect)
  • The speed the train will travel at
• A simple system may have 3 aspects:
  • red – stop.
  • yellow - proceed with caution.
  • green – move at max speed.
• The location of the train is determined by track circuit occupancy.
The signal engineer views the track in small chunks called blocks.

The block length determines:
- Safety - how far apart the trains will be kept from each other
- Capacity – how many trains can pass through the system

Challenge for the signal engineer
- Increase the block length means increased margin for safety but reduced capacity
- Reduce the block length means increased capacity but reduced margin for safety
• One block separation must be maintained between trains for safety.
Basic Concept

- One block separation must be maintained between trains for safety.
- When train 9 moves into block 4, train 8 will be given a permissive aspect (yellow or green signal).
One block separation must be maintained between trains for safety.
When train 9 moves into block 4, train 8 will be given a permissive aspect (yellow or green signal).
Train 8 will move forward and stop at signal C, it's an accordion effect.
If train 8 hits a trip stop travelling at 60kph and it requires 400m to stop, the block separating train 8 from train 9 must be at least 400m long to satisfy the safety requirement.
• As train 9 travels away from signal C, train 8 will not be granted a permissive aspect until train 9 has exited block 3.
• Instead, an artificial separation is created between train 8 and 9
  • even though train 8 can move closer and still maintain a safe braking distance.
• Train 9 must completely exit block 3 before signal B provides a permissive aspect to train 8.
• As train 9 moves further within block 3, the artificial separation grows.
• The trains can be closer together, but the fixed blocks prevent train 8 from moving.
• Once train 9 has exited block 3, train 8 will receive a permissive aspect from signal B.
• Impact to capacity –
  • 800m separation between train 8 and 9; 400m longer then what is required for safety.
  • Number of trains that can pass through the system is not optimal.
If a train is travelling at 40 km/h, it must adhere to the block separation designed for 60km/h.

Static design, the signalling system cannot adjust the safety distance to the speed of the trains.
Smaller blocks will reduce the train separation but at the expense of line speed. The slower speed may cancel out the benefits of smaller blocks.

- Fine balance between line speed and block size.
The signalling system considers the length of the train to be the same as the length of the block.

- If the block is 400m long, the train is considered to be 400m long.
Wrap Up

- Increasing the block size increases the margin for safety but reduces capacity.
- Reducing the block size decreases the margin for safety but increases capacity.
• Challenge for signal engineers is to calculate the block length for maximum capacity while ensuring safety.
CABS SIGNALLING
Enhanced Fixed Block Signalling
CABS Signalling

• Trackside signals are “usually” not used.
• Track circuits are used to determine the location of the train.
• The speed and distance to go are displayed on the Train Overview Display (TOD) inside the cab and enforced by the on board ATP.
• CAB signalling has the capability to allow a train to move at multiple speeds within a block.

• Note: CABS signaling discussed here is with ATP protection.
CABS signalling does not alter the fixed block/conventional signalling concept.
• In conventional systems, the block design is based on the line speed.
  • single speed profile.
• The block design does not allow for multiple speed profiles within the same block.
CABS signalling allows for multiple speed profiles within the same block.
The driver will receive an indication on the Train Overview Display (TOD) when there is a speed transition.
Allows the train to travel at higher speeds with smaller blocks.
Reduces the headway between trains, increasing the capacity.
• CABs signaling has similar limitations as conventional signaling.
• There is an artificial separation as train 9 moves away from signal C.
CABs signaling has similar limitations as conventional signaling.
There is an artificial separation as train 9 moves away from signal C.
Train 8 will not be given a permissive aspect until train 9 has exited block 3.
CABS signaling allows for smaller blocks, and therefore a marginal increase in capacity but the problems are similar to conventional signaling:

- Increasing the block size increases the margin for safety but reduces capacity.
- Reducing the block size decreases the margin for safety but increases capacity.
- Challenge for signal engineers is to calculate the block length for max capacity while ensuring safety.
- The track is not utilized to its maximum capacity.
CBTC SIGNALLING
Moving Block Signalling - A Brave New World
CBTC

- Trackside signals are not used.
- Track circuits are not used.
- Position is determined by a 2 way communication between the wayside and train.
  - Train transmits position.
  - Wayside transmits a target point.
- The train is able to determine its position with a resolution measured in centimeters.
A View of the Track

Conventional/CABS Signalling (Fixed Block) – Chain of Blocks

A View of the Track

CBTC Signalling (Moving Block) – Single Contiguous Track
Basic Operation

- If train 8 is travelling at 60 km/h, it must maintain a 400m separation from train 9.
- This separation is not enforced by physical track circuit blocks, but a dynamic calculation by train 8.
Basic Operation

- As train 9 moves forward, train 8 follows while maintaining the safety distance.
- There is no artificial separation between trains, only the bare minimum separation required to maintain the safety distance.
Basic Operation

- As train 9 and train 8 slow, the safety distance is reduce.
Comparison

Conventional/CABS Signalling

60km/h → Safety Distance → Wasted space

1. A
2. B (Train 8)
3. C
4. D (Train 9)
5. E

400m Block → 400m Block

CBTC Signalling

60km/h → Safety Distance

400m Block

Train 8 → Train 9
Wrap Up

• The separation between trains is kept to a bare minimum required to maintain a safety distance between trains.
Wrap Up

• Safety distance is no longer a static entity enforced by fixed blocks but an adjustable distance based on a real time calculation of the train speed.
  • If the train is travelling at a high speed the safety distance is long and shrinks as the train slows.
• CBTC signaling extracts the maximum capacity per the track design.
  • The maximum number of trains will run through the system.
Conclusion

- Capacity is affected by the separation between trains.
- Each signaling system has its own characteristic that affects train separation.
About the Author

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