Evaluation of the need for a Secondary Signaling System on CBTC projects

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Agenda

1. Project presentation
2. Problem Statement
3. Approach
4. Results
5. Conclusion
Project Presentation

- Project name: TCRP D-18

A Transit Agency Guide to Evaluating Secondary Train Detection/Protection Systems in Communications-Based Train Control (CBTC) Systems

- National Academy of Sciences (NAS)
- Transportation Research Board (TRB)
- Transit Cooperative Research Program (TCRP)

DISCLAIMER: The opinions and conclusions expressed or implied herein are those of the Contractor. They are not necessarily those of the Transportation Research Board, the National Academies, or the program sponsors
The objective of this research is to develop guidelines to enable a transit agency to evaluate the need for:

(1) Secondary train detection/protection systems

Or

(2) Operating practices in lieu of detection/protection systems

when implementing a CBTC system.
CBTC Basic principles

- Two way continuous communication between trains and wayside equipment
- On board equipment determines position and provides it to the wayside equipment
- Wayside equipment ensures safe train separation by sending Movement Authority Limit to each train
- On board equipment enforces this Limit and civil speed protection

No need for secondary signaling system!
**CBTC Basic principles**

- **ATS**: Automatic Train Supervision
- **ZC**: Zone Controller
- **CC**: Carborne Controller

**Operation Control Center**

**Communication Network**

**Access Point**

**ZC 1**

**CC 1** to **ZC 1**: Train 1 is located at location of X plus the travelled distance since X.

**CC 2** to **CC 1**: Movement Authority Limit is rear of Train 1.

**Max. speed**

**Safety Distance**

**Distance since X**

**Tracks**

**Transponders**

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Secondary Train Detection / Protection System

- **Detection** by block rather than train reporting its precise position
  - Using Track Circuits
  - Using Axle Counters

- **Protection:**
  - Signals present on the wayside for spacing between trains and for interlocking protection
  - Based on assuming Maximum Attainable/Authorized Speed rather than exact value of train speed
  - Signal enforcement such as train stops
Secondary Train Detection / Protection System

**STD/PS:** Conventional signaling system / Back-up / Fallback / Auxiliary Wayside System.

Example of conventional signaling system
Problem Statement


“To date, deployment of CBTC technology within the United States has been limited, due, at least in part, to a perception of higher costs associated with the implementation of this technology. This perception of higher costs is in turn driven, in part, by a perception that CBTC systems require a secondary track circuit-based or axle counter-based ‘fallback’ system to detect and protect trains in the event of CBTC system failures.”
## Approach – 2 Phases / 7 Tasks

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<thead>
<tr>
<th>Tasks TCRP D-18</th>
<th>2016</th>
<th>2017</th>
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<tbody>
<tr>
<td></td>
<td>Feb</td>
<td>Mar</td>
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<tr>
<td>PHASE 1</td>
<td>1</td>
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<tr>
<td>TASK 1 / Review Literature and quick agency and supplier survey</td>
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<td>TASK 2 / Determination of best case study, establish work plan for phase 2</td>
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<td>TASK 3 / Prepare an Interim Report</td>
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<tr>
<td>PHASE 2</td>
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<td>TASK 4 / Conduct case studies</td>
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<td>TASK 5 / Write a guide for transit agencies about CBTC implementation</td>
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<td>TASK 6 / Write Technical Memorandum</td>
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<td>TASK 7 / Produce Final Report</td>
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**Approach – 2 Phases / 7 Tasks**

- Literature Review
  - Review of industry practices and regulations
  - Only Federal Railroad Administration has a requirement to use track circuits

- Industry survey and case studies
  - Creation of a brief 10-minute survey
  - About 20 agencies using CBTC responded from all around the world
  - All major signaling suppliers provided information
  - 6 representative case studies selected
Supplier Participation

- Ansaldo Signaling and Transportation Systems (Pittsburgh, PA, USA)
- Alstom Transport (Saint-Ouen, France)
- Bombardier Transportation (Pittsburgh, PA, USA)
- China Railway Signal & Communication Co. (Shanghai, China)
- Frauscher Sensortechnik GmbH (Marienkirchen, Austria)
- Siemens Mobility – Rail Automation (Châtillon, France)
- Thales Transportation Solutions (Toronto, ON, Canada)
List of Case Studies

• New York City Transit (New York, NY, USA);
• Transport for London (London, UK);
• AirTrain JFK (New York, NY, USA);
• Maryland Transit Administration – Baltimore Metro Subway (Baltimore, MD, USA);
• British Columbia Rapid Transit Company (Vancouver, BC, Canada);
• Port Authority Trans-Hudson (Jersey City, NJ, USA).
Results – Different Categories of Projects

• Two main groups:
  ▪ 2: Without STD/PS
  ▪ 1: With STD/PS

• Among projects with STD/PS:
  ▪ 1.A: Capable of some level of peak or off-peak revenue service
    ▪ 1.A.1: peak
    ▪ 1.A.2: off peak
  ▪ 1.B: Design to handle a single non-CBTC train (failed train or unequipped work train)
    ▪ 1.B.1: One train per interstation
    ▪ 1.B.2: On train per interlocking
    ▪ 1.B.3: Only detection and no protection
Results – Different Categories of Projects

• Graphical representation:

1.A.1 Capable of peak revenue service

1.A.2 Capable of off-peak revenue service

1.B.1 Capable of one train per inter-station

1.B.2.1 Capable of one train per interlocking
Results – Different Categories of Projects

• Graphical representation:

1.B.2.2 Capable of one train per interlocking

2 No STD/PS

1.B.3 Capable of tracking but not protecting a non-CBTC train
Consequences of having an STD/PS

- Investment effort
- Maintenance effort
- Impact on CBTC operation availability
Consequences of having an STD/PS

• STD/PS Failures:
  ▪ Though secondary, STD/PS is always used when present
  ▪ Can impact CBTC operation
  ▪ Complex CBTC functions to handle STD/PS failures are possible
  ▪ More STD/PS implies more negative consequences

“It is clear that the minimum level of STD/PS which meets the agency need is the best option.
Consequences of not having an STD/PS

- Relying heavily on operating procedure during failures

- Higher pressure to equipping work trains, especially for 24/7 operation.
  - Equipping the work trains with CBTC equipment
  - Using a CBTC locomotive or trailer
  - Using a separate tracking system

Overall: minor consequences which can be mitigated
Results – Common reasons for having an STD/PS

• Despite:
  ▪ CBTC high redundancy and efficient monitoring of the health of the equipment
  ▪ Examples of successful CBTC projects without STD/PS all over the world
  ▪ Negative impacts on investment, maintenance, and CBTC availability

• Main cited reason is: “to manage CBTC failures”

• Other reasons are to:
  ▪ Manage non-equipped work trains
  ▪ Have a level of broken rail detection using track circuits
  ▪ Facilitate the transition from existing signaling system to CBTC
Results – Common reasons for having an STD/PS

- CBTC engineers must acknowledge that:
  1. Brownfield projects are complicated and STD/PS may help the transition
  2. More centralized architecture than in other signaling systems: a wayside ATS, DCS, or ZC equipment failure can affect a large area
  3. A large amount of electronics on-board the train subject to harsh environment can affect CBTC operation on a single train
  4. Software based: some errors are detected only after revenue service
Results – Decision factors

1. Mixed-fleet operation during the cut-over to CBTC

2. Using the STD/PS as a back-up system:
   a. Operation at **peak headway** with the secondary system
   b. Operation at **off-peak headway** with the secondary system
   c. Management of a **single train with CBTC failure** using the secondary system

3. Handling of unequipped work trains

4. Detection of broken rail by the signal system
Results – Decision Process Flow Diagrams

Mixed fleet during cut-over > Yes: 1.A.1 During Cutover > No: Mixed fleet during cut-over

Peak performance > Yes: 1.A.1 > No: Off-peak performance

Off-peak performance > Yes: 1.A.2 > No: Manage single train with CBTC failure

Manage single train with CBTC failure > Yes: See 1.B Selection Flow Diagram (Figure 13) > No: Manage unequipped work train

Manage unequipped work train > Yes: 1.8.1 1.8.2 1.8.3 > No: See 1.B Selection Flow Diagram (Figure 13)

Peak Performance permanently > Yes: 1.A.1 > No: Mixed fleet during cut-over

Off-peak performance > Yes: 1.A.2 > No: Manage single train with CBTC failure

Manage single train with CBTC failure > Yes: See 1.B Selection Flow Diagram (Figure 13) > No: Manage unequipped work train

Manage unequipped work train > Yes: 1.8.1 1.8.2 1.8.3 > No: See 1.B Selection Flow Diagram (Figure 13)

Station to station resolution > Yes: 1.B.1 > No: Detection everywhere

Detection everywhere > Yes: 1.B.2.2 > No: Signals at interlockings

Signals at interlockings > Yes: 1.B.2.1 > No: 1.8.3

: Need from STD/PS

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Results – Choosing the Secondary Detection

• Track Circuit principles:

Per Association of American Railroads, it is “An electrical circuit of which the rails of the track form a part.”

• Axle counter principles:

Magnetic sensors fixed on the running rails detecting wheels passing on the rail.
Results – Choosing the Secondary Detection

• Advantages of axle counters:
  ▪ Installation can be overlaid over existing track circuits, no impact on the traction return system >> convenient in particular for brownfield projects

  ▪ No limitation on length >> particularly useful for CBTC projects where STDS might only need long blocks

• Disadvantages of axle counters:
  ▪ Reset procedure needed

  ▪ No broken rail detection
Results – Choosing the Secondary Detection

• Advantages of track circuits:
  ▪ Industry familiarity
  ▪ Provide some level of detection of broken rails

• Disadvantages of track circuits:
  ▪ Installation and modification requires more labor than axle counters
  ▪ Requires periodic adjustment and testing
Results – Choosing the Secondary Detection method

• In the case of STD/PS for CBTC projects, axle counters appear to have more benefits than track circuits.

• Data from about 70 mass transit surveyed projects

• Only about 5% have no STD/PS. 95% have STD/PS.

• Among projects with STD/PS:

<table>
<thead>
<tr>
<th>Project with STD/PS</th>
<th>Total</th>
<th>Before 2005</th>
<th>After 2005</th>
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<tbody>
<tr>
<td>With Track Circuits</td>
<td>39%</td>
<td>91%</td>
<td>29%</td>
</tr>
<tr>
<td>With Axle Counters</td>
<td>61%</td>
<td>9%</td>
<td>71%</td>
</tr>
</tbody>
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Conclusion

- CBTC system is possible without STD/PS or with minimum level of STD/PS

- The minimum level of STD/PS is desirable to avoid adverse effects on CBTC deployment and operation

- Each agency needs to perform its own assessment. The guide was developed to provide the criteria for each decision
Conclusion

• Trends from projects in the US and around the world:
  ▪ STD/PS not designed as a back-up for revenue service with any performance level (peak or off-peak). No need to protect large failed zone.
  ▪ STD/PS only for managing failed trains and unequipped work trains.
  ▪ Axle counter use has increased in past decades

• Shifting from a full STD/PS to a minimal one is a culture change. Will the next shift be to go to no STD/PS, even in the case of brownfield projects?
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