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

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Kenneth Diemunsch, Parsons, New York, NY, USA

Stuart Landau, CH2M, Parsippany, NJ, USA

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)

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Project Presentation - Objective

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.

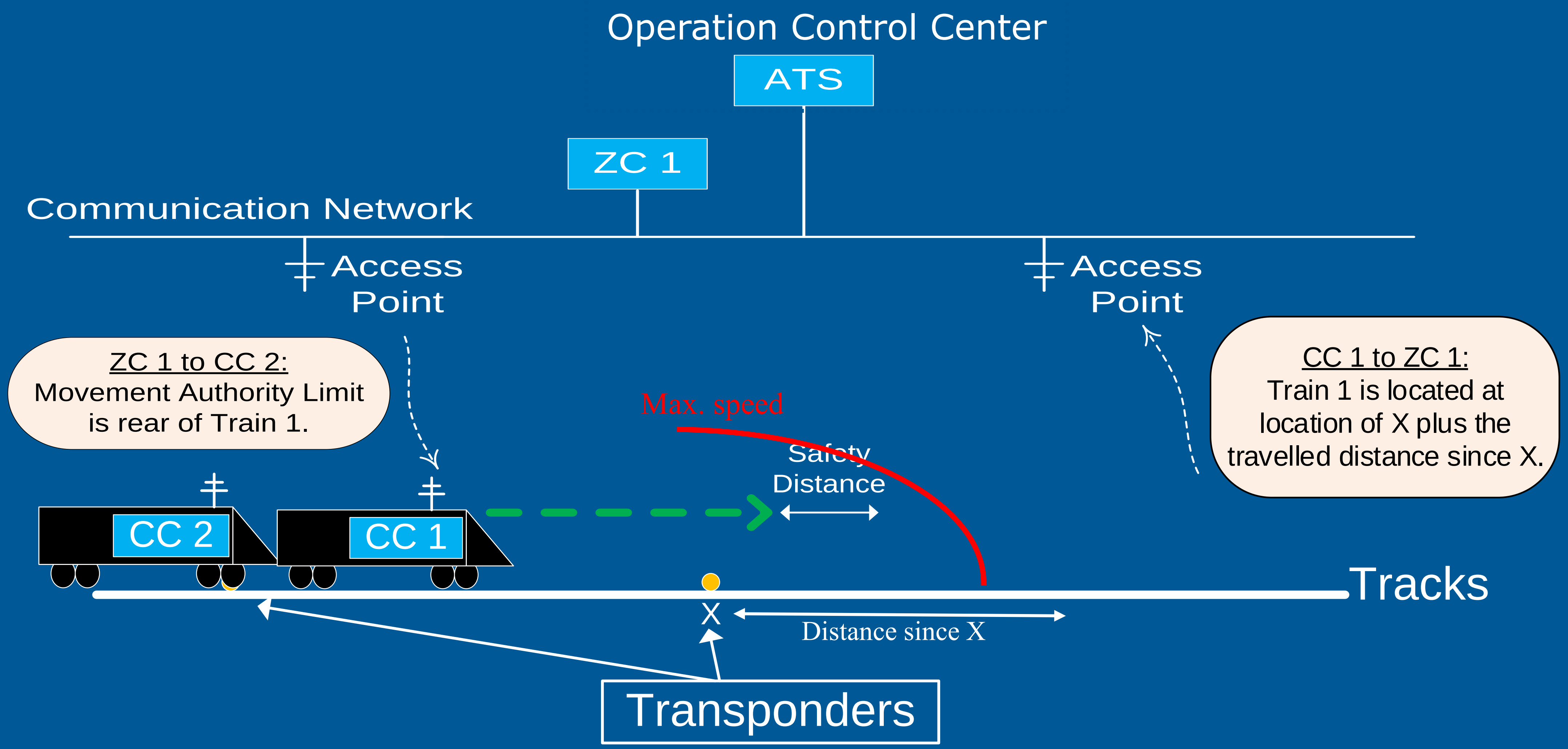
CBTC Basic principles

- 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



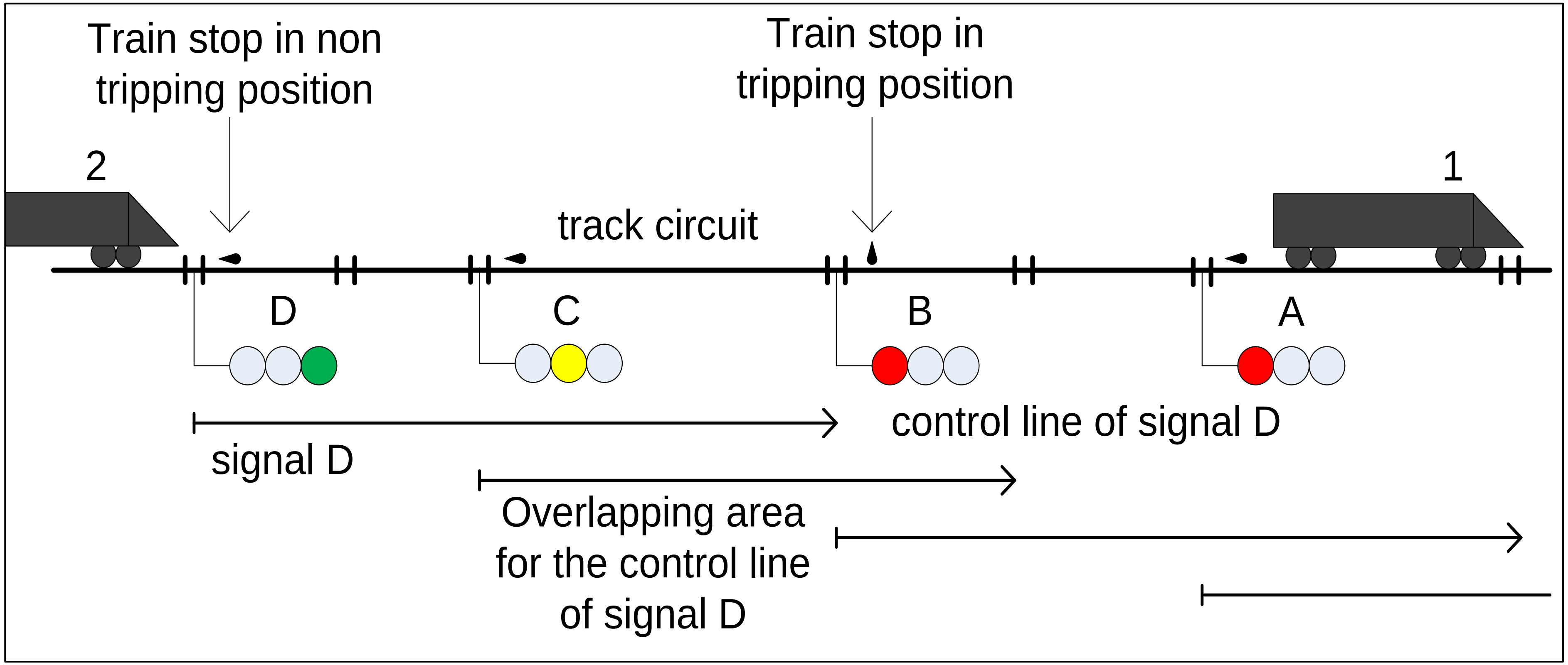
Secondary Train Detection / Protection System

- **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

Per Federal Transit Administration (FTA) Report No. 45, "An Assessment of the Business Case for CBTC:"

"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

Tasks TCRP D-18	2016											2017			
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PHASE 1															
TASK 1 / Review Literature and quick agency and supplier survey	■	■	■	■	■										
TASK 2 / Determination of best case study, establish work plan for phase 2			■	■	■										
TASK 3 / Prepare an Interim Report				■	■	■									
PHASE 2															
TASK 4 / Conduct case studies							■	■	■	■	■				
TASK 5 / Write a guide for transit agencies about CBTC implementation										■	■	■	■		
TASK 6 / Write Technical Memorandum													■		
TASK 7 / Produce Final Report													■	■	■

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).

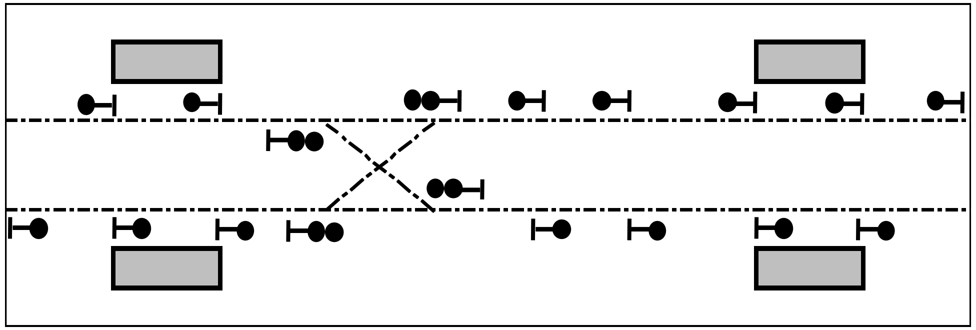
Results – Different Categories of Projects

- Two main groups:
  - 2: Without STD/PS
  - 1: With STD/PS

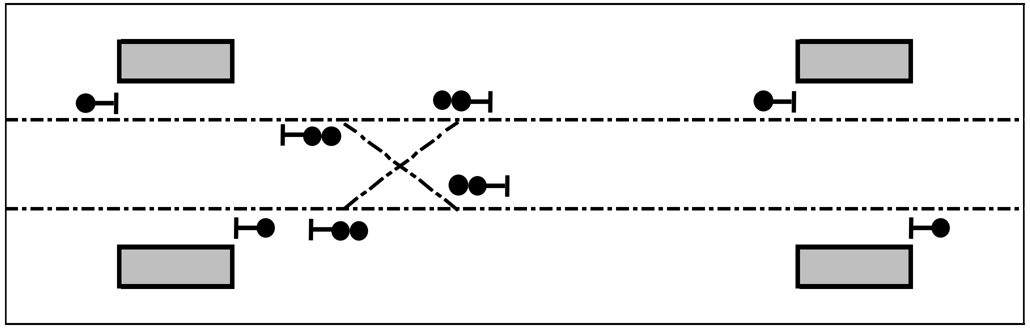
- Among projects with STD/PS:
  - 1.A: Capable of some level of peak or off-peak revenue service
    - 1.A.1: peak
    - 1.A.2: off peak
  - 1.B: Design to handle a single non-CBTC train (failed train or unequipped work train)
    - 1.B.1: One train per interstation
    - 1.B.2: On train per interlocking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

Results – Different Categories of Projects

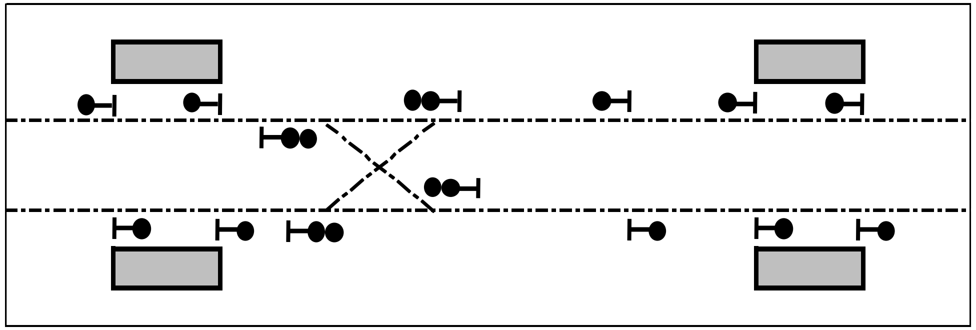
- Graphical representation:



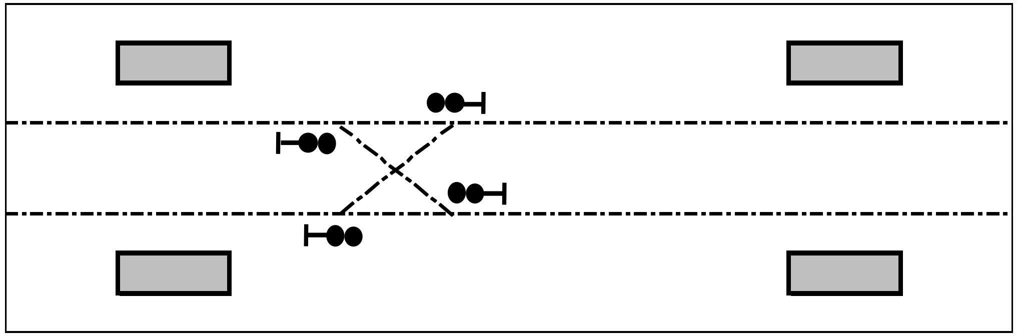
1.A.1 Capable of peak revenue service



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



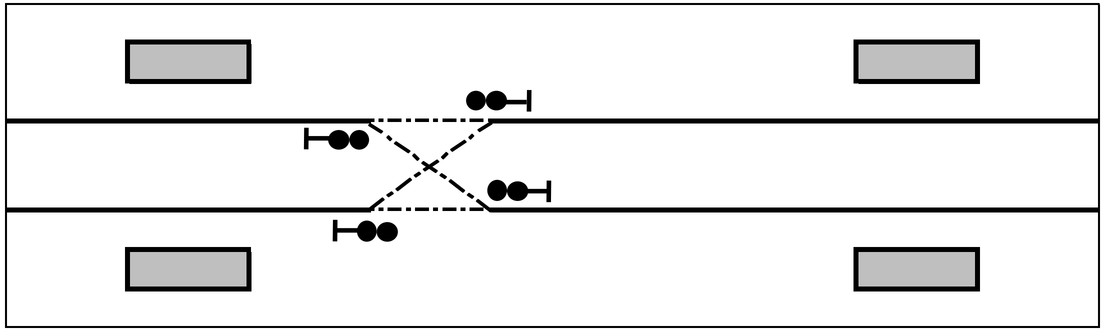
1.A.2 Capable of off-peak revenue service



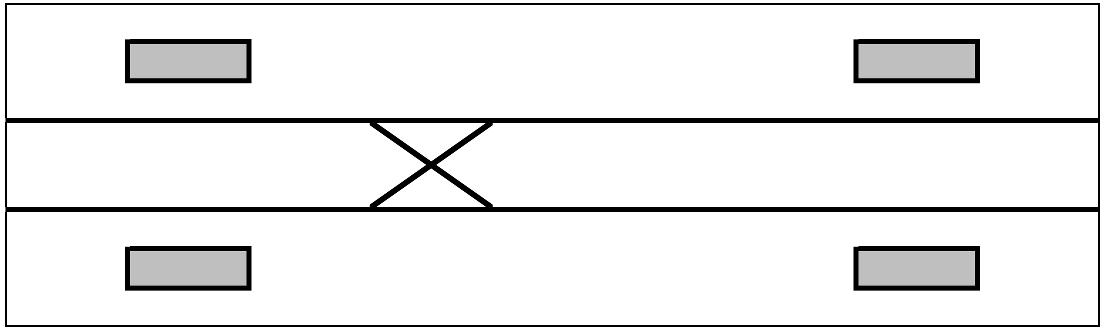
1.B.2.1 Capable of one train per interlocking

Results – Different Categories of Projects

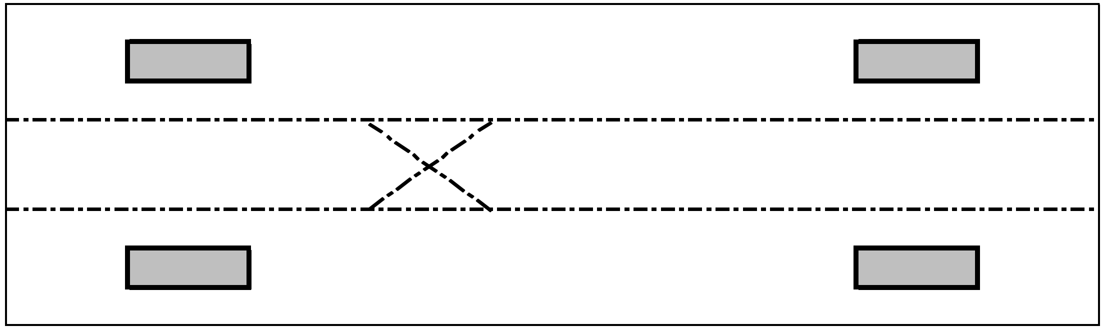
- Graphical representation:



1.B.2.2 Capable of one train per interlocking



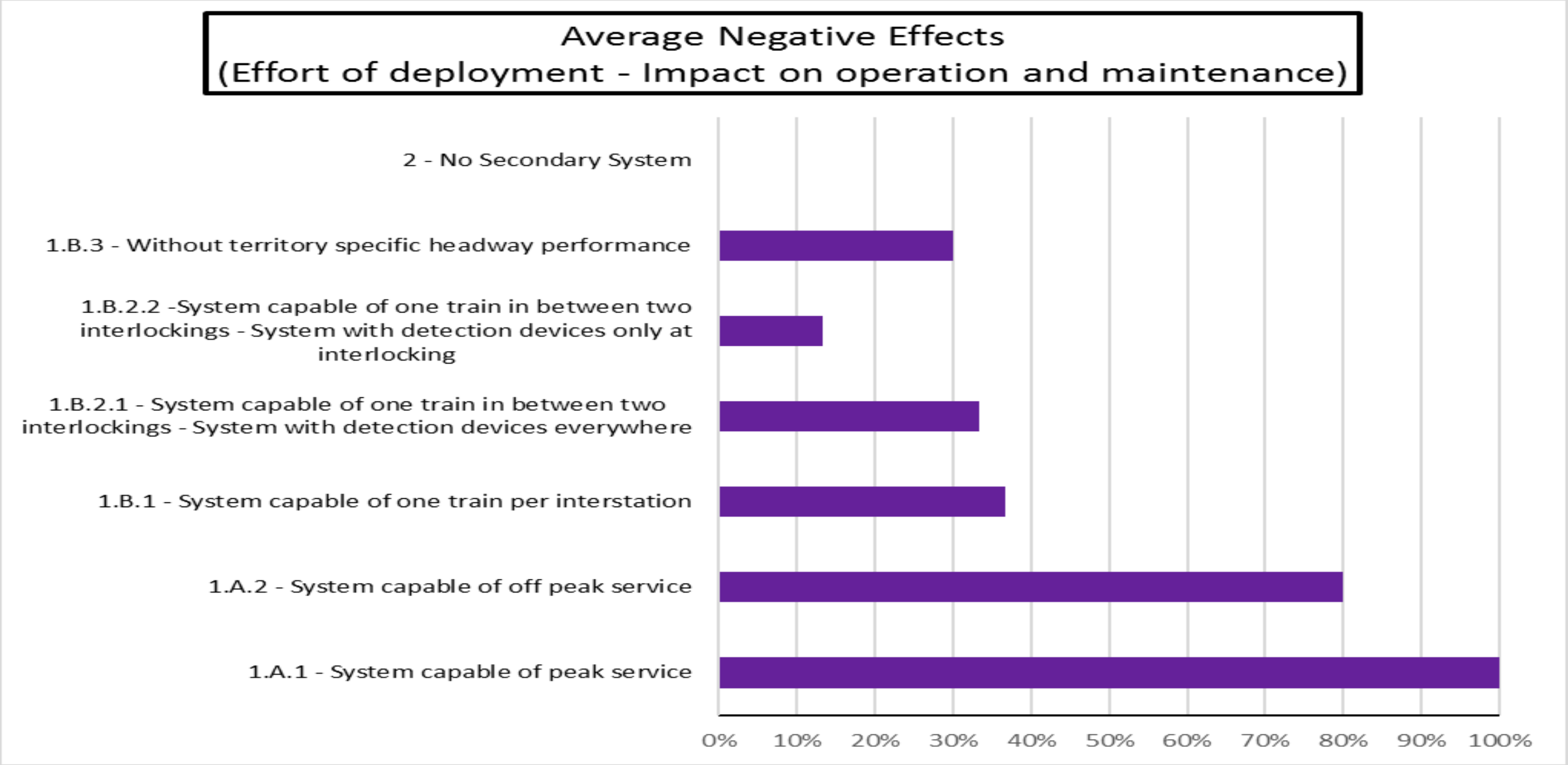
2 No STD/PS



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

“Simplicity is prerequisite for reliability” – Edsger W. Dijkstra

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

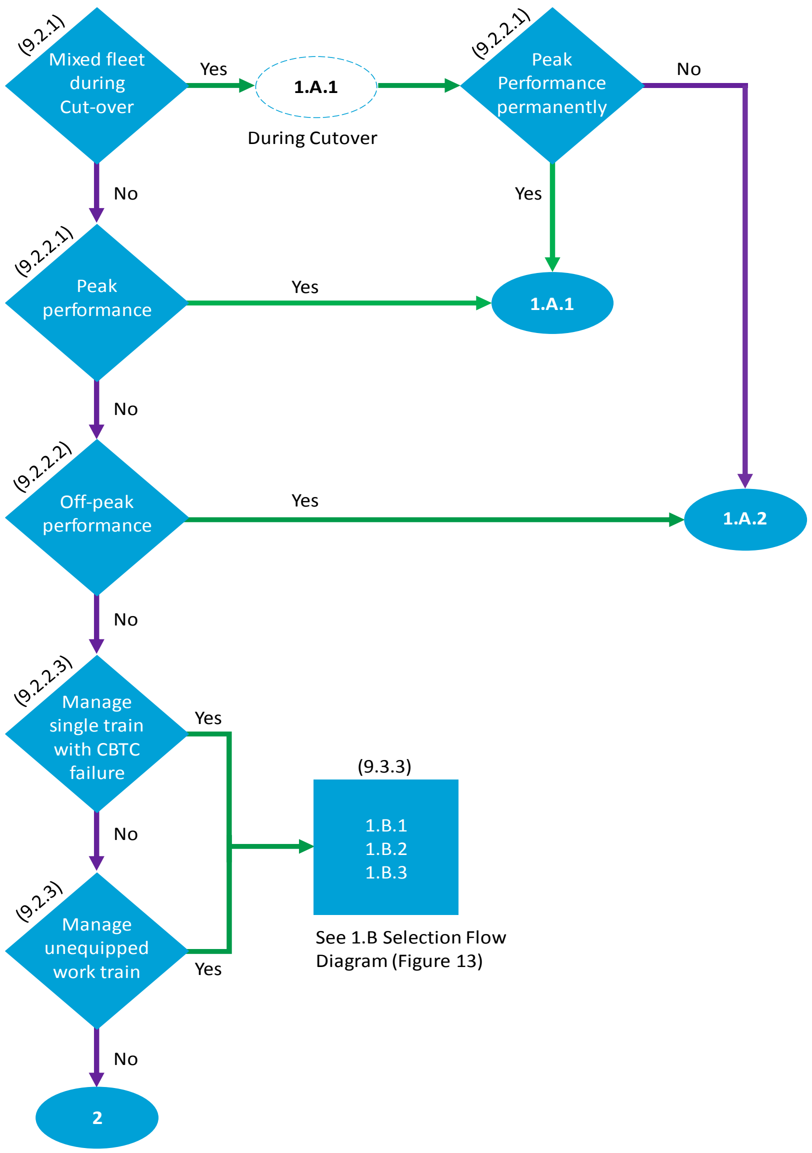
1. Mixed-fleet operation during the cut-over to CBTC

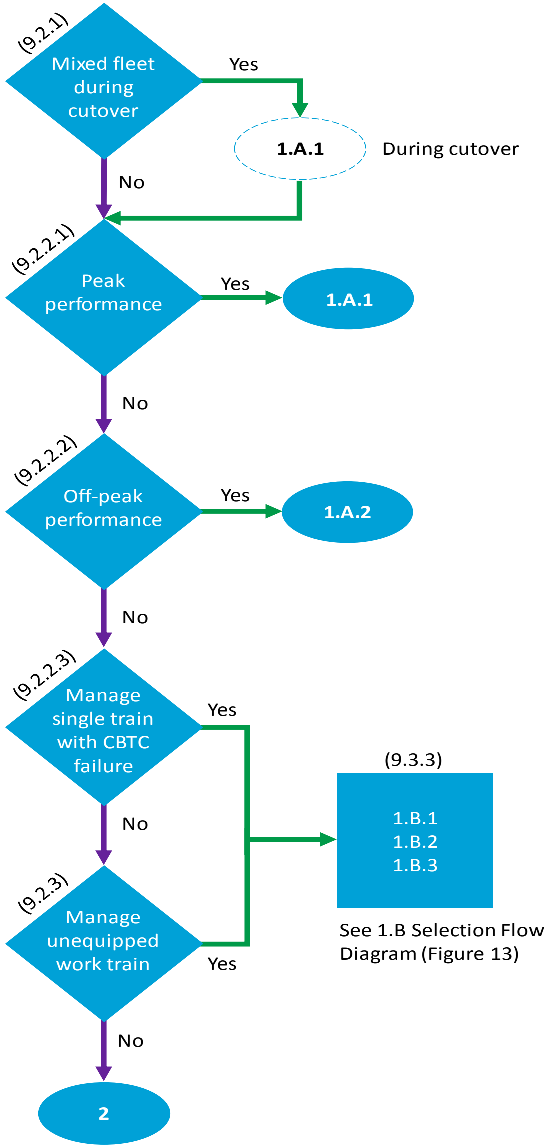
2. Using the STD/PS as a back-up system:
   a. Operation at <u>**peak headway**</u> with the secondary system
   b. Operation at <u>**off-peak headway**</u> with the secondary system
   c. Management of a <u>**single train with CBTC failure**</u> using the secondary system

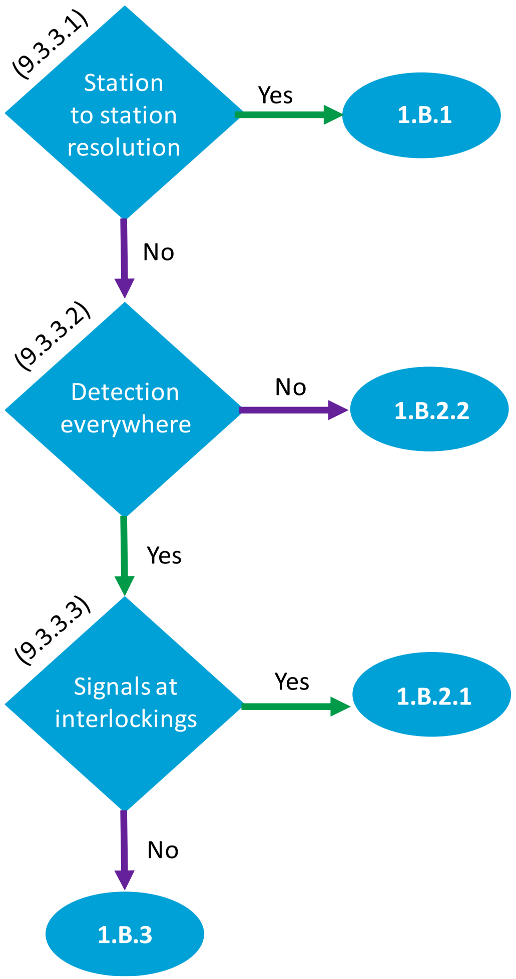
3. Handling of unequipped work trains

4. Detection of broken rail by the signal system

Results – Decision Process Flow Diagrams







: Need from STD/PS

: Need from STD/PS

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:

Project with STD/PS	Total	Before 2005	After 2005
With Track Circuits	39%	91%	29%
With Axle Counters	61%	9%	71%

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?

Contact information

Kenneth Diemunsch

Parsons

Senior Train Control Engineer

Kenneth.Diemunsch@parsons.com

Stuart Landau

CH2M, Inc.

Signal and Train Control Engineer

Stuart.Landau@ch2m.com