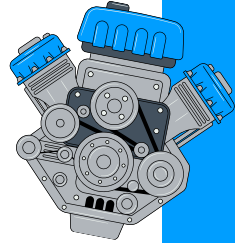


CBTC Technical Presentation

IEEE Long Island Consultants

Network

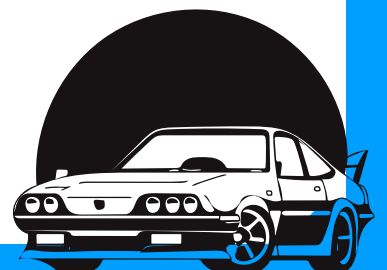
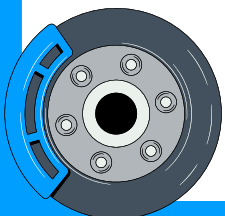
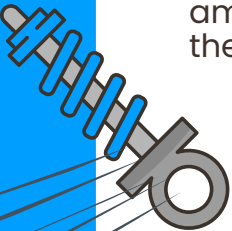


Presentation on Communications-Based Train Control (CBTC) for the Institute of Electrical and Electronic Engineers Long Island Consultant Network. IEEE LICN

On August 7th, 2025, I had the privilege of presenting to the IEEE Long Island Consultants Network on Communications-Based Train Control. CBTC is a cornerstone of modern railway signaling that is continually evolving today

In this presentation, I dove deep into the need for CBTC in subways and high speed rail, history and development, architecture and design, integration into modern railway systems and future design considerations.

I would like to give thanks to the Long Island Consultants Network, their chairman Christopher Early and vice chairwoman Rhonda Green for this amazing opportunity. I look forward to participating in future opportunities the consultants network will offer





Cab Signaling.

- Track circuit sends coded energy through the rails
- Pickup coils on train detect and convert the signal
- Cab equipment displays signal aspect in real time
- Driver must tap acknowledge on display.
- If the driver doesn't click acknowledge, auto braking in 8 seconds

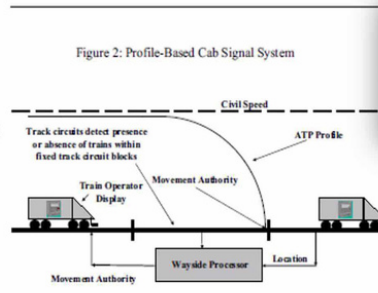


Image: Profile-Based Cab Signaling. S Morar. Evolution of CBTC Worldwide. (2012)

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Fixed block signaling train dispatcher's view.



Image: New York times. NYCT Hoyt Schermerhorn St Control tower.

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Alexander Impastato

Alexander Impastato's screen



CBTC Benefits Overview

+20 – 50%
capacity
increase.

Automatic
protection reduces
collisions.

Higher service
reliability; fewer
signal failures.

Foundation for
driverless
operation.

Alexander Impastato's screen

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Alexander Impastato



Fixed Block Signaling Drawbacks summary

- The fixed block system of signaling required some distance between trains, and this put a restriction on the speed of the trains on the track.
- The fixed block system also relied on human operators. They were prone to errors that could result in delays in determining how to move the trains.

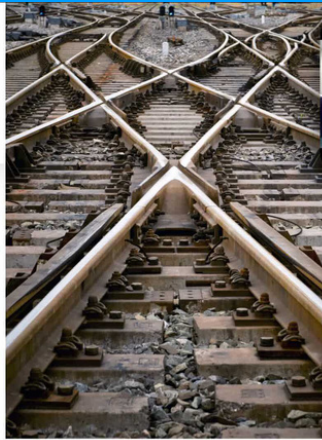


Image: Unsplash – rail junction photo 11

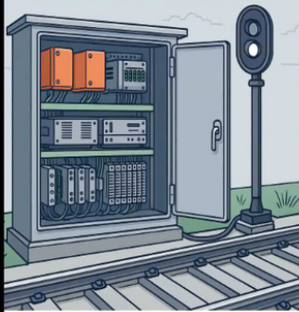


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Alexander Impastato's screen



WAYSIDE ZONE CONTROLLER



Wayside Zone Controller (ZC)

- The Zone Controller Computes safe Movement Authority (MA) for every train.
- Interfaces with Computer Interlocking (CI) to verify switch & route status
- Exchanges status with ATS for headway and dwell-time control
- Dual-computer, hot-standby design for fail-safe redundancy. When one component drops, the other performs its duties.

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Operational Control Center (ATS)

- Real-time train map with predicted arrivals
- Regulates headways by sending speed/dwell commands
- Manages incident response & degraded-mode scenarios
- Interfaces to passenger information & CCTV systems
- Generates performance reports for service planning.



Image: View inside NYC Subway Rail Control Center frame capture from MTA video "CBTC: Communications-Based Train Control" (YouTube, 2013)

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CBTC System Architecture Block Diagram

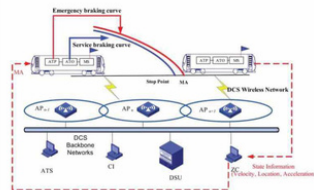


Fig. 1. CBTC systems.

Image: CBTC system architecture, Fig. 1 in A Cognitive Control Approach to CBTC Systems (IEEE, 2021).

- On-board VOB: ATP, ATO, MS run the train and perform safety checks.
- Radio rings (APn-1 / APn / APn+1): 10 Hz data link to the train.
- Wayside servers: ATS for schedule, CI for route locking, DSU for data logging.
- ZC (Zone Controller) sends live movement authority & braking curves.
- Continuous feedback keeps train inside its service or emergency envelope.



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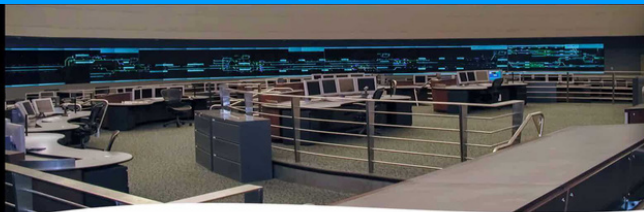


Image: Operations Control Center interior. RailWorks, from the "Automatic Train Supervision (ATS)" project page

ATS: Incident Management in a CBTC world

- Detects track-circuit failure. It flags affected block in under 5 s
- Automatically re-routes trains via crossover.
- Issues stop-and-proceed order to nearest train.
- Short-turns trailing trains to prevent bunching at terminals
- Pushes real-time alerts to PIDS, staff tablets & maintenance crew



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Track circuit analysis

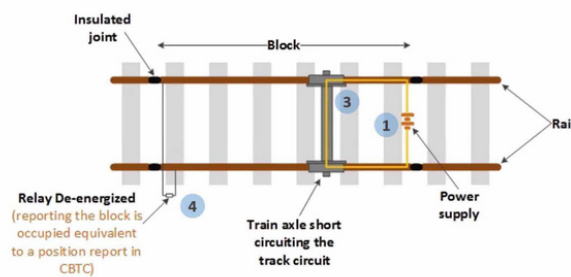


Image: RailSystem.net - "Track Circuit" diagram



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