Holistic Review of the Conventional and Modern Train Control and Traction Power Systems

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Key Presentation Topic

- Alignment
- Train Control
- Transit Signal Priority
- Power Transfer
- Alternative Power

CBTC LRT

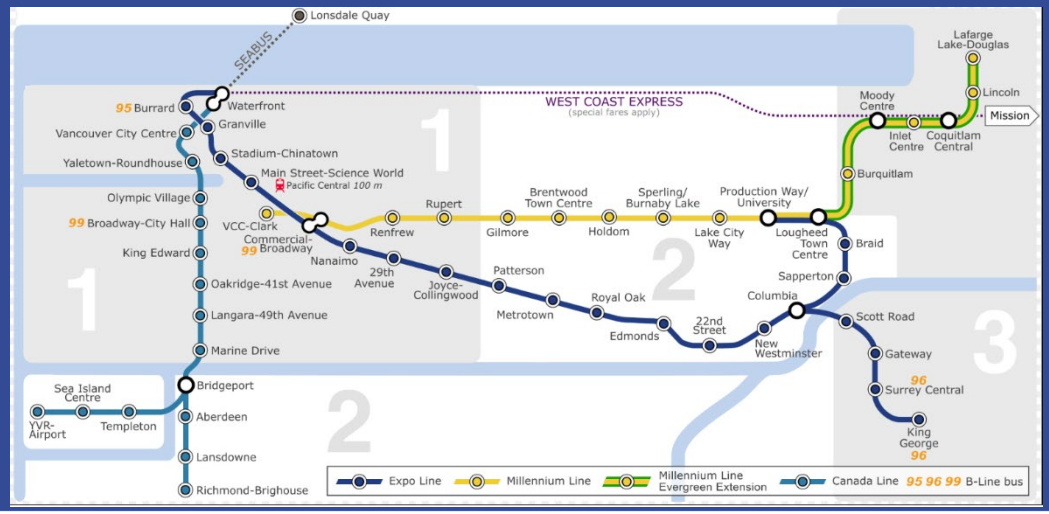
Grades of Automation
(IEC62267/62290)

Grade of Automation	Type of train operation	Setting train in motion	Stopping train	Door closure	Operation in event of disruption
GoA1 	ATP* with driver	Driver	Driver	Driver	Driver
GoA2 	ATP and ATO* with driver	Automatic	Automatic	Driver	Driver
GoA3 	Driverless	Automatic	Automatic	Train attendant	Train attendant
GoA4 	UTO	Automatic	Automatic	Automatic	Automatic

Skytrain - Vancouver

Skytrain Train Control System

- In Operation 1986
- Exclusive ROW
- Grade Separated
- CBTC - GoA4 - UTO
- Headway 2 min
- Network 79 km
- Ridership 150 million



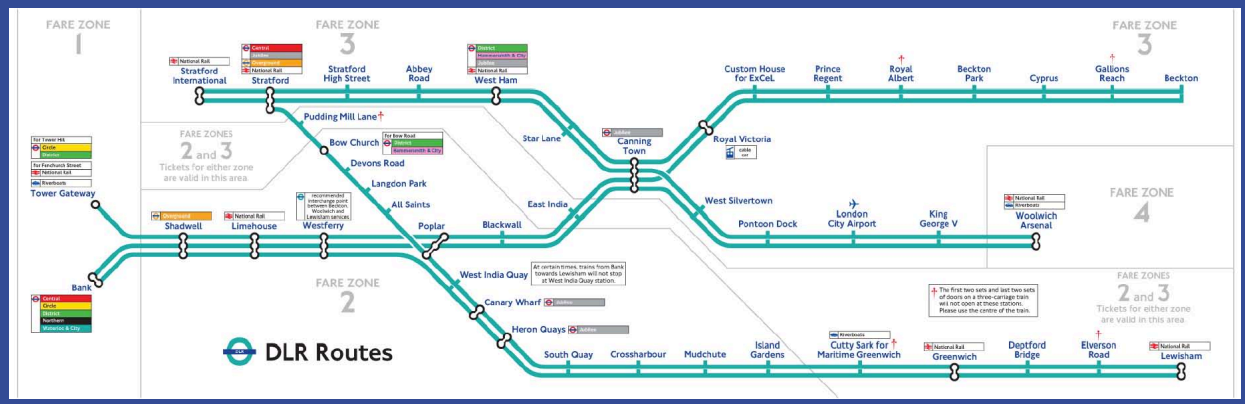
Skytrain Propulsion System

- Bombardier LIM Technology
- Higher Acceleration & Deceleration
- Less Moving Parts to Maintain
- Steeper Grades up to 5%
- Third Rail 650 DC

Docklands Light Railway DLR

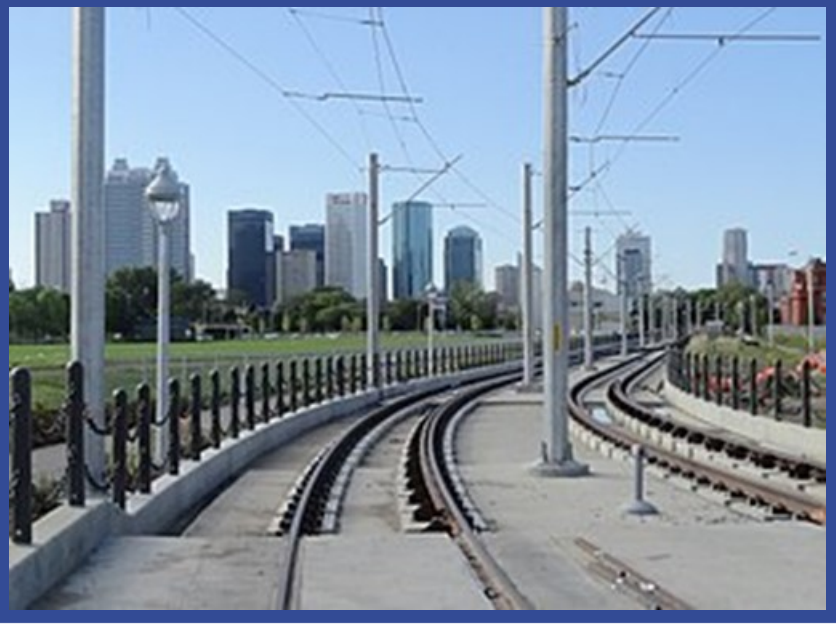
DLR Train Control System

- Exclusive ROW
- Grade Separated
- CBTC – GoA3 - DTO
- Headway 2 min
- Third Rail 750 V DC
- Network 38 km
- 120 million
- Since 1987



Edmonton Metro LRT Line

- Exclusive ROW
- Mostly at Grade
- CBTC – GoA2 - ATO



Edmonton LRT

- Integration:
  - Existing Level Crossings
  - Existing Capital Line
- Headway 2.5 min
- Pantograph 660 V DC
- Unconditional/Preemptive TSP

Toronto Eglinton Crosstown - LRT

- 19 km
- ~60% Underground
- ~40% at Grade
- 2 & 3 Car Consist
- 64 m & 96m Train Length

- 15 Underground Stations
- 10 at Grade Stops
- Operation 2021

Eglinton Crosstown LRT - Toronto

- CBTC – GoA2 - GoA4
- Yard: UTO
- Tunnel: ATO
- Semi Exclusive: ATP
- Headway:
  - 2 minute Exclusive ROW
  - 3 minute Semi Exclusive
- Pantograph 750 V DC

TRANSIT SIGNAL PRIORITY

TSP

Transit Signal Priority - TSP

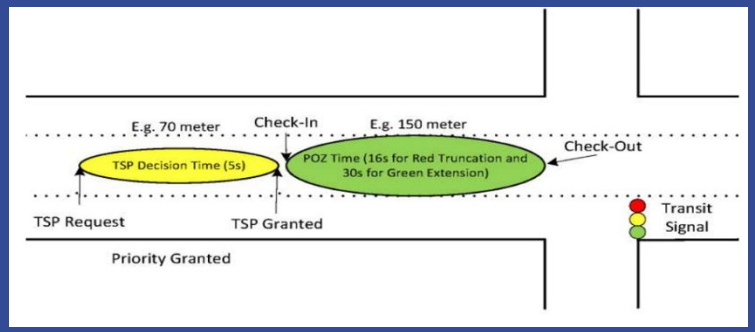
- Unconditional/Pre-emptive TSP – Edmonton LRT - ATO
- Conditional TSP – Late Runs – Eglinton Crosstown LRT

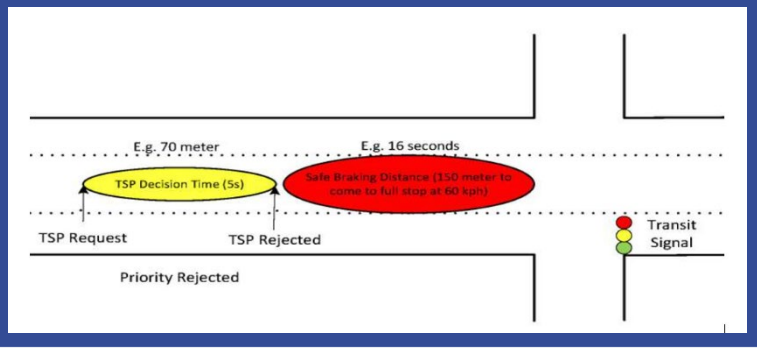
Yellow Zone: TSP Request

Green Zone: Priority Granted – Train Proceeds

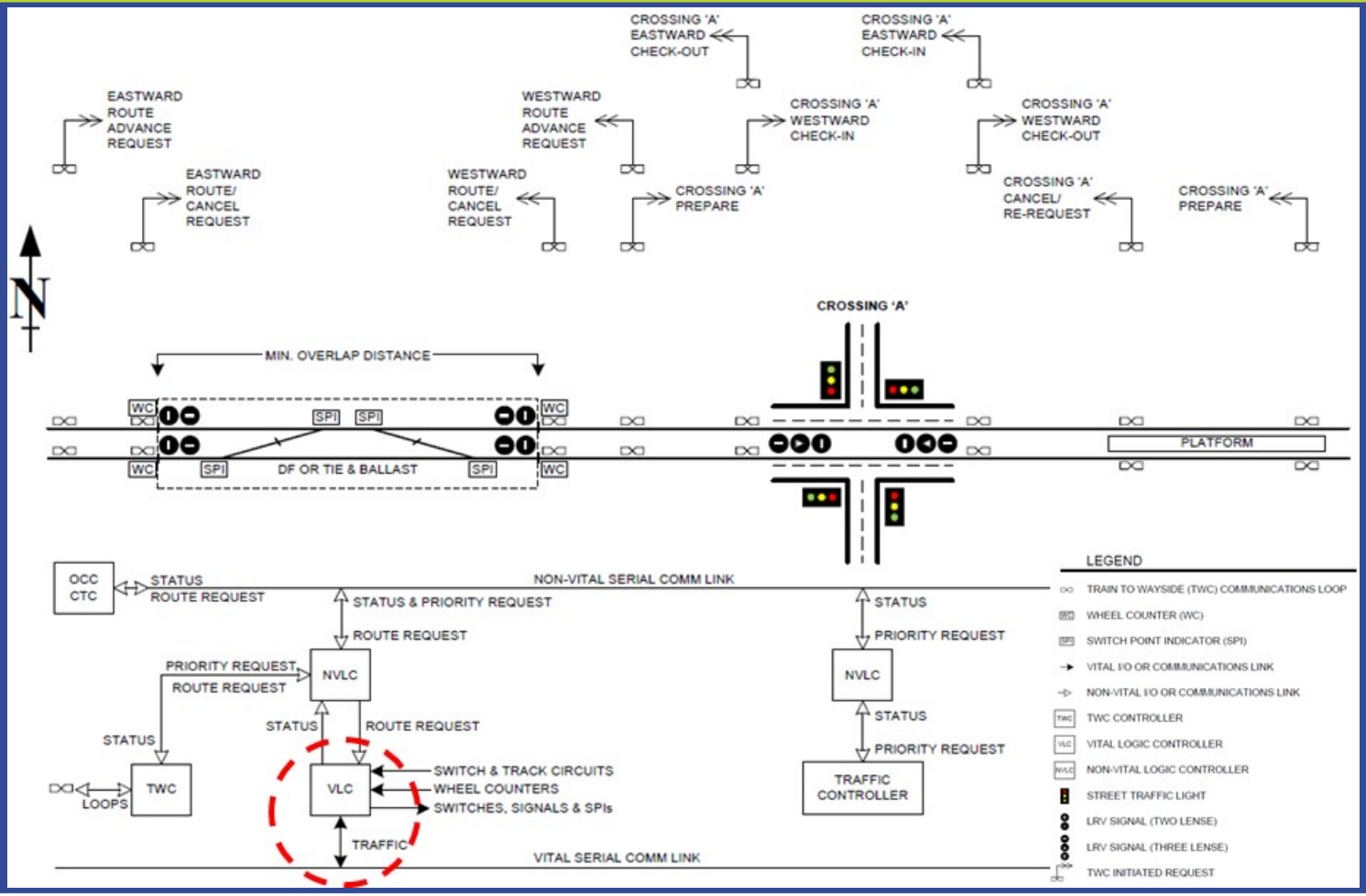
Red Zone: Priority Rejected – Train Stops

Check in – Check out





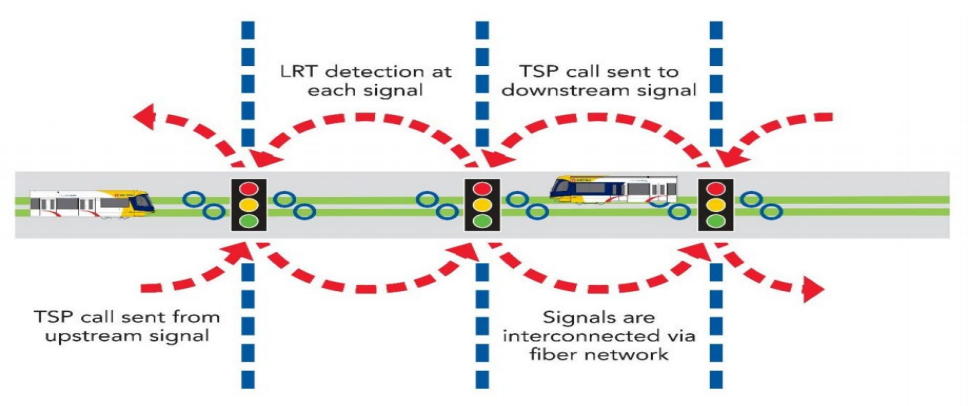
At-Grade Crossing Edmonton
LRT Technical Design Guidelines



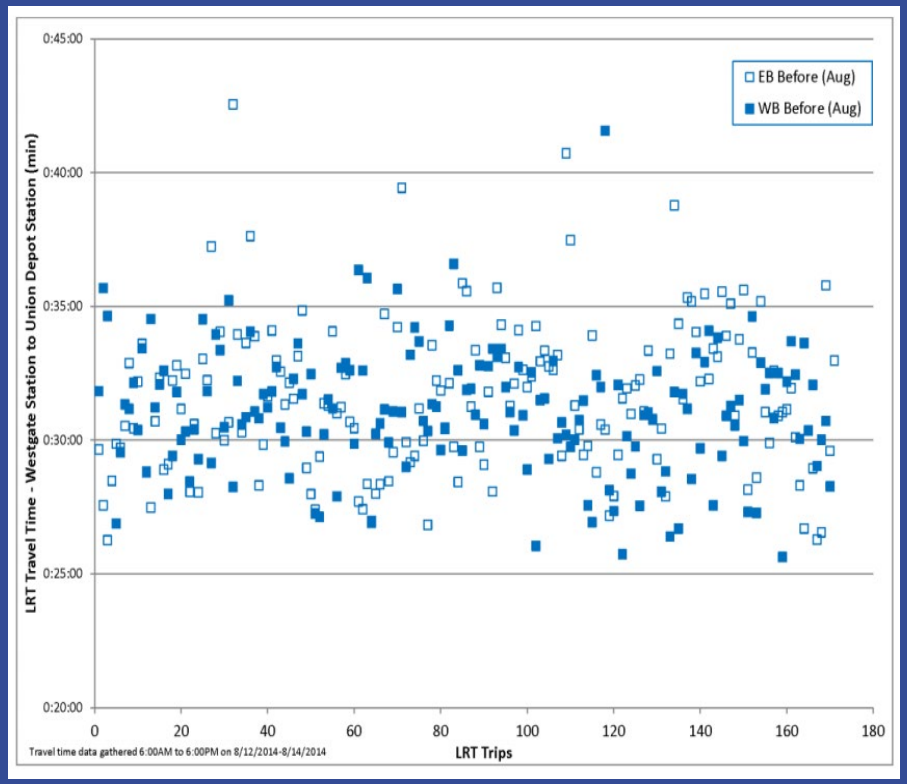
Predictive TSP

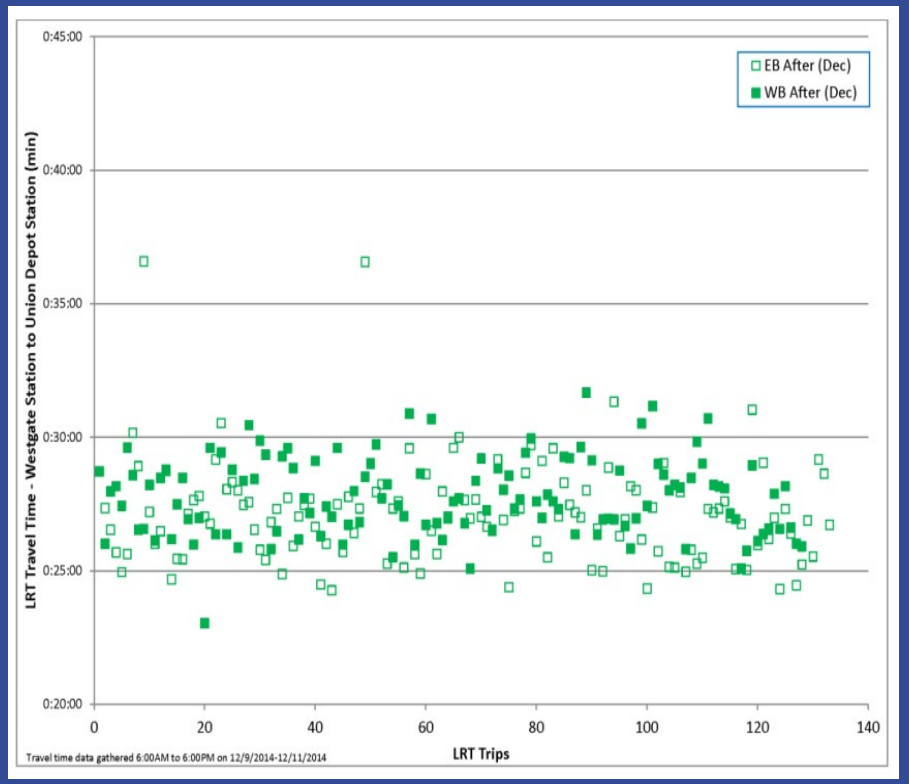
Predictive Priority - Continuous Fiberoptic Communication

- **Phoenix** - Peer to Peer Continuous Communication
- **Minneapolis** Green Line
  - Maximize Green Light Opportunity for LRT
  - Minimize Disruption of Signal Sequence and Traffic Operations
  - Avoid Significant Additional Delay to Road Vehicle & Pedestrian Signal Phase



Minneapolis LRT TSP Improvements





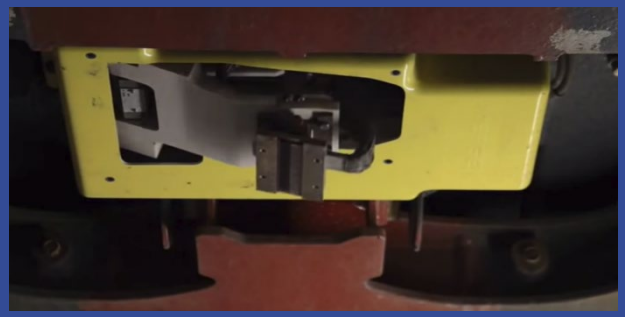
SOURCE: METRO Green Line Transit Signal Priority: Implementation and Lessons Learned
Dan Soler, PE, Metro Transit and JoNette Kuhnau, PE, PTOE, Kimley-Horn and Associates

MID TRACK THIRD RAIL

Ansaldo TramWave – Zhuhai China

Ansaldo TramWave – Zhuhai China

- In Ground Third Rail
- Only Energizes Under Tram
- Waterproof Leakage
- Earth Ring Safety
- No Stray Current
- Regenerative Braking
- Collector Shoes
  - In motion
  - Stationary



Alstom - Bordeaux Tram – APS

Alstom - Bordeaux Tram – APS

- Aesthetic Power Supply
- Hybrid Contacts
- Pantograph
- In Ground Third Rail

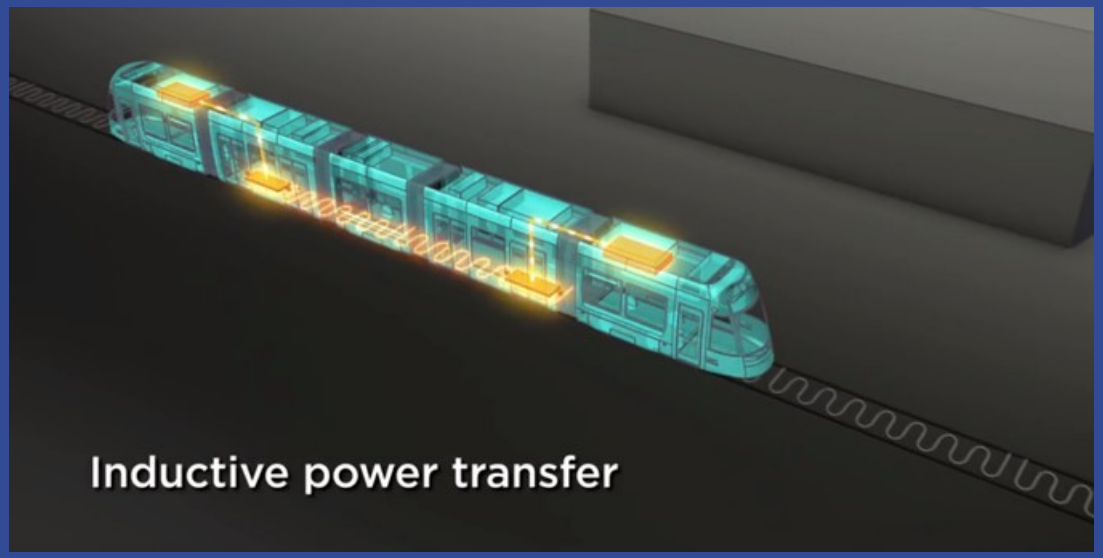
Reims France

INDUCTIVE POWER TRANSFER

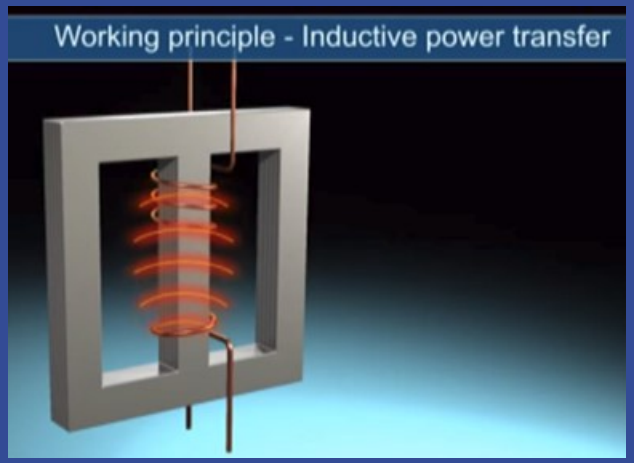
Bombardier PRIMOVE Catenary Free Augsburg Germany

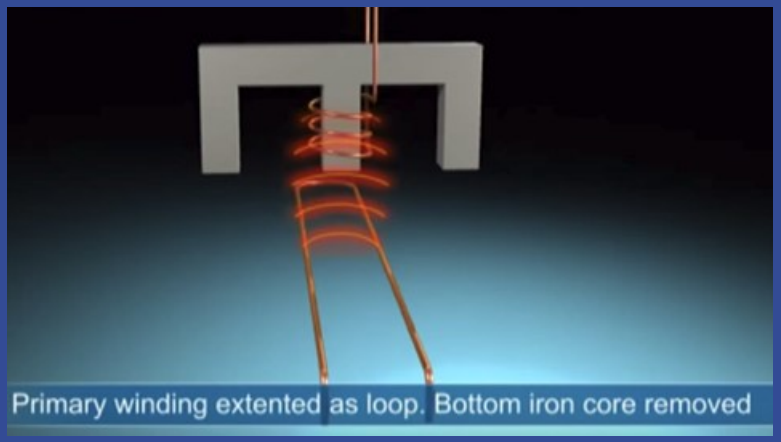
Bombardier PRIMOVE - Inductive

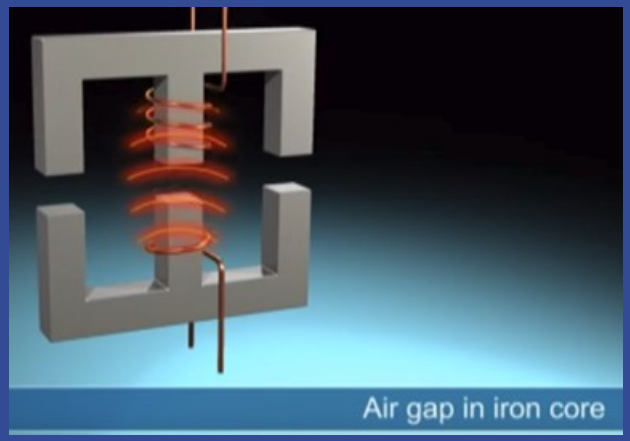
- 200kHz Induction Loop
- Gradient up to 6%, 50kph, 270kW
- Typical LRV, 30m to 42m
- MITRAC Energy Saver/Power Optimization
- Reliable in all Weather Conditions

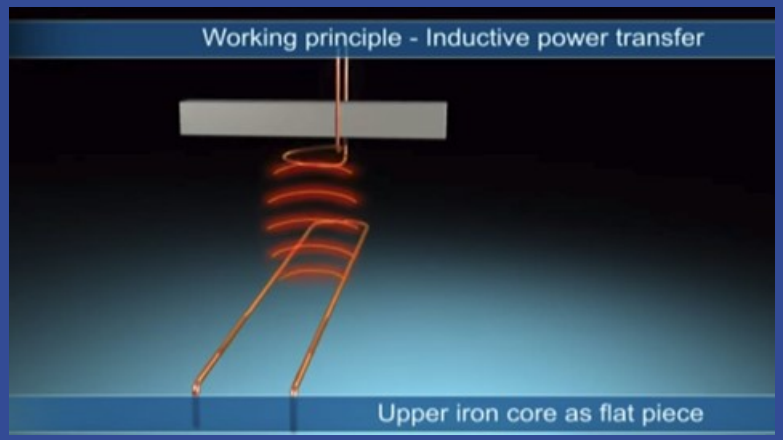


Working Principles









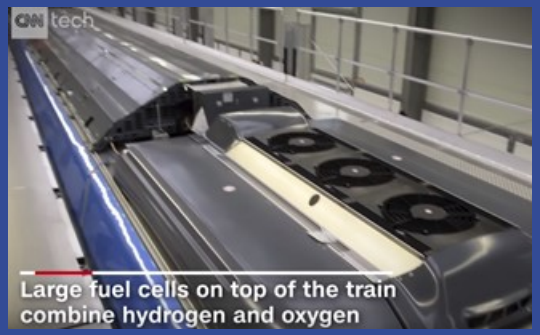
HYDROGEN FUEL CELL

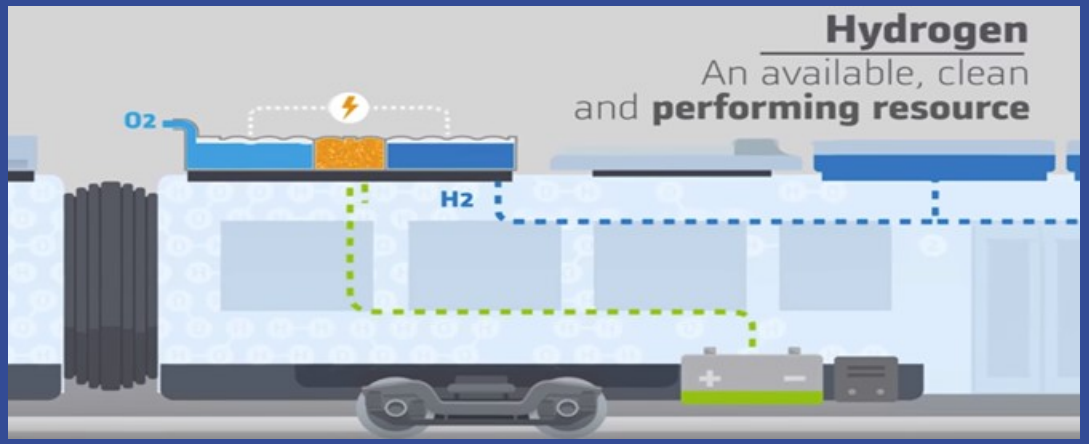
Alstom Coradia iLint Hydrogen Germany

Alstom Coradia iLint Hydrail

Hydrogen + Oxygen = Electricity + Water

- Fast Refueling
- Zero Emission
- Up to 140 kph
- Passengers:
  - Up to 300
  - 150 Seats
- One Tank:
  - 600 to 800 km



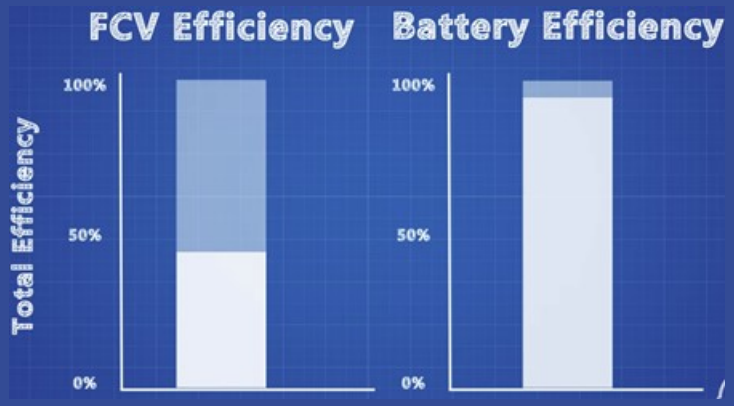


CRRC Hydrogen Tangshan Co Tram

- Hybrid – Hydrogen Main Power Source
- 12 Kg Hydrogen for 40 km @ 70 kph
- Control Nitrogen Oxide @ < 100 deg C
- 3 Carriage 66 Seat

Hydrogen VS. Battery

- Refuel 5min vs. 3 hours
- Cost 17.7C/km vs. 2.4 C/km



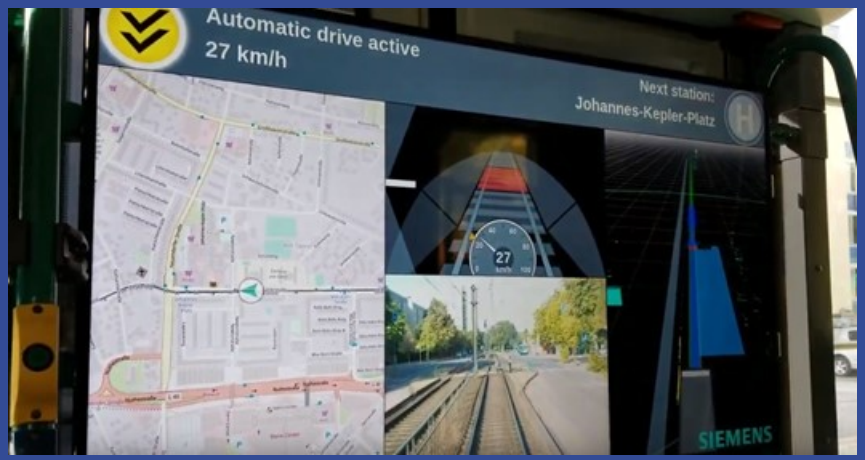
	Tesla Model 3	Toyota Mirai
Price to fully charge or fill	$10-$12	$85
Range	500 km	480 km
Price per km	2-2.4 cents	17.7 cents

AUTONOMOUS TRAM

Siemens Autonomous Tram

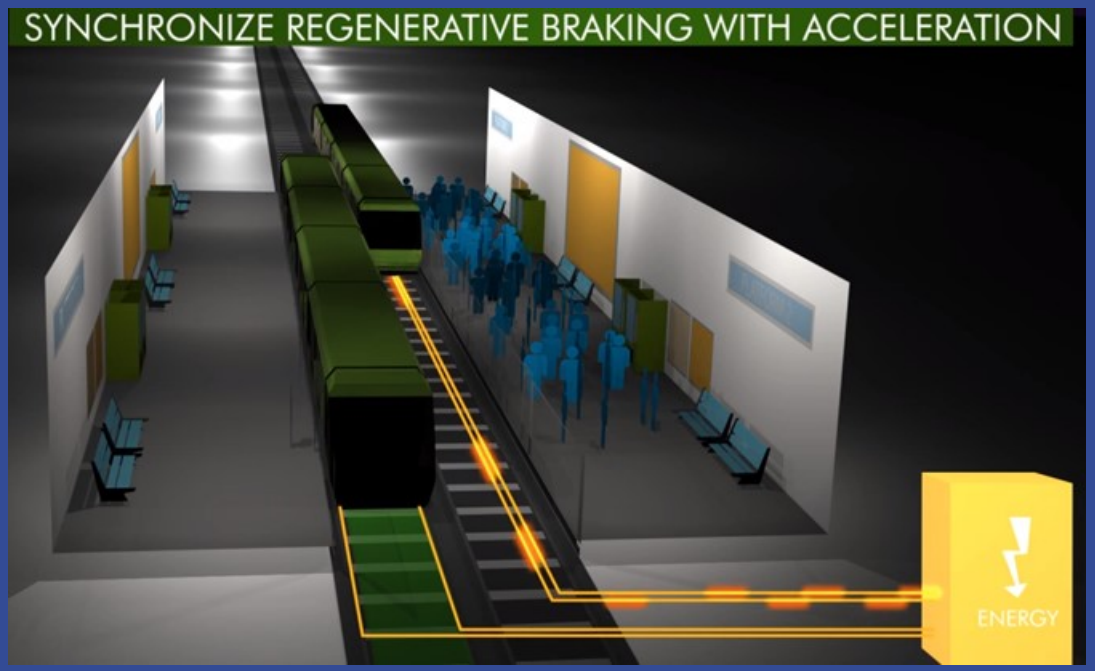
Test Facilities/Environment

- From Assisted to Autonomous Driving
- Simulator Testing
- Real Environment Testing
- Obstacle Detection
- Improve Energy Consumption
- Improve Safety
- Increase Capacity



Energy Conservation Green CBTC

- Speed Optimization vs. Maximization
- Align Trains Maximize Regenerative Braking Efficiency
- Optimized Slow and Go
- Increased Coasting at Minor Increased Travel Time



Conclusion

- Light Rail is Widely Adopted Globally
- Increased Service Frequency with Shorter Trains
- Increased Level of Automation Where Possible
- Catenary Free Technology Becoming More Advanced
- Alternative Power Systems - Taking Momentum and Becoming More Efficient
- Increased Safety by Adopting Assisted Driving Technologies
- Autonomous Operation is the Future Trend Making the Operation of Smaller Trains More Cost Efficient

THANK YOU

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