

Wire-Free Technology

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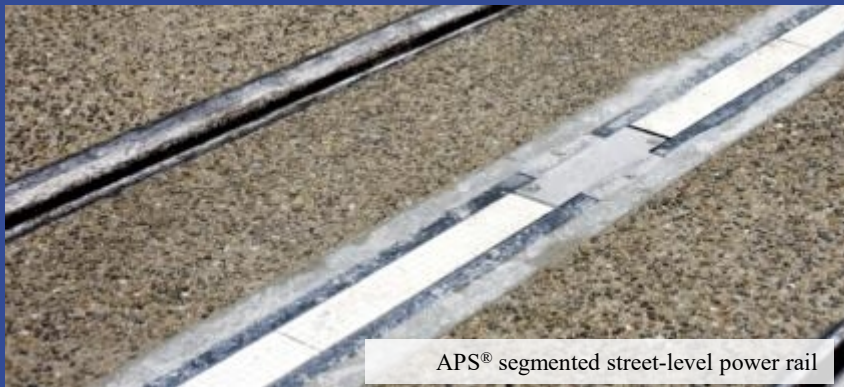
Agenda

1. Catenary-Free Solutions Overview
2. Wireless Systems Considerations
3. Extensions of Wireless Systems
4. Catenary-Free Maturity

Types of Catenary Free Solutions for Light Rail Wireless Lines

Continuous ground power supply (15+ years of operation)

- Power supplied by segmented third rail between running rails
- Third rail segments safely powered only under passing vehicle



Not “one size fits all”, a way to address diversity of needs...

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Types of Catenary Free Solutions for Light Rail Wireless Lines

On-Board Energy Storage & Charging System

- Super-capacitors, Batteries or mix of each
- Energy to run between one to several stations stored on-board the vehicle

On-board storage recharging:

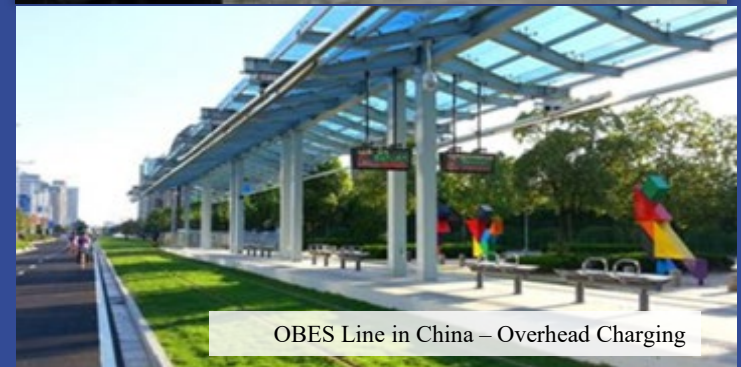
- **Super-capacitors:** fast charge (20s) every station - overhead line or ground based
- **Batteries:** slow charging under catenary sections or at dedicated points (5 to 8 minutes)



Nice Line 1 Battery Solution



Nice Line 2 – Ground Based Charging



OBES Line in China – Overhead Charging

Not “one size fits all”, a way to address diversity of needs...

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Alternate Power Supply (APS) integrated solution - key principles

- Power supplied to the tramway through a segmented street-level power rail
- Conductive segments are switched off/on/off as the tramway progresses, ensuring total safety for pedestrians
- Segmented power rail fed by buried power boxes
- Power picked up by collector shoes on tram central bogie



APS segmented street-level power rail



Tours

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Alternate Power Supply (APS) Benefits

- Freedom in line alignment
- Fluid operation
- Comfort
- No performance compromise vs. overhead line
- High availability
- Intrinsic safety
- Preserved aesthetics
- Non proprietary



On Board Energy Systems (OBES)

Complete integrated aesthetic solution

- **Battery systems**, charging with pantograph
- **Citadis Ecopack**, storage technology for rapid charge/discharge cycles
- **Station Charging Systems Ecollect[®]**
- **SRS**, a ground-based aesthetic static charging system



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Ecopack & SRS Integrated Solution - Key Principles

- Tram fed by on-board energy storage system: Citadis Ecopack
- Citadis Ecopack cubicles allow running over standard inter-station distances
- Recharge during standard dwell time at station via Ecollect
 - by SRS, ground-based static charging system
 - By safe overhead static charging system on rigid catenary



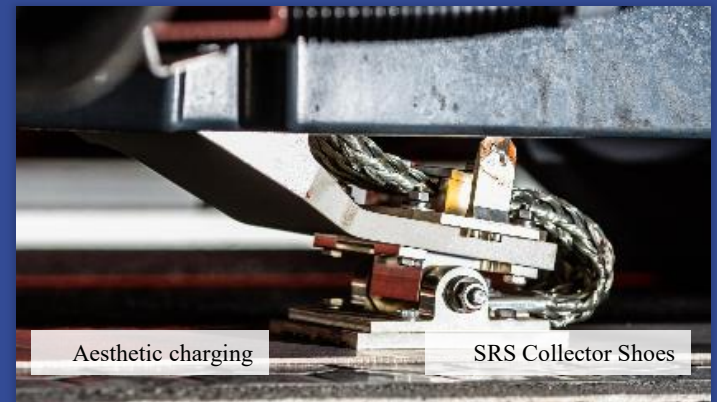
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On board Ecopack & Charging Systems - Key Elements

- **Ecopack cubicles**, High power & energy super-capacitor
- **Switching cubicle**, Selects power source
- **Antennas**, (on board & ground based)
 - Emits coded radio signal to detect vehicle and trigger power to rail / rigid catenary
- **SRS Collector shoes**, collects traction current from SRS power rails
- **Ecollect Collector shoes**, collects traction current from station rigid catenary



Station Charging Systems - Key Elements

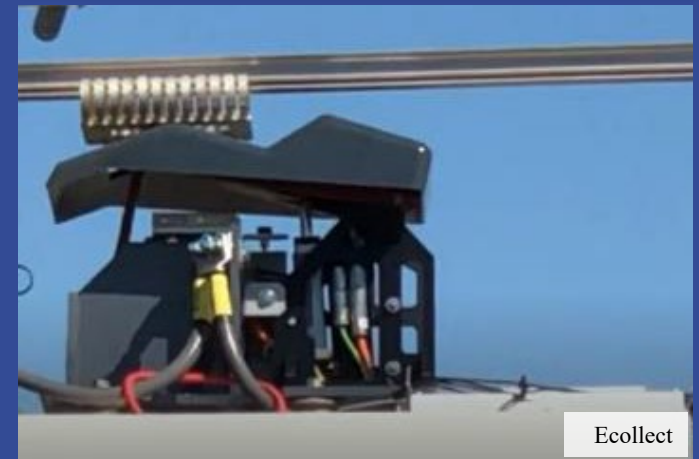
Ground-based static charging system

- SRS station ground power rails
- SRS station Power cubicles
- SRS Substation cubicle



Overhead static charging system

- Ecollect rigid catenary - in station only
- Ecollect Tram detection system
- Ecollect station cubicle



On Board Energy Systems (OBES) Benefits

- Freedom in line alignment
- Optimized combination Weight / Energy
- Open to technology evolutions in capacitors & batteries
- Smart energy management when line is obstructed
- Fluid operation
- Non proprietary
- Preserved aesthetics



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Wireless Systems Considerations

Systems view:

- Environment impact
- Passenger service quality impact
- CAPEX Impact
- OPEX / LCC impact

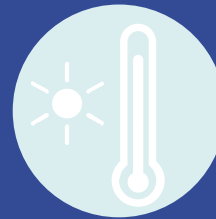


Wireless Systems Considerations

- Each line is specific
- No technology fits all

Alstom's 3-step methodology

Environment



Line Alignment & Traffic



CAPEX & OPEX

Environmental Factors



Hot Climate

- High HVAC requirements
- Recommended solution is based on continuous power supply: Citadis APS[®]



High Rain & Floods

- Flooded track
- Both Continuous power supply and on-board energy storage can cope



Harsh Winter Climate

- Snow & Ice on track
- Recommended solution is based on on-board energy storage: Citadis Ecopack[®]



Alignment & Mixed Traffic



Alignment with severe slopes, long inter-stations or mixed traffic

- Recommended solution is based on **continuous ground power supply: Citadis APS® or Mixed solutions**

Size of required on-board energy storage solutions compromises passenger capacity

Difficulties for on-board energy storage to manage long term stops due to crowding



Severe slope in Anger



Mixed Traffic in Reims



Crowd in Tours

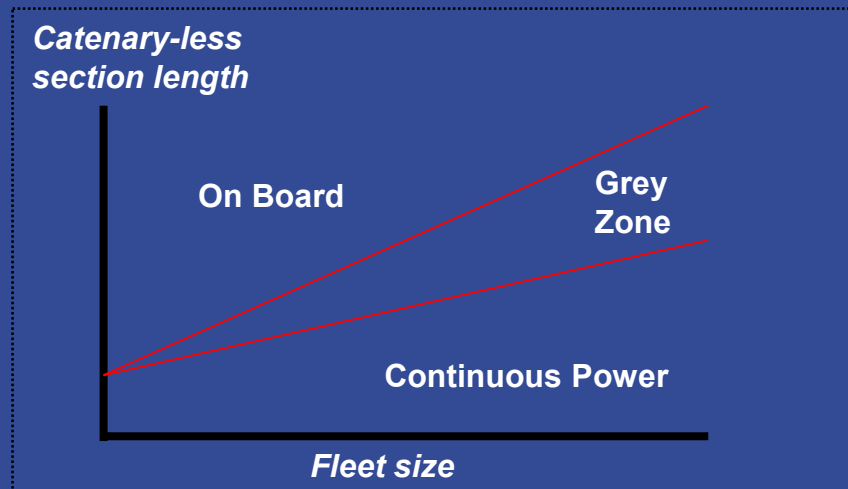
CAPEX OPEX Factors



CAPEX & OPEX Analysis

Based on line characteristics, such as:

- Line length, catenaryless length
- Required PPHPD at start & long term
- Required fleet size



Small fleet & long wireless section:

Citadis Ecopack[®] & SRS[®]

Grey zone

Any solution

Large fleet & short wireless section

Citadis APS[®]

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Implications of Integration for Extensions of Wireless Systems

Owner's objectives when extending a tram system

- Get a fully interoperable system
- Get best Value for Money from Competitive bids

But some equipment is “Non Standard” on any LRV system

Some scope will need to be carried over to ensure interoperability:

- *Automatic Vehicle Localisation System (AVLS)*
- *Communication system*
- *Passenger information system*
- *Tram & Road Signalling system*
- *Ticketing system...*



Each LRV system is Unique

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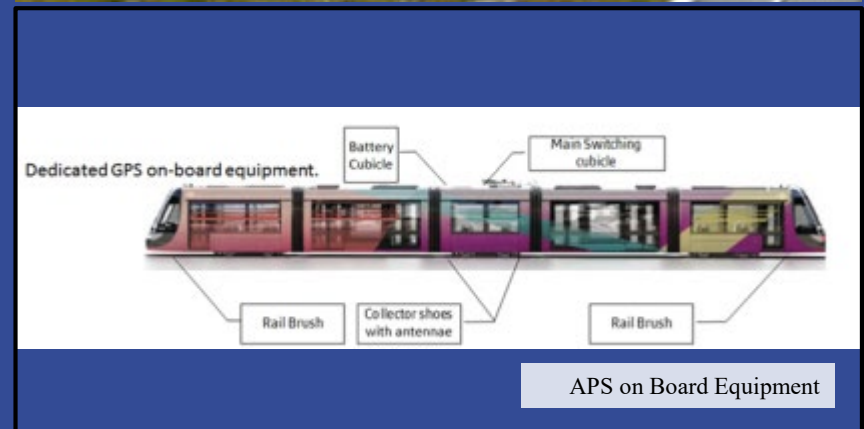
Fleet Expansion on a Line with a Wireless Section

How to get interoperable RS?

- Same situation for Ground Power Supply or OBES

Initial RS supplier to provide:

- Open Specification for necessary on board equipment
- Open Specification of communication protocol
- Open Specification of power supply needs



Each LRV system is Unique

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Fleet Expansion on a Line with a Wireless Section

How to get an interoperable line?

- Same for Ground Power Supply or OBES

Initial INFRA/RS suppliers to provide:

- Infra equipment and installation (GPS or Ground charging system)
- Open Specification of communication protocol
- Open Specification of power supply needs



Each LRV system is Unique

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System Extension Conclusions

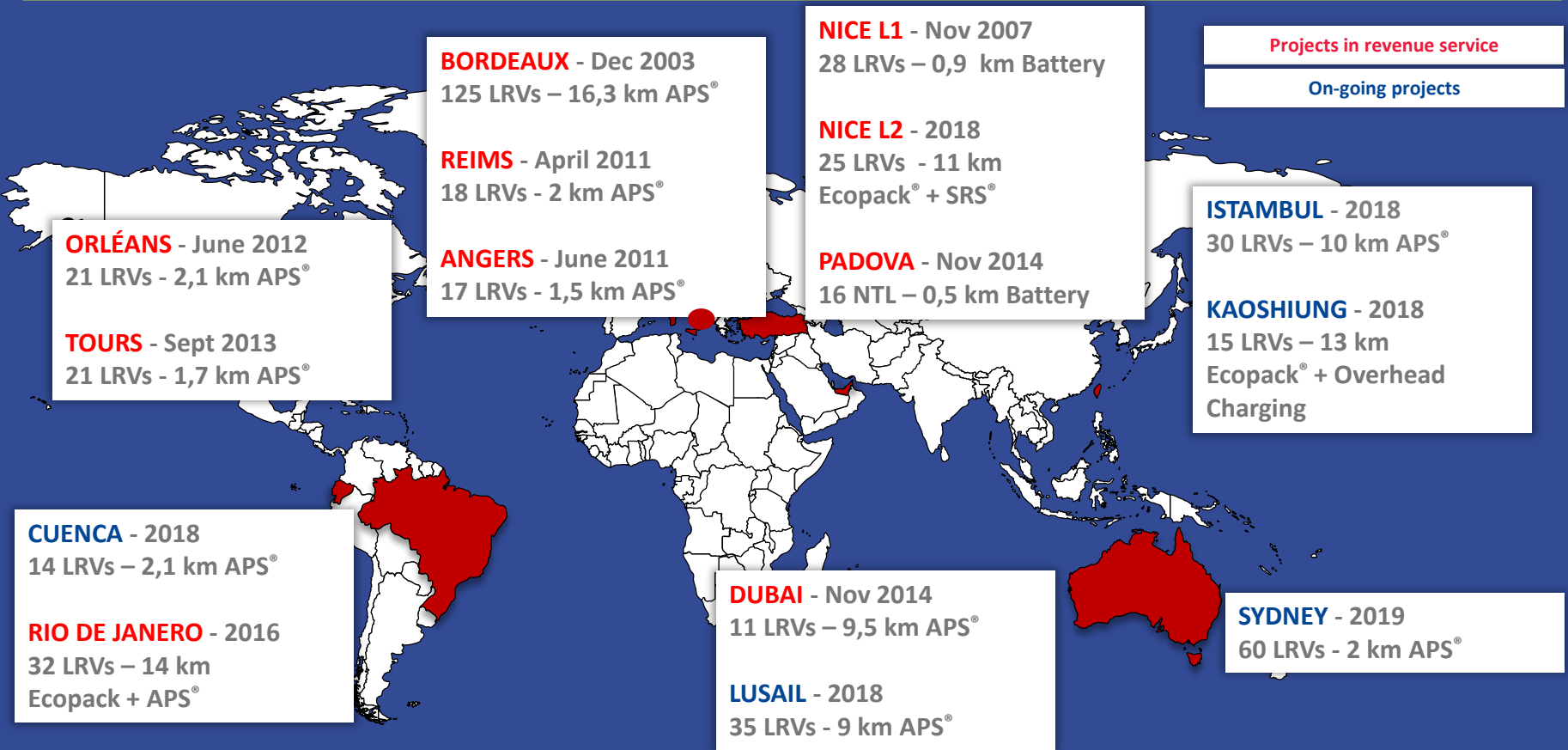
- No technology is necessarily simpler than another to extend
- All have proprietary elements
- No design constraints exported to extensions with APS[®]
- Design constraints exported to extensions with OBES
 - Dimensioning of OBES energy to cope with different alignment & gradients on stage 2
 - Dimensioning of charging infra to cope with different RS requirement...



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4. **Catenary-Free Maturity**

Catenary-Free: 15 Lines to date



Pioneers and #1 in Wireless Light Rail Systems

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Key Presentation Take-Aways

- Each line has a Unique Solution
- Mix of Technologies Possible
- Catenary-Free a Mature Product
- Catenary-Free not Carbuilder Specific

