

LIGHT RAIL VEHICLES

CITADIS X05

LATEST EVOLUTION OF CITADIS

PRODUCT SHEET



Alstom's Citadis is the low-floor tram reference for modern urban solutions and is at the core of multiple city renewal projects.

Citadis was upgraded to deliver extra dimensions, capacity, flexibility, speed and passenger experience, to allow higher frequency throughout the day and thereby increase the number of people an operator can carry on a network per year.

GENERAL DESCRIPTION

Citadis X05 offers new choices on tram dimensions and configurations (in single-unit or double-unit operation), performance, comfort level and special features met by a system of service-proven modules that fit together. Innovations include: integration of new technologies for lower energy consumption (Permanent Magnet Motors); easier sub-system integration and maintenance which reduces LCC; higher speed of up to 80 km/h; operable on existing and new tracks; catenary-free range (besides APS) now incorporating new full on-board autonomy systems - optimized and completely integrated. All these new technological advances offer cities of all sizes the highest performance tramway solutions - in order to meet the current and future evolving mobility challenges.

CUSTOMER BENEFITS

High degree of passenger comfort and convenience

New levels of comfort include spacious design with double doors (15% passenger exchange ratio increase), 40% more window surface, ergonomic seat design option, real-time information on-board, direct & indirect lighting based on LED technology - all leading up to a more pleasurable urban commuter experience.

Advanced catenary-free offering

Alstom's solutions span most service-proven APS and Citadis Ecopack full on-board autonomy management system composed of the latest generation super-capacitor and batteries. Key advantages of Alstom's catenary free solutions: preservation of the aesthetics of city centres; unlimited power supply; high performances (matching catenary performances), high availability (99.95% on 2-km double track applications); robustness and limited impact on infrastructure.

Lower OPEX

11% reduction of maintenance costs based on technical innovations including: optimized monitoring system through a Design to Serviceability process; Ethernet network for a quick download of monitoring data from a single access point for the upload of infotainment and passenger information system in manual or automatic wireless mode.

Up to 25% reduction in energy consumption thanks to latest design improvements :

- Proven ONIX traction drive with closed self-ventilated Permanent Magnet Motors (PMM) highly efficient (96%)
- Optimized HVAC function (air flow, passenger load, ...) and auxiliaries (auxiliary with variable frequency)

KEY BENEFITS / KEY FIGURES

- 2,600 Citadis vehicles sold to 60 cities worldwide
- Over 300 Citadis X05 ordered
- 2,300 Citadis vehicles in service
- 20 billion passengers transported, Over 4 million per day
- 1 billion km run by the Citadis vehicle fleets
- 1 out of 4 low-floor trams in service worldwide manufactured by Alstom
- 33 % of catenary-free lines in operation and under construction
- Over 30 million km travelled without catenary

CITADIS X05

KEY TECHNICAL FEATURES

Specification criteria	Values specific to each nominal length		
	20 nominal meter versions	30 nominal meter versions	40 nominal meter versions
	CITADIS 205	CITADIS 305	CITADIS 405
Vehicle length (depending on door width type)	24 m	32 m to 37 m	43 m to 45 m
Vehicle width	2.4 m	2.4 m and 2.65 m	
Track gauge	1435 mm		
Number of bogies per tram	2	3	4
Number of car modules per tram	3	5	7
Provision for subsequent tram extension	Up to 5 modules (37 m)	up to 7 modules / 4 bogies	extendable (case by case)
Low floor percentage	100%		
Access height (entrance)	intermediate doors:325 mm, front doors: 334 mm (above top rail)		
Central aisle width over bogies	Up to 750 mm		
Number and type of doors per side (Sliding plug doors)	4 double doors	4 to 6 double doors or 2 to 4 double doors + 2 single doors	5 to 8 double doors or 3 to 6 double doors + 2 single doors
Seating configuration	modular arrangements (see diagram)		
Passenger capacity seated	41	42 to 66	57 to 82
(@ 4 pax /m²) standing	101	152 to 184	215 to 237
TOTAL	142	202 to 238	271 to 341
comfort ratio ⁽¹⁾	29%	up to 28%	up to 25%
exchange ratio ⁽²⁾	26%	up to 27%	up to 25%
wheelchair areas	1	1 or 2	1 or 2
Passenger information equipment	different packages available		
HVAC (Heating, Ventilation, Air Conditioning)	independent controls for passenger & driver zones / scaled to relevant climatic conditions		
Motorization ratio	100%	67%	75%
Maximum speed in service	70 km/h	Up to 80 km/h	
Maximum acceleration	1.3 m/s²		
Service deceleration	1.2 m/s²		
Compression load	400 kN		
Crash absorption resistance	meets EN15227 standards		
Minimum horizontal curve radius	18 m in depot / 25 m on line		
Operation	bidirectional or unidirectional operation in single or double unit		
Traction motors	2 air-cooled permanent magnet motors per motorized bogie		
Power supply voltage	750 Vdc (600 Vdc as an option)		

(1) number of seats for passengers / total passenger capacity per tram

(2) sum of widths of doors / total length of passenger zone per tram



FOR MORE INFORMATION:

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ALSTOM

CITADIS DUALIS

ACCESSIBILITY
MODULARITY
RELIABILITY
COMFORT
CUSTOMIZATION

COMBINING THE BEST
OF TRAINS AND TRAMWAYS

*We are shaping the future**

ALSTOM

CITADIS DUALIS



Optimized access for all

With its full low floor and wide gangways, Citadis Dualis is the first tram-train vehicle certified according to STI PRM* standards.



Passenger comfort

Citadis Dualis offers many options dedicated to passenger comfort, depending on the profile of the line served. Among the possibilities are toilets, more comfortable seats, window shades and umbrella racks... Citadis Dualis makes on-board comfort a priority.



Operating tools

Citadis Dualis also offers anti-vandalism and passenger-counting options to optimize public transit operations for maximum vehicle availability.



Modular Design

Citadis Dualis may be configured to the needs of each operator. Urban or peri-urban configuration, number of doors per side, interior spaces... the design and layout of your Citadis Dualis are modular to fit the type of itinerary.



* Excluding the toilet option

4 DEGREES OF FREEDOM

LENGTH

42 Meters and 52 Meters

WIDTH

2.4 Meters and 2.65 Meters

INTERIOR FITTINGS

ELECTRIC POWER SUPPLY

Dual voltage 750 Vdc / 25 KVac 50 Hz
Or dual voltage 750 Vdc / 1500 Vdc



- Length: 42 m
- Width: 2.4 m
- 4 doors
- 93 seated places
- 141 standing places



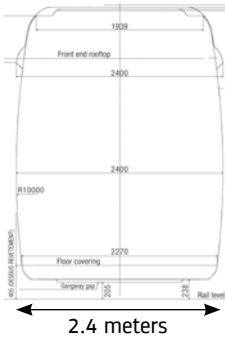
- Length: 42 m
- Width: 2.65 m
- 4 doors
- 98 seated places
- 153 standing places



- Length: 42 m
- Width: 2.65 m
- 5 doors
- 92 seated places
- 159 standing places

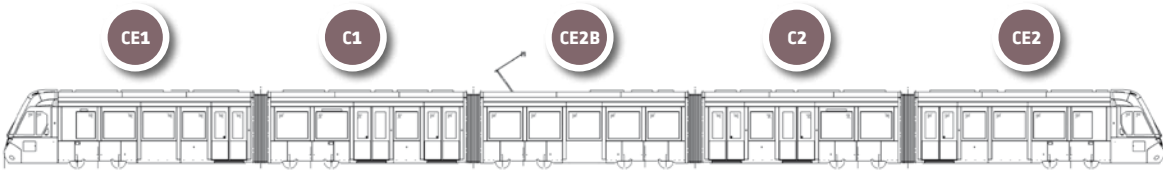


- Length: 51.5 m
- Width: 2.4 m
- 6 doors
- 116 seated places
- 176 standing places



CAPACITIES

	VERSION 2.65 M 4 CARS 4 DOORS	VERSION 2.65 m 4 CARS 5 DOORS	VERSION 2.40 m 4 CARS 4 DOORS	VERSION 2.40 m 5 CARS 6 DOORS
Seats + Tip-up seats				
CE2	18 + 2	18 + 2	16 + 2	16 + 2
C2	32	32	32	20
CE2B	24 + 2	20	22 + 3	40
C1	18 + 2	18 + 2	16 + 2	20
CE1				16 + 2
Total	92 + 6	88 + 4	86 + 7	112 + 4
Passenger in Wheelchair space	2	2	2	2
Bicycle rack	1	0	1	0
Luggage rack	1	0	1	0
Total passengers				
4 persons/m ²	251	251	234	292
6 persons/m ²	330	332	307	382
8 persons/m ²	410	414	381	472



TECHNICAL SPECIFICATIONS

Type	Articulated – 4 to 5 car bodies
Length	4 car bodies: 42 m 5 car bodies : 52m
Width	2.65 m (4 car bodies) or 2.40 m (4 or 5 car bodies)
Height	3.5 m
Floor height (4 pers/m² + seats folded, new wheels) • Access (gap-filler) • Corridor central part • Corridor above bogies	370 mm 405 mm 537 mm
Multiple Unit	Up to 3 units (MU3) with 4 car bodies
Structure • Compression • Passive safety	600 kN complies with standards EN12663 and EN15227
Performance • Maximum speed • Maximum acceleration from start up	100 km/h 1,09 m/s² from 0 to 40 km /h (base version)
Braking • Types • Maximum Emergency braking deceleration	Electric, Electrohydraulic and Electromagnetic 2.8 m/s speed ≤ 70 km/h 2.5 m/s speed > 70 km/h
Weight • Tare weight • Maximum load per axle (6 persons/m2 + seats extended)	≈77 t (4- car vehicle) 11.5 t
Traction • Type • Continuous Motor power	IGBT, 3-phase permanent magnet synchronous motor Motor 6 x 150 kW
Train Control / Command	Redundant MVB network / WTB Cabled commands for safety functions
Electric power supply	Dual voltage 750 Vdc / 25 kVac 50 Hz Dual voltage 750 Vdc / 1500 Vdc
Auxiliary power	400 Vac /50 Hz 24 Vdc
Minimum curve radius	25 m
Capacity in EL4 (4 pas/m²) • 4-car vehicle • 5-car vehicle	Fixed seats / Total 86-92 / 234-251 112 / 292
Corridor width	600 mm (2.65 m version)
Passenger access width	Double sliding door / 1,300 mm passage
Platform access	Fill-gap
Passenger Information • Base • Option	Interior and exterior LED display screens + audio TFT screens

OPTIONS

DESIGN OPTIONS	Length (in m.)	42	42	42	52
	Width (in m.)	2,65	2,65	2,4	2,4
	Number of cars	4	4	4	5
	Number of doors per side	4	5	4	6
	Luggage space	●	●	●	●
	Bicycle space	●	●	●	●
	Retractable steps	●	●	●	●
	Maximum number of doors per side	5	5	5	7
CONTRACTUAL OPTIONS	Toilets	●			
	Fixed steps for the doors	●	●	●	●
	Supply and installation of passenger-counting system	●	●	●	●
	Lengthwise umbrella rack	●		●	
	Exterior livery	●	●	●	●
	Trash receptacles	●	●	●	●
	Passenger window shade	●	●	●	●
	More comfortable seats (cannot be combined with anti-vandalism option)	●			
	Anti-vandalism (cannot be combined with more comfortable seat option)	●			

COMFORT OPTIONS

TOILET OPTION*

The toilet option* is offered aboard the CITADIS DUALIS in a suburban configuration (2 m65 in width) in order to improve passenger comfort for trips that exceed 30 minutes. This is a unique option in a tramway-type LRV. Two variants are possible for this option:

- Factory-fitted toilets,
- Preparation for toilet integration at a later time (for example in the case of a line extension)

* Option non-certified STI PRM



LENGTHWISE UMBRELLA RACK OPTION

CITADIS DUALIS can also be equipped with lengthwise overhead racks. These allow passengers to put small objects, umbrellas, jackets... above their seats and also improve passenger comfort in freeing up space.

TRASH RECEPTACLE OPTION

Trash receptacles can be installed as an option aboard the CITADIS DUALIS. They facilitate maintaining a high level of on-board cleanliness, improving both the trip's ambiance and the cleaning work.

PASSENGER WINDOW SHADE OPTION

Passengers are able to adjust sunlight to what's comfortable.

MORE COMFORTABLE SEAT OPTION (CANNOT BE COMBINED WITH THE ANTI-VANDALISM OPTION)

Improved seating and an added headrest offer passengers greater travel comfort.



TECHNICAL OPTIONS

FIXED STEPS OPTION

Removal of the retractable steps (standard edition) in order to reduce passenger exchange times at stations. This option requires an appropriate infrastructure.



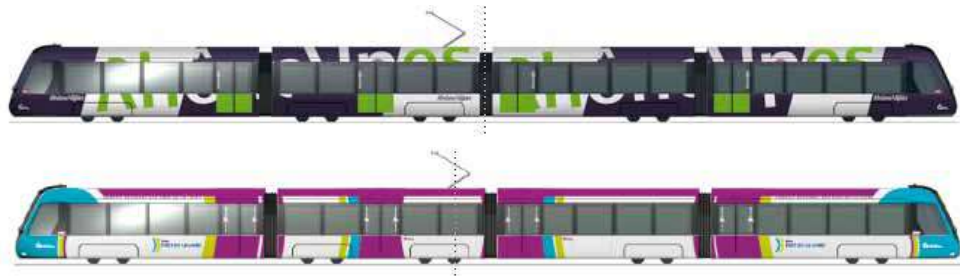
PASSENGER COUNTING OPTION

All vehicle accesses are equipped with a system that makes it possible to note passengers getting on and off. The number of passengers aboard is thus known at all times. This is an essential element for tram-train operations.



INDIVIDUALIZED EXTERIOR LIVERY

To facilitate its integration in the regional landscape, the livery of the CITADIS DUALIS can be individualized with the colors of the region.



ANTI-VANDALISM OPTION

CITADIS DUALIS's anti-vandalism resistance can be reinforced with an interior and exterior film protection on the car.

BICYCLE SPACE / LUGGAGE SPACE (OPTION DEPENDS ON THE BODY CAR' DESIGN)





OTTAWA LRT

VEHICLE AND TRAIN CONTROL

PREQUALIFICATION

MAIN SECTION

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(ii) Executive Summary

We are confident in our ability to deliver an optimized system and services based on proven solutions that will meet or exceed the ORLT requirements.

We are proposing the service proven Citadis Dualis vehicle - a variant of the CITADIS LRT that has been sold to regional customers in France. The Dualis benefits from more than 15 years return of experience from the Citadis family product range. It complies totally with performance requirements for the ORLT project. Capable of running on multiple voltages such as 750V or 1500 V, the Citadis Dualis is adapted to a downtown circulator-type service as well as regional service on a segregated rail infrastructure. This vehicle meets European mainline standards for crash resistance. Equipped with high power compact motors, the train features a full low floor while being able to run at a speed of 100 km/h. The full low floor allows a great accessibility throughout the vehicle and reduces station infrastructures.

The specific environmental conditions encountered in Ottawa Specific have been carefully accounted for in our proposal. Based on our extensive experience in Northern Europe (regional trains, in Sweden, high speed trains in Finland and currently tramways in Russia) Alstom will adapt certain equipment in the Citadis Dualis in order to provide a safe, reliable vehicle meeting the required operational performances under Ottawa climatic conditions.

With a large experience of technology transfers in the world and in particular in North America, Alstom is confident in achieving the local content requirement of 25%. Procurement, assembly of trucks and traction drives, cabling and fitting of vehicles, testing, commissioning and warranty, will all be considered for localization in the frame of the ORLT project.

ALSTOM will seek to re-use the assets that will be invested locally for the ORLT project in the frame of other LRT developments in North America.

With regard to Train control, Alstom proposes its URBALIS solution for mass transit CBTC applications which is in service since 2003, the first application being the Singapore NEL. This solution has also been delivered to other transit systems in the world such as Santiago, Lausanne, Sao Paulo, Milano....

The URBALIS system is a radio-based CBTC based on a proven moving block principle. The solution is able to perform all ATC, Interlocking, TMS and maintenance functions required for automatic mass transit rail operation with Train Drivers or for Driverless operation.

The URBALIS principles enable to achieve the requested performances for Ottawa LRT in particular in terms of headway, RAMS and stopping accuracy. The URBALIS solution ensures the highest level of safety either with driver or driverless operation.

Also, its advanced and modular architecture enables it to achieve other important performance goals namely regarding expandability.

Last but not least, Maintenance has been considered at all stages of this proposal, with special emphasis on Life Cycle Cost, key criteria for the ORLT project. Alstom's extensive experience in Design Build Maintain projects will be used in the early stages of the project to ensure an effective design for maintenance. Indeed, maintenance and renovation is a core activity at Alstom, representing more than 20% of Alstom's transportation business. After 20 years in maintenance operations, working in close collaboration with rail operators of all types and in highly varied environments, Alstom provides the solutions that are best suited to the needs and requirements of customers in terms of availability levels and life cycle costs.

Since 1988, Alstom Train Life Services (TLS) activities have experienced significant growth. With 8,000 skilled and dedicated employees, we now maintain and renovate more than 7,000 railway vehicles produced by multiple manufacturers - including nearly 400 LRVs - at more than 40 industrial sites in 29 countries. A contributing factor in our success is our global expertise and knowledge in rolling stock maintenance, modernization, supply chain management, innovation, safety, quality and environmental standards.

The Vehicle and Train Control prequalification package submitted by Alstom describes in detail how Alstom will make sure this strategic project will become a successful reference in North America.

(iii) Organization, Structure and Integration into Proponent's Team

A. Description of how the Vehicle and Train Control Key Individuals will function and integrate into the overall Proponent's team and organization.

Alstom is proposing to supply 2 lots under a subcontracting scheme: 1 for Vehicle and 1 for Train Control. Each lot has its own organization, which will be described below.

Please note that, should the 2 lots be awarded together, there will be only one contract governing the 2 lots then a Global Project Director will be assigned on the top of the two lot organizations in order to manage the whole scope.

The related maintenance will be performed under a separate contract. However, there will be Coordination between the Construction and the Maintenance at all stages of the Contract, from Design to Trial Run with coordinated Team mobilization, in order to ensure design to maintenance as well as proper maintenance activities launch. This is described in details Section vii – Maintenance Capability.

Below is a figure showing contractual relationship between Alstom Transport acting as subcontractor, and the RTP proponent. Details on how the Vehicle and the Train Control are integrated and interfaced are given in sections (iii)-B and C and (vii).

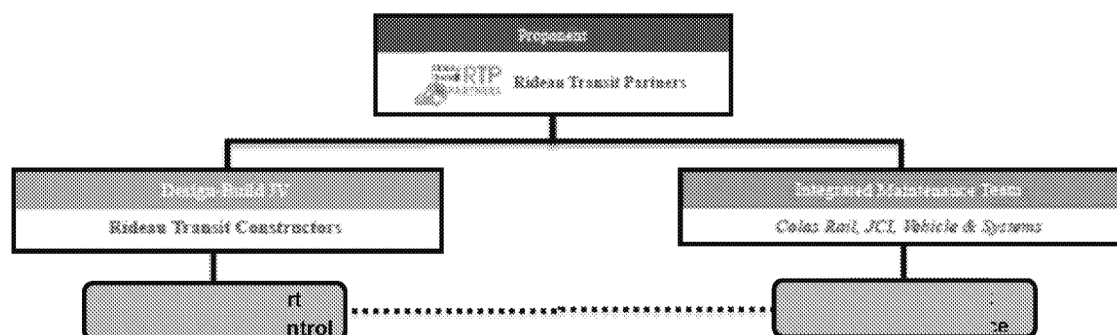


Figure 1: Case where either vehicle or Train Control is awarded to Alstom

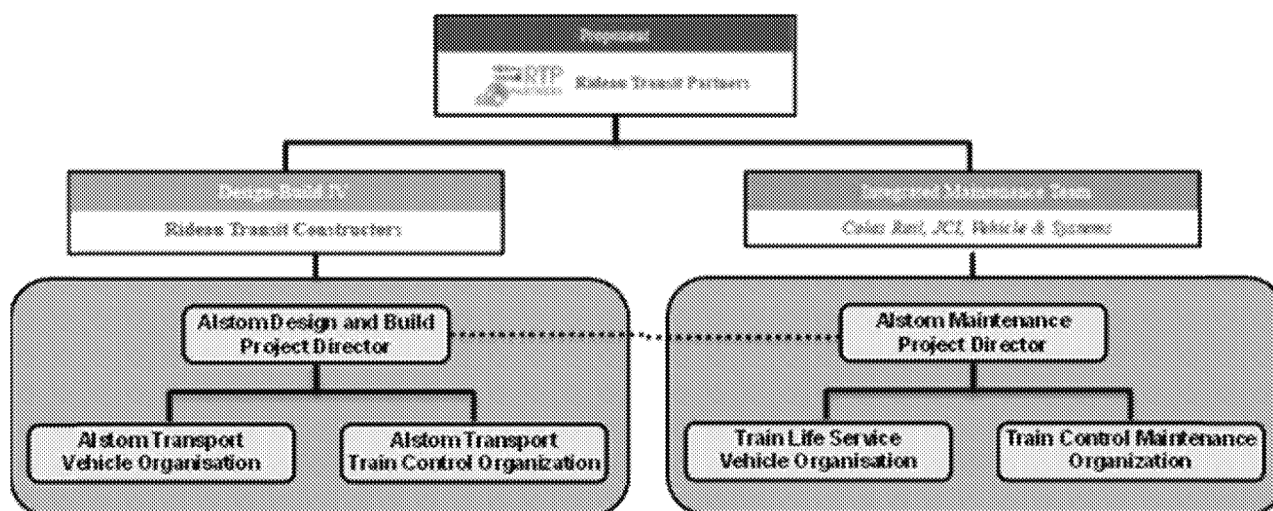
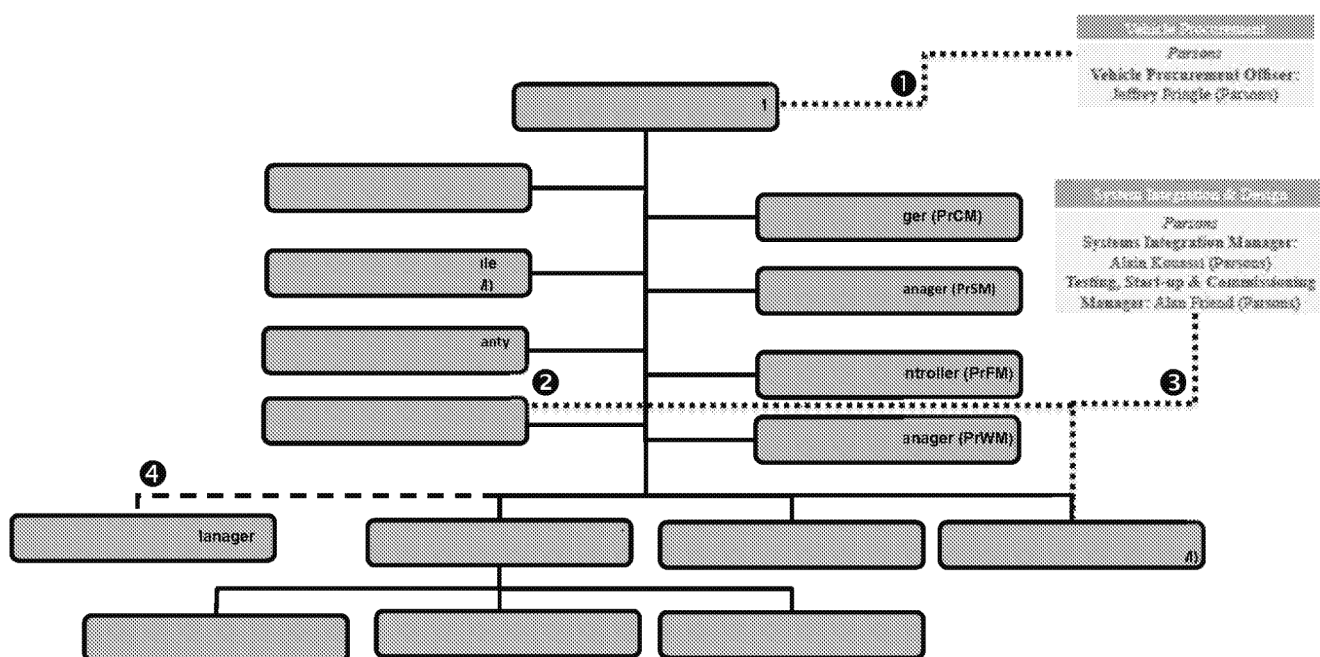


Figure 2: Case where vehicle and Train Control are awarded together to Alstom

Vehicle and Train Control organization in figures 1 and 2 are detailed below

Vehicle Organization Chart

ALSTOM will assign a dedicated Vehicle Management Structure. In line with the standard Project Management procedures of ALSTOM Transport, the Project organization will be the following, with a perspective on how it integrates with the overall RTP organization from a Design and Build standpoint. A special focus on maintenance will also be given below



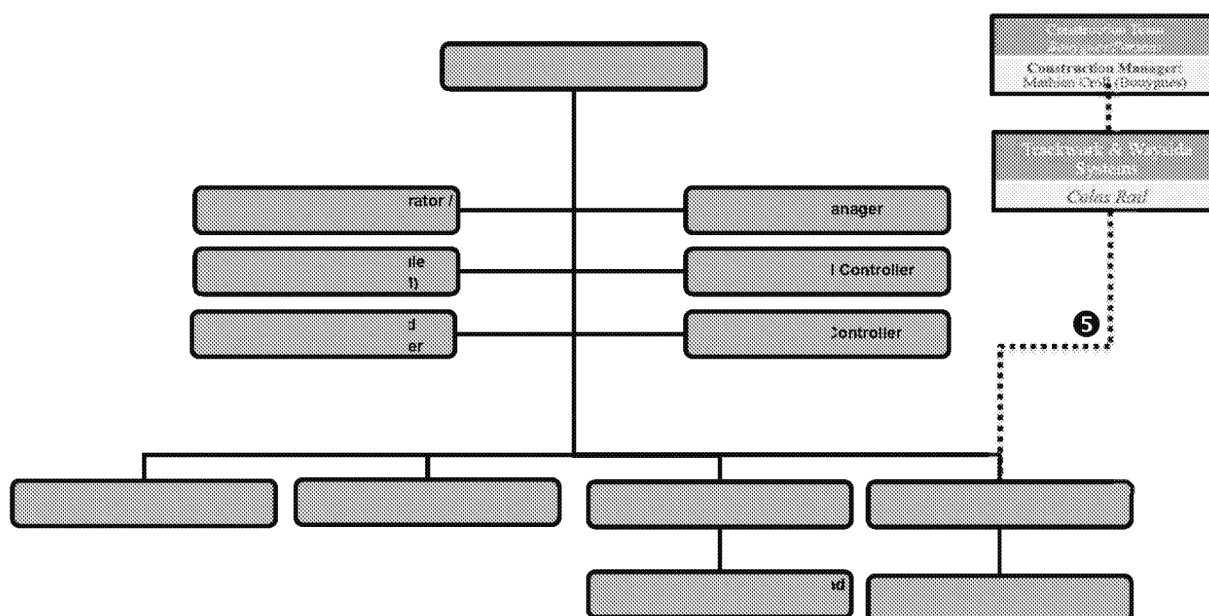
The primary contact point for this subcontract is the RTP Vehicle Procurement Officer, Jeffrey Pringle. In that position, M Pringle will manage all aspects of the subcontract.

As show in the figure above, the main interfaces are the following:

- ❶ - At Project Management level
This is the main interface, allowing coordination in all aspects of the project: planning consolidation, contract performance and monitoring,
- ❷ - At design level
The Vehicle Technical Manager. He coordinates Interface resolution, including interface with Civil Works (CW), such as Vehicle dynamic envelope to be taken into account for CW design. He has the authority, reporting to the Vehicle Project Manager, to address all design issues relative to the Vehicle and the related interfaces. He is a member of the RTP Design and Integration Team.
In that position, he ensures Design coordination, including documentation, data such as energy needs, ECM...
- ❸ - At Test and Commissioning (T&C) level.
The Vehicle is part of the overall T&C plan. For that purpose a T&C plan is issued by RTP with inputs from Alstom, in line with the Project schedule. Milestones for vehicle site delivery are for instance identified to ensure running proper sub-system testing before the final Commissioning.
- ❹ - At Maintenance level

Even if it is run under a separate contract, Maintenance is involved at early stages of the project and is part of the Alstom internal gate review. Goal is to anticipate Maintenance mobilization. This is part of Alstom standard Project Management process.

Train control Project Organization Chart

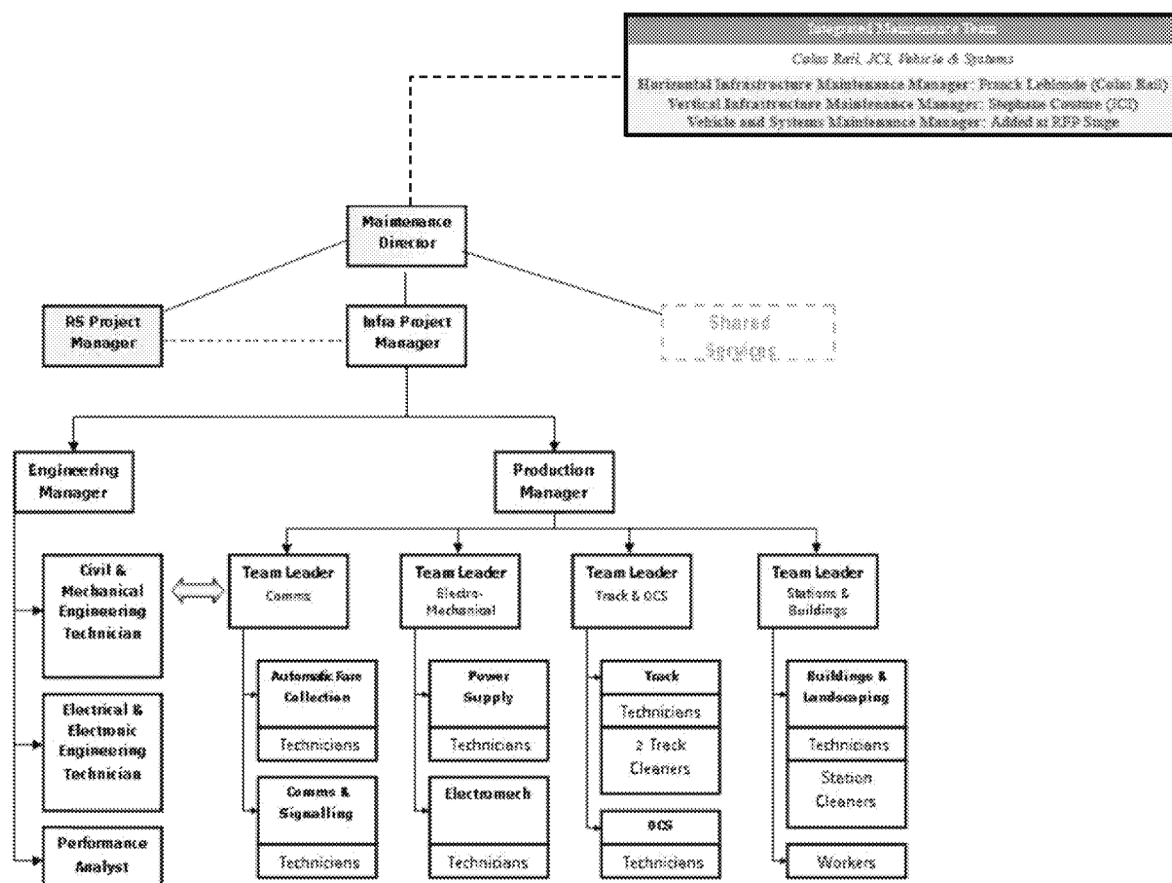


The same principles apply to the Train Control Scope (❶ to ❹ in Vehicle section above). In addition to the Interfaces described in the Vehicle section above, the only additional interface is the Installation of the wayside equipment where works coordination is needed between, CW, Track, Catenary...

For that purpose, The Project Installation Manager ensures proper information coordination of works planning, supply, with the Track work and wayside System Construction Managers, this latter being part of the overall Construction team led by Mathieu CROL.

Maintenance Organization Chart

The Maintenance of the Alstom Scope, whether it consist of Vehicle alone, Train Control alone or both together, is performed directly within the Integrated Maintenance Team. See figure below:



The maintenance organization is mobilized at the early stages of the design to ensure proper design to maintenance. Special care is given to interfaces. As the project enters into commissioning phase the maintenance team completes mobilization, and at Commercial service, takes full responsibility of the maintenance, with a handover period managed with the Vehicle Design and Build team.

More details are shown in Sections (iii)-B and C and (vii).

B. Details about the roles and responsibilities of the Vehicle and Train Control Key Individuals.

Vehicle

As Alstom will undertake an optimization in the selection of the most appropriate vehicle for the Ottawa project, and then supply this optimized vehicle, including design, construction, assembly, test and commission, and Quality assurance:

Responsibilities and Contributions on this Project

- » He will be responsible for the successful planning and execution of the design, construction, assembly and test & commissioning of Alstom vehicles for the Ottawa project with respect to budget, delivery timelines, expected quality.
- » Reporting to the Director of E&M Systems Integration he will organize and lead the Vehicle project team, identify roles, responsibilities and objectives to project team members and define interfaces.
- » He will define, monitor and report project dashboard and key performance indications.
- » He will define the project risk management plan and constantly review and update, vehicle project performance, identify risk and opportunities and follow up these with action to improve the project outcomes.
- » He will have full responsibility for the vehicle within the project throughout its full life cycle and take necessary actions to improve the project process.
- » He will control and manage relationships with relevant stakeholders and the customer (in relation to the vehicle).

Train Control

Train Control Project Manager

Reporting hierarchically to Alstom Transport Information Solutions Urban organization and operationally to the Customer Director, the Project Manager is the official interface between the customer and the Alstom organization. He/she is responsible for the whole project and manages the successful achievement of the project. He/she manages the project in conformity with the contract and with the ALSTOM procedures and rules. He/she is the primary contact with customer and partners for:

- Daily contact with customer's Project Management Team for project progress and related issues,
- Capturing the needs of the customer and make sure they are understood by the Alstom organization and management,
- Managing the day to day relationship with partners,
- Drives and makes decisions to ensure successful project execution (decides for resolving key issues within the project and ensures that all decisions are executed),
- Ensures project costs and deliveries objectives are met,
- Manages at project level all project reviews and gate reviews including organization and reporting,
- Defines, commits and implements the project safety policy,
- Ensures that Health and Safety ALSTOM requirements are fulfilled at all times and that Health & Safety is properly integrated,
- Provides leadership and manages the Project Core Team (establishes an effective and efficient Project Core Team and ensures that ways of working are applied to all project activities).

The Project Manager is based in Ottawa.

Train Control Project Engineering Manager

OTTAWA LRT – Vehicle and Train Control Prequalification

January 6th, 2012

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Reporting hierarchically to the URBALIS Engineering Director and operationally to the Project Manager, the Project Engineering Manager is the most senior technical manager and is responsible for overall technical definition and integration of the CBTC system in accordance with the requirements of the contract, including:

- Management of the engineering team, including the subsystem engineering managers,
- Capture of the customer technical requirement and production of the technical and functional specifications,
- Definition of the system architecture,
- Definition of the general performance for the System and ensuring its implementation,
- Management of the scope of work such that each Sub-System is interfaced with one another to ensure a fully integrated system which meets the performance requirements is delivered to the customer,
- Implementation of the methods and Engineering tools,
- Identification and management of technical risks in accordance with the Project Management process,
- Definition of internal and external interfaces until agreed and integrated within the respective designs,
- Management of the Configuration Management Process as far documentation is concerned and chaired the Configuration Control Board (CCB),
- Management of the operability of the System as well as the coordination for the Operation and Maintenance manual,
- Demonstration of the Contractual performance,
- Management of the "as-designed", "as-delivered" and "as-installed" configuration (software + hardware), Coordination with the Installation Manager to assure the proper installation of the system,
- Coordination with the Project Test & Commissioning Manager to assure the proper validation of the system.

The Project Engineering Manager will share his time between Ottawa and Paris Engineering back-office to ensure efficient coordination of the teams.

Maintenance

Responsibilities

- Financial responsibility :
 - Ensure the profitability of the Project,
 - Optimise the performance of the global system, so as to minimise the losses of availability/quality leading to penalties, and taking in account the costs of Maintenance,
 - Make sure the maintenance services are duly and on-time paid,
 - Check and validate the accountancy conducted by the Site controller.
- EHS responsibilities :
 - Make sure the staff can work safely, without harm to their health, and without harming other workers or people around,
 - Make sure the work done by the City Tramway Consortium is respectful for environment and that all kind of pollution, noise included, are minimised,
 - Check and validate the Quality plan, the Environmental Plan and the Health and Safety Plan proposed by the EHS manager. By the way, ensure that the City Tramway Consortium meets the requirements of ISO 9001:2000, ISO 14001, and Safety Processes and Practices meet the requirement of OSHAS 18001,
- Legal responsibilities :
 - Make sure City Tramway Consortium respects all the legal requirements, particularly concerning the work legislations,
 - Keep informed about any change of law which may affect the contract.
- Human Resources responsibility :
 - Manage all the team leaders and support staff, delegate tasks to appropriate competent people
 - Monitor and evaluate the performance of the management team, following City Tramway Consortium Guidelines,
 - Evaluate the needs for recruiting, and assist the HR Manager in the recruiting process
 - Lead implementation of organisational changes. Ensure the Organisational chart is kept up to date.
 - Develop and maintain constructive relationships with workers and staff representatives, with the help of the HR Manager.
- Customer relationships :



- Develop and maintain a robust and professional working relationship with customers and suppliers, with a view of ensuring both the continued viability and profitability of City Tramway Consortium.
- Lead the City Tramway Consortium team at monthly Customer Review Meetings.
- Other relationships :
 - Manage relations with local authorities

Manage 3rd parties relationships, preserving at all times the interests of City Tramway Consortium, and maintaining at all times the good image of City Tramway Consortium.

C. Update to the Proponent's team organization chart.

See above

(iv) Technical Submission Requirements

- A. The technical submission requirements for the Vehicle and Train Control package shall follow the Technical Submission Requirements for Vehicle and Train Control outlined in Section 5.4 of Part 1 of Schedule 3 of this RFP, and all other additional information that may provide clarity and further detail of the Vehicle and Train Control.**

Refer to Answer to Section 5.4 attached.

B. Description of how the Vehicle and Train Control package will be commissioned and placed into Revenue Service.

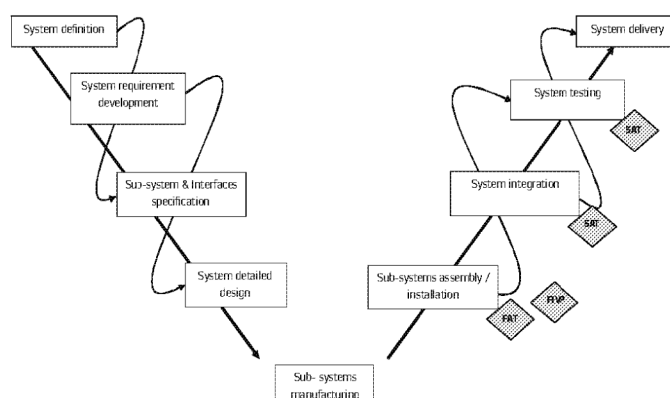
The Ottawa LRT is a Turn Key project. That means The EPC Test & Commissioning Team is responsible of the overall Testing and Commissioning of all the lots and their integration.

Under the Coordination of this T&C Team, Alstom will perform its T&C at sub-system level, but will also support the on-site system level T&C, giving inputs, dedicating T&C personnel throughout the whole T&C period including preparation prior to the T&C activities.

As a prominent turnkey rail system designer, ALSTOM has a proven capability to set-up design and validation process to successfully deliver public rail transportation systems.

Thanks to experienced experts, supported by a solid organization and strengthened by many successful projects, ALSTOM can guarantee the delivery to site of vehicles and train control systems in compliance with the RFP requirements.

The success of ALSTOM is based on its ability to master both the design and validation part of any sub-system development according to the "V" cycle diagram.



The development 'V' cycle diagram

The validation starts at factory level to ensure proper compliance of the equipment built with RFP requirement.

In addition to this equipment acceptance, Alstom has put in place an integration acceptance step of those equipment using FIVP. This is a key success factor of the validation process is the capability of ALSTOM to set-up Factory Integrated Validation Process (FIVP) ensuring the safe factory validation of about 70% of all equipment integration process prior to shipment (risk mitigation prior to shipment).

That reduction of validation and acceptance activities on-site is beneficial for the project overall schedule. For more details, please refer to chapter iv-A (Answers to schedule 3-1, section 5.4) where the Train Control T&C plan is detailed.

Test activities prior to commissioning:

Prior to the site commissioning, the vehicles and their equipment undergo production (routine) tests and qualification (type) tests.

The qualification activities are conducted following bottom up approach:

- Equipment type testing.



- Initial Integration and tuning testing
- Train level type testing on completed train.
- Train Static Type Testing
- Train Dynamic Type Testing

If a test has already been performed on a different project using the same equipment under the same conditions, a waiver can be requested and the previous test report will be made available.

Equipment and subassembly test are performed at the manufacturers' facilities that can be an ALSTOM factory or an equipment supplier's factory.

All test on assembled vehicles and train consists are intended to be performed in Canada.

Similar activities applied to the control package (refer to chapter iv-A - Answers to schedule 3-1, section 5.4, where the Train Control T&C plan is detailed).

Commissioning of the vehicles and of the train control package

The vehicles are shipped from the assembly factory to the Ottawa LRT Maintenance and Storage Facility (MSF) where a dedicated ALSTOM T&C team takes them over. The ALSTOM team is composed of dedicated test and commissioning personnel assisted by the ALSTOM maintenance and warranty personnel assigned to the Ottawa LRT. Prior to their arrival on site, most people have taken part to the vehicle tests in the assembly factory. They can be supported, as required, by experts from ALSTOM component factories or equipment suppliers experts.

Their main tasks are:

- Re-couple the vehicles to form the train consists at the MSF.
- Run the train-consist static routine (production) tests at the MSF.
 - At that stage on board train control equipment are functionally checked if this has not been done already in the assembly factory.
- Perform the routine (production) dynamic tests on a section of track that is already built and that can be used safely to run the rolling stock. In particular, traction and brake performances are checked to ensure the train is safe to operate.
 - At that stage some dynamic vehicle / train control test can be performed if the section of track is equipped with beacons.

The rolling stock is then ready for the integration testing which purpose is to demonstrate that the various systems of the transit system operate satisfactorily.

Prior to running the vehicles all the subsystems, their interfaces and all the transfer functions must have been tested, the OCC powered on and the track gauge test completed.

In that respect the ALSTOM Signalling personnel install and the integration of all the trackside control equipment. They also test the interfaces and transfer functions with other systems.

Once all the foregoing is completed, the dynamic integration tests can then be performed under the responsibility of the JV T&C team of which ALSTOM is a part.

A test program agreed by all stakeholders lists all the commissioning activities.

The main dynamic commissioning activities for the vehicle and train control package are:

- Check Train Management Function (e.g.: check vehicle / control system identification)
- Control Train Movement
- Ensure Passenger Safety



- Operate a train Operation Timetable
- Regulate Train Traffic
- Check Performances

Specific tests are run to demonstrate that the safety requirements of the Ottawa LRT system are fulfilled either in normal or degraded mode (i.e. braking distances, running behaviour...).

All running train configurations are experimented, on both the depot tracks and the main line, either in normal or degraded service conditions.

In particular, Test procedures are run to demonstrate the operation of the signalling system in the conditions of absolute capacity and to demonstrate the operational performance of the rolling stock under worst case conditions. This why a **Running Test** consisting in simulating the line operation based on peak time "time tables" is performed. Such a test has usually a duration of 2 to 3 days.

Because the foregoing tests are directly related to the Line Operation, the teams in charge of operating the Ottawa LRT transit system is invited to attend them.

Placing into revenue service

The trial running starts after completion of the integrated tests, once all stakeholders have agreed that the system is safe and ready for operation.

That period corresponds to the progressive putting into operation of the integrated System. This activity is usually under the supervision of the Operator with the support of EPC Team.

The start of this period should also match the end of the training of the Operator staff, which means that the Operation Regulation and Standard Procedures have previously been completed and validated.

Under the responsibility of EPC Team, The ALSTOM commissioning team including the maintenance personnel is available on site to assist the operator during that period

The "rise to power" is carried out gradually to lead to the last phase which consists of the simulation of the revenue service of the line, with all trained manpower in place, without passenger.

All day-to-day operation conditions are to be met according to the timetables so as to assess the performance of the System.

In addition, evacuation exercises are led at different location (tunnel, station, open air), in liaison with the Ottawa city's Authorities (Fire Department, Police Department, the Health Services)

the Ottawa city's Authorities (Fire Department, Police Department, the Health Services)

Quality management and risk mitigation

- **Quality assurance**

In order to support risk mitigation, ALSTOM has implemented a strong quality policy per the latest standards (ALSTOM Transport is certified ISO 9001)

This ALSTOM quality plan is deployed in all phases of the project, from design to T&C to allow traceability and consistent open issues closing, as shown below:

- **Processing the anomalies**

In the framework of the quality management, a failure or non-conformance of an equipment or material occurring at any test stage will be recorded, documented and reported by ALSTOM to the stakeholders.

Any failure or non-conformance (NC) is managed according to a specific NC Control Procedure. A Change Control Board (CCB) whose members come from design team, but also project management takes in charge the follow-up of the NC until it is resolved at which point it has the responsibility to close the issue. NC leadtime for closure and numbers are Key performance indicators used by the project manager to assess level of risk and put if need be additional/specific effort for closure.

- **Regression testing**

The purpose of a regression test is to check that after a change of hardware or software configuration, the performance has not been degraded, putting project objectives in question. ALSTOM controls the test and records all the parameters, results, like with any other test.

- **Configuration management**

Throughout the test process ALSTOM manages the configuration of every subsystem or system according to the project configuration management plan.

Thus the technical description of every system or subsystem (vehicle, train control ...) is known at any time and its evolution can be mastered.

A few references

This process has been implemented in many ALSTOM projects successfully delivered high capacity rail systems, including at least the vehicles and CBTC based train control packages similar to Ottawa requirements, among which:

Project	Type	In service
Singapore North-East Line	Driverless CBTC	June 2003
Lausanne m2	Driverless CBTC	October 2008
Singapore Circle Line	Driverless CBTC	May 2009

(v) Key Individuals and Experience**A. Description of three (3) previous projects illustrating where the Vehicle and Train Control package has been successfully implemented.****Train Control****Beijing L2 and Beijing Airport Link**

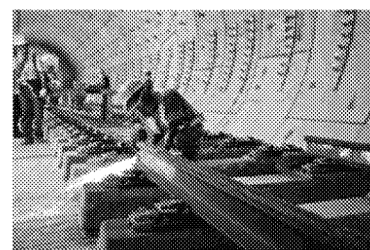
These 2 lines were put in service for the Beijing Olympic Games in 2008, which was bringing a high level of visibility and pressure. The Urbalis CBTC Signalling System has been installed in 10 Bombardier Trains on BJ Airport Link and on more than 60 trains on BJL2 (12 of them old-type Chinese trains).

The operation of the new BJAL line is full driverless mode and the revamped BJL2 line is operated in ATO mode with driver. The same Urbalis CBTC Signaling system will be implemented for Ottawa LRT project.

Alstom's reputation in China was particularly enhanced as the Beijing customers « were very satisfied and relieved that the project objectives were met despite the very tight time schedules.

**Singapore North-East Line (NEL) and Circle Line (CCL)**

These 2 new lines were equipped with Urbalis driverless CBTC systems. NEL was the world's first driverless CBTC on a heavy metro line, in service since 2003, and CCL the longest line with driverless CBTC, in service since 2009. The system was installed on 40 trains for NEL and 46 for CCL, all of them Alstom Metropolis trains.

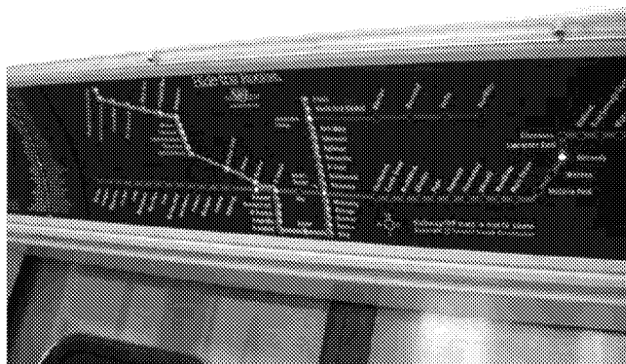
**Toronto YUS CBTC Project**

ALSTOM Urbalis CBTC system is currently in design and installation phase on the Toronto YUS revamping project. The first revenue service of this line is forecasted in 2013. ALSTOM Urbalis equipment is validated using AREMA Standards. Toronto iVPI (Rochester Interlocking) will be installed for the 2nd part of the line (AREMA compatible).

Signaling equipment meets the standards for bungalow area (-40°C/+75°C) and station area (-25°C/+75°C). All ALSTOM equipment for Toronto could be installed in these 2 areas (winterization requirement).

It is worth noting that Alstom's VPI2 interlocking has been installed on the Sheppard Line, also in Toronto, to TTC's full satisfaction.

ALSTOM

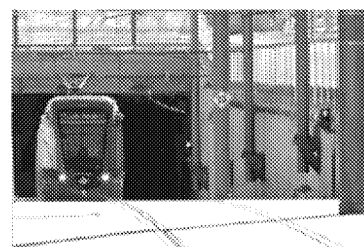
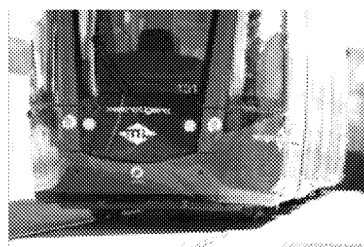


Madrid LRT L1

This line is in service since 2007.

Eight ALSTOM Citadis trains with URBALIS solution are running on this line. ATO is deployed in tunnel and a mixed traffic is in service outside the tunnel. This shows Alstom has a strong reference in this type of operation.

The operation of Ottawa LRT is similar to the Madrid tramway.

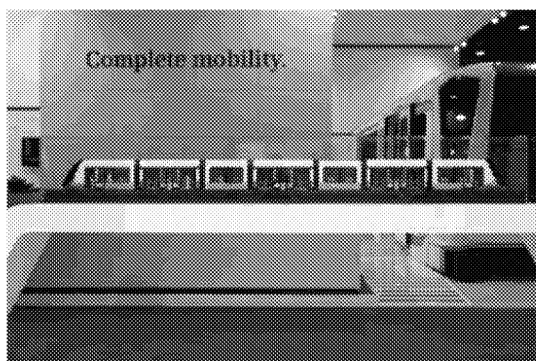


Dubai Al Safouh LRT

This new LRT line in Dubai is being equipped with the Urbalis CBTC system. All at grade stations will be equipped with platform screen doors (PSD), allowing the stations to be air-conditioned.

The passenger keeps then the same comfort whether waiting in the stations or sitting in the vehicle.

Moreover the line (elevated or at-grade) will also be equipped with the catenary-free APS technology (traction power system under the line). 25 Alstom Citadis LRT vehicles will be equipped. The line will enter revenue service in 2014



About winterization subject of Train Control Products, the reference datasheets of equipment installed outside are attached to this document to prove ALSTOM equipment can be installed in a winterized country:

- On-Board Beacon Antenna
- On-Board Odometer

OTTAWA LRT -- Vehicle and Train Control Prequalification

January 6th, 2012

All information within this document is the property of ALSTOM Transport.

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ALSTOM

- Trackside Beacon
- On-Board DCS Antenna
- Trackside DCS Antenna and Trackside Modem Box
- Example of Trackside P80 point machine

All other equipment are installed in some protected areas (climatized rooms for trackside equipment, protected areas for on-board equipment)

Vehicle

Nantes (France)

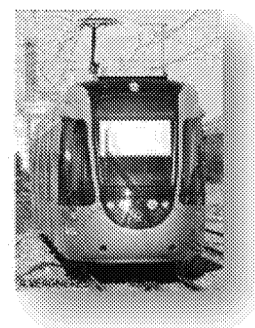
The line is in service since June 2011

7 trains are already running on this line with a good feed-back from SNCF regarding the reliability and availability.

The train is a 4 cars train from CITADIS –DUALIS range powered by bi-voltage 25kV and 750V.

17 others trains will be produced soon in order to be put in commercial service in the Nantes suburb from late 2012.

Speed : 100 kph



Reims (France)

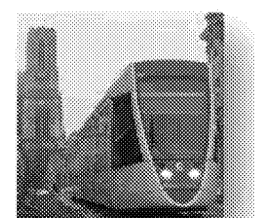
The line is in service since October 2010

The contract is a turnkey contract.

Trackworks with Appitrack & Power supply with APS

Alstom was awarded the full system maintenance from start-up of operation (Trams & infrastructure)

Speed : 80 kph



Barcelone (Spain)

The line is in service since April 2004

The contract is a turnkey contract.

Alstom was awarded the full system maintenance from start-up of operation (Trams & infrastructure)

Speed : 80 kph



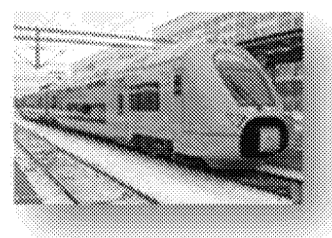
Winterisation return of experience

SWEDEN

The line is in service since 2004

Range : Coradia Nordic type X40 qty of trains : 43

Speed : 160 kph



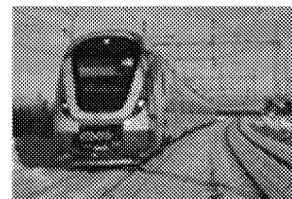
ALSTOM

SWEDEN

The line is in service since 2002

Range : Coradia Nordic type X60 qty of trains : 71+12

Speed : 200 kph



NAM return of experience

US – New york

The 62 trains are in service since 2005

Steel wheels - Stainless steel carbodyshell

Speed : 68.5 kph





B. Identify, and provide a brief experience summary, for each Key Individual identified below:

i- Train Control and Integration Manager

Project Manager Train Control and Integration (Hugues Mellerio)

- Nationality: French
- Age: 51
- Languages: French (mother tongue), English (fluent)
- Higher Education & Qualification: Electronics engineer, ESME SUDRIA, Paris
- Experience: 22 years (10 years in ALSTOM TRANSPORT)
 - Project Manager in Train Control (6 years, Beijing, Dehli, Bangalore)
 - Senior Bid Manager (4 years)

Project Engineering Manager Train Control and Integration (Jean-Marc Morin)

- Nationality: french
- Age: 53
- Languages: French (mother tongue), English (fluent)
- Higher Education & Qualification: Engineer degree in computer science from ENSEEIHT
- Experience: 29 years (10 years in ALSTOM TRANSPORT Information Solution)
 - Project Engineering Manager (10 years)

Project Engineering Manager Train Control and Integration (Didier De Hauteclouque)

- Nationality: French
- Age: 55
- Languages: French (mother tongue), English (fluent)
- Higher Education & Qualification: Electronics engineer, ESEO, France
- Experience: 31 years (22 years in ALSTOM TRANSPORT Information Solution)
 - Senior System Architect (2 years)
 - Project Technical Manager (3 years)
 - System Manager (3 years)
 - Chief System Designer (9 years)
 - ATS System Design Manager (5 years)



ii- Vehicle Maintenance Manager

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Brian Ealey 30 years' experience in the maintenance of rail vehicles including metro's Electrical Multiple Units (EMU) light rail vehicles and suburban diesel and multiple units (DMU). Maintenance management experience at all levels from multi-skilled technician thorough supervisory management and senior management.

Project management 10 years' experience in the project management for the introduction of new trains onto both new and existing infrastructure.

Vehicle maintenance management had the full responsibility for safety of the vehicle and the workforce. Full responsibility for the contracted vehicle availability and reliability. The direct management of the vehicle commissioning and warranty teams. Direct interface with customer project, railway operational and senior managers. The management of subcontractors for products and services.

Project management the full responsibility for starting up projects including the worksites, recruitment and employee training. The development of maintenance strategies including Reliability Centred Maintenance (RCM) and Condition Based Maintenance (CBM). Direct interface with customer project, railway operational and senior managers also customer and Alstom subcontractors.

iii- Vehicle Supply Lead

Mr. WURSTEISEN Train Control and Integration Manager

Mr. WURSTEISEN has had over 22 years of progressive and extensive experience managing the manufacturing, delivery, testing and commission, of major electric vehicle programs, including those for both LRT and subway (metro) systems, integration of CBTC train control on these vehicles. Among his many accomplishments he was formerly the Director of Traction Engineering at Alstom's Charleroi manufacturing facility, and the RAMs Engineering manager for the R160 vehicle program for New York City.

Tony Sanchez – project technical Manager - Alstom

Current activity:

With Alstom April 2005 to present:

Mr. Sanchez is currently the Engineering Director for the Rochester Rolling Stock group. His is responsible for the overall management, control and performance of the engineering department. His role includes all activities related to design, system qualification and engineering support to other departments such as sourcing, production, quality etc., resource management and budget/schedule performance on all RS engineering projects. Projects include Metros, Locos, Bi-level Coaches and Single Level Coaches. Mr. Sanchez joined Alstom in 2005 as a Project Engineering Manager for the R160 NYCT project.

Previous to Alstom:

Siemens Transportation Systems Inc. – Sacramento CA, 2000 – 2005: Engineering Project Manager for Houston, San Diego and Charlotte S70 LRV projects as well as system engineer for various LRV projects with an emphasis on systems integration of rail vehicle on-board systems.

Union Carriage and Wagon Co, Nigel South Africa 1994 – 2000: Electrical Design Engineer. Responsible for all aspects of electrical and electronic design for local and international rail projects (locomotives, electrical multiple units, metro cars and coaches).

Other Experience:

Mr. Sanchez worked as Electrical engineer on various South African Coal and Gold mines after graduating in 1989 to 1994, where he was involved in various activities from new projects involving high voltage power distribution and protection to maintenance of the electrical equipment.



(vi) Maintenance Capability

A. Describe how the Vehicle and Train Control maintenance team, and its members, will integrate and coordinate with other maintenance and rehabilitation activities.

The ALSTOM Transport (Alstom) Vehicle/Train Control Maintenance Team will be integrated into the Light Rail Transportation System (LRT) Project during its design phase and will become increasingly more implicated into the LRT System operations and into the integration of its maintenance and rehabilitation requirements with the City's Operational Units and other on-site maintenance teams during the life of the Project

• Vehicle/Train Control Maintenance

The Vehicle and Train Control Maintenance Team will be combined under one "Maintenance" organisation. This Maintenance Organization, under the direction of by an Alstom Maintenance Director, will be responsible for the Alstom scope of supply to the City. Maintenance will be supported by a dedicated, combined Alstom vehicle and train control engineering team under the direction of an Alstom Engineering Manager.

Fleet management will be a key element in the role of the Maintenance Organization. The Vehicle Maintenance Team will interface daily with the vehicle Operator at both the start and end of shifts. The Train Control Maintenance Team will be available at all times to support the City's Operational Units but will not normally have contact with the operator, apart from when applying for access to the lines.

Both the vehicle and train control systems will be monitored via remote diagnosis through data and system download analysis designed to best suit the City's Operational requirements. Maintenance Technicians will perform fault finding and fault rectification processes and procedures to the vehicles and the train control systems and will perform all Project specific preventive maintenance and inspection requirements. When required, these same Maintenance Technicians will perform all required line replaceable unit exchange on both vehicle and train control equipment. .

Line Support Technicians will support the activities of the Maintenance Technicians and will respond to both vehicle and the train control system defects. Both the Line Support Technicians and the Maintenance Technicians will be key members of an emergency response team responsible for conducting repairs to trackside train control equipment and, when required, re-railing of vehicles.

The Maintenance Organization will have a single procurement and warehousing system which will use the same Maintenance Management Information System (MMIS) to control and manage maintenance requirements for the vehicle and train control systems.

• Critical interfaces

System Maintenance will be delivered to the City in a seamless fashion through critical interfaces between the Alstom Maintenance Organization and other on-site Maintenance Teams

Joint Safety Committee

The Joint Safety Committee will perform a pivotal role in managing the safety of the City's Tramway System. The Committee will consist of permanent representatives from the Operator, Infrastructure maintainer (including Train Control Maintainer and Civil Works Maintainer), Rolling Stock Maintainer, Safety Representatives from the various on-site Trade Unions and the Railway Safety Authority. Representatives of the Emergency Services and of the Utility Services providers will be invited to participate as active members of the Committee when appropriate.

The Joint Safety Committee will accept or reject proposals for:-

- Organisational changes
- Equipment changes (other than like-for-like replacements)
- Changes to the General Maintenance Plan
- Operational and Engineering Rule changes
- Changes to the Response and Recovery Plan
- Other changes to the Safety Case



Decisions of the Joint Safety Committee will be based on the agreement of four out of the five representatives. However, the Railway Safety Authority representative will have the right to veto all decisions which are deemed to be unsafe.

Operator Interfaces

The Maintenance Organization and the Operator will co-operate at all times to achieve a safe and reliable tram service for the travelling public. The Operator must allow the Maintenance Organization as much access as possible to the LRT System and the Maintainer must use best endeavours to carry out his work without interference with the revenue service.

In order to maintain and to ensure the highest level of safety, the interface between the Operator and the Maintenance Organization must be managed closely through a meeting structure ranging from daily tram operating meetings, weekly engineering meetings, monthly progress meetings and six month staff liaison meetings. The activities of both parties must be carried out in accordance with strict Operating and Engineering Rules established under the guidance of the Alstom Maintenance Director and designed to minimise conflicts and prevent service disruption to the public.

Rolling Stock Maintainer Interfaces

The Rolling Stock physically interfaces with the Infrastructure at track, pantograph, third rail, signalling and communications levels. To ensure optimum reliability and performance at these interfaces, the maintainers of both the Rolling Stock and of the Infrastructure must establish a superb working relationship. This physical interface will be managed formally by the Alstom Engineering Manager but informal contact will occur at all levels of operations.

City Tramway Authority Interfaces

The Alstom Maintenance Organization will liaise with the City Tramway Authority via the Operator.

The Alstom Maintenance Organization will support this interface by collecting data requested by the City and reporting it on time and in the required format. The Alstom Maintenance Organization must allow the City free access to the LRT System when requested, subject to compliance with safety regulations.

Railway Safety Authority Interfaces

At a formal level, the Alstom Maintenance Organization will liaise with the Railway Safety Authority via the Operator. While the Operator is ultimately responsible to ensure the safe operations of the LRT System, the Alstom Maintenance Organization together with all other members of the Joint Safety Committee will be responsible to the Railway Safety Authority to ensure all staff complies with all safety requirements. The Railway Safety Authority will have a permanent seat at Joint Safety Committee, has the right to inspect all aspects of the City's LRT System operations, has the right to speak with any member of staff at any time, without notice and has the right to veto all decisions of the Joint safety Committee which are deemed to be unsafe.

Third Parties affected by Maintenance Activities

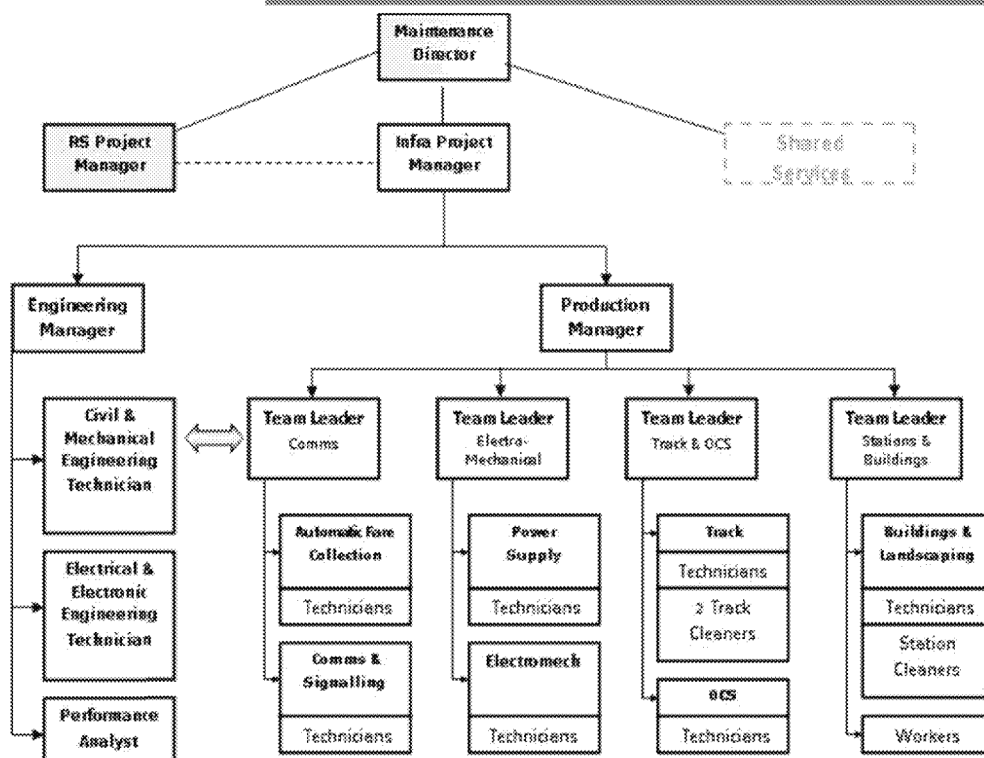
The Operator will be responsible for liaising with people affected, or likely to be affected by maintenance activities. The Alstom Maintenance Organization must inform the Operator at least four weeks prior to the start of any activity likely to affect the occupants of local premises to permit adequate notices of pending work to be issued to both local residents and to the local environmental health department of the proposed work.

The Operator will be responsible to receive messages from Third parties and to manage complaints from the public concerning service provided by the Operator. The Alstom Maintenance Organization will support the Operator in this activity, by providing written responses to the public on behalf of the Operator and by implementing any actions as may be necessary to alleviate identified problems.

• Maintenance organisation

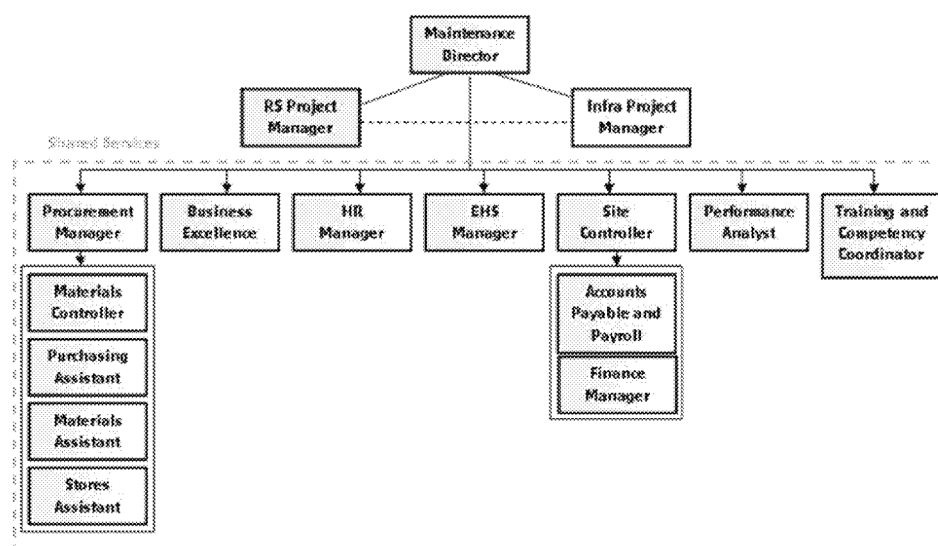
Alstom has experience in maintenance operations of LRT Systems under many different contractual structures and with many different scopes (reference §C herein). The role of the Alstom Maintenance Director is to ensure that all the interfaces among the different stakeholders (maintenance teams, operators, non-maintenance parties, etc.) are established and maintained in an efficient manner for all the sub-systems and for all the interfaces for the benefit of the City.

The key individuals proposed to lead the maintenance and rehabilitation management under the direction of the Alstom Maintenance Director are presented pictorially in the following LRT System chart:



Alstom will manage the maintenance of the LRT System through a series of activities and controlled/monitored through reports and weekly and monthly meetings. All the key Project members, covering all sub-systems and services will participate in these meetings. The key outputs of these meetings are plans of activities (coordinated with the Operator), previous month workload analysis, specific training needs and plans, shifts planning, resources planning, among others.

Work activity leaders, the Quality, Environment and Planning leaders, the Alstom Maintenance Director the Alstom Engineering Manager, and the Operator's representative will attend the weekly and daily Maintenance Activity Plan meetings. The key outputs for these meetings are analysis of work requests, prioritizing the work, analysing the safety and environmental condition for the working teams, issuing/confirming safety instructions, establishing responsibilities for ensuring the availability of special apparel, assignment of the maintenance work, duration of the work, etc.



Responsibilities for the "Shared Services" identified in the LRT System chart will be managed by the maintainer of each subsystem. Some are more critical to the short term operations than others (e.g. material management and payroll).



However the Alstom experience has demonstrated that all of these Shared Services must be managed efficiently in order to deliver a high performance maintenance organisation and that significant synergies can be achieved if the number of maintenance organisations is limited. In addition the number of suppliers will be kept to a minimum as the Alstom experience has demonstrated that fragmented suppliers with small scopes of supply are unlikely to accept the levels of performance being required of the Alstom Maintenance Director and therefore represent a significant technical risk to manage. This solution is a trade-off between the level of redundant non-productive costs with many small suppliers and the acceptable risk for the Alstom Maintenance Director and his organisation to deliver a system performance.

B. Describe the implementation strategies

Training of the Operator by the Constructor for Operation and Maintenance

Objective of the O&M Support Services during final testing

The objective of the Alstom training process is to ensure that all personnel required to operate and maintain the railway system are able to perform all the operation and maintenance tasks related to the different subsystems and equipment necessary for the functioning of railway system efficiently and safely.

To achieve this objective, the primary focus of the Alstom Training Program is a number of underlying principles based on our past experiences during the execution of a number of similar projects. These principles include:

- competencies of our staff tailored to the specific project requirements;
- demanding excellence in promoting the delivery of customer service;
- maximising use of Alstom capabilities and resources;
- capitalising on all aspects of the design, testing, commissioning and trial operation phases as hands-on learning experiences for the operator's staff;
- providing multi-disciplined resources to ensure a well-rounded training of the operator's staff;
- developing a team of customer-focussed, true professionals on the operator's team

Operations and maintenance training outlined herein includes Train Control equipment which will be a critical part of any operations training and will need to be incorporated into the other operations sub systems (AVLS, OCC, SCADA, Coms etc.) whether or not such are included in the Alstom responsibility and scope.

General Design of the Training Services

Type of Training

The training principle adopted by Alstom is that of a "step-by-step training" cascaded approach in 2 cycles.

In general, Alstom expert trainers train key members of the operations staff to prepare them for revenue service requirements. These key staff members then deliver the same training courses to other staff before the commencement of revenue service. The final stage of this initial transfer of competency is to be carried out during the "Trial Running" period during which the level of "know how" of the operations staff must be clearly demonstrated.

Not all participants in the training programs are assured a pass. Trainees who fail to demonstrate acceptable operational knowledge at the end of the training program are not qualified as properly trained employees. There is however some flexibility allowed in order to minimize the training cost for the operator. In certain cases, if there are positive potentials identified in the trainee's profile and overall delivery during the training, the trainers may recommend additional training days to reinforce the training of those trainees who have failed the initial program but who may benefit from the additional training period and additional assessment.

Cycle 1 "Training of the Key Instructors"

This cycle will consist of training given by Alstom to a group of 10 City and/or Operator trainees who will become Key Instructors. The attendees will be dependent on the timing of the training program and employee availability.

This training will include but not be limited to the technical knowledge (utilization and operating instructions) of the system and its subsystems and will encompass the operation method of the specific railway system.

Two main training groups will be considered -

- Key instructors for the operation of the railway system
- Key instructors for the maintenance of the railway system

To optimize the training of the two groups of "key instructors", Alstom will divide the Cycle 1 training into four stages:

- Stage 1: Common Trunk for Maintenance and Operation (General knowledge of system and sub-system of the LRT System)

"Common Trunk" targets the two groups of future "key Instructors" (maintenance and operation). The general knowledge of the system and of each sub-system is of key importance in this stage. The training

will allow the future "key Instructors" to acquire a global vision of the equipment and general features of the railway system on which they are going to work on. Furthermore this will allow them to more easily integrate the specific knowledge related to their jobs and to understand with more clarity the various relationships between each piece of equipment and the different skill sets employed across the railway system. Stage 1 will also encompass the training related to safety rules such as, walking on tracks, electric danger, track possession procedures, fire safety, etc.

- **Stage 2 : Training in the "use of the systems and equipment" (Systems Familiarization)**

The stage 2 targets employees who will be responsible for driving the rolling stock, for operating the railway system from within the OCC and/or for intervening for operation purposes on site.

This stage will focus on:

- General description of the entire system
- Description of the sub-systems
- Training in driving under both normal and downgraded conditions to ensure familiarity with the various sub-systems
- Training in the "use of equipment" interfacing with the operating system (key points, safety devices, traction apparatus, signalling, etc.)
- Training in the "use of all equipment" of the entire main transport system and sub-systems

Familiarization of the various systems and sub-systems for the trainees will be through these "hands-on/full-use" training sessions which will include both theoretical and practical sessions. During the practical sessions, the trainees will have the opportunity to visualize the complete range of control and monitoring systems, wherever they are located in tunnels, in the yard and/or within the OCC.

Trainees will operate and control the systems themselves, and will be placed in situations equivalent to those they will meet in their professional activities thereby ensuring familiarization with the systems and their behavior.

- **Stage 3 : Training of the Job of Operator**

Stage 3 Training focusses on the "Job of Operator" for normal modes of operation as well as for degraded and/or emergency modes of operation. Throughout the training, the railway system regulation will be used to support the courses and training drills so that the trainees will immediately become familiar with the strict operation and philosophy of the applicable regulations. The Training is structure to cover:

- Organizational aspects of operations and the various jobs involved,
- Jobs within the operation,
- Operation philosophies and strategies,
- Operation principles and Regulation,
- Operation scenarios and procedures,

- **Stage 4: Training for Maintenance of the Railway System**

Stage 4 Training focusses on the trainers of future maintenance operators. Stage 4 is designed around 3 main principles:

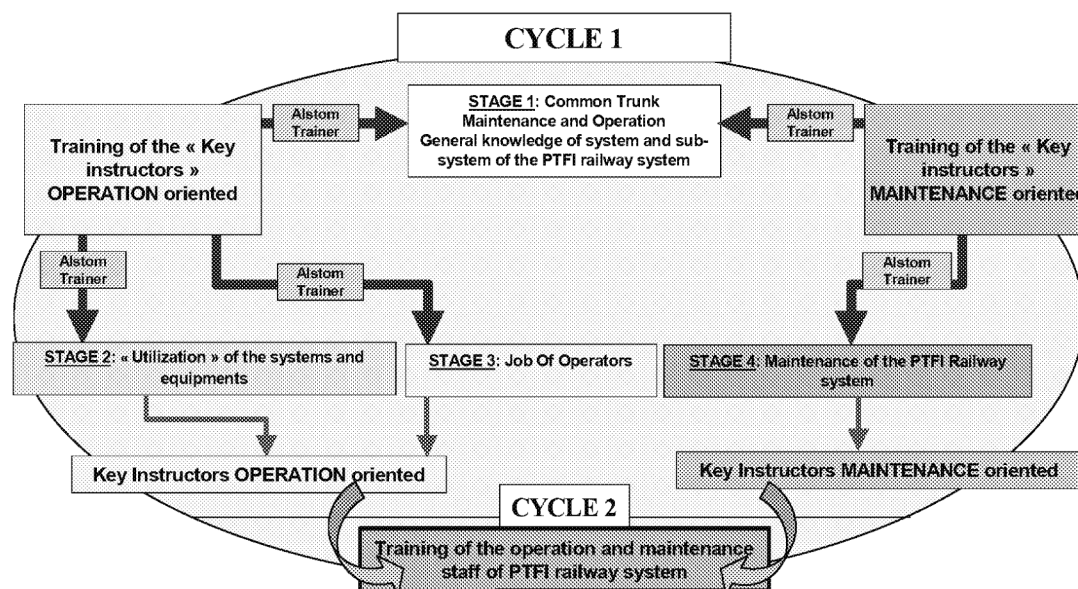
- Training in mechanical maintenance of systems, sub-systems and equipment
- Training in electrical maintenance of systems, sub-systems and equipment,
- When applicable, training in computer maintenance (use, administration and management) of systems, sub-systems and equipment.

Stage 4 uses description and presentations as wells as "hands-on use" of each of the modules before starting the maintenance itself. In addition to maintenance training, this Stage ensure hands-on use of all sub-systems to ensure that maintenance personnel are properly trained in the event that the trainee must intervene in the operation of a sub-system

Cycle 2 "Training of the operation and maintenance staff of the railway system"

Cycle 2 training will be given by the Key Instructors (previously trained by Alstom in Cycle 1) to create teams to operate and to maintain and to operate the railway system. This training for all operating and maintenance personnel will be

completed in time to allow Key instructors to finalize their courses and other training materials and to train the relevant number of both operation and maintenance staff needed before the commencement of the commissioning stage of the LRT System



Mobilisation of the Alstom Maintenance Organisation

Mobilization for a maintenance project will vary from one project to another. Irrespective of the scheduling, the Alstom Maintenance Organisation must be involved in the Project as early as possible. Where construction is involved, Alstom Maintenance Engineering will monitor the Project from the early stages of design to ensure that maintenance needs are designed and constructed into the project. Only as construction comes to an end, will the Alstom Maintenance Director be appointed.

The Alstom Maintenance Engineer, the first person to arrive on site, will establish required Alstom office facilities and begin the process of preparing Alstom Maintenance Organisation's accommodation for the arrival of the remainder of the workforce, spares and equipment as well as the preparation of the depot building. Assistance will be provided by the shared services representatives from Finance, Procurement, Buildings Managers as and when appointed to the Project Team.

Recruiting Process

There will be several phases of Recruitment depending on the project. These phases are broadly as follows:-

- Preparatory phase

During this phase the Alstom Engineering Manager will be appointed. The role of the Alstom Engineering Manager will be to influence the design and construction process to ensure optimum maintainability of the LRT System. As the project moves from the design phase to the construction phase, the Alstom Engineering Manager will become more involved and work more and more on site. Towards the end of construction, the Alstom Maintenance Director will be appointed and the mobilisation phase will begin.

- Mobilisation phase

The Alstom Engineering Manager and the Alstom Maintenance Director will confirm the organisation they need to recruit and start the process by appointing an Alstom Human Resources Manager. These three will have considerable experience in their fields and of the internal processes applicable to the required teams for the organisation for LRT System Maintenance Projects. These individuals will be recruited internally from within Alstom and/or associate companies and may well be expatriates to Canada and/or staff seconded from other established projects.

The remainder of the Alstom Management Team will be recruited in accordance with the previous mobilisation experience which they have prior to the start of the maintenance phase of this LRT System Project. The Finance and Procurement



Managers will be recruited/appointed next followed by the Quality Manager and HSE Advisor. The Production Managers will be appointed thereafter.

Alstom Management support staff will be appointed in a similar order to the managers. These individuals will prepare for the appointment of the main workforce who will start to arrive from approximately three months prior to the start of the maintenance of the LRT System. A significant portion of this workforce will be taken from the commissioning and testing teams from previous projects which will have had previous hands-on experience with the system design and operation.

Training Process

The training will follow the same methodology as described above. The trainees for the initial training program during the Mobilization Phase will be members of the Alstom Maintenance Organization.

Documentation Production

Key Documents required to be produced during the Mobilisation Phase include:-

- General Maintenance Plan
- Annual Maintenance Plan
- Method Statements
- Risk Assessments
- Safety Policy Statement
- Health & Safety Plan
- Environmental Management Plan
- Quality Plan

In addition to the existing models at the Alstom Engineering Manager's disposal, the Alstom Engineering Manager will ensure that the documentation that is supplied is the most suitable to the LRT System project. This may include site visits to operations with similar parameters and constraints in order to benefit from the all available return of experience – in particular with local enterprises that would share the same environmental issues.

Receipt of Initial Spares and Maintenance Equipment

- Initial Spares

A stock of Initial Spares will be supplied by the Alstom Construction Organisation. These spares will consist of at least 6 months supply of consumables and replacements for small parts likely to need replacement from time to time as a result of incidents and failures.

It will be the responsibility of the Alstom Procurement Manager to ensure the parts are accurately logged into the stores as they arrive and stored in appropriate storage conditions to ensure they remain fit for use when required.

- Maintenance Machines and Tools

Major Maintenance Machines and Tools required specifically to maintain particular assets of the LRT System will be supplied by the City Authority as per specifications provided by Alstom. Special tools may be provided direct from the asset supplier but general purpose machines may be supplied by appropriate specialist equipment manufacturers.

C. The Proponent must articulate and demonstrate how prior experiences and/or lessons learned on high capacity rail systems will be implemented for this Project.

Maintenance and Rehabilitation is a core activity for Alstom. This represents approximately 30% of its business through a dedicated organisation. This structure is complemented by a comprehensive system and set of processes for monitoring all aspects of every project's experience in all areas from product design and production, installation, commissioning and maintenance. Every process is studied, reviewed and compared on a regular basis to assure constant excellence and improvement in customer service. In this manner, maintenance processes are adapted and changed for the specific requirements of the project in hand – as for winterisation in very cold climatic conditions.

Alstom tools and processes for improved asset management

Alstom has developed integrated tools and systems that greatly improve asset management to ensure end of life hand-back standards are achieved. Some examples are:

- Alstom Safety Management System (SMS)
- Design for Quality (DFQ) the process for ensuring the quality of design
- Design for maintainability (DFM) the process for continually improving the maintainability of vehicles and products.
- Alstom Production System (APSYS) the tools used to develop and implement the best processes in build, installation and maintenance
- Products designed for maintainability (DFM) based on the return of experience from Alstom and customer maintenance organizations continually fed back to the product builder
- Condition Based Monitoring (CBM) systems, such as Traintracer, enable the service provider to determine wear levels on main components and sub-systems;
- E-documentation which links the maintainers via a web page to field operators
- e-Catalogue links Maintainers to their specific project's parts inventory to enable faster on-line ordering to occur

Alstom Experience at Maintaining Asset Value during the Contract Duration

Overhauls and Handover

With long maintenance contracts there is a requirement to address significant capital expenditure programmes during the course of the contract as well as operational expenditure on preventive and corrective maintenance. These investments will be in the form of overhauls of major subsystems or complete systems that will ensure continued performance for a significant period of time. At that time, the City may wish to benefit from the opportunity to possibly upgrade the equipment to provide higher performances and/or to rehabilitate in kind. Such decisions will be made during open discussions between the City and Alstom to best benefit the City. Whichever solution were to be selected, this to-be-agreed work would not be considered as part of the asset management programme.

For the Ottawa LRT System, the asset management at the end of the contract will be measured against a number of indicators during 3 major inspections, one of which will be the Remaining Design Life of principle System Elements. In addition, overhauls of systems and sub-systems will be planned to allow at least 10 years of operational life after the Handover of the LRT System without the complete system element needing replacement. This will be most critical for the elements that include sub-systems with the shortest product life expectancy (e.g. - IT, Telecoms, etc.) which will therefore need to be planned during the closing years of the contract. Obsolescence will also need to be taken into account in the lead up to the Handover of the LRT System with a decision to stock or replace any components that may be at risk after the end of the contract.

Alstom has delivered maintenance services to many world-wide Transit Agencies and Operators as noted in the following table. Alstom has responded to end of life and obsolescence issues on infrastructure and rolling stock equipment. Alstom has sound experience in producing renewal plans for all its products and hand-back condition reports in the case of projects that have already been completed.

Project	Km	End	Track	Power Supply	OCL	Signalling Telecom	Station Utilities	Depot	Rolling Stock
Reims Tramway Line 1	11.5	2036	✓	✓	✓	✓	✓	✓	✓
Jerusalem Tramway Line 1	14	2032	✓	✓	✓	✓	✓	✓	✓
Barcelona Trambesús / Trambaix	30	2029	✓	✓	✓	✓	✓	✓	✓
Algiers Tramway Line 1	16.3	2016	✓	✓	✓	✓	✓	✓	✓
Dublin Tramway Lin 1 & 2	40	2014	✓	✓	✓	✓	✓	✓	✓
Bordeaux Tramway Lines	5	2013		✓					✓
Merval Suburban Line	43	2012		✓		✓			
Athens Suburban Line	110	2012			✓	✓	✓		
Madrid Barcelona High Speed Line		2009		✓					
Cairo Metro Line 1 & 2	61	2008		✓		✓	✓		✓
Brasília Metro Line	40	2007	✓	✓	✓	✓	✓	✓	✓
Cairo Alexandria Main Line		2007				✓	✓		
Paris Suburban Lines A & B	208	2005				✓			

Other long term Alstom service contracts include:

- Parla Tram: over 38 years of operation (complete system)
- Valenciennes tramway: 15 years of operation (Rolling Stock)
- London Underground: 25 years of operation (Rolling Stock)
- Valparaiso Metro: 30 years of operation (Rolling Stock),
- Italy NTV VHST: 30 years of operation (Rolling Stock)
- Bucharest Metrorex: 15 years of operation (Rolling Stock)

Alstom's return of experience can be further demonstrated through 2 processes that have been developed to optimise maintenance at Alstom.

Alstom LIFE CYCLE COSTING MODEL (LCC)

The life cycle costing model forecasts the whole life cost of maintenance for a vehicle through forecasting consumption and cost in 3 key areas: -

1. Preventative material consumption
 - Planned materials, filters, oils etc.
 - Change on condition materials, brake pads, pantograph carbons, wheels etc.
2. Corrective material consumption
 - Unplanned materials
 - Non reparable components
 - Repairable components
3. Man-hours consumed
 - Preventive maintenance man-hours (Including daily pre-revenue service testing)
 - Overhaul man-hours
 - Corrective maintenance man-hours

Preventive Maintenance

The preventative maintenance plan is built into the model and driven by the planned annual mileage. Each maintenance revision has a Bill of Materials (BOM) and the man-hours required to deliver the operation. The BOM is created from the scope of work in the plan and the change on condition parts based on return of experience from maintenance of similar vehicles. Using this method a confident cost forecast can be allocated the full cycle of preventative maintenance revisions.

Overhaul



The same process is employed for the vehicle overhaul with a BOM based on the overhaul scope and man-hours based on return of experience.

Corrective Maintenance

The cost of corrective maintenance is achieved by forecasting the cost by vehicle system e.g. traction, braking, doors. Each system is treated individually using the predicted and return on experience Mean Distance Between Failure (MDBF) for the major components in the system. The cost of the component and the man-hours required for fault finding and correction calculates into the cost of corrective maintenance.

LCC Creation and Validation

Alstom uses Reference Solutions within its Reference Libraries as the basis for the modelling. This process involves a PDCA-type (Plan Do Check Act) review that takes place at least once a year between the design/manufacturing team and the maintenance team. Previous results in LCC optimisation are reviewed, new actions are proposed along with new LCC targets for the coming year. It is this closed-loop approach that enables Alstom to consistently improve their LCC forecasts year-on-year over the life of the product and not only the project.

The full LCC cost for a reference solution is established using data from the Alstom Maintenance Management Information System (MMIS) which is a key module of the integrated Enterprise Resource Management (ERP) system. A standard coding system is used for MMIS work orders on all Alstom maintenance contracts. This standardisation allows for performance and cost analysis between vehicles, system, sub-systems down to individual components. The data from all maintenance projects is captured in a fully automated data warehouse. The quantity of current data being added to the warehouse weekly and the automated reporting allows for the reference vehicle data to be accurate and up to date. This data is used to continually update the reference vehicles LCC.

Alstom MATERIAL SUPPLY AND MANAGEMENT

Material management and procurement is managed using the Alstom Enterprise Resource Planning systems (ERP) Material Resource Planning (MRP) module. The ERP uses the Life Cycle Costing (LCC) model data at the commencement of a project to establish the initial stock levels. The ERP then continually takes the following data from the Maintenance Management Information System (MMIS):-

- The preventative maintenance plan
- The BOM for all the activities in the maintenance plan
- The current vehicle mileage
- The forecasted vehicle mileage
- The consumption of material with the work type that consumed the material

Using the above data, as materials are drawn from stock to a vehicle, the MRP systems forecasts the future needs for that material and adjusts the stock level against the forecast and the lead time to replenish. The strength in the MRP is that it looks forward based on continually readjusting the forecast. If the fleet mileage changes either an increase or a decrease then the MRP detects this and readjusts the stock levels based on a change. As a project becomes mature the MRP can detect changes caused by seasonal events and rebuilt its forecast to manage these infrequent events.

The generation of purchase orders to replenish stock is automated in the MRP.

Stock Value

By the use of the MRP forecasting, stock is maintained at an optimal level. The Alstom MRP system is then further overlaid with software designed to fully optimise stock levels.

Data analysis and KPI's

Data from the MRP forecast is used to drive KPI's on material consumption and to detect unplanned changes to material consumption in either direction. If the cause of this change of consumption cannot be detected through mileage or maintenance plan changes this report is relayed back the maintenance organisation to investigate the cause of the change. This reporting process has proved to be beneficial in the early detection of equipment failures.

RAILSYS - Alstom's Maintenance Knowhow Transformed into a Single ERP System

OTTAWA LRT -- Vehicle and Train Control Prequalification

January 6th, 2012

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Since 2003 Alstom has continued to develop RAILSYS - an ERP system that is 100% dedicated to the maintenance needs of railway rolling stock and railway infrastructure equipment. Alstom is the only railway manufacturer-maintainer to have invested in such a system. RAILSYS enables the local Alstom Maintenance Team to provide the Client with reports that are built on a very detailed level of data that is specific to its complete railway system, not only data from collected from its vehicles. In addition, as the data is managed centrally by the Alstom Maintenance Platform, RAILSYS allows Alstom maintenance teams world-wide to benefit from the return of experience of systems which in return provides design and maintenance benefits to Alstoms' Clients.

The maintenance programs to be developed for the Ottawa LRT System will fully benefit from application of RAILSYS. The implementation of the benefits of RAILSYS will begin through open discussions among the City, its Operators and the Alstom Maintenance Organization once the Alstom Maintenance Director and Alstom Engineering Manager are in place.

Obsolescence Management Plan

Obsolescence Management is based on a transparent approach that will allow the City to select from various Obsolescence Management Solutions to be proposed by the Alstom Maintenance Organization which is best suited to the City's operational needs. The selected Obsolescence Management Plan which will be based on the following criteria and objectives:

- The dedicated plan will be implemented at the beginning of the Maintenance Contract;
- New obsolescence information will be gradually added and revised throughout the Contract as it is made available;
- The Obsolescence Management Plan takes into account technology, complexity, costs and operational considerations and operational constraints;
- The Obsolescence Management Plan is used throughout the entire life of the products and parts in order to best identify the activities and associated responsibilities related to the Obsolescence Management;
- Various options will be available to manage obsolescence and the choice of these options must be regularly reviewed with our customer. The decision will be based on Life-Cycle Cost considerations as well as practicality and sustainability solutions. These include -
 - To define all interfaces so that the consequences of obsolescence in all cases are limited to the exchange of a module (transparent with technology);
 - To manage the elements, materials, and used processes in the product/part to treat obsolescence;
 - To manage the evolution of the equipment with the obsolescence of the components or materials;
 - To analyse the possible "end of life" storage of certain components;

Maintenance of Rail Vehicles and Signalling during Winter and Summer Operations

Winter Operation

Research carried out by Alstom and practical project experience has shown that a disciplined preventive maintenance regime and other protective measures are the most cost effective solution to managing winter conditions, especially when conditions fluctuate year on year. Capital expenditure (product design or corrective equipment) is never sufficient if specific preventive maintenance tasks are omitted.

The winterisation of vehicles will be a planned maintenance activity in the autumn to be completed before the onset of winter. Although a planned activity the long term weather will be continually reviewed at the weekly meetings and if there is a change in the normal weather pattern then any vehicle which has not been winterised will be immediately targeted for winterisation.



Alstom experience of vehicle maintenance in Sweden

Alstom's train building experience in Sweden and Finland, combined with its Design for Maintainability processes, has allowed it to develop a specific range of solutions for winter conditions. The following systems are subject to additional disciplined preventive maintenance regimes and other protective measures to prepare the vehicle for winter: -

- HVAC
 - Air inlet grill heater functional check
 - HVAC control software change to winter settings
 - Electrical and functional check of all heater elements
 - Change to winter grade filters
- Auxiliary convertor case heating electrical and functional check
- Pantograph carbon change to winter grade
- Sanding heater electrical and functional check
- Passenger foot step heater electrical and functional check (If fitted)
- Coupler heater electrical and functional check
- Change of window washer fluids and other fluids to winter grade

Where necessary, protective covers are fitted to external equipment which are vulnerable to ingress of snow (e.g. coupler skirts, horn covers, snow air filters etc.). All fluid pipelines are heated or insulated and the aerodynamics are managed to limit the build-up and compacting of snow into ice. Snow ploughs will be added to ends of the vehicles, along with brushes, to clear snow from the track.

Even with these on-board measures, it will be critical that attention is focussed on the infrastructure - the operating environment of the vehicle. The use of customised railway snow blower machines will be required prior to the first operation of the LRT System Trams and/or throughout the night in the event of heavy forecasted snowfall. Snow will be then be manually collected at designated snow storage zones next to the right of way and removed by digger and truck. If this preventive work is managed correctly then low floor vehicles should not encounter any increased difficulty. Experience with high floor commuter trains in Scandinavia has demonstrated that the exposed under-frames collect snow and ice very rapidly resulting in a long de-icing process which directly impacts vehicle availability for both the maintainer and the operator.

If the climatic conditions are severe then an overhead line heating system may be installed at construction to prevent ice formation during long periods of time. This often comprises of a heating cable that is attached directly to the contact wire. If this system is not in place then regular preventive inspections/cleaning will need to be added to the infrastructure maintenance plan.

All trackside components for the signalling system will be installed in heated central or local technical rooms. Alstom proposes to use P80 Switch Machines which can operate at up to -40°C for track products for installation with and control by the signalling system. These P80 Switch Machines have been installed in and have operated successfully in Nordic countries. If climatic conditions dictate, these P80 Switch Machines can also be heated.

The seasonal preventive maintenance plan will be modified in a similar fashion as to that to be implemented for the rolling stock. This would include the application of anti-freeze agents to unheated switches (e.g. "Kilfrostr" which Alstom uses in northern Europe for the maintenance of depot switches) to prevent freeze-ups.

Summer Operation

Rolling stock will be returned to summer operating mode through a planned maintenance activity in the spring to be completed before the onset of summer by reversing the winter operation process. Although a planned activity the long term weather will be continually reviewed at the weekly meetings and if there is a change in the normal weather pattern then any vehicle which has not been prepared for the summer will be immediately targeted for preparation for summer operations.

The focus of summer operations will be the HVAC cooling systems which will not have been used during the winter months. The HVAC will be subject to full inspection and functional testing. Filters will be changed to summer grade. Snow covers will be removed and all fluids will be replenished with summer grade fluids.

(vii) Resumes of Key Individuals (limit of 3 pages per resume).

Hugues MELLERIO Project Manager Alstom Transport	
Nationality:	French
Age:	51
Languages:	French (mother tongue), English
Higher education & qualification:	
	Electronics engineer, ESME SUDRIA, Paris
Experience:	22 years
10 years	Alstom Transport Information Solutions
2010-xxxx	Project Manager Project Director: Bangalore Metro lines 1 & 2, India, Urbalis signalling system (100+ Meuros)
2008-2010	Project Director, Urbalis signalling system projects: Delhi metro lines 1 & 2, initial contract and contract BS01 for extensions (100+ Meuros)
2007-2008	- Project Manager, CBTC signalling system projects in China: - Beijing Metro Line 2 Revamping (30 Meuros) - Beijing Airport Link driverless line (25 Meuros)
2001-2006	Senior bid manager: management of tenders for Multisystem Mass Transit, Main Line Railway or LRT projects – Signalling, ATS, SCADA, Radio, Telecom and Passenger Information systems (from 10 to 300 Meuros)
1998-2001	GTMH, France - Project Manager in Electrical Subsystems for Transport Department of Installation Major - Marketing strategy, tender and project realisation for traffic monitoring systems and electrical systems for motorways
1992-1998	- Tendering, design, implementation installation of very low voltage systems - Project Manager in Electrical Subsystem for Very Low Voltage Department
1989-1992	Forclum, France - Project Manager in Automation systems for Installation Major - Tendering and sales for SCADA systems.
1988-1989	Chauvin-Arnoux, France Sales Engineer: temperature monitoring and control equipment

Jean-Marc MORIN Project Manager Alstom Transport	
Nationality:	French
Age:	53
Languages:	French (mother tongue), English (fluent)
Higher education & qualification:	
	Engineer degree in computer science from ENSEEIHT (Toulouse, 1982)
Experience:	29 years
10 years 2010-xxxx 2001-2010	Alstom Transport Information Solutions Project Engineering Manager - Head of system engineering department in Rochester (ALSTOM Transport) Project Engineering Manager - STM ICC: control center for Montreal metro (controlling 4 lines – 75 km, 68 stations) based on Iconis™ product - Beijing Line 2: Urbalis™ CBTC signalling system in major metro revamping project, completed in 2 years for Beijing Olympic Games - Delhi SYS1 project: Urbalis™ signalling system for 2 new lines in India - Hong Kong LAR four tracking project - Bid Technical Manager on the Beijing Line 2 and Line 4 tenders
2 years 1999-2001	TRANSWITCH, France Technical director for R&D on internet routers products - In charge of microprocessor architecture - Definition of engineering process & tools - Coordination of hardware and software developments
10 years 1989-1999	DGA, France System manager for submarine weapon systems - Specification and preliminary design - Performance allocation, modelling and monitoring - Engineering process & tools definition - Development follow up
3 years 1986-1989	AEROSPATIALE (AIRBUS), France Project Manager for software developments
4 years 1982-1986	IGL, France Developer then project Manager for software development

Didier DE HAUTECLOQUE Project Engineering Manager Alstom Transport	
Nationality:	French
Age:	55
Languages:	French (mother tongue), English
Higher education & qualification:	
	Electronics engineer (ESEO Ecole Supérieure d'Electronique de l'Ouest, France)
Experience:	31 years
22 years	Alstom Transport Information Solutions Chief System Designer and Project Technical Leader
2009-....	• Senior System Architect: urban signalling system tenders (CBTC systems)
2007 -2009	• Project Technical Manager: Bosphorus Crossing & Commuter Rail (Turkey). Signalling & train control system (CBTC) with ERTMS level 1 backup, trackside and trainborne equipment, centralised traffic control
2005-2007	• System manager for signalling tenders: responsible for giving technical strategy according to customer requirements and Alstom solutions, supervising subsystem deliveries, leading performance simulations
2003-2004	• In charge of securing deliveries of products and integrated system for Athens Olympic Games (ASR project, GREECE)
2001-2003	• Chief system designer, SINGAPORE Circle line driverless metro
1994-2000	• Chief system designer, Lantau & Airport Railway (HONG-KONG)
1989-1994	• ATS system design manager, Automatic Train Supervision
1984-1989	SINFOR, France • Software engineer (shipbuilding industry)
1980-1984	SCHLUMBERGER, France • Electronic design engineer (factory automation)

Experience Summary

don

ondon

ance

Brian Ealey 30 years' experience in the maintenance of rail vehicles including metro's Electrical Multiple Units (EMU) light rail vehicles and suburban diesel and multiple units (DMU). Maintenance management experience at all levels from multi-skilled technician thorough supervisory management and senior management.

Project management 10 years' experience in the project management for the introduction of new trains onto both new and existing infrastructure.

Vehicle maintenance management had the full responsibility for safety of the vehicle and the workforce. Full responsibility for the contracted vehicle availability and reliability. The direct management of the vehicle commissioning and warranty teams. Direct interface with customer project, railway operational and senior managers. The management of subcontractors for products and services.

Project management the full responsibility for starting up projects including the worksites, recruitment and employee training. The development of maintenance strategies including Reliability Centred Maintenance (RCM) and Condition Based Maintenance (CBM). Direct interface with customer project, railway operational and senior managers also customer and Alstom subcontractors.

Selected Project Experience

Alstom TLS Naperville II USA. June 2009 – to date - **Industrialization and Transit Manager.**

The role is to develop and improve the performance of the renovation and modification business and the development of the in-house repair and remanufacture business through the implementation of best practice processes. The role includes development and standardization of business systems and processes also to develop the transit maintenance and renovation business within the USA and Canada.

Burlington Northern and Santa Fe Railroad (BNSF) Project Improvement Team Leader. March 2008 to June 2009 –

In this role I lead a small team responsible for improving both the operational and financial performance of the BNSF diesel electric locomotive project. Since January 2009 I also took on the additional role of Engineering Manager for the BNSF project. The project was restructured and delivering fully the contracted service for availability and reliability with the financial improvements.

Train System Improvement Team Leader. London Underground Northern Line. 2006- February 2008

The role was to manage improvements to the traction and pneumatic systems also maintenance operations with the introduction of advanced tools, condition based maintenance and best practice preventative and corrective maintenance. The development and delivery of a pneumatic and braking overhaul on 636 cars.

Return on Experience Manager UK. 2006

The role was to report on vehicle and organisational performance feeding back data to Rolling Stock builders and other internal maintenance business to improve new vehicle builds and maintenance operational performance.

I had corporate responsibilities for the development of the company Maintenance Management Information System with a light version for tram projects.



During my time in this role I was part of the team who developed world wide automated vehicle performance reporting using data warehouses. The role also included support to maintenance projects worldwide for maintenance and organisational development as and when required.

Maintenance Business Improvement Team Leader, Dublin City Luas Tram 2005-2006

This role required the development and implementation of a new organisation to overcome the existing organisational and tram performance problems. This support resulted in a new maintenance and technical staff structure with new grades and working practices. During this time I also acted as mentor and coach for the new Production Manager.

Maintenance Operations Director, Bucharest Metro Romania 2004-2005

In this role I took over the existing vehicle maintenance operations and 1700 employees from the client Metrorex. I was responsible for the development and implementation of new work methods, safety and quality systems to European standards. The introduction of advanced maintenance tools also coaching and development of the local managers in the use on Maintenance Management Information System.

The role also required the setting up of an asbestos removal facility including an in-house fully accredited air sampling laboratory to full European and World Health Authority standards for the removal of asbestos from 326 metro cars.

Maintenance Operations Director for Alstom Metro Trains London Underground. 2002-2004

Responsible for the delivery of the contracted train maintenance services service to London Underground for the Northern and Jubilee Lines (990cars) The contracted services were for the maintenance of the customer owned trains on the Jubilee Line also for the leased trains and track side communications equipment on the Northern Line. The total number of trains in maintenance was 165 x 6 cars with a total workforce of 240 people. The role of the Operations Director was to manage the Maintenance Operations, Engineering and Material Provision departments.

Continuous Improvement Manager for Alstom Transport UK. 1999 to 2002

Developing and implementing improvement processes, procedures and practices throughout UK maintenance sites.

Contract Manager for the Alstom London Underground Jubilee Line train maintenance project. 1996 to 1999

In this position I was the senior manager responsible for starting up of the train maintenance contract from an existing London Underground depot, the recruitment and development of a workforce and the introduction of a fleet of 59 trains with the maintenance delivery strategy and the development of quality, health and safety systems to ISO standards.

In 1998 I was required to transfer all the above operations to a new depot at Stratford Market, which included the enabling of the site and the running of the site as a full maintenance facility whilst building work was completed.

Fleet and depot management positions within London Underground on the Northern line. 1991 to 1995

First Line manager on London Underground Victoria and District Lines. 1985 to 1991

Current Projects

MARTA Business Process Reengineering (2010 to date)

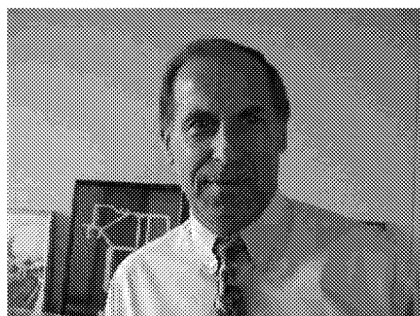
New Jersey Transit Condition Based Maintenance and technical support (2008 to date)

Caltrans passenger door modifications (2009-2012)

Caltrans collision repairs (2009 to date)

Michel Wursteisen

Mr. Wursteisen has had over 22 years of progressive and extensive experience managing the manufacturing, delivery, testing and commission, of major electric vehicle programs, including those for both LRT and subway (metro) systems, integration of CBTC train control on these vehicles. Among his many accomplishments he was formerly the Director of Traction Engineering at Alstom's Charleroi manufacturing facility, and the RAMs Engineering manager for the R160 vehicle program for New York City.



A. Role on this Project: Light Rail Vehicle (Procurement) Manager

Mr. Wursteisen will be the Light Rail Procurement Vehicle Manager. As Alstom will undertake an optimization in the selection of the most appropriate vehicle for the Ottawa project, and then supply this optimized vehicle, including design, construction, assembly, test and commission, and Quality assurance.

Responsibilities and Contributions on this Project

- » He will be responsible for the successful planning and execution of the design, construction, assembly and test & commissioning of Alstom Citadis vehicles for the Ottawa project with respect to budget, delivery timelines, expected quality.
- » Reporting to the Director of E&M Systems Integration he will organize and lead the Vehicle project team, identify roles, responsibilities and objectives to project team members and define interfaces.
- » He will define, monitor and report project dashboard and key performance indications.
- » He will define the project risk management plan and constantly review and update, vehicle project performance, identify risk and opportunities and follow up these with action to improve the project outcomes.
- » He will have full responsibility for the vehicle within the project throughout its full life cycle and take necessary actions to improve the project process.
- » He will control and manage relationships with relevant stakeholders and the customer (in relation to the vehicle).

B. Education / Training (including specialized training courses)

- » Institut Polytechnique Grenoble
- » Languages: English, French
- » Project Management Courses – Alstom University
- » Project Risk Management – Alstom University
- » ISO procedures, FMC testing training, Inductive Conductive ATC
- » Procurement Management – Alstom University
- » Performance Management Training
- » Alstom propulsion training

C. Project Specific Experience and Qualifications

RELEVANT PROJECT EXPERIENCE

Project Name:	Singapore MRT	Location:	Singapore
Role on Project:	Project Manager	Involvement	10 years
Project Type:	Rolling Stock – Driver less Metro	Duration:	
		Delivery Method:	Manufactured in France, Test & Commissioned in Singapore. Separate Vehicle procurement with integration responsibilities to CBTC, track, power, construction
Size / Value:	150 k€	Completion Date:	12/2008

Project Description:

Design, construction, testing and commission of 25 trains sets of 6 cars (150 subway cars) – First high capacity CBTC driverless in the world – coordination/integration interface with other activities such as CBTC train control and signalling, Operations Control Centre (OCC), power supply and SCADA system, trackwork, and workshop

Challenges Overcome and Contribution:

- » First CBTC Metropolis- driver less- new system in the world
- » Complex CBTC system, involving tunnel operations, integration with different system wide contractors (E
- » Many stakeholders: client (LTA) operator (SMRT), partner (STE) different Alstom units, Civilw works companies and other contractors.
- » High technology level, difficult climate conditions (high heat and humidity conditions, full system integration and system wide interfaces.

Responsibilities Summary:

- » Project Manager for Vehicles
- » Planning and execution of design, construction, assembly and test and commissioning of vehicles
- » Organize and lead the project team
- » Define, monitor and report project dashboard and key performance indicators
- » Full responsibility for vehicles throughout their lifecycle
- » Control and manage relationships with relevant stakeholders and the customer

Project Relevance

- » All Singapore lines are driverless rail (automated train control provided by Alstom)
- » Close relation with operator to successfully handover the line
- » Subsequent conversion and integration of existing stations in extensions
- » Full System integration (interfaces to ATC, track, power etc.
- » Sustainability implementation and certifications in programs comparable to LEED and GREENROADS
- Rail project in densely populated urban and commercial areas.
- Train s operate in tunnels and mined underground stations, including experiences with fire and life safety systems.
- Environmental management system programs.
- Quality management systems and controls.
- Schedule, budget and risk management performance
- Vehicular, pedestrian, emergency project development areas.

Reference:

Company Name: LTA
Location: Singapore
Preferred Language: English

#1

RELEVANT PROJECT EXPERIENCE

Project Name:	Istanbul LRT	Location:	Istanbul, Turkey
Role on Project:	Project manager	Involvement Duration:	2 years
Project Type:	Citadis tramway (LRT)	Delivery Method:	Manufactured in France and Poland; Test & Commissioned in Istanbul, Turkey Separate Vehicle procurement with integration responsibilities to train control, track, power, construction.
Size / Value:	72 k€	Completion Date:	12/2011

Project Description:

7 Citadis 301, capable of 100 km per hour with Permanent Magnet traction motors (air cooled)

Challenges Overcome and Contribution:

- » New product
- » Project Delivery schedule was very fast
- » Complex project in tunnel, automated train control, integration with different system wide contractors (vehicle supplier, ECS, tunnel ventilation, fire detection/protection).
- » Many stakeholders: client (LTA), operator (SMRT), partner (STE), different Alstom units, Civil works companies, System wide contractors (ECS, tunnel ventilation, fire detection/protection)
- » Safety to be ensured in tunnel with construction work still on going during the T&C period.
- » Scope included in factory and at customer location installation, test and commissioning of all vehicle systems and performance metrics, train control, train operation, and telecom subsystems new vehicles.
- » Full System integration and system wide test and commissioning.

#2

Responsibilities Summary:

- » Project Manager for Vehicles
- » Planning and execution of design, construction, assembly and test and commissioning of vehicles
- » Define, monitor and report project dashboard and key performance indicators
- » Organize and lead the project team
- » Full responsibility for vehicles throughout their lifecycle
- » Control and manage relationships with relevant stakeholders and the customer

Project Relevance

- » LRT vehicle very similar to Ottawa requirements
- » Design build project?
- » Conversion and integration of existing bus line to LRT
- » IS THERE TUNNEL SECTION?
- » Environmental management system programs
- » Quality management systems and controls,
- » Schedule, budget and risk management for large complex project
- » Full system integration including responsibilities for signalling and train control
- » Rail project in densely populated urban and commercial areas (Istanbul is a city of over 10 million people)
- » Vehicular, pedestrian, emergency and BRT traffic management within and adjacent to the LRT project development areas.

Reference:

Company Name: Ulasim
 Location: Istanbul
 Contact / Title: XXXXX / XXXX
 Phone: XXXXX
 Email: XXXXX
 Preferred Language: English

RELEVANT PROJECT EXPERIENCE

#3	Project Name:	SNCF double deck EMU	Location:	france
	Role on Project:	Project manager	Involvement Duration:	3 years
	Project Type:	Vehicle Contract EMU	Delivery Method:	Manufactured in France
	Size / Value:	500 k€	Completion Date:	12/2000
	Project Description:			
	[80 double deck EMU trains for SNCF (5 car trains = 400 double deck electric multiple unit cars)]			
	Challenges Overcome and Contribution:			
	» New product with new traction drive system, based on extensive optimization discussions with Customer. » Planning and delivery on a very tight timeframe. » Scope included in factory and at customer location installation, test and commissioning of all vehicle systems and performance metrics, train control, train operation, and telecom subsystems new vehicles.			
	Responsibilities Summary:			
	» Project manager » Planning and execution of design, construction, assembly and test and commissioning of vehicles » Define, monitor and report project dashboard and key performance indicators » Organize and lead the project team » Full responsibility for vehicles throughout their lifecycle » Control and manage relationships with relevant stakeholders and the customer			
	Project Relevance			
	» Major vehicle procurement program			
	» Electrical powered vehicles			
	» High standards for reliability and maintainability			
	Reference:			
	Company Name:	SNCF		
	Location:	Paris		
	Contact / Title	XXXXX / XXXX		
	Phone:	XXXXX		
	Email:	XXXXX		
	Preferred Language:	french		

D. Other Relevant Projects

PROJECT NAME	ROLE	RELEVANCE
New york Metro	Engineering manager	XXXX
VAL Orly/Toulouse	Project manager	XXXX

E. Current Project Involvement

PROJECT NAME	LOCATION	ROLE	COMPLETION DATE
Citadis istanbul	istanbul	project management	12/2011



Tony Sanchez – project technical Manager - Alstom

Current activity:

With Alstom April 2005 to present:

Mr. Sanchez is currently the Engineering Director for the Rochester Rolling Stock group. His is responsible for the overall management, control and performance of the engineering department. His role includes all activities related to design, system qualification and engineering support to other departments such as sourcing, production, quality etc., resource management and budget/schedule performance on all RS engineering projects. Projects include Metros, Locos, Bi-level Coaches and Single Level Coaches. Mr. Sanchez joined Alstom in 2005 as a Project Engineering Manager for the R160 NYCT project.

Previous to Alstom:

Siemens Transportation Systems Inc. – Sacramento CA, 2000 – 2005: Engineering Project Manager for Houston, San Diego and Charlotte S70 LRV projects as well as system engineer for various LRV projects with an emphasis on systems integration of rail vehicle on-board systems.

Union Carriage and Wagon Co, Nigel South Africa 1994 – 2000: Electrical Design Engineer. Responsible for all aspects of electrical and electronic design for local and international rail projects (locomotives, electrical multiple units, metro cars and coaches).

Other Experience:

Mr. Sanchez worked as Electrical engineer on various South African Coal and Gold mines after graduating in 1989 to 1994, where he was involved in various activities from new projects involving high voltage power distribution and protection to maintenance of the electrical equipment.

The ALSTOM logo is displayed in white, uppercase letters on a dark grey background. The logo is positioned on the left side of a horizontal bar that spans the width of the page. The bar has a white, curved shape on its left end, creating a stylized graphic element.

Annex 1 - iv-A Technical Submission Requirements



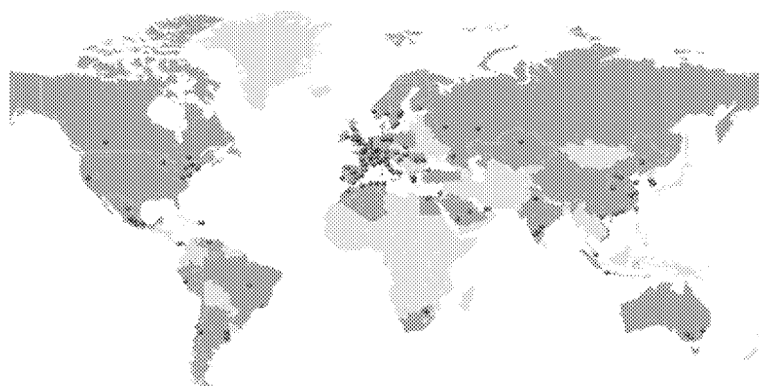
OTTAWA LRT VEHICLE AND TRAIN CONTROL PREQUALIFICATION

SECTION 5.4

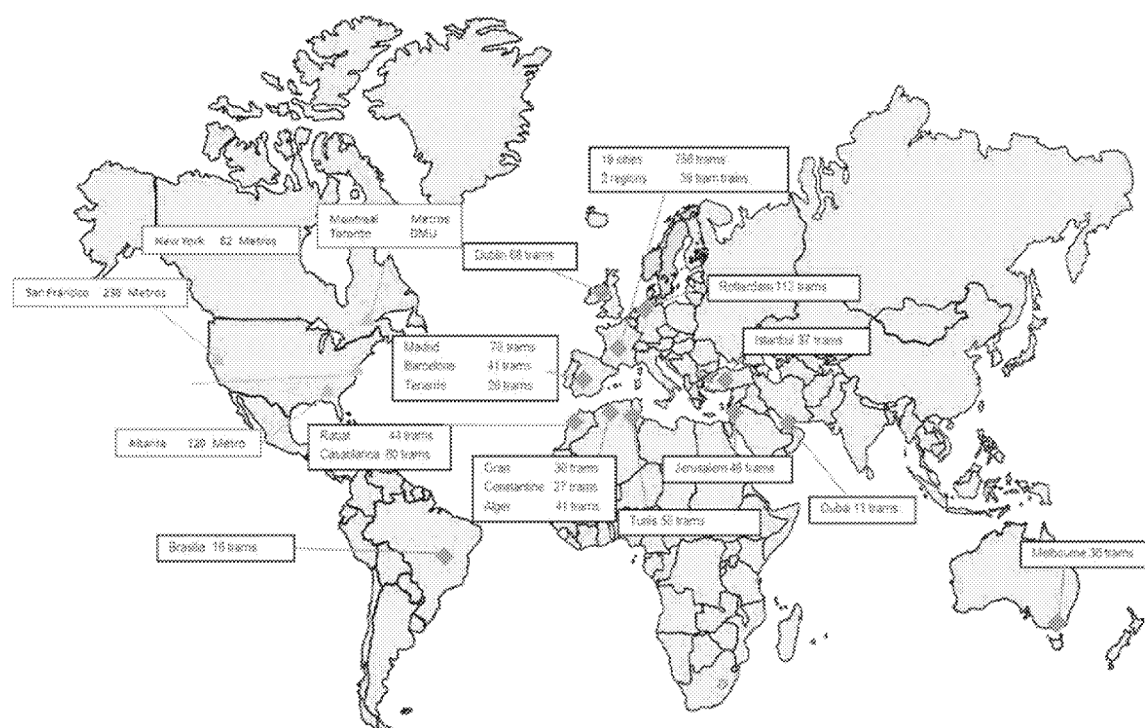
INTRODUCTION

Alstom Transport is a supplier of railway equipment and services of worldwide scope and renown, offering a wide range of products and facilities fully capable of meeting customer's specific product and project needs.

ALSTOM TRANSPORT achieves customer excellence through a global presence with Centers of Excellence and satellite Operational and Maintenance facilities to design, develop, manufacture and project manage all aspects of a new projects or developments.



This geographical diversity has contributed to the successful delivery of Tramway projects over the last 25 years. During this period, Alstom has developed a wide range of Tramways which have been build and delivered to more than 40 cities in 12 different countries throughout the world. To date, over 1500 "CITADIS" have been manufactured by ALSTOM TRANSPORT.





The Proponent shall address the Vehicle and Train Control design at an appropriate level of detail, as set out in or otherwise referenced in Schedule 15-2 of the Project Agreement, and is to include the following:

Light Rail Vehicles

A. An acceptable strategy to meet the Canadian Content Policy, including:

Proponents must certify that the Vehicles proposed in their Proposals meet the requirements of the Canadian Content Policy, including the required twenty-five percent (25%) Canadian content requirement for the Vehicles.

Proponents must also expressly provide their consent to the disclosure, verification and audit of the information forming the basis of their certification, during the evaluation stage, and any other steps taken before Commercial Close and, for the Successful Proponent and Vehicle manufacturer, during and after the term of the Project Agreement.

Proponents must demonstrate that the overall Canadian content of the transit vehicles proposed meets the minimum of 25% threshold, calculated as a percentage of the total final costs to the manufacturer, less applicable taxes. Proponents are required to provide sufficient information to demonstrate their compliance with the Canadian Content Policy. In particular, Proponents must address and provide information about expenditures for eligible costs in respect of transit vehicles for the following items and which are directly related to the transit vehicle manufacturing process, distribution and acquisition, including:

- Labour
- Sub-components and components:
- Project management
- Engineering
- Manual
- Special tools
- Test equipment
- Freights; and
- Warranty.

1 – LOCAL CONTENT

ALSTOM confirms compliance to the minimum 25% local content required by this contract through the current footprint in North America and more specifically in Canada.

Local resources

The map below shows the multi-specialized facilities in North America and Canada. Over 2000 employees are based in Canada, of which 460 work on railway equipment,



The major centers are:

Alstom Transport Information Solutions in Montreal:

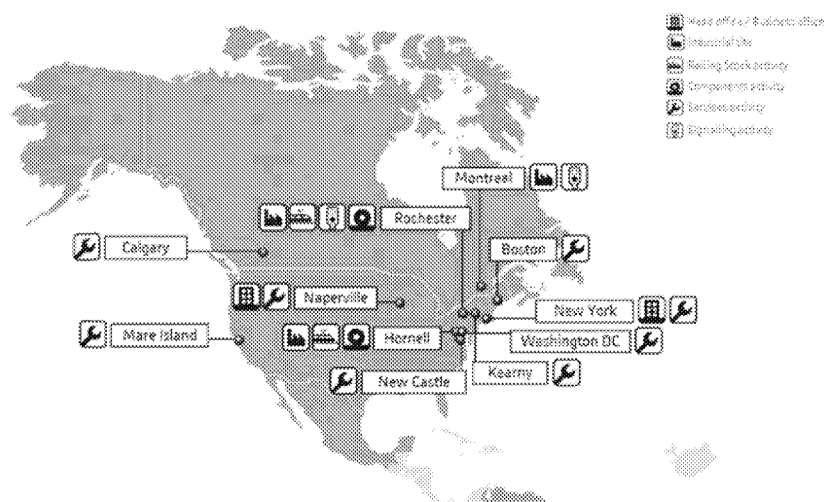
This site is Alstom Center of Excellence for Passenger Information Systems, Security systems for both onboard and wayside. Activities include the software and hardware design, development, manufacturing, commissioning, product training and after-sales services.

This site also deploys and delivers to North American customer the ICONIS™ ATS and SCADA (Integrated Control Center) solution. The site has over 50 active projects across 17 countries.

Railway maintenance center in Montreal and a Trucks manufacturing facilities in Sorel-Tracy:

Alstom was awarded by the STM (Société de Transport de Montreal) a \$1.2 B CAD contract in consortium with Bombardier for the manufacturing of 465 metro cars. This project has a Canadian content requirement of 65%.

In order to meet its share of contribution to this Canadian content, ALSTOM has transferred the entire procurement, assembly and production of the Trucks from the Center of Excellence in Le Creusot, France to a new industrial facility within the existing ALSTOM industrial site in Sorel-Tracy, Quebec. A total of 62 (minimum) new employees will be employed starting July 2012. The capacity at the new facility is planned such that the production can be increase and if necessary doubled. This site is currently forecasted to have a load until year 2020 and is part of Alstom's strategy to cater to other potential contract in North America.



Local Sourcing

At the present time, we are already working with Canadian suppliers or with other qualified suppliers working through joint ventures or as subsidiary to Canadian companies.

Example of potential key railway suppliers:

Passenger doors: VAPOR

Brakes: Faiveley

Internal appointments: CEIT



Final assembly

The train will be fully validated and certified in our Center of Excellence in Hornell, New York. As part of Alstom industrial process, a Transfer of Technology is planned to ensure that sub-components and train assembly are performed in Canadian production sites.

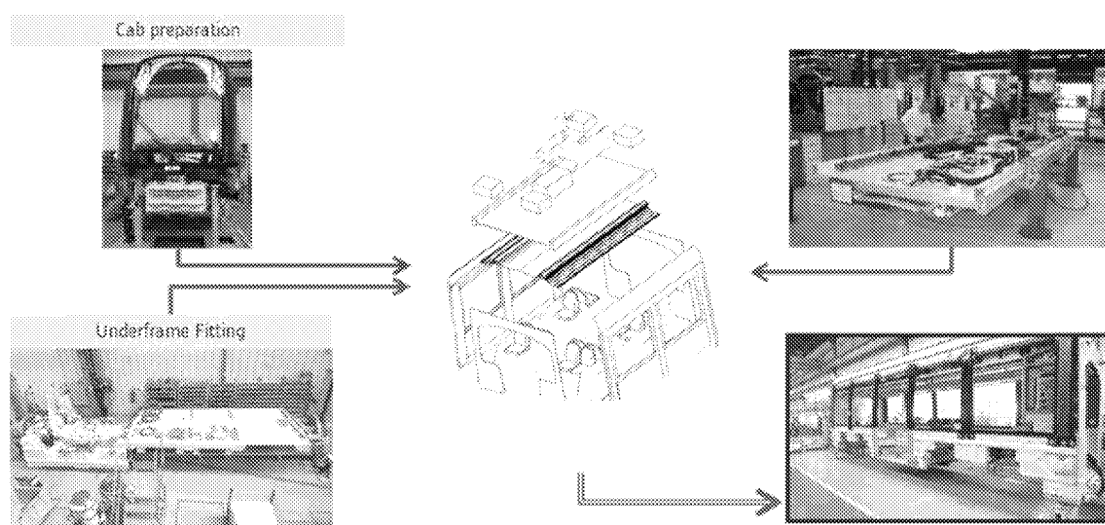
Alstom transport has 12 rolling stock manufacturing units in Europe, North and South America and Asia. All of them are similarly organized uses a production system taking into account World Class Manufacturing (WCM) principles and tools, called APSYS (Alstom Production SYStem)



This approach and process has been successfully executed by ALSTOM TRANSPORT on major projects as show below:

Equipment	Location	Year	Number of units
High Speed Train	Korea	1994	34*20 carriages
Subway	Melbourne	2001	58*3 carriages
Tram Madrid	Spain	2005	70*3 carriages
Locomotives	China	2007	500 carriages
Tram Istanbul	Poland	2009	35*6 carriages
Trucks Montreal	Canada	2012	465 cars * 2 Trucks

The modularity of the CITADIS product line significantly simplifies the Transfer of Technology. The transfer of modules to local suppliers and the production and final assemblies of these modules can readily be carried out without difficulty in the Canadian shops specifically fitted out



Likewise, ALSTOM TRANSPORT ensures commissioning and follow-up of warranty through the Canadian teams.

Based on past experience, a typical local content breakdown is illustrated below:

item	% item / Total	% Localisation	LOCAL CONTENT
Labour	7%	100%	7%
Sub-components and components:	64%	20%	13%
Project management	7%	25%	2%
Engineering	15%	5%	1%
Manual	0%	0%	0%
Special tools	1%	0%	0%
Test equipment	2%	75%	1%
Freights	1%	100%	1%
Warranty	4%	100%	4%
TOTAL	100%		28%

The breakdown indicated in this table is a typical breakdown and is provided for information purpose only.

If Proponents have additional items which they feel should be taken into account in the evaluation of their compliance with the Canadian Content Policy, they are required to itemized those particular items and indicate how they factor into the Proponent's compliance with the Canadian Content Policy.

Recent Canadian experiences:

STM Control Center Contract:

Contract was awarded to ALSTOM TRANSPORT in 2003. A deployment center was created in Montreal in 2004. All adaptation to standard ICONIS platform, application software, testing and commissions, project management, procurement, and Quality control were executed by a local team and supported by an expert team expatriated from St. Ouen, France. The local team in Montreal grew to over 100 professionals (Engineers, Technicians, Software developers, etc.) and currently has 80 professionals actively involved in ICONIS project activities and development.

STM Metro – MPM-10 Contract:

Contract was awarded to the Bombardier Transport and ALSTOM Transport consortium in 2010. The contract has a 65% Canadian content to which ALSTOM will be supplying critical systems such as Automatic Train Control (ATS), Trucks, Traction, Braking System, Passenger Information System, and On-Board Security/surveillance System.

In addition to the existing installations and facilities in Canada, Alstom is opening a new facility within the Sorel-Tracy industrial complex for the manufacturing and assembly of Trucks. This Transfer of Technology ensures compliancy to a minimum of 30% Canadian content of the above sub-systems,

A list of proposed sub-suppliers for all major LRV systems;

List of leading potential suppliers for LRT OTTAWA
(in blue for suppliers located in Canada)

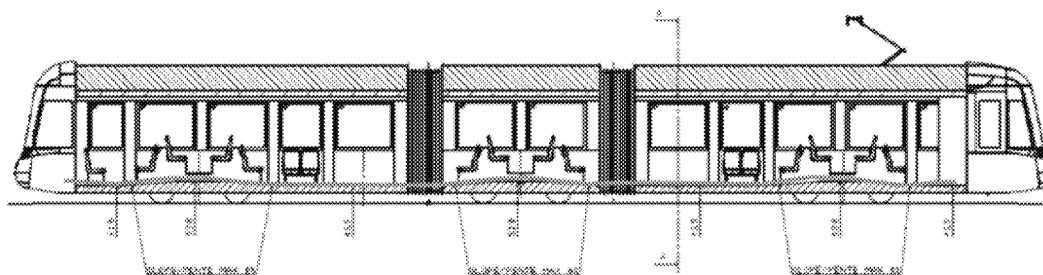
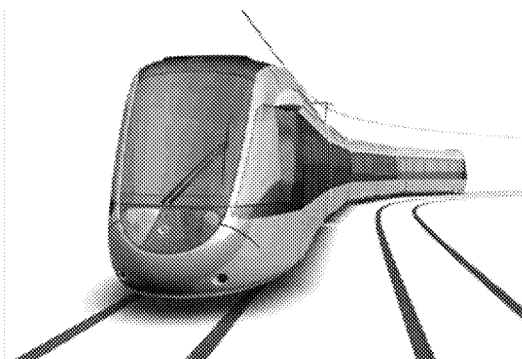
ITEM	SUPPLIER
BATTERIE	SAFT
CVS	ABB / TRANSTECHNIK GMBH & CO. KG
BRAKE	KNORR (Kingston CAN) / FAIVELEY
WINDOWS	DIAZ / PRELCO
WINDSHIELD	ST GOBAIN / PRELCO
HVAC	FAIVELEY / THERMOKING / VAPOR Stone (Plattsburg (US) & (CAN)
DOORS	VAPOR Stone (US & CAN) / IFE (Westminster (US) or KB Kingston (CAN) tbc) / FAIVELEY
PANTOGRAPH	FAIVELEY (Greenville SC (US)) / SCHUNK
CUBICLES	SANMINA-CONVERTEAM
CAB STRUCTURE	ZTS / FABSPEC
ROOF STRUCT	W GESSMANN GMBH
RETROVISION	FAIVELEY
AIR PRODUCTION	DURR GMBH & CO KG/ FAIVELEY
COUPLEURS	FAIVELEY / DELLNER
CABLES	NEXANS / OMERIN
INTERIOR GARNISHING	CEIT / KN
LINE INDUCTOR	TRANSRAIL B&V / IEC HOLDEN
BOGIE	ALSTOM LE CREUSOT
TRACTION	ALSTOM SESTO
TCMS	ALSTOM VILLEURBANNE
PA/PIS	ALSTOM MONTREAL
ALUMINIUM PROFILE	SAPA - ALCAN
SEATS	KIEL (US) / SAIRA (CAN & NY)

The type of LRV proposed (general arrangement, performance level, etc.);

3 – DESCRIPTION OF PRODUCTION PROPOSED

To meet widespread requirements requested by the industry, an innovative product line termed CITADIS DUALIS - a variant of the CITADIS product range was created by ALSTOM. Just like the CITADIS tramway, the interior and exterior design is adaptable to customer specifications and its modularity allows, train formation consisting of 3, 4 or 5 bodies and used in multiple units.

Capable of running on 750V, 25 kV or 1500 V power, the Citadis Dualis is compatible with both a regional or urban network. Equipped with a high power but compact motor, it integrates a « dropped floor » design and ensures a commercial service speed of 100 km/h.



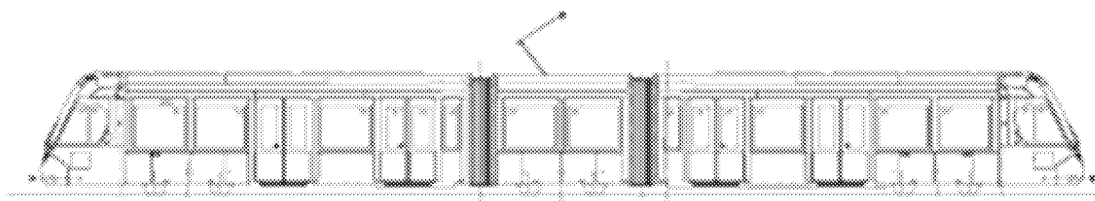
Compliant with EN 15227 crash standards, it has SNCF homologation and has been running in commercial service on the Nantes-Clisson (France) since June 2010.



In the framework of the OTTAWA contract, the CITADIS DUALIS train consisting of 3 carriages is proposed.

Composition of train:

The train will consist of 3 carriages 30 meters long and 2.65 m wide equipped with a 100% low floor.



It can be proposed either in the dual or single cabin version, running in multiple 5-train units.

The capacity of the train will be about 200 passengers under AW2 conditions (4 passengers / m²).

The dimensions of the vehicle comply with tables 4-3.1 and 4-3.2 of the RFP. The maximum weight of the train under AW0 conditions is 47 tons and 71 tons under AW4 conditions calculated on the basis of a mean weight of 70 kg per passenger. The weight distribution of the train complies with chap. 3.8 of the RFP.

The traction/braking performance of the vehicle complies with table 4-3.4 of the RFP, particularly with respect to:

Commercial speed : 100 km/h
Acceleration : 1.34m/s² under AW2 conditions

Overall, the train is designed to provide 100,000 kilometers of commercial service per year when supported by optimized maintenance, for a period of 30 years

Noise performance :

The train complies with requirements on emission of noise and in particular the following

Parked:

- 68 dBA inside the train
- 70 dBA outside the train, at a distance of 20 meters.

Running at a speed of 100 km/h:

- 78 dBA inside the train
- 80 dBA outside the train, at a distance of 20 meters.

EMC performance:

The train complies with standards governing EMC.

Fire-Smoke hazard standards

The train complies globally with standards NFPA 130, 49 CFR part 238 and BSS 7239. The floor and ceiling are designed in compliance with standards ASTM E119, NFPA 130 and 49 CFR part 238.

Environmental requirements:

The train is compatible with the environmental requirements stipulated in the contract ingress of water indicated in paragraph 3.4

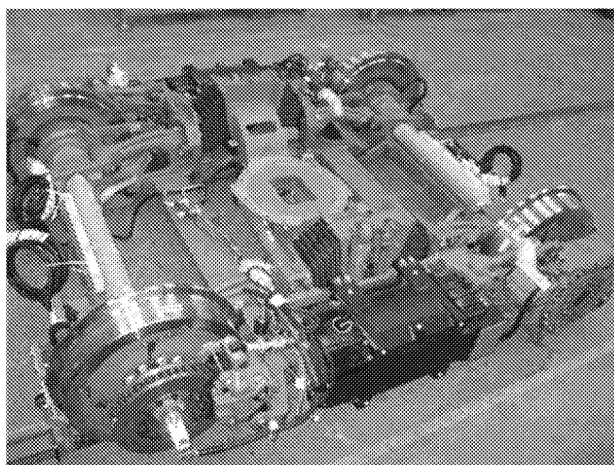
Interfaces with the environment:

The vehicle shall be compatible with the different interfaces (tunnels, traction power, Train control, signalization, SIV, other equipment present in the depot)

Operation in Multiple units:

Each end of the train is equipped with an automatic and foldable coupler to accomplish the coupling and uncoupling operations needed to form a multiple unit convoy

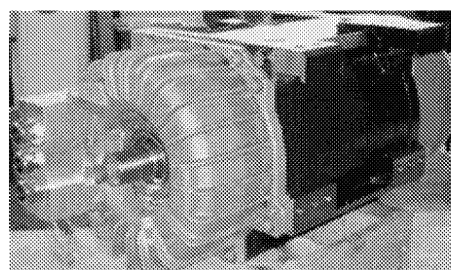
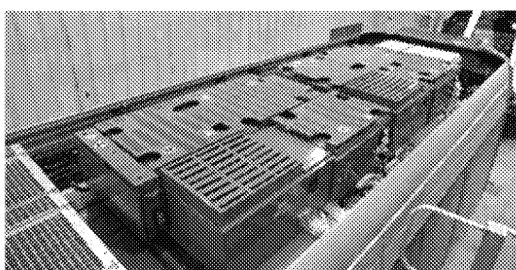
Trucks:



Each carriage will be equipped with a truck: a power truck for the end carriages and a trailer truck for the central carriage. Each axle of each truck is equipped with an independent disk brake. An automatic leveling system will maintain the level of the floor of the carriage constant with relation to that of the platform.

Traction:

Each power Truck is equipped with 2 independent axles moved by a synchronous electric motor with a permanent magnet (PMM) controlled by a traction box mounted on the roof.



Current collection & Auxiliaries :

A current collection system by pantograph supplies the train with power at 1500 volts for the traction drive and a auxiliary converter that in turn supplies the air conditioning system, the compressor, low truck voltage network and the battery charger. The train is equipped with 2 independent battery boxes.

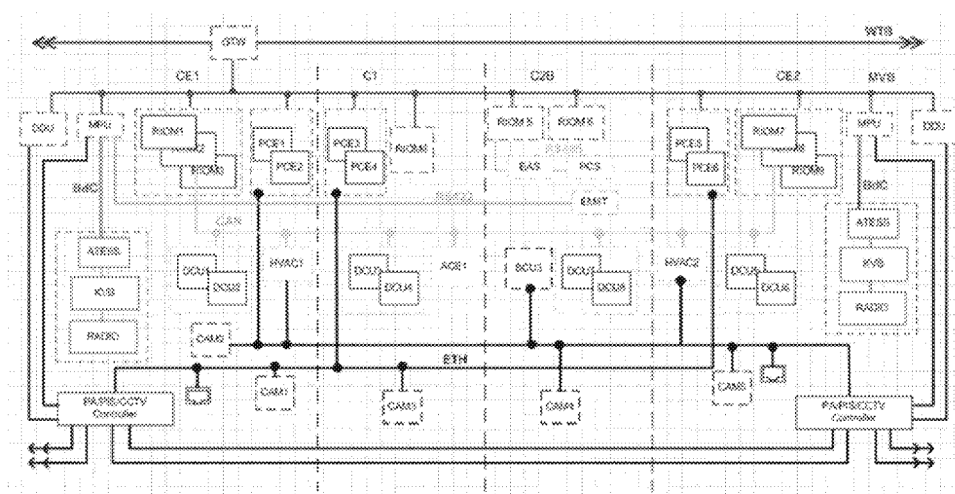
Train Control & Monitoring System (TCMS):

The Train Control and Monitoring system (TCMS) aims to process a maximum of functions. The TCMS is the combination of hard wired logic and data processing. The TCMS software is developed according to the SIL 0 level defined EN50128 using an internal development platform and a dedicated programming language based on standardized programming language for industrial automation.

Hard-wired logic will therefore be maintained for safety circuits, function that needs high availability (mainly for degraded mode), simple function (i.e: windscreen washing), or power circuits.

The TCMS interfaces a large number of sub-system, such as Brake, HVAC, Traction, PACIS, Recorder, Auxiliaries and many others through different networks such as MVB, CAN or Ethernet networks.

The architecture of the TCMS consists of 2 redundant MPU (Main Processor Unit), 2 Driver display units, several Remote Input/Output Module (riom) and WTB gateways. The RIOM interfaces Low voltage logic and acts as gateway for CAN or RS485 networks. The MPUs and DDUs are also connected to an Ethernet Network used for maintenance purposes and PACIS function.



TCMS architecture of a Citadis Dualis

The MPUs centralizes the default and events at train levels, based on data send by sub-system control units or monitoring data computed by the MPU software. These data are used to display train status to the driver and assistance for driving. Maintenance Data are also stored in FIFO memory. It can be displayed for maintenance purposes on dedicated DDU pages and can be locally or remotely retrieved. The maintenance data aims to identify the LRU in default, as detailed defaults are available locally on each subsystem.

Passenger doors:

The train is equipped on each side with 4 bi-parting sliding plug powered per train face. There is also an obstacle detection system to ensure passenger safety, a tried and proven control panel system controls door closing and opening in accordance with the protocol described in the specification. Door lock-out systems enable the door to be isolated in complete safety whilst keeping the remainder of train in service. The train is also equipped with internal lock release systems to enable doors to be opened in the event of an emergency in complete safety. Each door will also be equipped with a pushbutton to enable the passenger to open the door manually.

Intercar gangway:

An intercar gangway is installed between each car offering a 1.2-meter wide passage via a double row of bellows. The floor and roof in the gangway are designed to accommodate the relative movement of parts when passing through curved track sections.

Heating and air conditioning system:

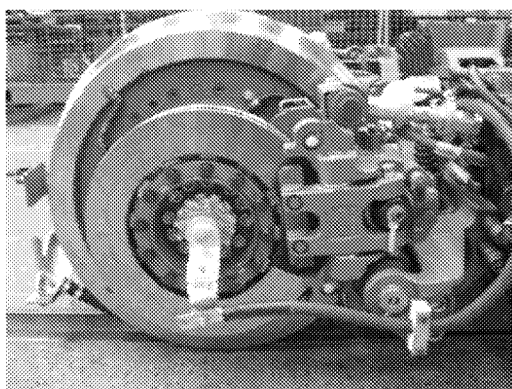
The heating and air conditioning system comprises 2 units mounted on the roof on the end cars, together with a heating system and ducts fitted into the carbody, providing a temperature of 19 to 22°C inside the car regardless of the external climatic conditions in ASHRAE. It is endowed with a control system enabling the temperature inside the train to be adjusted and kept constant to within plus or minus 2°C around the level selected.

A separate independent system will be installed above the driving cab to ensure the comfort of the driver.

Braking system:

The braking system appropriately combines mechanical and electric braking systems for the different braking scenarios through a tried and proven electronic control system. All the bogeys are equipped with a hydraulic braking system, a mechanical parking brake and a magnetic track brake.

Operating in conjunction with the disk brake system, a sanding box and wheelslide prevention system are installed on the train.



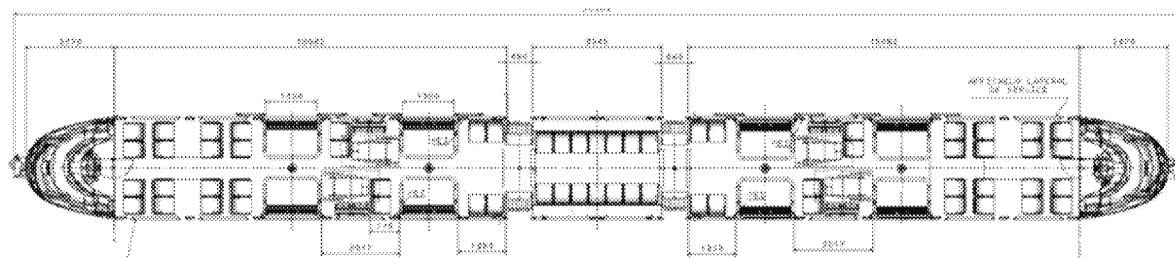
The outer faces are straight and endowed with upper and lower trimming insignia making for a harmonious appearance. The design proposed for the ends of the train will be contemporary whilst at the same time complying with applicable crash requirements. The carbody shell is in steel / aluminum or FRP and is designed for an expected service life of 40 years. The vehicle is insulated in order to comply with the stipulations of the specification within a temperature gradient around the temperature selected, for conditions of performance down to an external temperature of -25°C . It is dimensioned to meet the requirements indicated in tables 4-3.6. and 4-3.7 (compression, static load in either direction, coupling at different speeds).

A combination of lateral, longitudinal and flip seats will enable passengers to move about inside the train, particularly during rush hour periods. The train will be provided with 4 clear areas equipped with flip seats to provide access for wheelchairs, prams and bikes...Holding bars will run along the full length of the train to enable the passengers to stand in a safe and stable position. The inside of the vehicle is designed to be covered adhesive film. An LED lighting system will be built into the ceiling to enable lighting zones to comply with the different scenarios indicated in the Request for Tender.

Wide dark-tinted window bays provide natural lighting inside the train.

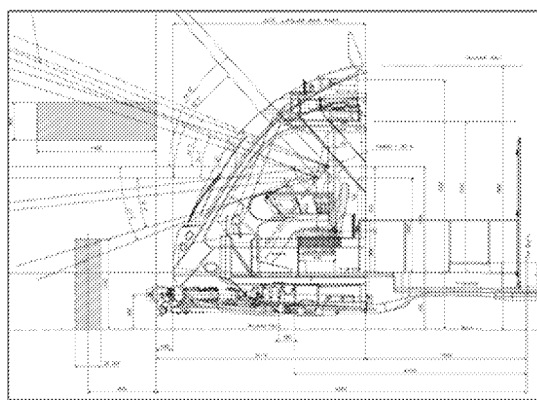
Destination display panels will be situated on the front and on each side of the train.

The side faces will enable messages concerning information and safety of the passengers to be displayed.



Cab equipment:

Rules of ergonomic practice have been adopted in designing the cab (lighting, angle of visibility cone, accessibility of controls, heated driver's seat) together with the applicable standards (dimensions of side windows and windscreen). The cab is separated from the passenger compartment by a partially glazed partition and fitted with a lockable door. It is installed with all the necessary equipment for driving the train in full safety (windscreen wipers, lights, klaxons...). A mock-up constructed during the design phase shall enable the different aesthetic, ergonomic and functional aspects of the driving cab space to be validated. The driver has at his disposal several screens, including a rear-view screen displaying the sides of the train when in a station and on track thanks to video cameras. The driver's desk shall include all the necessary equipment to enable the driver to communicate with the operating system or passengers.



Ergonomic study for SNCF

Technical documentation:

The following is a list of the principal documents which shall be provided to the customer:

- The train technical file
- The homologation and security folder
- The maintenance folder
- The train validation plan (traction, braking, air conditioning/heating, noise abatement, EMC, carbody shell ...)
- Report on conformity with fire-smoke standards
- Report on routine series tests for each train

Aesthetic design of train:

The Design & Styling Department of Alstom Transport provides assistance in finalizing the internal and external design of the train to meet the desires of the end customer.



Performance, reliability and safety of the proposed vehicle in similar climatic conditions;

AVAILABILITY PERFORMANCES

CITADIS DUALIS has been designed in such a way that it allows quick replacement of defective parts. Under the French SNCF operating conditions, this design allows us to ensure a high level of availability equivalent to those specified in the RFP (99, 99%).

Similar Process will be used for Ottawa LRT project

SAFETY PERFORMANCES

The safety holds an central place within ALSTOM Transport. A dedicated organization is in charge of this activity structured in network within Alstom share best practices. A project safety Assurance Manager is appointed for every project. Fire and smoke specialists provide support to the Project Team.

The ALSTOM's commitment is to supply a reliable and safe rolling stock. The development and manufacturing of the CITADIS DUALIS are based on the European standards:

- EN50126 "specification and demonstration of the reliability, the availability, the maintainability and the safety (RAMS)"
- EN50128 "Communication, signalling and processing system – software for railway control and protection systems"
- EN50129 "Communication, signalling and processing system – safety related electronic systems for signalling"

This section shows typical levels of security for key equipment on the existing CITADIS DUALIS:

- Non-compliance with the performance of an emergency braking CITADIS DUALIS (4 cars) in a single unit at maximal load activated at 100 km /h and 1.5 m / s^2 is $<10^{-7} / \text{h}$
- Inadvertent opening of a door of a passenger CITADIS DUALIS (4 doors per side) in a single unit is $<10^{-9} / \text{h}$
- Inadvertent de-coupling between CITADIS DUALIS trains in multiple units without activating an emergency braking is $<10^{-9} / \text{h}$
- No release of the emergency brake and safety device (command + execution) $<10^{-9} / \text{h}$
- SSIL 2 on traction and passenger access doors software

Those levels will be implemented on the Ottawa LRT, in compliance with the NFPA130 standard, or winterisation requirement. Safety studies are an integral part of development described in Section Design for Quality and are part of Project design reviews deliverables.

RELIABILITY

Aside from Safety, please find below Current Citadis service proven reliability figures

Reminder of the definitions

Amongst all the failures counted, 3 levels should be distinguished for which target values of the failure rates have been defined, namely:

OTTAWA LRT – Vehicle and Train Control Prequalification

January 6th, 2012

All information within this document is the property of ALSTOM Transport.

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Categories	Definition
A	Service failure means that the train cannot continue to maintain business operations or failures that have greater impact on business operations, including : - Rescue: requiring another train to trail the failing train to the depot - Transfer of passengers in another train (not in station)
B	Failure which is not A type and : - Delay > 5 mn - Withdrawal : train set without passengers to return at depot - Exchange of the train set at the beginning of the mission
C	Failure which is not A and B type : - Exchange of the train set at the end of day - Exchange of the train set at the end of round trip - Failure detected in maintenance - ...

The above table does not include failures caused by vandalism, accidents or incorrect manoeuvres by a passenger or operating agent.

Reliability commitments for the CITADIS DUALIS

The following are our reliability commitments for a CITADIS DUALIS :

Final objective:

Categories	FPMK	MDBF (km)
A	1,8	555 555
B	15	66 666
C	300	3 333

These target failure rates correspond to a measurement made on the fleet of vehicles as a whole, on reaching maturity. The failure rates will be determined each month for the fleet of vehicles as a whole.

The failure rate commitments of above table are final objectives, assuming a minimum fleet of CITADIS DUALIS with each vehicle running 110,000 km every year.

These commitments concern the basic vehicles, excluding options and "invited" functions, like PIS, dispatching,

Reliability growth

The following is the reliability growth curve, on the basis of the above assumptions:

Operating phase	Reliability
When the fleet starts commercial service	$5 \lambda_0$
12 months after starting commercial service	$2 \lambda_0$
Between 13th and 24th months after starting commercial service	λ_0

Achievement of objectives

The reliability will be calculated each month with a confidence level

The final reliability commitment for the fleet shall be considered as achieved when the following condition is met:

an $MKBF_{\text{borne sup.}}$ [Measured over a 6 sliding month basis] $\geq MKBF_{\text{commitment}}$
 (or expressed by the failure rate: λ_{inf} [Measured over a 6 sliding month period] $\leq \lambda_{\text{commitment}}$).

Service history of proposed vehicle (agencies used, years in operation, and number of cars);

REX of the existing product

CITADIS product range

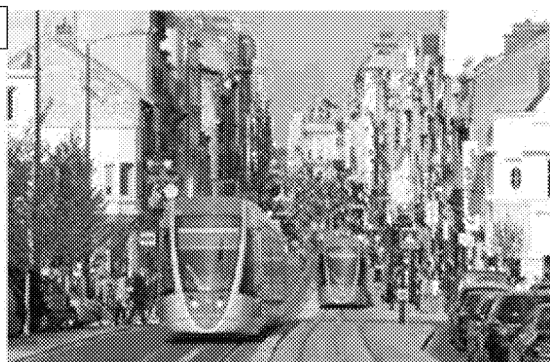
Reims:

This is a turnkey project /PPP project

N° of trains: 18

Commissioning date: October 2010

Tram life service: ALSTOM



Barcelona:

This tramway is a turnkey project

N° of trains: 41

Commissioning date: April 2004



ALSTOM

CITADIS-DUALIS product range

Nantes

N° of trains: 7

Commissioning date: June 2011.

The trains consists of four 25 kV/750 V cars operated by the SNCF.

Additional order of 17 trains currently being manufactured and will be progressively brought into service by end of 2012

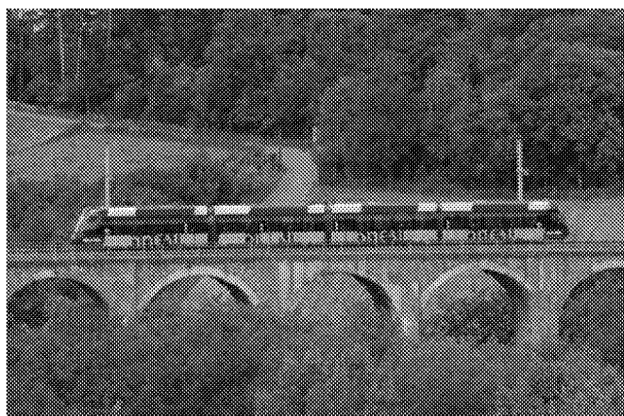


Lyon

N° of trains: 24

Commissioning date: May 2012

CITADIS DUALIS 1500 V/ 750 V. Trains are undergoing validation and homologation in the Lyons region (France).

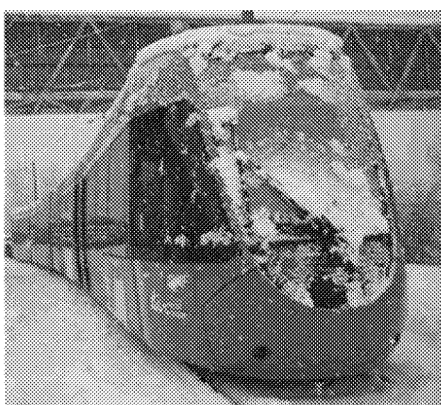


Redesigns/modifications/variances intended for the Project application of the proposed vehicle; and

WINTERISATION

Adaptation of the present CITADIS DUALIS range

As already pointed out, the CITADIS DUALIS range is already designed for commercial service at a temperature of -25°C (standard EN 50125-1).



CITADIS DUALIS during traction test

Backed by our experience on regional trains in Sweden and Finland and our partnership with Transmasholding for Russian and Kazakh trains, the Citadis Dualis product will be specifically adapted to take into account the climatic requirements of OTTAWA (very low temperature, snow and ice). In order to guarantee the performance requirements specified some adaptations will be implemented as follow:

Most of the adaptations involve the following:

- protection of the electronic equipment
- replacement of certain materials (steel, joints,...)
- reinforcement of the insulation and the draining
- heating of certain articles sensitive to dew points condensation such as nozzles, pneumatic circuit pipes, threshold...

The full winterization analysis of the Citadis product range has already been performed by our engineers as several offers have been realized, elected and under contract negotiations for St-Petersbourg and Kazakstan where similar or more stringent climatic requirement are specified.

Successful winterisation experience: Winterization of the CORADIA Duplex range

As an example, in 2000, winterisation works was carried out similar on our Coradia Duplex range of trains (TER 2Nng => X 40) :

- TER2Nng operating in France (climate requirements of EN50125-1)
- winterised X40 operating in Sweden (climate requirements of up to -40° C)

The technical adaptations are similar to those planned for winterizing the CITADIS DUALIS (heating, insulation, drainage, etc.) with the addition of a "workshop plugs" to:

- maintain the trains ready for commercial service in case of absence of catenary voltage.
- progressively heat up the train following extended parking time at very low temperature.

The Coradia X40 trains are also fitted with devices that automatically close the circuit breaker following disappearance/re-appearance of the catenary voltage. These devices enabled us to guarantee quick operability of the train and to attain the contractual requirements for availability and reliability in commercial service. In fact, the progressive temperature rise and/or the temperature hold of the equipment allow the use of standard proven equipment and also make it possible to avoid "stress" that could shorten their standard service life. As to the bogies, passageways and inter-carbody links (cables and pipes), a de-icing/snow removal procedure makes it possible to ensure service under the best conditions, with the frequency adapted to the climatic conditions. On Coradia X40, it included two devices:

- spraying of the bogie to remove ice and snow (on the exterior)
- blowing of hot air on the entire train (in the depot)

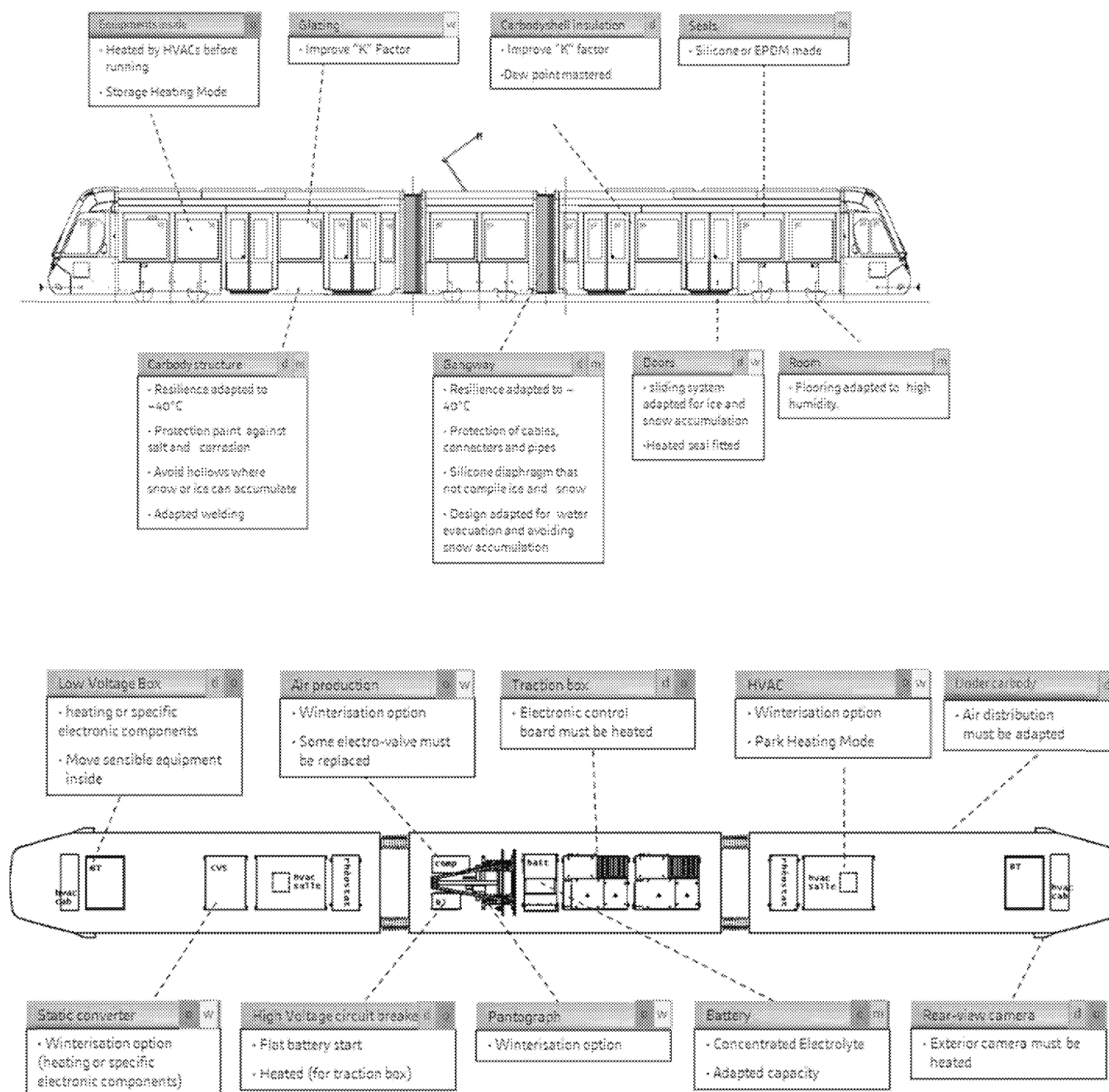
Winterisation of the Coradia duplex was perfectly executed within the contractual schedule and fully met the required performance criteria.

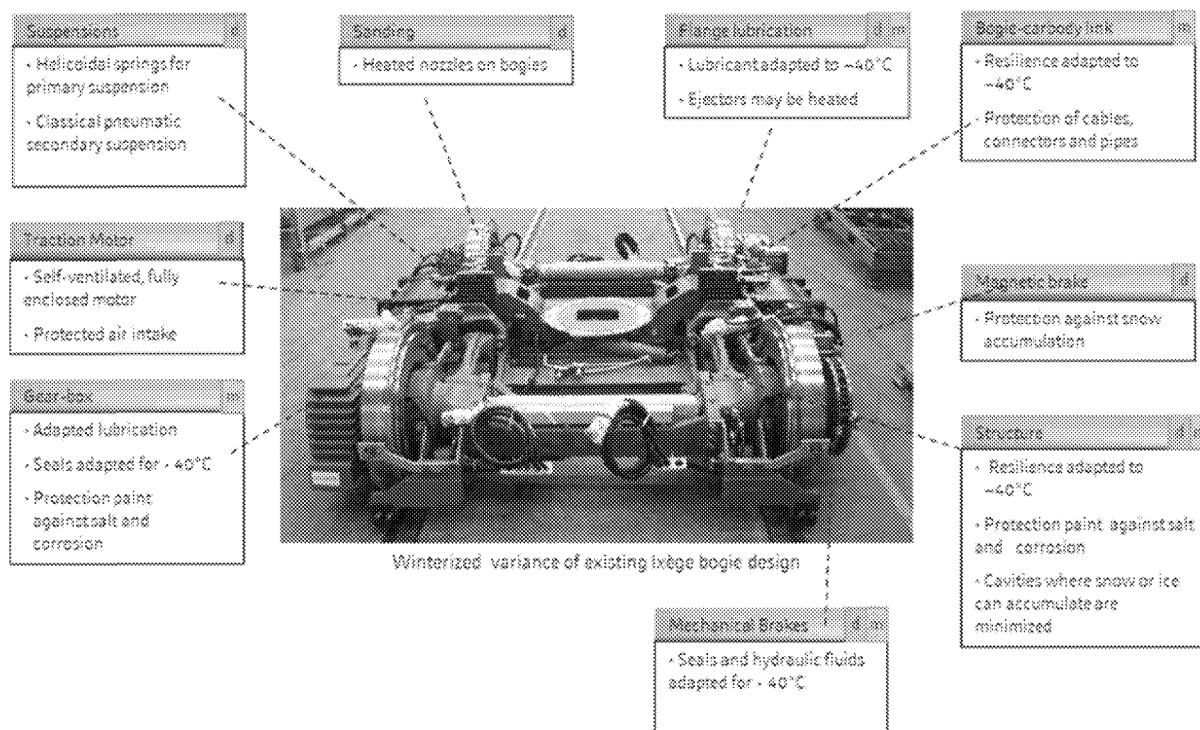
Description of adaptations planned for the current CITADIS DUALIS range:

Please find enclosed the detail of the adaptations analysed and required for the Ottawa project under the climatic conditions stipulated and performance requirements.

The colour codification shown in the schematics corresponds to the adaptations described hereunder:

- | | |
|---|---|
|  | "Design" – Adjustment of the sub-assembly design as a function of winterisation adaptations |
|  | "Operational" - Prerequisites of operating conditions |
|  | "Winterisation option" - option already included in the supplier range |
|  | "Material" – Change or reinforcement of material subjected to T° constraints |





All of the modifications described above do not form major challenges for Alstom and remain within the normal course of customisation adaptations required on our proven and standard products within the specific context of each project.

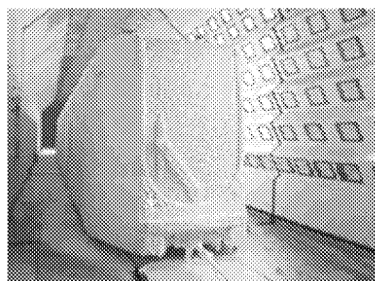
These technical arrangements, associated with the adapted operational provisions (storage, pre-heating) agreed upon beforehand, will guarantee commercial service at up to -38°C and will not impact train performance, as required by Ottawa. However, the provisions that are finally retained by Alstom, within the OTTAWA framework, will depend on the train operation and storage conditions specified by the operator.

Validation of adaptations required by winterisation:

For upstream validation of all the adaptations implemented within the scope of CITADIS DUALIS winterisation, a specific plan for component or train level validation will be set up in laboratories and/or on the track.

Climatic tests can be performed in several locations depending on the required test :

- Up to -25°C in La Rochelle ,FR
- Up to -30°C in Hornell, NY or in Ottawa, ON -38°C .
- Up to -40°C In Vienna (included a wind chamber)

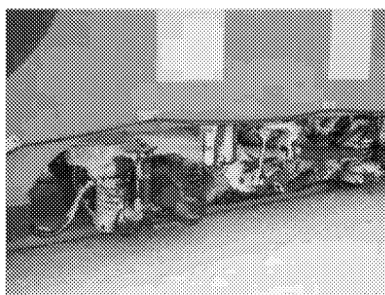


Climatic type test in Vienna

This test is aimed at verifying the static performance levels of the vehicle (heating/air conditioning – temperature distribution inside the vehicle – behaviour of battery/CVS, etc.) in the contractual temperature range mentioned in the contract.

Other type tests at train level will be performed on track. The main verifications to be done are the following:

- stabling or parking in extreme cold
- start up of stabled train during extreme cold (electronics, batteries, pantograph, auxiliary air compressor, braking oil systems, heating of the cab and of passengers compartments ...)
- start up during snowy conditions (pantograph, windshield heating and wiper, ventilation systems ...)
- operation during extreme cold in particular due to icing following the way out of tunnels or depots (pantograph, gangways, traction with ice on catenary, doors, bogies, wheel speed systems, hoses..)
- operation during snowy conditions (air intakes of traction, heating and other systems, pantograph, doors, bogies)



X40 Winter Test in Sweden on Luleå – Ånge line (13 km)

With Regards to the signaling system, all trackside components will be installed in heated central or local technical rooms. The onboard components all operate at down to -40°C.

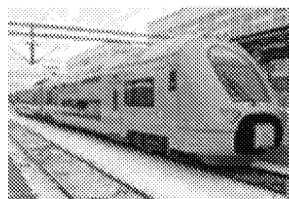
For the track products we propose the proven P80 switch machine which operates at down to -40°C and is installed in Nordic countries. This switch machine can be heated if required.

Please refer to the attached datasheets.

The following section illustrates different trains which have been commissioned and are in commercial service by ALSTOM TRANSPORT for operating conditions similar to those of OTTAWA.

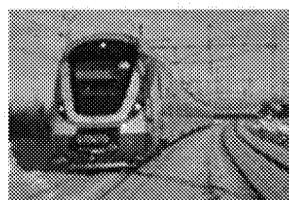
SWEDEN

Coradia Nordic product range type X40
Qty of trains: 43
Commissioning date: October 2004



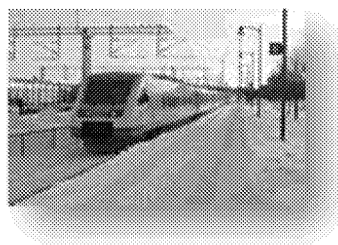
SWEDEN

Coradia Nordic product range type X60
Qty of trains: 71+12
Commissioning date: 71 trains in 2002
12 trains in 2010



FINLAND

Pendolino product range
Qty of trains: 42
Commissioning date: 2002



ADA/ADOA adaptation

Specific NAM standards fit verification will be worked out on the Ixége type bogeys.

Regarding ADA, a leveling system already in service in the MP05 METRO and X40, will be reused to ensure a constant distance between the height of the platform and that of the train floor, regardless of the loads in the train. No specific maintenance will be required to this leveling device. Our interior design focuses on facilitating circulation of disabled persons and the overall flows of passengers aboard the train.



Adaptation to NFPA130 / FIRE & SMOKE STANDARDS

The product shall be NFPA-certified. This Certification will be done with the support of North-American Center of Excellence in Hornell, who have already accomplished similar certifications for projects with New York, Chicago or Atlanta.

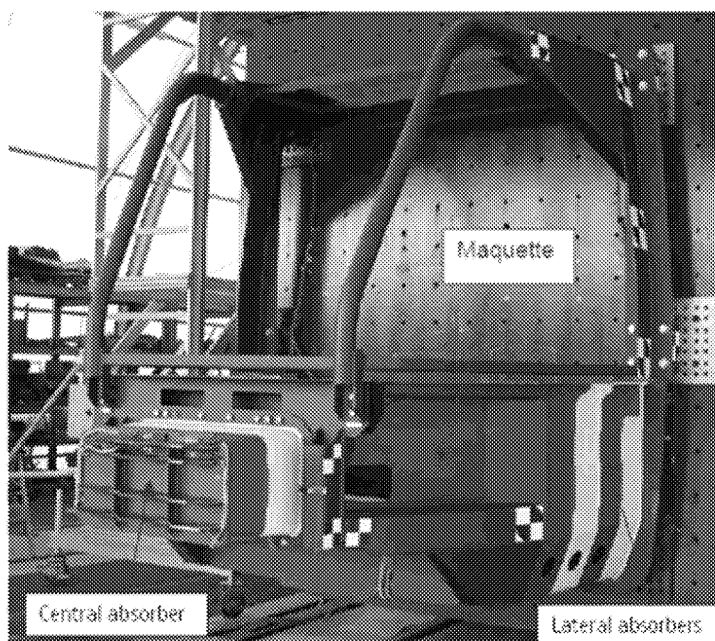
The CITADIS DUALIS product shall be suitably adapted to fully comply with NFPA 130. Minor modifications such as specific wiring assembly rules and material modification will be implemented. These NFPA 130 material adaptations are well known to our supplier base.

Adaptation to ASME

With the current design, the driver's cab and the driver himself are protected via a system anti-crash compliant to the EN 15227. Current CITADIS DUALIS trainset exceeds the crash requirements as defined in the standard EN 15227 C-III.

Although the ASME and EN 15227 are comparable, a complete validation process for OTTAWA LRT will be performed again using calculation note and / or full-scale test.

The design will be done in partnership with Alstom Reichshoffen site (France, Alstom Transport Center of Expertise in for body structure and passive safety. It is equipped with a platform crash test, used for the CITADIS DUALIS cabin in 2009 (see photo below)



Vehicle testing and commissioning schedule and strategy

VALIDATION / ROUTINE TESTS

Control of design

Alstom relies on a proven DFQ (Design for Quality) design validation process which systematically validates and ensures that contract requirements and milestones are fully met and respected.

Design reviews with suppliers, the customer, and internal partners (Truck, traction, signalization, infrastructure ...) take place at regular intervals as each design phase is accomplished.

GO-NO GO project reviews are organized with the full Project core team and platform management to ensure that the project progress matches and complies with the contract milestones.

All the above are embodied in the V-cycle illustrated below.

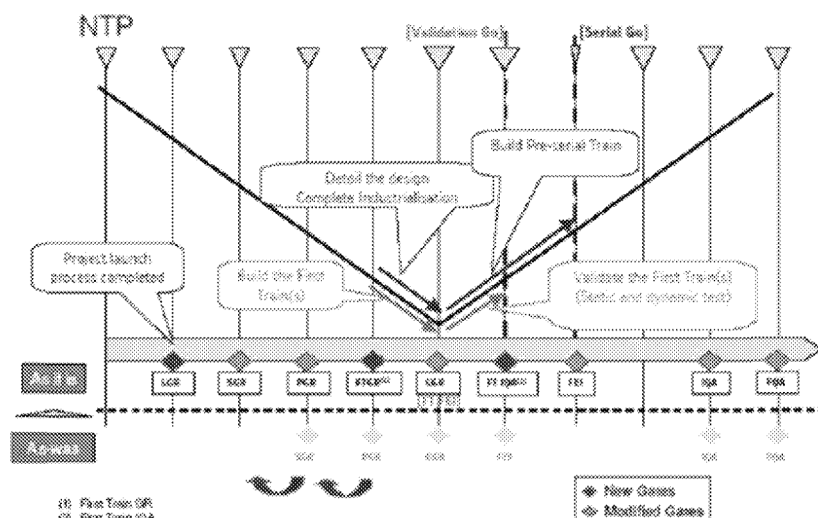


Figure 2 - Jalons GR

Control of purchases

We attach the utmost importance to validating the quality of our outsourced products. To this end, a specific quality process termed SFQ (Sourcing for Quality) is set up and a dedicated person (the SQA) shall stand warrant for compliance of procedure for issuing orders, right up to delivery of the First Article at the site. In particular, the SQA shall ensure compliance with the contracts specifications and quality of the human and material resources applied to ensure quality throughout execution of the order.

Control of industrialization

Control of industrialization is a major parameter for successful transfer of technology to another production site and to provide the customer with the necessary and sustainable quality level.

Accordingly, during manufacture of the first train and with each stage in manufacture of its subassemblies, formal meetings are organized by the PRIM (Industrialization Project Manager) in the workshop with all the entities involved (Design office, Industrialization, logistics, supplier quality, industrial quality, team leader, ...) in order to check that all the parameters have been brought together to ensure high quality series manufacture of the product.

Control of validation

Validation of the train takes place in several stages:

Validation of each individual subassembly:

- Validation of subassembly combines several parameters, depending on the subassembly concerned:
- Material tests in compliance with the applicable standards
- Static, dynamic and endurance performance tests
- Integration tests
- FAI (First Article Inspection) at the supplier's plant

Validation on the train during the pre-testing manufacture phase:

- Validation of manufacture by GO/NO-GO during each key subassembly manufacture stage
- Validation of the electrical circuits

Validation on the train by type tests:

As a general rule, these test are conducted once and once only on the complete manufacturing line, enabling the functional performance of the train to be verified during normal and degraded operation in accordance with the specification, before starting series manufacture :

For example :

- Compliance of the gauge limits under extreme operating conditions
- Compliance with acoustic, EMC , climatic constraints...
- Compliance with traction/ braking performance
- Functional compliance of « guest » equipment (SIV, signalization)...

The location of these tests varies (ALSTOM test tack, customer test rack, external laboratory...)

Validation on the train by routine tests:

As a general rule, these test are carried out on each manufacture item or each train in order to check the functional performance of the train in the normal operating mode :

For example :

- Weighing the train
- Tightness of the train
- Functional tests, doors ...

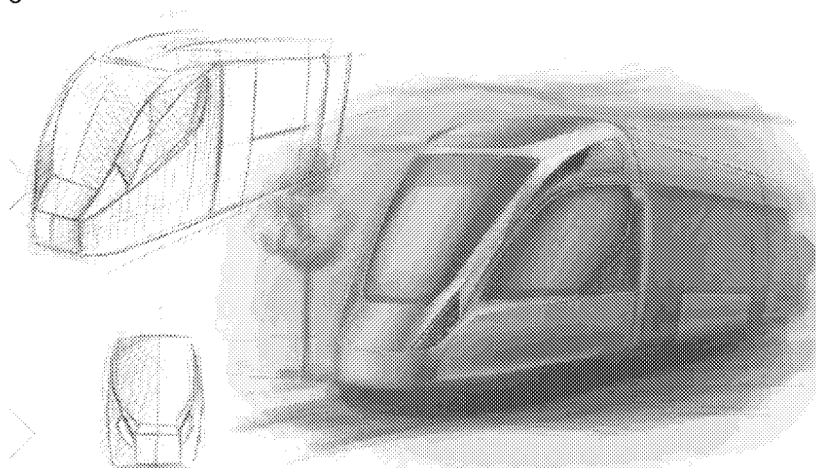
A preliminary plan summarizing equipment's compliancy is presented to the customer during the tendering phase. If the equipment has already been validated against given references/specifications, the test will not be repeated if the test results exist and are made available. If the equipment has already been validated in accordance with an equivalent reference, Alstom will be responsible to demonstrate equivalency and provide the relevant test reports.

ALSTOM TRANSPORT KNOW-HOW

Design for Aesthetic: The Alstom Interactive Design Cell

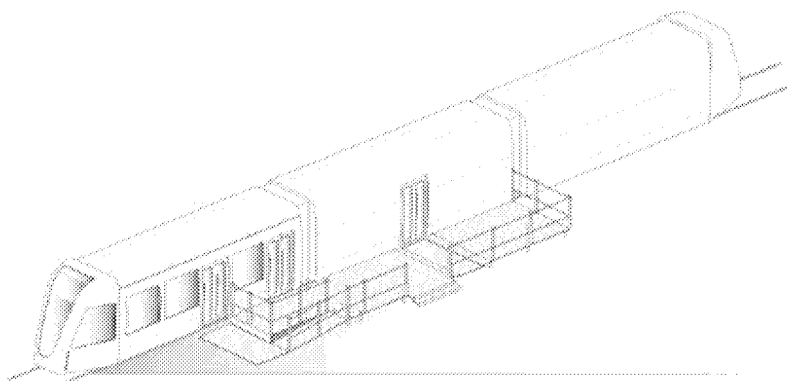
In view of the feedback gained from experience in aesthetic choices in a number of cities for their public transport systems, our Design & Styling department has set up specific cell dedicated to interactive design.

During sketching sessions conducted directly with our Designers, the customer can proceed by successive approaches by successive real-time iterations in order to define the feature, the lines and the physiognomy of what is to become THE CUSTOMER'S personally deigned train.

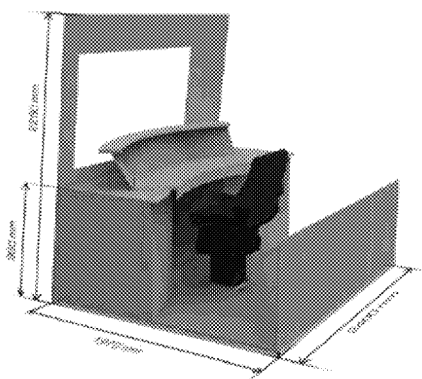


Design Close to the Customer:

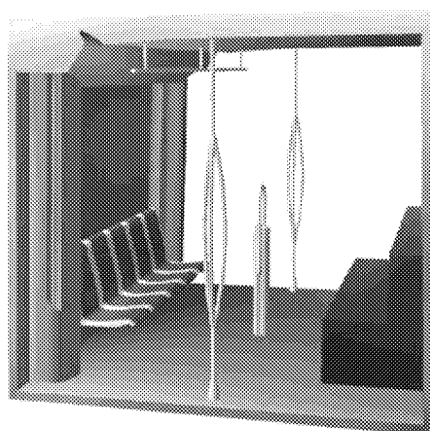
To perfectly match the needs of the customers, the drivers and the passengers, we may execute a number of mock-ups to validate different technical, functional or ergonomic aspects before launching final production of the train.



Mock-up for passengers or authorities



Functional cab mock-up

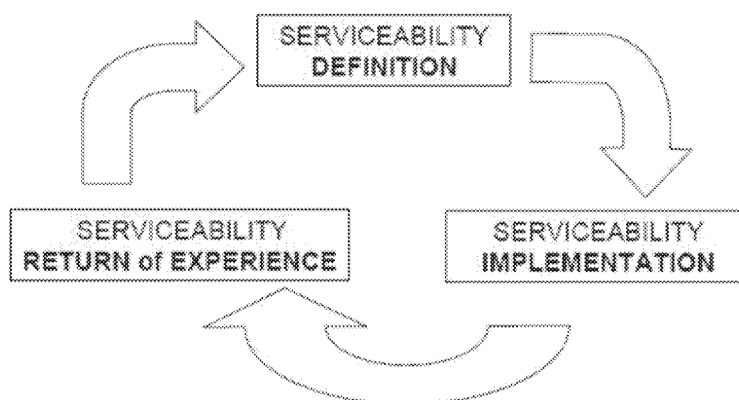


functional passenger area

Design for Serviceability:

In its constant quest to optimize maintenance of its equipment and continuously improve reliability, Alstom Transport includes a TLS (Train Life service) manager in its rolling stock project team right from the beginning of the design phase. This manager will provide his experience gained from existing equipment already in service and ensure optimized

maintenance of the equipment. He will also set the target levels for cost of acquisition of each subassembly throughout the lifetime of the train.



The contemporary and up-to-date design permits the CITADIS DUALIS product to provide an optimized maintenance through:

- Return of experience gained through the CITADIS product range plus further return of experience gained in today's CITADIS-DUALIS products
- « Sensitive » equipment of the Ixége type by locating it outside the bogey unit itself
- Mounting equipment such as air conditioning, batteries, and traction boxes on the roof of the vehicles.

Design for Ecology :

Respect of the environment is a key focal point for the ALSTOM Group. At ALSTOM TRANSPORT, we take care to limit the consumption of the train by applying leading-edge technology and providing our customer with a product featuring a high recyclability ratio.

The CITADIS-DUALIS Product offers the following major advantages:

- Recovery braking
- PMM motors (lower in weight, with better power ratings)
- 94 % recyclability

Train Control

Identification of the proposed train control system, proposed train control system software and hardware including software validation data and a customer reference list.

Proposed train control system

The URBALIS solution is Alstom's standard solution for mass transit CBTC applications.

This URBALIS solution is service proven since 2003, the first application being the successful Singapore NEL.

The URBALIS system is a radio-based CBTC based on a proven moving block principle. The solution is able to perform all ATC, Interlocking, TMS and Maintenance functions required for automatic mass transit rail operation with Train Drivers or for Driverless operation.

The URBALIS moving block principles enables it to achieve the requested performances for Ottawa LRT in particular in terms of headway, RAMS and stopping accuracy. The URBALIS solution has the highest level of safety either with driver or driverless operation.

Also, its advanced and modular architecture enables it to achieve other important performance goals namely regarding expandability.

URBALIS is already compliant with AREMA standards (please refer to Toronto YUS project. Design in closing phase. No deviation left. Refer also to Amtrak already in service).

Primary components of the proposed Urbalis™ system

A Traffic Management System for Automatic Train Supervision function (COTS based), based on the ICONIS™ Alstom solution, with:

- Central TMS servers,
- Front-End Processors,

Interlocking sub-system for Interlocking function

- Central Smartlock Interlocking or Distributed Smartlock Interlocking
- IO modules, based on the Alstom Smart IO product,

ATC sub-system for Automatic Train Control

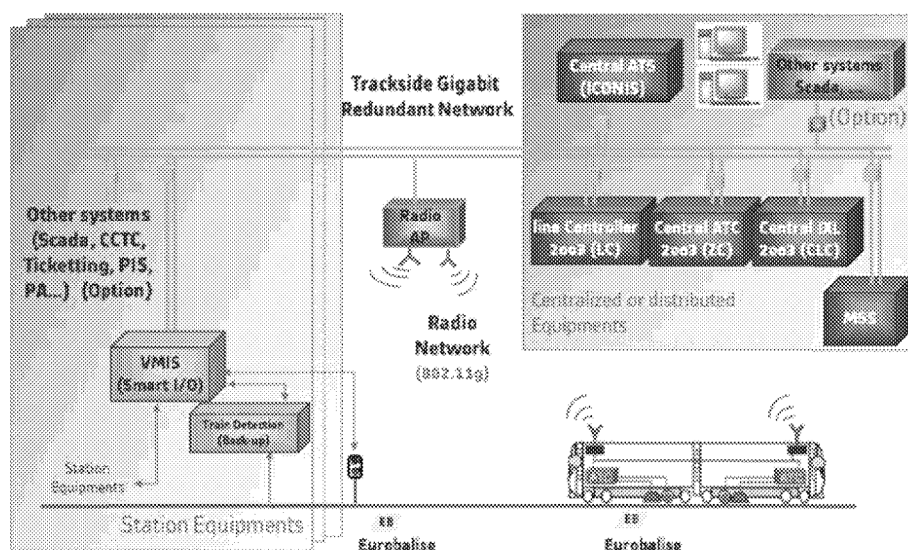
- Carborne Controller,
- Zone Controller,
- Line Controller,
- Data Storage Unit,

Maintenance Support System (MSS) for maintenance supervision (COTS based),

Data Communication System which is made of:

- Fixed Transmission Network (COTS based),
- Radio Transmission System through the free propagation medium (COTS based).
- Network Management system IP and FTN (NMS)

Below an architecture schematic of the proposal CBTC system for Ottawa LRT project :



URBALIS Networked CBTC: General Architecture

CBTC references list

Project	Type	In service
Singapore North-East Line	Driverless CBTC (distributed interlocking and train control architecture)	June 2003
Beijing Line 2	CBTC revamping	June 2008
Beijing Airport Link	Driverless CBTC	July 2008
Lausanne m2	Driverless CBTC	October 2008
Singapore Circle Line	Driverless CBTC (distributed interlocking and train control architecture)	May 2009
Milan Line 1	CBTC revamping	December 2009
Shanghai Line 10	Driverless CBTC	April 2010
Sao Paulo Line 2	« Driverless ready » CBTC (mainline interlocking and train control interfaced with depot interlocking and train control and with Line 1&3 interlocking and train control)	August 2010
Shenzhen Line 2	CBTC	December 2010
Beijing Fangshan Line	CBTC	December 2010
Shenzhen Line 5	CBTC	June 2011
Sao Paulo Line 1	« Driverless ready » CBTC (mainline interlocking and train control interfaced with depot interlocking and train control and with Line 2&3 interlocking and train control)	2012
Sao Paulo Line 3	« Driverless ready » CBTC (mainline interlocking and train control interfaced with depot interlocking and train control and with Line 1&2 interlocking and train control)	2012
Santiago Line 1	« Driverless ready » CBTC revamping (mainline	2012

	interlocking and train control interfaced with depot interlocking and train control)	
Beijing Line 9	CBTC	2012
Beijing Line 6	CBTC	2012
Shanghai Line 12	CBTC	2012
Shanghai Line 13	CBTC	2012
Shanghai Line 16	CBTC	2012
Guangzhou line 6	CBTC	2012
Wuhan Line 2	CBTC	2012
Wuhan Line 4	CBTC	2012
Mexico Line 12	CBTC	2012
Toronto YUS Line	CBTC revamping (train control interfaced with non-ALSTOM distributed interlocking architecture)	2013
Kunming Line 1	CBTC	2013
Malaga LRT	CBTC	2013
Ningbo Line 1	CBTC	2014
Panama Line 1	CBTC	2014
Al Safouh LRT	CBTC	2014
Taichung Green Line	Driverless CBTC	2018

Architecture

As can be seen from the above table, Alstom is able to offer both a centralised interlocking and train control architecture, with the central interlocking (CLC) installed in a central equipment room, as well as a distributed or semi-distributed architecture, based on iVPI with equipment installed in CIHs, as mentioned in the RFP.

A functional description of the train control system and backup methodology in case of communication failure and methodology for broken rail protection.

System principles

A limited set of basic principles is used in order to provide the best easy-to-operate system. These principles are described hereafter:

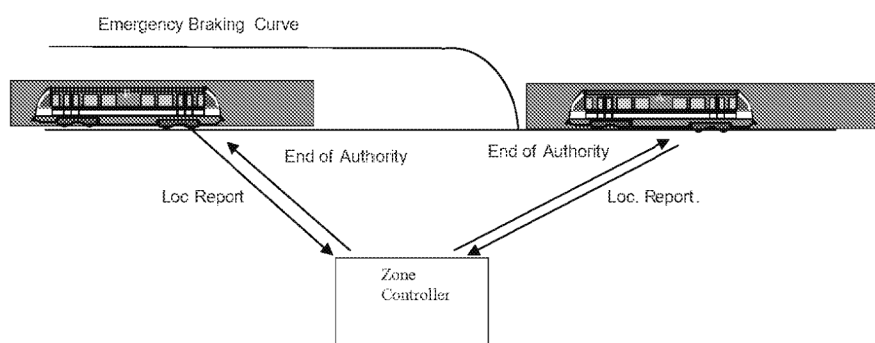
Separate ATC and interlocking functions: A separate ATC and Interlocking ensures that the line will continue to be operated in degraded operation with safeguarding from the Interlocking if a failure occurs in the ATC sub-systems. The CBTC system takes in charge the train separation function in order to reach improved headway performances fully independent of train detection devices' occupancy status.

Separate vital and non-vital functions: This is a requirement of the European standards. By placing the vital functions in hardware different from those used in non-vital functions the safety assurance demonstration is simplified.

Provide fault tolerant data transmission system: The data transmission system plays a major role in the CBTC train control system. Therefore the redundant network covers the whole line and the radio transmission system allows for direct communication between all trains and all trackside equipment at all times, even in case of single point failure.

Use full Redundancy: A high availability is requested in particular for driverless mass transit applications. Full redundancy is used for all critical paths and equipment. In the event a common mode failure should occur, the line can continue to operate under planned degraded modes.

Use moving block principles and "distance to go" principles:



URBALIS™ Moving Block Principle

The URBALIS™ Moving Block system is based upon the following concepts:

Positive detection of Trains: trains localize themselves, and provide regularly their position to the Trackside equipment by means of Localization Report messages. The train localization is elaborated at initialization, re-localization or for precise berthing purposes by using a proven onboard odometer system, and information transmitted via spot (intermittent) transmission (trackside beacons). The Localization Report messages are periodically sent to the Zone Controller (ZC). Each Zone Controller is in charge of a geographical zone.

Moving Block Protection: the Zone Controller collects all trains positions in its area. It attributes a required safety envelope (called Automatic Protection, AP) to each train taking into account: the location, speed and train attributes indicated in the Localization Report, an anticipation component, hence making relevant the Automatic Protection till the reception of the next localization from the train.

After updating all the AP, the ZC equipment calculates for each train the relevant movement authority, and sends it to the train through the End of Authority message (EOA).

The movement authority domain for a defined train is defined by searching ahead of the considered train, the first point to protect such as the AP associated to a preceding train, an uncontrolled route, an undetected point, etc.

Each train is able to determine its speed and distance profile up to the End-of-Authority (considered as a "brick wall").

In the nominal situation described above, the updating of AP is independent of track occupancy from conventional train detection system. For movement authority, the track occupancy status from the conventional train detection system is not used as well, but the route has to be set accordingly. If the route is not set, or if the CBTC train runs in the unauthorized direction, then it receives a restrictive EOA.



For availability and robustness purposes, the URBALIS system is tolerant to the loss of some messages. The shape of AP takes into account (in the anticipation component) possible losses.

For safety purpose, the messages have time validity. When a message is out of date, a restrictive EOA is applied.

In case of degraded situation (non-communicating train), or for non-equipped trains, the ZC performs a tracking of these trains through the occupancy of track circuit areas.

Backup methodology in case of communication failure

Trackside ATC failure:

In case of total trackside ATC failure, fallback interlocking operation is possible. Train spacing function is ensured by line side signaling. Restricted Manual mode is available to drive the train at a limited speed. The speed limit is controlled by onboard ATC.

In case of trackside ATC restart, the system operation is recovered when all train locations are discriminated by the trackside ATC. Trains are discriminated on secondary detection boundary with condition on secondary detection device length for tail discrimination. Typically, the train locations are fully discriminated when they stop in a station.

On board ATC failure:

In case of loss of localization, the on board ATC applies EB until the train is stopped. Then the train shall be driven manually until the train is localized.

In case of onboard software reset, the on-board restart time is lower than one minute. Then the train shall be driven manually until the train is localized.

Broken Rail detection

ALSTOM proposed track circuits solution for the secondary detection.

When ATC detects a default between the information coming from the Interlocking and the information coming from the train located on the track, failure information is generated on this track circuit. The Maintenance System generates an alarm sent to the ATS operator.

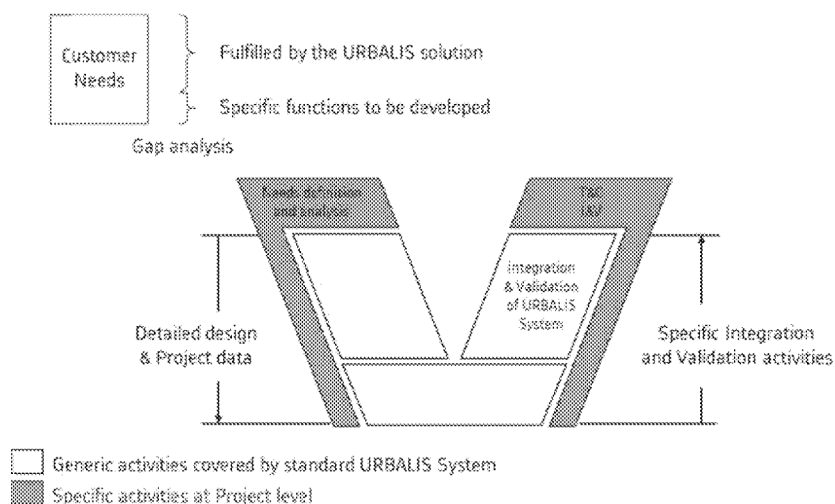
A train control installation, testing and commissioning schedule and strategy.

For Urbalis deployment process, the tests and commissioning are starting in factory.

Before sending hardware on site, some Factory Acceptance Tests are performed in the ALSTOM factories or in ALSTOM partnerships.

The Urbalis Software is validated in a Factory Integration and Validation Platform for generic and specific parts.

The schematics below shows the Design, Integration and Validation Process of Urbalis Solution :

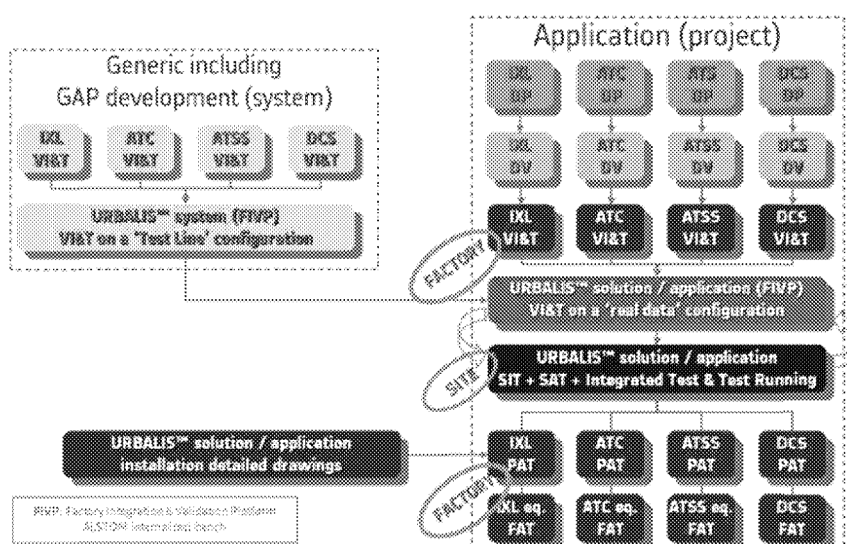


URBALIS™ system deployment for CBTC application

URBALIS™ solution is a generic platform configurable with parameters. This generic platform is already integrated and validated with generic data, and it is instantiated for deployment with specific project data.

The benefits of this strategy are multiples :

- No need to redevelop a new solution for each project
- The solution built on experiences then it is benefits from previous projects
- The solution is proven, mature and safety mastered
- The “platforming” method allows better ability to react and better traceability with regard to the specifications changes.



Overall view applied for the Testing Strategy

According to this organization and strategy, 70% of all Integration and Validation Process is performed in factory.

From installation phase to revenue service, the commissioning is composed of different progressive activities:

- Vehicle and Train Control Static Tests
- Vehicle and Train Control Dynamic Tests
- Train Control Trackside Integration Tests

- Train Control On-Board Integration Tests
- Vehicle and Train Control System Acceptance Tests
- System Trial Running

A description of the proposed yard operation and control strategy.

ALSTOM has several operation strategy processes for the depot management.

- The depot could be full CBTC signalized, meaning there is no stop between the exit of the mainline and the stabling where the trains shut down during the service end. Trackside Train Control and Interlocking equipment manage the system in this case. This solution brings same level of signaling features in depot than in mainline. Usually, a test track is installed somewhere in the depot to test the train after maintenance or for the project commissioning.
- The depot could be partial signalized. In fact, there is also an interlocking in the depot. A full CBTC signalized test track as for the first example to perform the same functions is also installed but a driver should drive the train from a transfer track or transfer yard to the stabling area. In this case, the train can run from the mainline to the transfer track in a CBTC mode (ATO for example). The train stops on the transfer track then the driver manages the CBTC mode selector to a manual mode to run the train to the stabling yard. ALSTOM recommends to cover by communication radio all parts of the stabling because of automatic software uploads during the nights for the CBTC on-board equipment.

Below is a table summarizing the different configuration already in service for depot operation :

References	Highest CBTC mode	IXL depot	in CBTC depot	in CBTC Test Track	Transfer Track	Option on-board software upload
Singapore NEL	Driverless	Yes	Yes	Yes	No	No
Lausanne m2	Driverless	Yes	Yes	Yes	No	No
Singapore CCL	Driverless	Yes	Yes	Yes	No	No
Beijing L2	Manual	Yes	No	Yes	Yes	Yes
Beijing Airport Link	Driverless	Yes	Yes	Yes	No	Yes
Milan L1	Manual	Yes	No	Yes	Yes	Yes
Shanghai L10	Driverless	Yes	Yes	Yes	Yes	Yes
Sao Paulo L123	Manual	Yes	Yes	Yes	Yes	Yes
Shenzhen L2-L5 Guangzhou L6 Beijing L9, Beijing Fangshan	Manual	Yes	No	Yes	Yes	Yes



For information, the following configuration has been chosen for Toronto YUS :

References	Highest CBTC mode	IXL depot	in CBTC depot	CBTC Test Track	Transfer Track	Option on-board software upload
Toronto YUS	Manual	Yes	No	Yes	Yes	Yes

A train control preventive and corrective maintenance plan.

Please refer to the attached document « Maintenance Organization Plan » which is an example of what we would supply for a standalone Signaling system at the tender stage. For general considerations on Alstom's maintenance strategy, please also refer to « vi Maintenance Capability »

ALSTOM uses obsolescence monitoring for all of its projects :

ALSTOM obsolescence management strategy is aimed at covering or mitigating risk of manufacturing and software upgrade. An Obsolescence Management Plan is supplied during the project phase for validation by the customer.

Life Cycle Duration:

For all Signaling equipment, the life cycle duration is approximately 30 years.

The proposed interlocking equipment has a 1,100,000 hr MTBF. Some internal electronic boards have a 500,000 hr MTBF.

The proposed point machines have a life limit of 1,000,000 movements.

For each type of equipment, preventive maintenance is performed during the proposed equipment life cycle. Details of this preventive maintenance will be given during tender phase.

A typical maintenance plan is provided for reference

Operational Performance Requirements

- The Proponent must address the operational performance at an appropriate level of detail as set out in or otherwise referenced in schedule 15-2 of the Project Agreement and must address the following:
- Validation of operational capabilities and capacity through system performance simulations;
- Capability to reliably support the headways required (including single track operation);
- Terminal operations;
- Station dwell time analysis;
- Validation of Operating Scenarios 1 and 2;
- Approach to expansion of the system to accommodate Operating Scenario 3; and
- Projected end to end trip times for manual and ATO modes.

Headway, Trip time and Power supply sizing are identified as main system performance drivers, which require subsystem co-ordination because of strong interactions between them, and resulting from the integration of many external and internal interfaces.

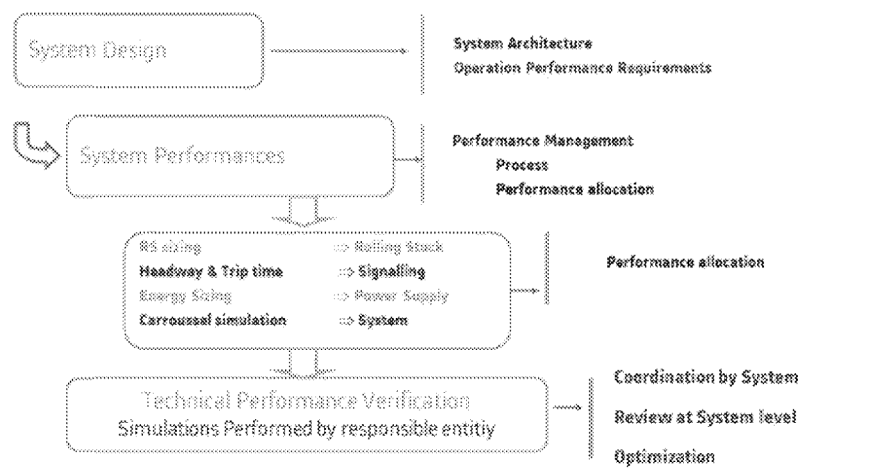
The main impacted Electro- Mechanical subsystems are the followings, and are the ones responsible to carry out the related simulations during the design phase

Subsystem	Required type of performance
Power Supply	DC traction power
Train Control System	Theoretical headway in relation with the required operational headway Performance of the ATP/ATO train driving system to result in high commercial speed
Vehicle	Riding performance (relation to speed, curves and cant) Performance of the traction/braking equipment
System	Carroussel simulation and fleet sizing verification

This approach is integrated into a performance based system design process :

- Identify system fundamental performance requirements
- Allocates the responsibility of each performance to responsible entity,
- Define the reference for Project Technical Data, including operational assumptions and sizing conditions (train load, train driving mode,
- Optimize equipment sizing and architecture
- Validate the chosen solutions

The activity articulates as follows:



System Performance Principle

The activities carried out by ALSTOM for the Vehicle and Train Control systems are the following:

- Headway simulation and trip time calculation
- Vehicle Sizing

The Vehicle and Train Control subsystems are managed like the other lots from a system perspective at EPC Design Coordination level. This ensures proper interfaces management and subsystem performances and requirement allocation and validation (V cycle)

Required transport Capacity

The Request for Proposal identifies 3 operating scenario:

Operating Scenario 1, Opening day operation: 3.25 minutes peak headway and 12,000 PPHPD

Operating Scenario 2, Year 2031 operation: 2.1 minutes and 18,600 PPHPD

Operating Scenario 3: Ultimate capacity operation: no more than 2-minute peak period Headways and 24,000 PPHPD

This implies that although the system will be deployed for the initial stage, then implication of future expansion is to be considered for sizing and simulations. In particular, Headway simulations are to be carried out for ultimate capacity.

Some other requirements are captured in the RFP and will be reflected into the sizing conditions, such as:
Vehicle load standard, Maximum Trip times during peak period or Single track operation during maintenance:

Vehicle Capacity and Headway

A preliminary Vehicle diagram as indicated in the RFP is the following:

- Seated capacity: 62 pass.
- Total capacity (4 pass/m²) : 200 pass.
- Total capacity (3.33 pass/m²) : 177 pass.

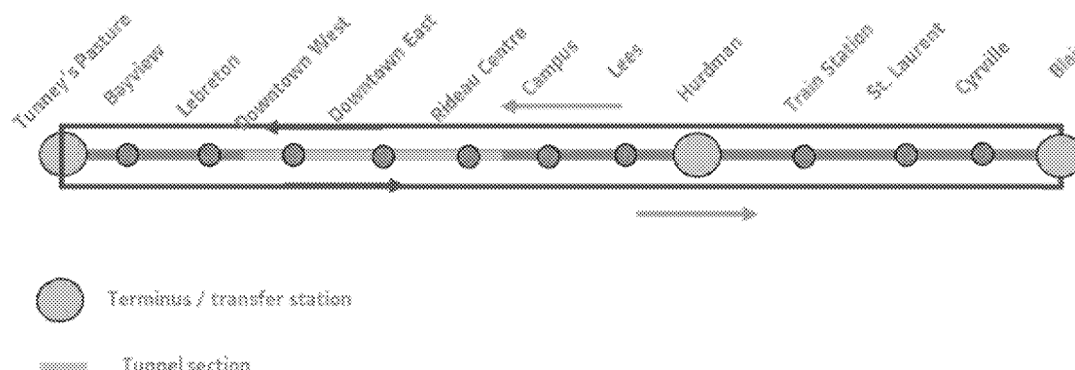
The operating scenario is addressed as follows:

Scenario	Vehicle length	Train transport capacity (Passengers)	Peak Headway (sec)	Transport capacity (pphpd)
Scenario 1	max 120 (4 x 30 m)	708 (3.33 pers/m ²)	205	12433
Scenario 2	max 120 (4 x 30 m)	708 (3.33 pers/m ²)	135	18880
Scenario 3	max 150 (5 x 30 m)	885 (3.33 pers/m ²)	130	24507

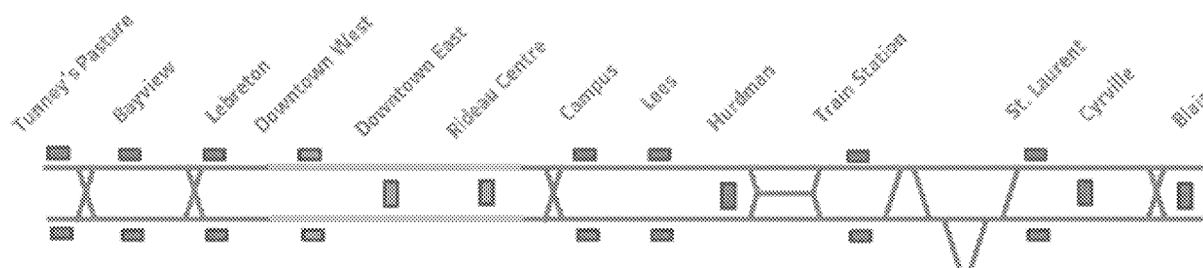
This calculation is to be confirmed with the proposed Vehicle and will define the peak target operational headway for each scenario.

Track layout

The following figure identifies the transfer station and central tunnel section:



The track layout as shown on the track drawings is the following:



Based on this track layout and considering also the traction Power single line diagram and sectioning, it is possible to propose partial service definition. Partial service definition will only consider the requirement for single track operation for maintenance purpose.

Considering the anticipated alternate platform operation at terminus with crossover located in front of terminus station, then Blair's configuration with central platform is more convenient from operational point of view compared to Tunney's Pasture's configuration where passengers will have to choose the right platform to take the next train.

Simulations data

In order to perform simulations with regard to operational capabilities and capacity, data are required, such as:

- Alignment

Revised alignment has been posted on the 25th Nov 11

- Speed

Speed limits in curves are given on the alignment : this can be considered as preliminary data but will have to be confirmed and optimized by the system integration entity.

- Dwell time

The Passenger flow data is required to assess the dwell time considering the Vehicle door width characteristics and traffic flow sizing assumption. This calculation is under the responsibility of the system integration entity.

- Operation

Some operational assumptions are required for carousel simulations : trip time recovery margin, driver reaction delay.

Nevertheless, ALSTOM solutions have definitively the capacity to achieve the required performances:

As an example, minimum Urbalis headway capability is 90s in service (Beijing L2 or CCL for instance), above the 132s in scenario 2, and achieving the ultimate headway as described in scenario 3.

Same for Vehicle capacity, the preliminary calculation shows compliance with the RFP.

Technical Performance Verification

A review is performed by the system integrator in order to verify that each identified performance is addressed and achieved.

In case of deviation, then solutions are elaborated and their impact and the overall system evaluated.

Also optimizations are analyzed.



Non-Revenue Vehicles

A list of proposed vehicles indicating vehicle purpose, specification and performance.

Description of which maintenance vehicle tasks are anticipated to be outsourced.

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General Description

A towing rail/road vehicle equipped with a crane and elevator platform.

The Unimog is used for the installation and maintenance of the OCS (overhead contact system) and particularly for the contact wire unwinding operations in the event of a severed line.

Suitable as a safe and mobile scaffolding platform for the workers in charge of OCS maintenance activities at height

Can be used for towing heavy plant equipment, like the wire unwinding trailer

Advantages

- Pulling power for re-railing of trams
- Rapid adaptation between rail and road
- Powerful crane 14t/m



Lifting system

A 'Centrama' design.

Serial number: BBC 001 3A

New lifting system is similar to VX 750 with a 1m extension.

Maximum elevation of basket floor: 5 m 50

Unimog can be driven from the basket on rails

Lifting system basket:

Length: 1 730 mm.

Width: 2 005 mm.

Height: 1 180 mm.

Load capacity: 265 Kgs.

UNIMOG U1450 Technical specifications

Total mass 10 t

Load max 0.5 t

Dimensions

Length 5 500 mm

Width 2 500 mm

Height 3 800 mm

Kinematic Gauge UIC 505.1

Gauge 1 435 mm

Serial number: 427 112 1w 173 834

Performance on road 90 km/h

Performance on rail 25km/h

Working Radius ≥25m

Towing power on the flat: 1200 t

Crane PM 14023 :

N° Equipment 15228

Load capacity :

6 500 Kgs at 2 m.

5 200 Kgs at 2 m 40.

3 290 Kgs at 4 m.

2 170 Kgs at 5.9m.

Guiding system:

Guiding system on rail guiding wheels (400 mm diameter for a gauge of 1435 mm).

Each homing head equipped with a hydraulic jack for lowering and lifting.

Front and rear homing heads with 2double pressure gauge monitoring.

Jamming on front wheel to drive on rails.

Console in cab.



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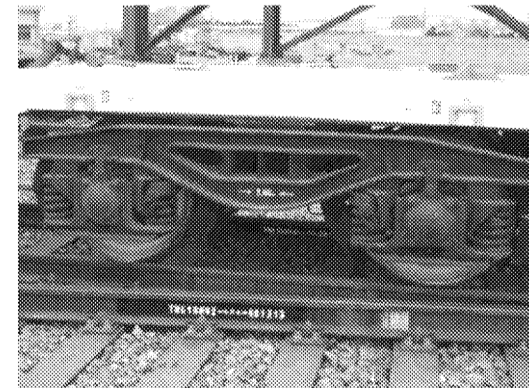
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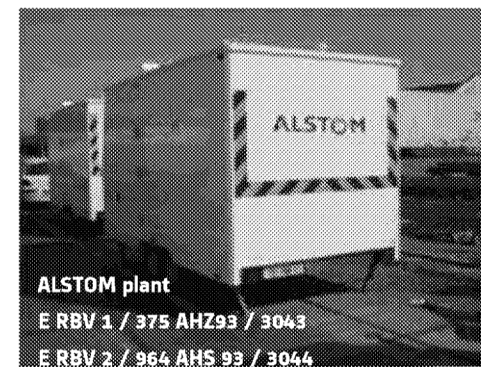
ALSTOM plant TWK-PL-31



ALSTOM plant TWK-PL-31



ALSTOM



OTTAWA LRT -- Vehicle and Train Control Prequalification

January 6th, 2012

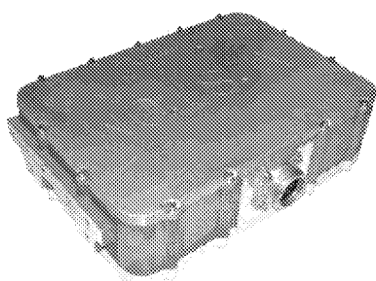
All information within this document is the property of ALSTOM Transport.

Page 44 of 44

The ALSTOM logo is displayed in white, uppercase letters on a dark grey background. The letter 'O' is stylized with a horizontal line through its center.

Annex 2 – Train Control Product Sheets

EUROANTENNA



General description

EUROANTENNA is fixed under the train.

The aim of the antenna's electronics is to :

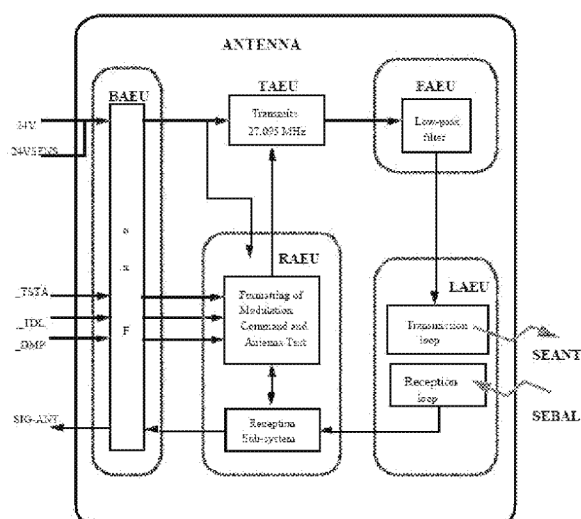
- supply the power needed to energize a EUROBALISE located on the tracks .
- sense and preamplify the signal sent by the EUROBALISE.
- check and report to the BTM* on the antenna's operation.

Application

Typical application

Compact EUROBALISE is a product developed for ERTMS (European Rail Traffic Management System). She energizes EUROBALISE and receives Eurotelegrams. These Eurotelegrams are used by the train's speed control system.

Internal Architecture



- BAEU Borrier Antenna Electronic Unit (input/output signals filtering board)
- FAEU Filter Antenna Electronic Unit (filter for the transmission loop)

- * BTM Balise Transmission Module (antenna data and signal processing equipment)
- FSK Frequency Shift Keying
- LAEU Loop Antenna Electronic Unit (board supporting the compact antenna's transmission/reception loops)
- RAEU Reception Antenna Electronic Unit (reception board)
- TAEU Transmission Antenna Electronic Unit (transmission board)
- SEBAL Eurobalise transmission signal
- SEANT Antenna transmission signal

Technical features

Main characteristics

Power supply (DC Voltage) 24 V

Power consumption 60 W

maximum distance for the power source 30 m

Operating conditions

Temperature -40°C to +70°C

Storage Temperature -40°C to +85°C

Mechanical Outline

Size

Width/Height/Depth 345/127/448 (mm)

Weight

15Kg

Maintenance

Preventive Maintenance

recommended to change shocks absorbers after 18750 hours service time.

Annually control

- Antenna not damaged
- Link cable not damaged
- Antenna connector plug insertion, check it is correctly screwed.
- Earth bond electrical test, to check continuity between antenna and body/bogie
- No wires broken on the shocks absorbers

Reliability & quality

MTBF (depending on configuration and environment)

As an indication > 20 years

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Compliance w/ standards

Protection against solid foreign	IP 65 (screen)
Sinusoidal Vibration	EN 50155 (EN61373)
Random Vibration	EN 50155(EN61373)
Shocks	EN 50155(EN61373)
Humidity	EN 50155 (EN 50125-1)
Altitude	EN 50155
Immunity	EN 50121 -3-2
Emission	EN 50121 -3-2
Fire-Smoke	NF F 16-101
Earthing	NF F 60100
Functioning Safety	SIL 4

Major references

SCMT Italia
SBB Switzerland
TASS United Kingdom

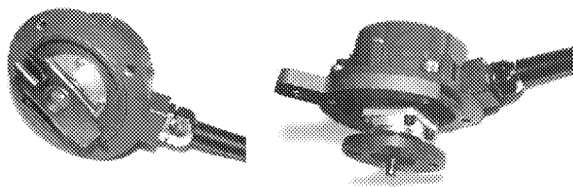
ALSTOM**Product data sheet – EUROANTENNA**

Products and data mentioned in this document are subject to change without further notice

Date of issue: 29/09/06

WHEEL SENSOR

The wheel sensor provides information of train speed, and instantaneous acceleration.



General description

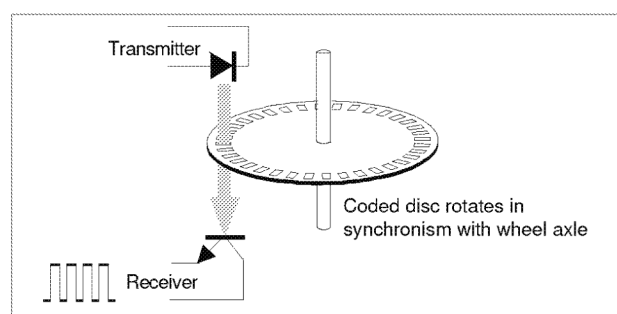
The optical axle and sensor described here is based on optical principle. The sensor is mechanically linked to the rotating axle by a drive element. It contains a punched code disc and several optical probes arranged on the circumference of the code disc. The electronic circuits of each probe are based on LED and phototransistor. When the disc rotates, the continuous light beam from the LED is transmitted through the holes to the phototransistor, providing a pulse signal at the frequency of disc rotation. As a result, the output signal is square wave at a frequency proportional to the rotation speed of wheel.

Application

Typical application

The wheel sensor plays the role of speed measurement device.

Internal Architecture



Technical features

Main characteristics

Electrical characteristics

Nominal Power supply	10 to 30 V dc
Power consumption	<900 mW by sensor
Max output frequency	3000 Hz
Discs	1 or 2 tracks coded from 1 to 200 (400) Holes by track

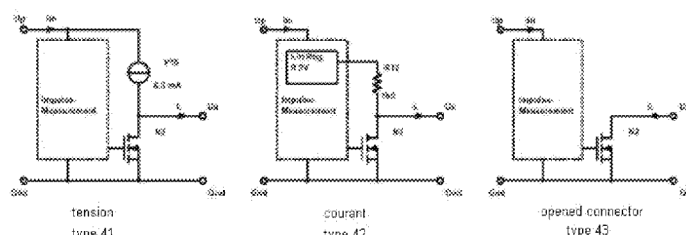
numbers of sensors by generator

generator 5.8600	1-4 sensors
generator 5.8601	1-4 sensors
generator 5.8602	1-4 sensors
generator 5.8604	max 6 sensors
generator 5.8610	max 3 sensors

numbers of turn
Couple of training

3200 /min
< 6 Ncm

The choice of the type of sensor depends on the electric interface of equipment connected to speed sensor.



Operating conditions

Temperature -40°C to +70°C

Mechanical Outline

Size

Diameter/Height 155/66 (mm)

Weight

2,4 kg

Maintenance

Preventive Maintenance

Every 6 months	Control if saw them of fixation are squeezed well.
After 10 years or after 2 000 000 km	Control the cable of connecting and, if necessary, replace it. The wheel sensor must be cleaned.

Reliability & quality

Typical operational MTBF (depending on configuration and environment)

MIL-HDBK-217F notice 2 (1995) 186 500h

Compliance w/ standards

Sinusoidal Vibration	EN 50155-2-1
Shocks	EN 50155-2-1
High Voltage	EN 50155-2-1
Humidity	EN 50155-2-1
Cold	IEC 60068-2-1
Heat dries	IEC 60068-2-2
Change in temperature	IEC 60068-2-14

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CEM	EN 50121-3-2
Field of interference	EN 50011
Radiated, RF, EMG field	EN 61000-4-3
Immunity test	
Fast transient Burst	EN 61000-4-4
Immunity to conducted disturbances	EN 61000-4-6

Major references

SA-NBS Project(Switzerland)	550 Units	ERTMS level 2
Athens / Rotem (Greece)	30 Units	ERTMS level 1
CFL (Luxembourg)	46 Units	ERTMS level 1
M6 (Belgium)	56 Units	ERTMS level 2

Project	SBB (ICB1, Re483, Re465,Am841)	SBB (Re420, Re620, Re 425, Tm234, Mermet)	CFL	Athens / Rotem / STW_EMG	SBB ICN	ETR 470
Wheel Sensor Reference	5.8600.034/10	5.8600.034/11	5.8600.034/14	5.8600.034/15	5.8600.034/16	5.8600.034/23
Drawing N°	5.0066.001	5.0066.001	5.0066.001	5.0066.000	5.0066.001	5.0066.001
Sensor location	43	43	43	43	43	43
Outer track A - Type 5.8600.120/	43	43	43	43	43	43
Outer track B - Type 5.8600.120/	43	43	43	43	43	43
Inner track C - Type 5.8600.120/	43	43	43	43	43	43
Inner track D - Type 5.8600.120/	43	43	43	43	43	43
Electrical Adjustment	C - D790*	C - D790*	C - D790*	C - D790*	C - D790*	C - D790*
N° of pulses	ref	ref	ref	ref	ref	ref
Outer track	2*20 spec code	2*20 spec code	2*20 spec code	2*20 spec code	2*20 spec code	2*20 spec code
Inner track	32	32	32	100	32	32
Cable set	ref	ref	ref	ref	ref	ref
Free end cut	-	-	X	X	-	X
with connector	X	X	-	-	X	-
Connector type	ref	ref	ref	ref	ref	ref
coding	none*	none*	-	-	none*	-
Cable length	Customer length (l)	1765 mm	1300 mm	3000 mm	1580 mm	3000 mm
Free cable length (L)	1495 mm	1030 mm	2885 mm	3685 mm	1710 mm	2885 mm
Driver	ref	ref	ref	ref	ref	ref
Accessory data	ref	ref	ref	ref	ref	ref

*** Codedisc mounted upside down (printed side to bearings)

* 4xM5x10 instead of coding

Position of connector according to drawing 5.8600.010 B6.4 / Fig 6

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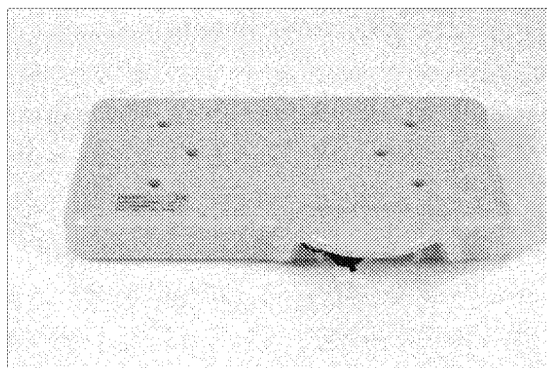
Product data sheet – WHEEL SENSOR

Products and data mentioned in this document are subject to change without further notice

Date of issue: 12/09/06 v1

Way side Electronics Information Solutions

Class A COMPACT EUROBALISE



General description

The Compact EUROBALISE is installed on the middle of tracks with an adapted support.

It's intended to transmit information in the form of coded messages to the onboard Compact EUROBALISE system when the train passes by. These Eurotelegrams are used by the train's speed control system, therefore the Compact EUROBALISE has safety constraints with a level of "SIL 4".

The Compact EUROBALISE is an active electromagnetic transponder which receives through its antenna loop the power from the EUROANTENNA located on the train or from the BEPT during the programming / maintenance operations.

Application

Typical application

Compact EUROBALISE is a product developed for ERTMS (European Rail Traffic Management System).

Compact EUROBALISE is fully ERTMS Class A compliant (UNISIG subset 036 & subset 085)

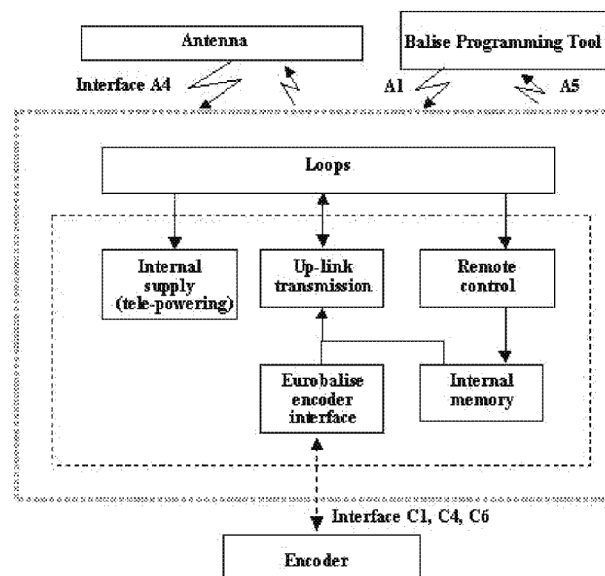
It sends to the train a telegram corresponding to the state of the signalling from a fixed message in its memory or from an EUROCODER. At the level 2 and 3 of ERTMS, the telegram is always fixed on the Compact EUROBALISE memory.

Air-gap programming (wireless)

The programming of the Compact EUROBALISE is performed without cable to be connected to the balise (Also the programming tool operates without wires):



Internal architecture



Interfaces :

- A1 : transmits the message to the train.
- A4 : transmits the electrical power to the Compact EUROBALISE and discriminates ERTMS and KER.
- A5 : allows the reprogramming of the Compact EUROBALISE message memory.
- C1 : transmits the message from the EUROCODER to the Compact EUROBALISE.
- C4 : transmits the "presence train" information to the EUROCODER.
- C6 : transmits the electrical power to the Compact EUROBALISE input circuits.

Technical features

Main characteristics

Balise tele-powering signal 27.095 MHz

Up-link data transmission 4.24 MHz
FSK Modulation
565 Kbits/s

Balise reading with a train speed up to 500km/h

Transmission telegrams

- Short format 210 users bits 331 transmitted bits
- Long format 830 users bits 1023 transmitted bits

Interfaces

Encoder interfaces : differential bi phase, 565 kbits/s

ALSTOM

Operating conditions**Temperature** -40°C to 70°C**Storage Temperature** -40°C to 85°C**Mechanical Outline****Size**

Width/Height/Depth 450/320/59 mm

Weight 7Kg**Maintenance****Tools** BEPT**Reliability & quality****MTBF** (depending on configuration and environment)

UTE C 80-180 >1 000 000h

Compliance w/ standards

Protection against solid foreign bodies and rain(EN60529) IP 67

Functioning Safety SIL 4

Basic standard (test reference)	Comments
Vibration EN 50125-3	5g, 10min
Shocks EN 50125-3	30g acceleration, 8ms
Humidity EN 50125-3	Classification 4K3

EMC EN 50121-4 (Ed 2000)

Basic standard (test reference)	Comments
EN 61000-4-2 Electrostatic discharges	NA contact discharges +/- 4,6,8kV discharges
EN 61000-4-3 Radiated electromagnetic field	10 V/m (80-1000MHz)
ENV50204 RF electromagnetic field-keyed carrier	900 MHz (20 V/m)
EN 61000-4-4 Electrical fast transient burst	+/-2kV (1) +/-2kV (2)
EN61000-4-5 Surge immunity	+/-2kV (1) +/-2kV (2)
EN61000-4-6 Conducted discharges	10 Vrms (1) 10 Vrms (2)
EN61000-4-8 50 Hz magnetic field	100 A/m
EN61000-4-9 Pulse magnetic field	+/-300 A/m

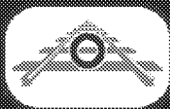
(1) :The both ending of the cable shield and the encoder connected to the ground reference plane.

(2) :The cable shield connected to the Encoder, the encoder and the shield at Eurobalise level insulated to the ground references plane.

Major referencesSCMT Italy
Betuweroute (Belgium – Netherlands)
China**ALSTOM****Product data sheet – Compact EUROBALISE**

Products and data mentioned in this document are subject to change without further notice

Date of issue: 10/07/07



SMARTWAY™ Point Machine

P80

MAJOR REFERENCES

- Italy: RFI mainlines, urban lines in various cities
- Greece: Ergose Athens Suburban line
- Tunisia: SNCFT mainlines
- Bangladesh: national railway
- Kazakhstan: national railway
- Vietnam: national railway
- Chile: Santiago urban lines
- Argentina: Buenos Aires urban lines
- Brazil: VALE & MRS freight lines



GENERAL DESCRIPTION

The P80 is part of the SMARTWAY range of point machine among the MET (in sleeper electromechanical point machine) and the SO (in tie electrohydraulic point machine). The P80 is Alstom wayside electromechanical point machine.

The mechanism (motor, clutch, electrical contacts and optional devices) is integrated and sealed in a single housing without any internal adjustment needed. Customers can specify point locking can be embedded in the point machine or in the turnout according to their requirements.

APPLICATION

The P80 is available in "trailable" and "non trailable" versions, ideal for rails weighing 65/60/50 Kg/m, with single switch and double-slip switch and for tangent up to 1:14.

The P80 is suitable for all types of lines: mainlines, metro lines, freight lines.

The P80 is available in back drive configuration and with external clamp lock.

KEY FIGURES

- Developed in 1980: service proven over 20 years and in 9 countries on 3 continents
- In 2010: more than 10 000 P80 point machine in revenue service worldwide
- MTBF > 500 000 hours

THE BENEFITS

- * Service proven product, first certified in Italy
- * Significantly reduced maintenance: no clutch on the switch turnout area, no internal adjustment needed, integration of a sensing function to automatically check the Superstructure robustness and fixation
- * Easy installation: no need for external device installation up to 180 km/h thanks to internal locking homologation
- * Reduced number of equipment: detection of the trailing without external device
- * Suitable for wide temperature range and polluted environment: operational temperature from -40° to 70°

TECHNICAL KEY FEATURES

> Functional

- * The P80 provides the main functions for a point machine (motorization, locking and controlling).
- * The trailability feature ensures that standard operating conditions may be programmed to be restored automatically after trailing has occurred (no human action required).
- * To avoid extreme stress when the tongue encounters an excessively hard obstruction the clutch device disconnects the kinematic chain motor-approach rod and cuts off the power supply to the motor. This device has lifetime settings (no maintenance needs).

> Configuration

- * The P80 is manufactured in two versions: single switch and double-switch versions (Double English turnout).
- * The double- switch version has 4 detection rods.
- * All the versions can be operated manually by hand crank.
- * The standard configuration is trailable but the P80 can also be configured as non-trailable by installing an additional device.
- * There are different type of installation:
 - * Single switch right installation
 - * Single switch left installation
 - * Double switch right installation
 - * Double switch left installation

> Environment

Operating temperature	-40°C to 70°C
Humidity	0 to 100%

> Electrical & Mechanical

- * Weight: 240 Kg
- * Size: 913x565x334 mm

Version	220 DC motor	250 3 phase motor	Double switch	Russian	Italian
Power supply	144 ± 15%	3 x 380 ± 15% Vac 50 Hz 3 x 220± 15% Vac 50 Hz	144 ± 15% Vdc	220 ± 15% Vdc	144 ± 15% Vdc

> Safety & Reliability

Mean Time Between Failure > 500 000 hours in operation

Version	220 DC motor	250 3 phase motor	Double switch	Russian	Italian
Operating time at 120 Vdc	3 ± 10% s	5 ± 15% s	2,5 s	2 s	2.5 s
Absorbed current during switch operation	2 ÷ 3 A	1.5 A 2.6 A	2 ÷ 3 A	2 ÷ 3 A	2 ÷ 3 A
External stroke	220 ± 1 mm	250 ± 2 mm	149÷153 mm	149÷153 mm	149÷153 mm
Sensitive Force (Stock rail checking)	NA	NA	200 ÷ 300 kg	200 ÷ 300 kg	200 ÷ 300 kg
Throwing Force (max load with obstacle)	≥ 500 kg	≥ 500 kg	>680 kg	≥ 550 kg	≥ 600 kg
Trailing force	770 ÷ 950 kg	770 ÷ 950 kg	950 ÷ 1150 kg	770 ÷ 950 kg	900 ÷ 1100 kg
Max speed	≤ 250km/h	≤ 250km/h	≤ 180km/h	≤ 180km/h	≤ 180km/h

> Maintenance

The clutch-less system significantly reduces maintenance (a spring-loaded device ensures the clutch functions) and allows stability and internal adjustment elimination.



Annex 3 – Train Control maintenance Plan

**THE SIGNALLING PROGRAMME
S-BANE SIGNALLING SYSTEM TENDER**

PROPOSAL TO BANEDANMARK

BAFO

**Appendix 5 – Attachment 12 –
The Tenderer's Maintenance Organisation Plan**

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1 INTRODUCTION

This document presents the Maintenance Organisation Plan suitable to perform the maintenance services for which the Supplier (Alstom) is responsible for; this document could be renamed as "Maintenance Project Management Plan", in Project phase.

The Maintenance Plan will then be tailored to address project specific needs during the development phase of the S-Bane project, while keeping its structure and scope.

It has to be noted that such document will be reviewed, agreed and finalised during the Maintenance Preparation Sub-project; then submitted to the Customer for validation.

2 MAINTENANCE MANAGEMENT PLAN

These paragraphs present the organisation and the associated workflows defined by Alstom to manage the Maintenance Project or Maintenance Service Project (here after the "Maintenance Project").

2.1 Project Structure and Organisation

2.1.1 Partners, Customer and / or Consortium Organisation

All relevant information regarding partners, System owner's company, operator(s) will be collected: their structure, characteristics, the terms of agreement, the scope of their work and importance within the Maintenance Contract will be collected, as well as the main contact names and positions.

2.1.2 Supplier's Project Organisation

The Organisation Chart that the Supplier intends to deploy in the frame of the Maintenance Project dedicated to the Delivery is the following:

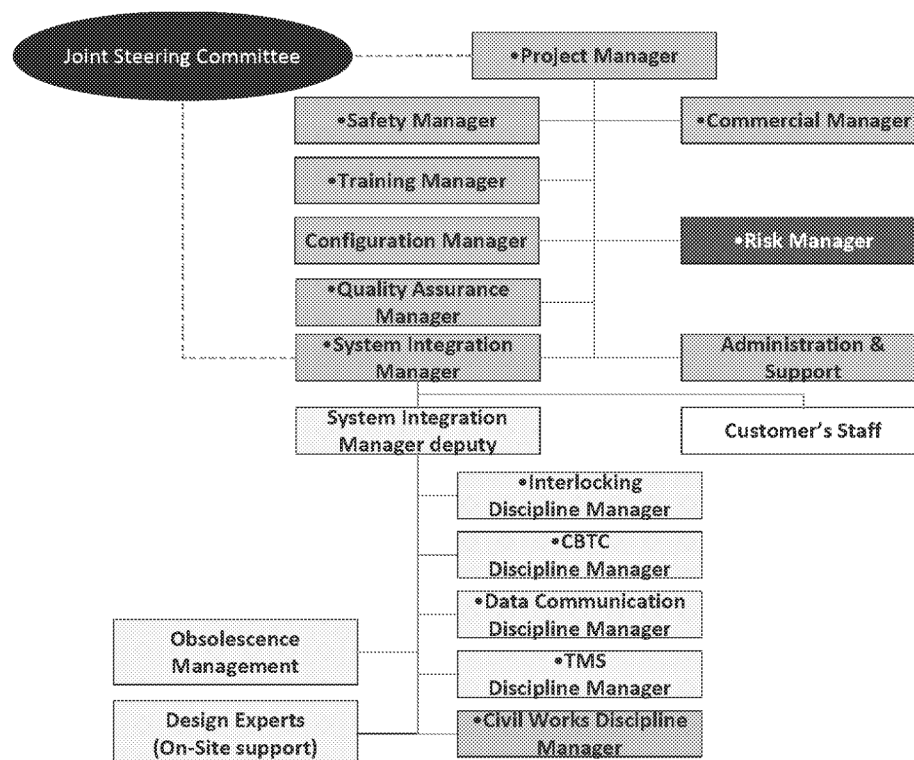


Figure 1. Maintenance Project Organisation chart

The Organisation Chart of the Maintenance Project will be redefined (it may be different depending on the stage of the maintenance project) and shared with the Customer; it has to be noted that such document will be reviewed, agreed and finalised during the Maintenance Preparation Sub-project; then submitted to the Customer for validation.

2.1.2.1 Roles and Responsibility

The Key Roles and Responsibilities are the following:

- Maintenance Manager,
- Production Manager,
- Production Team Leaders,
- Multi-Skilled Technicians (MST),
- General Operative,
- Infrastructure Engineering Manager,
- Infrastructure Maintenance Engineer,
- Business Excellence Manager,
- Material Manager,
- Materials Controller,
- Project Cost Controller,
- EHS Advisor.

The relevant Job Description are defined based on Alstom's maintenance projects guidelines and return of experience.

It is also mandatory to define the Project's Key relationships between participants and their important aspects (interdependencies in terms of information and decision, key success factors, mechanisms for collaboration, etc).

2.1.2.2 Key Function

The Key Function are the following, thanks to Customer's classification:

- Project Manager
- Safety Manager
- Training Manager
- Quality Assurance Manager
- System Integration Manager
- Commercial Manager
- Risk Manager (BDK Posted Staff)
- Civil Works Discipline Manager

The relevant Job Description are defined based on Alstom's maintenance projects guidelines and return of experience.

2.2 Projects Core Activities

2.2.1 Project Management

The project follows the principles and processes defined in Alstom:

- following Project Management Process guidelines for processing of financial data,
- managed through Quality, Cost, Delivery objectives with a specific focus and management of the Risks and Opportunities,
- subject to Project Gate Reviews to ensure that the Customer's satisfaction is monitored and achieved, in line with internal operational and financial objectives.

2.2.2 Engineering and Planning

Engineering and planning comprises of:

- defining the maintenance activities to be carried, in line with the requirements of the Contract(s),
- producing the instructions required by the Production team to perform the maintenance activities,
- assisting the Production and Material Management teams in all technical issues.

2.2.3 Materials Management

The Material Management comprises:

- Sourcing,
- Purchasing,
- Storing.

All Spare Parts, Consumables and material required for the proper execution of the Contract(s) obligations.

2.3 Project Execution Strategy

2.3.1 Risk and Opportunity Management

The principles and work process applied when dealing with Risks and Opportunities throughout the entire duration of the project rely on:

- risk management methodology/procedure to be used,
- programme of risk sessions,
- planned reviews of status on specific risks.

The main risks and related mitigation plan will be tracked and reviewed throughout the maintenance period. Our risk assessment plan and related mitigation plan are subject to review and approval from Alstom's Top Management. They have to state the basic coverage strategies adopted, the main features of the action plans developed as well as the people responsible for leading those actions (List of risks, severity and probability, allocations, mitigation actions, responsibilities, schedule, etc).

2.3.2 Time Management

We apply the basic methods and work principles shared within the maintenance project community for creating the planning of the project and following its progress during the project (including data collection process and planning network, LCC, Reliability Data, Annual Maintenance Plan, etc).

The Customer master programme is the major Input data (including the key Milestones for deliverables and customer meetings).

Our Internal project master plan covers the General programme of the project, rendering explicit the key interdependencies to be managed over time and the way different parts will be integrated into the whole including:

- Master plan showing links to entity project plans
- Main tasks and their critical paths, showing interdependencies between actors
- Critical paths for decision making on key issues and information exchange.

2.3.3 Cost Control

A file summarizing the financial conditions will be created, describing:

- The contractual financial conditions with the different participating entities (internal and external) and of main procedures.
- The actions or approaches for cost optimisation in the framework of the project (and not only within Alstom's units and/or Businesses).

Including:

- R&D reallocation, capital, project cost breakdown
- Procedures for internal billing and payments
- Procedures for invoicing and payments with the customer
- Taxation, import duties, cash flow.

Cost monitoring systems will be identified, as well as cost optimisation actions:

- Cost optimisation that are specific to the project
- Transversal actions that are required for the project to reach its cost objectives (product development, investments, etc.).

2.3.4 Resources Management

The Staffing Plan is a key aspect of the Maintenance Project Management Plan.

For instance, it has to identify the type of resources required for staff defined in the organisation structure (core project team and entity project teams) with profiles, number and minimum of competency required. Requirements schedule with dates indicating duration of employment on the project for each of the members including entity resources with names assigned.

Alstom will provide an updated list of contacts for all major Maintenance Staff. This list will include, at least, the following information:

- Name,
- Position within the maintenance organisation including whether the person is a Key Resource,
- Working areas,
- Key Resource CV,
- Office address,
- E-mail address,
- Telephone number(s),
- Fax number(s).

Also, Alstom will provide a Role & Responsibility description for all Key Functions. This description will include the following information:

- Key Function ID,
- A short, but precise description of the Key Function,
- A short, but precise description of the Key Function's main tasks and responsibilities in the maintenance,
- A short, but precise description of the Key Function's authorities,
- A short, but precise description of the Key Function's required education and experiences.

In terms of team development and management, the training plan summary is part of the scope of the Maintenance Project Management Plan.

All the HR management principles/arrangements have to be clarified

- Expatriation rules summary and procedures (if applicable)
- Appraisal principles (see Matrix Appraisal approach), etc.

2.3.4.1 "On Site" / "On-Shore" Maintenance Resources

2.3.4.1.1 Customer's Staff:

- Preventive Maintenance,
- Corrective Maintenance, levels 1 (L1) and 2 (L2).

2.3.4.1.2 Supplier's Staff:

- Project Management,
- Scheduling of the Maintenance tasks,
- Spare Parts and consumables management,
- and all other services related to Maintenance Management...

2.3.4.2 "Off-Shore" Maintenance Resources

2.3.4.2.1 Customer's Staff:

Not Applicable.

2.3.4.2.2 Supplier's Staff:

- Corrective Maintenance, level 3 (repairs),
- Renewals and Refurbishment management.

2.3.4.3 Calculation principles applied for determining the numbers of staff

The Calculation Principles applied for determining the number of Customer's Staff is based on the "System Maintenance Plan - variant Regular" (for both Preventive and Corrective Maintenance); the results of the application of such methodology is given throughout the dedicated Price Schedule (see M3.6 for Preventive) as part of the Appendix 12 – Delivery Payment and Payment Schedule as well as other Prices.

Please refer to the dedicated appendix related to the Preventive and Corrective Maintenance workload estimation.

2.3.4.4 Location of the different Maintenance Staff

2.3.4.4.1 Customer's Staff:

Not Applicable.

Nevertheless, it has to be noticed that the Customer's Staff has to be quite closed to the Supplier's Staff for Maintenance and Support Organisation needs.

2.3.4.4.2 Supplier's Staff:

- "On-Shore", based in **Copenhagen**, mainly in the facilities (as part of the Customer's Participation) restricted to Maintenance Project resources, at the Old freight TCC depot;
- "Off-Shore", based either in Saint-Ouen (France) or Villeurbanne (France) depending the services and/or resources involved.

2.3.4.5 Employment Schedule for the Maintenance Staff (workload)

2.3.4.5.1 Customer's Staff:

The Employment Workload related to the Customer's Staff, dedicated to Maintenance, will increase progressively, from the Partial Acceptance of the Early Deployment Phase as part of the Delivery (in fact few months before this Partial Acceptance, for training of maintenance resources during "On Site" Test & Commissioning or even Installation activities prior to the Partial Acceptance) up to the Partial Acceptance of the last phase of the Roll-Out Phase as part of the Delivery. Then the Employment Workload related to the Customer's Staff, dedicated to Maintenance, will be nominal and stable.

The Employment Schedule of the Customer's Staff, dedicated to Maintenance, could be discussed and reviewed during progress and periodical meetings between the Supplier and the Customer.

2.3.4.5.2 Supplier's Staff:

The Employment Workload related to the ("On-Shore") Supplier's Staff, dedicated to Maintenance, will be nominal and stable, from the kick-off of the Maintenance and Support Project.

2.3.4.6 Training Schedule of the Maintenance Staff

2.3.4.6.1 Customer's Staff:

The training of the Customer's Staff, dedicated to Maintenance, will be held during the Maintenance Preparation Sub-project (on a non recurrent basis) and also during the Maintenance and Support Project (on a recurrent basis); moreover, the Customer's Staff, dedicated to Maintenance, will be trained during the execution of "On-Site" activities (such as "On Site" Test & Commissioning or even Installation activities prior, to the Partial Acceptance, during the deployment of Partial Deliveries).

2.3.4.6.2 Supplier's Staff:

Not Applicable.

Please refer to the dedicated document "Appendix 5 – Attachment 9 – The Tenderer's Customer Participation Specification".

2.3.5 Quality Management

This aspect will be covered by the dedicated Maintenance Project Quality Plan, if any and/or relevant.

2.3.6 Project Work Process and Communication

All the basic principles of the joint work process and definition of clear communication rules both internally and externally have to be defined, especially in the following areas:

- Meetings and reviews: types, objectives, participants, schedule, frequency, typical agenda, prerequisites, inputs, expected outputs and possibly venue including:
- Project progress
- Ad hoc meetings for particular decision-making, problem solving
- Co-ordination meetings on main sections of train/signalling systems and main interfaces
- Risk management meetings
- Customer project progress meetings.

The Reporting process shall also be clarified:

- Type and frequency of all reports both internal/external with details of authors, content, distribution (including reports not directed to hierarchy for approval)
- Details of reporting process (e.g. flow chart) including approval system
- Applicable communication rules with the customer (formal and informal communication: written communication, frequency of customer visits to the site, approval process for visits, etc)

Internal communication Rules, methods and systems / channels of communication must be set up and agreed as early as possible (mobilisation).

Some principles have to be defined regarding Communication media, as well as Document management and control rules (may be part of the Quality Project plan).

2.3.7 Warranty Management

Maintenance during the warranty period is used as a basis for Return on Experience (REX) from Alstom as the Maintainer to the Engineering and New build project team.

Depending on contractual specifications, in some cases Alstom might report to the Customer or to the Operator.

Each Project partner shall set up the internal organization to deal with the assistance activities.

The Maintainer will appoint his Representative, who shall be the sole authority for presenting defects and warranty claims, as interface with the Customer / Operator / New build project team ("Constructor") at Mobilisation phase of the Contract.

The New build project team will appoint a single point of contact with the maintainer. He will be responsible for receiving the Defect Notification, distribution to the relevant partner, and updating the relevant documentation.

The Maintainer Representative shall forward to the Constructor written Defect Notification, using the formal "Defect Notification Form".

The applicable formal procedure for Defect Notification will be defined in details, as it is very important to perform the remedial works as soon as possible, but also to ensure the defect are treated whilst continuously optimising this process.

2.3.8 Performance Measurement

The set of Key Performance Indicators (KPI) and objectives shall be defined as soon as possible, some general and some specific to the project (based on customer requirements, key success factors, and strategic objectives...), to monitor the progress of the project and measure the performance of different project contributors.

3 ANNEXE: MTBF/ MTTR DATA BASE

According to the architecture defined for the S-bane Signalling system (Delivery) the MTBF/ MTTR data will be the ones presented and reminded into the dedicated Price Schedule, as part of the Appendix 12 Delivery Payment and Payment Schedule as well as other prices.

4 ANNEXE: LIST OF MAINTENANCE TOOLS

The following specific tools should be used for the maintenance of the S-bane Signalling equipment (Delivery) that will be installed within the main contract

4.1 Tools identical to T&C tools

4.1.1 ATC Trackside

SUB-SYSTEM	KIND OF TOOLS	NAME AND FUNCTION
TRACKSIDE ATC	Software	OMAP software + OMAP database (software for trackside analysis logs)
	Hardware	Laptop
	Equipment	Laser
	Equipment	BEPT (Beacon Encoder Programming Tool)
	Tools	Digital display multimeter
	Tools	Insulated tools sets
	Tools	Complete sets of mechanical engineering tools
	Tools	Lighting
	Tools	Power supply extension cord
	Tools	Low voltage cables
	Hardware	Ethernet cable
	Hardware	RS 232 cable with SUB DB9
	Tools	Cabling Tools
	Tools	Identity device programmer
	Software	USB Key programmer
	Hardware	Polyswitches resettable fuses

4.1.1.1 ATC OnBoard

SUB-SYSTEM	KIND OF TOOLS	NAME
ONBOARD ATC	Hardware	Laptop with Ethernet and Serial port
	Hardware	BDM for ColdFire 52xx/53xx/54xx
	Hardware	HE10 cables minimal to program UNIVIC boards.
	Hardware	Straight cables Ethernet
	Hardware	Crossover cables Ethernet
	Hardware	M12-RJ45 cables
	Software	A data plug programmer
	Software	OVLI Software (ATC data verification software tool)
	Software	OMAP Software + OMAP database (software for trackside analysis logs)
	Software	TFTPD32

	Software	FTP Software
	Software	Train Tracer
	Software	Extraputty
	Hardware	Data plug manager
	Software	Usb-serial driver & Converter
	Software	PROGCFZ - ColdFire Programmer
	Hardware	Cable - 1 mm ² - 200m
	Tools	F21+4 Harting connectors (09 06 025 3203)
	Tools	Extraction tool
	Tools	Insertion tool
	Tools	Crimping pliers
	Tools	Extractor / inserter
	Tools	F48 Harting connectors
	Tools	Multi-meter

4.1.1.2 IXL and track equipment

SUB-SYSTEM	KIND OF TOOLS	NAME
SML400	Equipment	SDM (Diagnostic and Maintenance System) Local Maintenance Terminal Maintenance Server
	Hardware	Laptops
	Hardware	Compact Flash Card
	Tools	Digital display multimeter
	Hardware	RJ45 Cable
SMIO	Hardware	Test Module Board
	Hardware	CKPT - Programmer tool
	Hardware	Probe programmer
	Software	SmartIOCAA
	Software	SmartIODAA
	Tools	Crimps contact AWG 20-16 (0,5-1,5 mm ²)
	Tools	Crimping tool
	Tools	Removal tool
	Tools	Cable - 1 m ² - 50 m for test
	Tools	Torx screwdriver
	Tools	Insulated tools sets

EQUIPMENT	KIND OF TOOLS	NAME
AXLE COUNTER	Tools	Iron Plate

EQUIPMENT	KIND OF TOOLS	NAME
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POINT MACHINE	Tools	Insulated tools set
	Tools	Mechanical tools set
	Tools	Torque screwdrivers sets
	Tools	Torque wrenches sets
	Tools	2-4 mm detection checking tool
	Tools	Hand crank
	Tools	Digital display multimeter

4.1.1.3 ATS

SUB-SYSTEM	KIND OF TOOLS	NAME
ATS	Software	FTP Software
	Hardware	USB Key 2G
	Software	Matrikon
	Software	VNC Viewer Free Edition

4.1.2 Dedicated maintenance tools

Specific tools for maintenance:

- CVM Test bench for Maintenance UNIVIC Level 2. (for on-board sub-contracts)

Equipment have also their own maintenance equipment in their system which helps the maintenance team for the monitoring of the system .They are deliver with the equipment but not specifically as maintenance tools: It is:

- SDM for the Interlocking (one per CLC),
- The NMS IP and SDH are used by Maintenance team,
- ATS Maintenance workstation.



Annex 4 – Train Control Acronyms

Abbreviations and acronyms

AP	Automatic Protection
ATC	Automatic Train Control
ATP/ATO	Automatic Train Protection/Automatic Train Operation
ATS	Automatic Train Supervision
CBTC	Communication-Based Train Control
CLC	Central Logic Computer
COTS	Components Off The Shelf
EB	Emergency Braking
EMC	Electro-Magnetic Compatibility
EOA	End Of Authority
IXL	Interlocking
LRT	Light Rail Transit
SCADA	Supervisory Control And Data Transmission
MSS	Maintenance Support System
MTBF	Mean Time Between Failures
NMS	Network Management System
PACIS	Passenger Address and Communication Interphone System
PPHPD	Passengers Per Hour Per Day
RAMS	Reliability Availability Maintainability Safety
TCMS/TMS	Train Control and Management System/ Train Management System
ZC	Zone Controller



TramWave



The Ultimate CATENARY FREE TRAMWAY SYSTEM

Ansaldo STS pioneered the modern technology for transit systems without overhead catenary.

- First prototype development: year 1998
- First pilot plant of intermediate transit systems: year 2000
- First test of ASTS technology for a rail vehicle: year 2000

TramWave is now a product:

- Particularly focused and developed for different tramway systems
- Based on a “core technology” well proved and tested
- Presently customized for “SIRIO” tramway breed but able to be fitted on any tram



Ansaldo STS technology is founded on the following concepts:

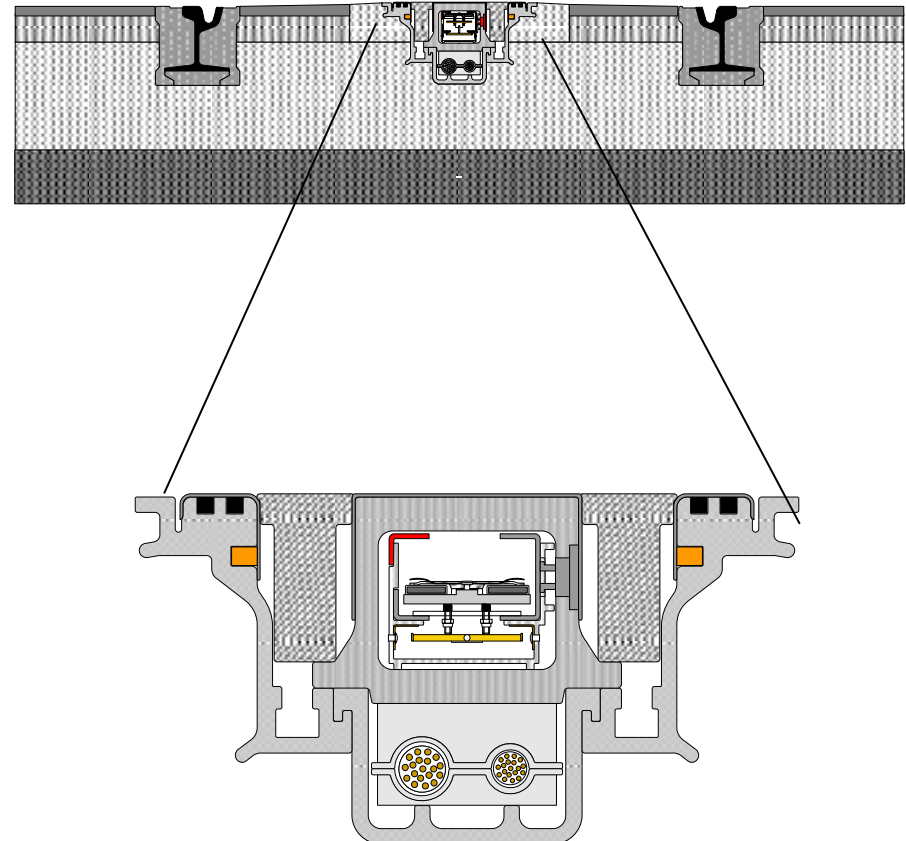
- *Use of a “closed conduit”, embedded on the ground*
- *Transmission of power through a segmented surface contact line, where each segment is insulated and normally connected to ground.*
- *Simple physical principles are governing the whole operation of the system.*
 - *The contact segments are switched on to the positive feeder only by the presence of the power collector over the contact line, by means of the pulling force of a “built in” permanent magnet on a flexible ferromagnetic belt, located inside the conduit.*
 - *The contact segments are switched off to negative feeder by the same flexible ferromagnetic belt that falls down by gravity force*
 - *The total length of the segments that are in live condition is very short (1 meter max), reducing to the minimum the “unsafe” area, (allowing the use of the technology even for short length vehicles).*
 - *The safety of the system is assured in all the possible normal and upset operating condition.*

- The system technology is specially designed and manufactured to facilitate the installation of all the system components:
 - in a new plants and vehicles
 - as retrofit in already existing installations.

Many different operational and functional configurations may be envisaged.

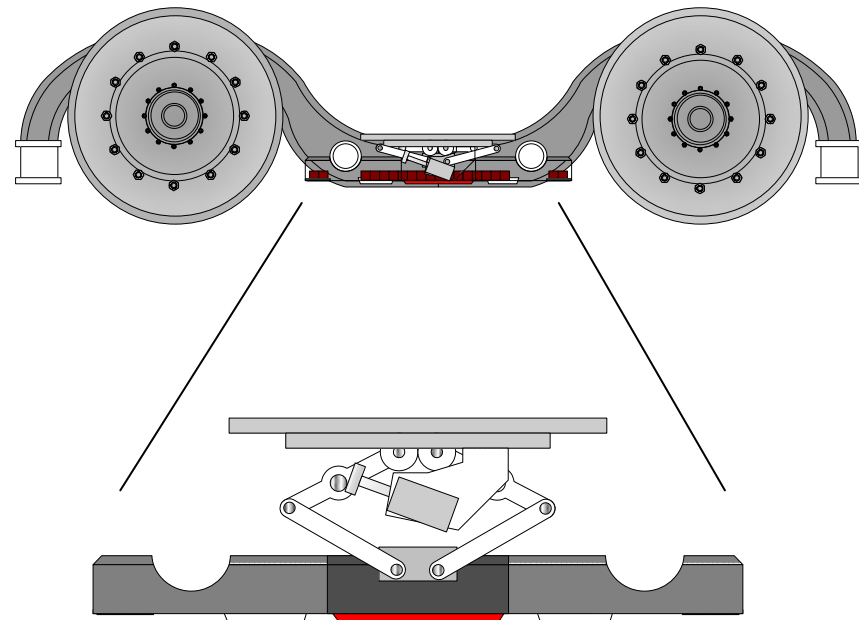
The “Tramwave” power line can be easily installed between the running rails.

- *The section of the power line is very compact.*
- *The overall dimensions are of the line components are compatible with a wide range of track equipments*
- *All the main components of the power line are located inside the line section.*
- *The traction current could return on the same power line, without involving the running rails*
- *No need of special protection against stray currents*
- *No electromagnetic emission inside or outside the vehicle.*

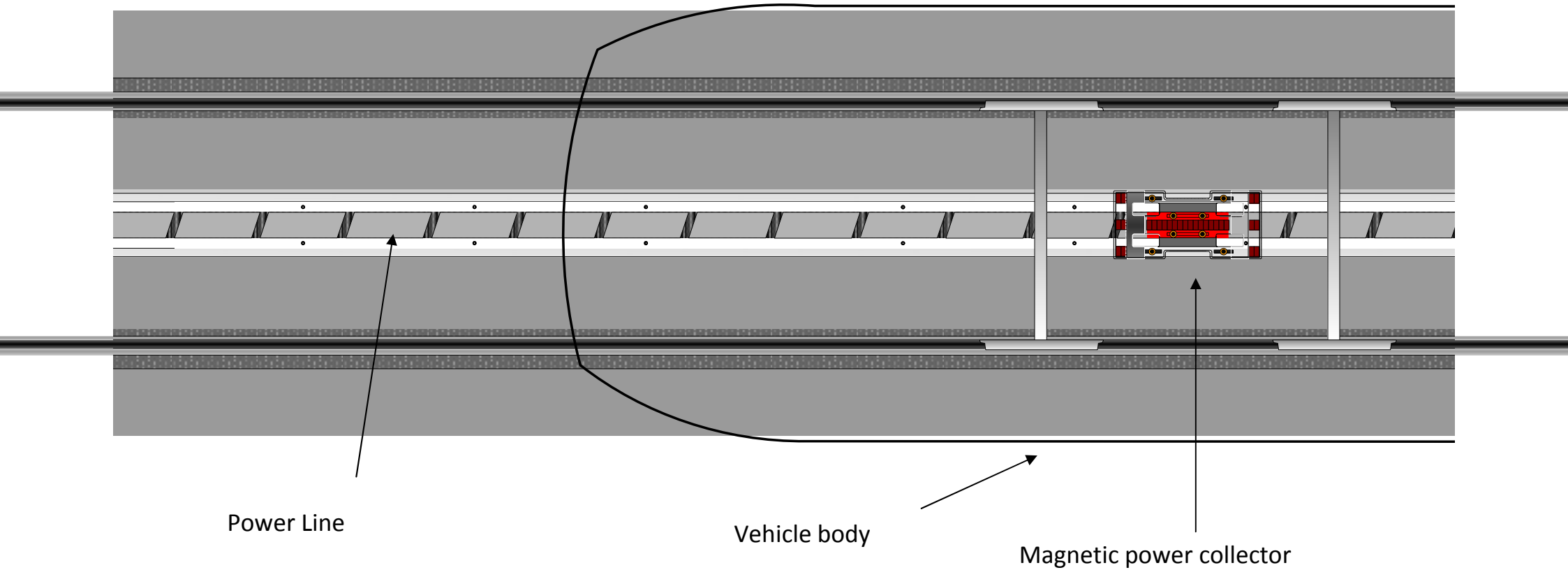


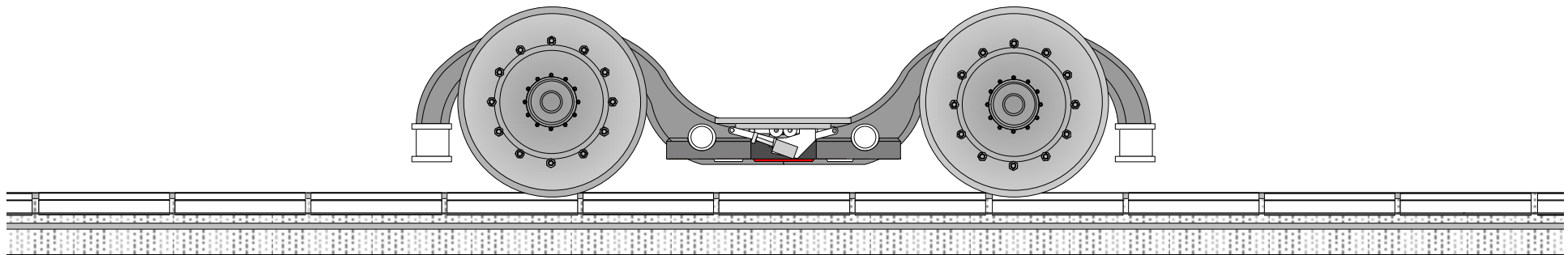
The overall dimensions and functional characteristics of “TramWave” power collector are enough compact to be inserted inside a tram bogie, or, if necessary, under the vehicle body.

- *The power collector is lifted up and down over the contact line by a special pantograph.*
- *The interfacing of the power collector/pantograph with the vehicle bogie and the other parts of the vehicle is very simple and could be studied and rearranged for different types of bogies.*
- *A simple command equipments could manage the global operation of the power collector, power sources switching, etc.*



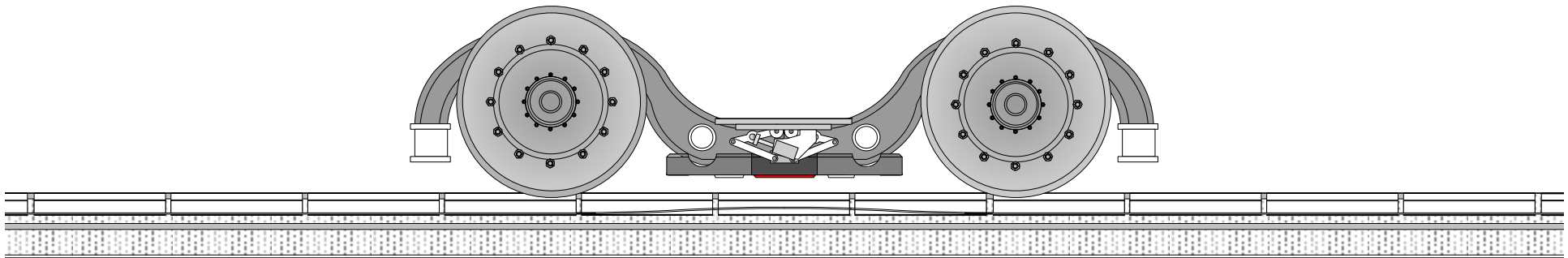
Tramwave components





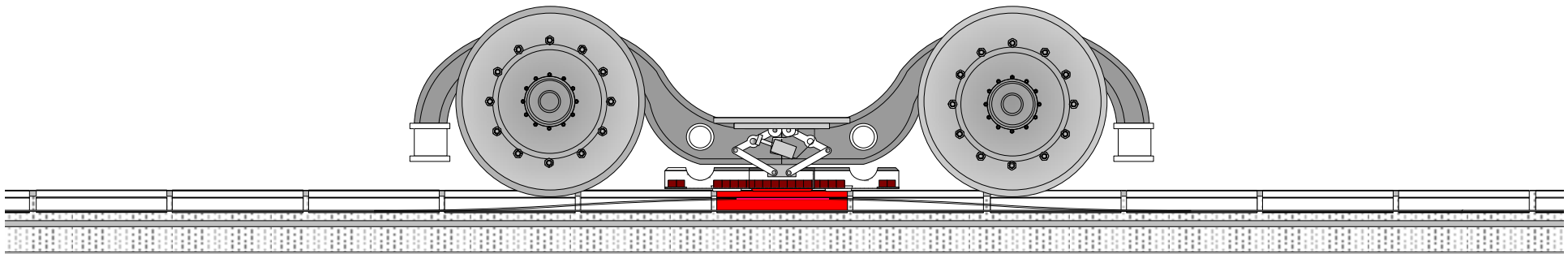
When the pantograph is retracted in rest position:

- *The magnetic power collector in the upper position is unable to activate the power line segments; the pulling force is not enough to lift up the belt.*
- *The vehicle can run over the line without activating the segments*
- *All the segments stay connected to ground.*



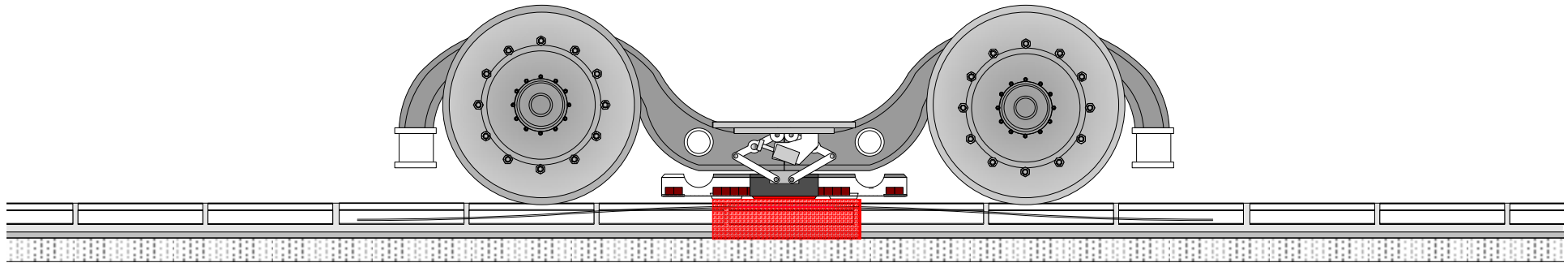
When the pantograph is released:

- *the power collector goes down to the line*
- *the pulling force increase and induces the rising of flexible belt inside*
- *some segments (1-2-3) under the power collector are disconnected from ground.*



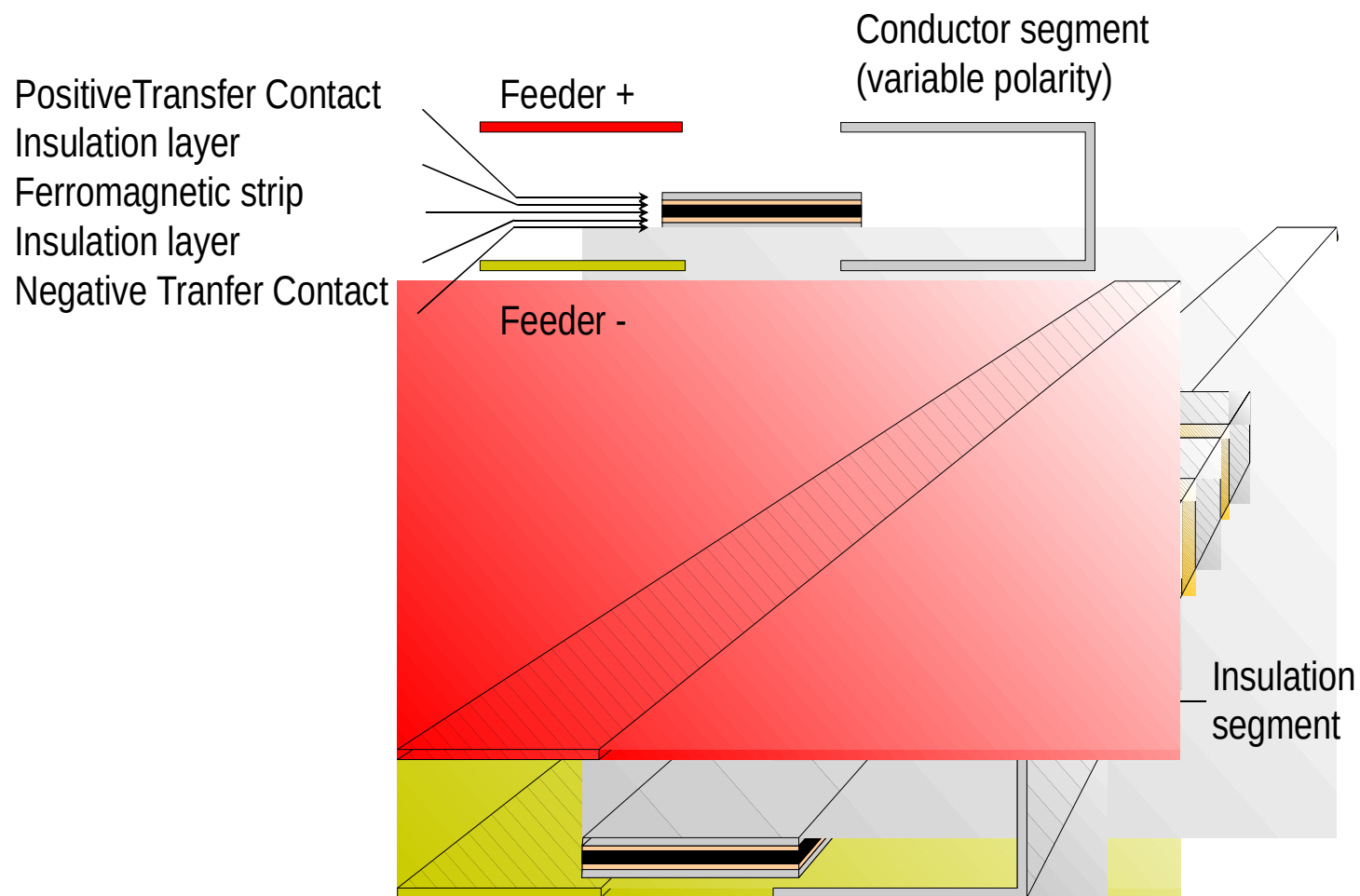
When the pantograph is completely released :

- *the power collector is in contact with the line segments*
- *the flexible belt reaches its working position and activates the underlying segment (s)*

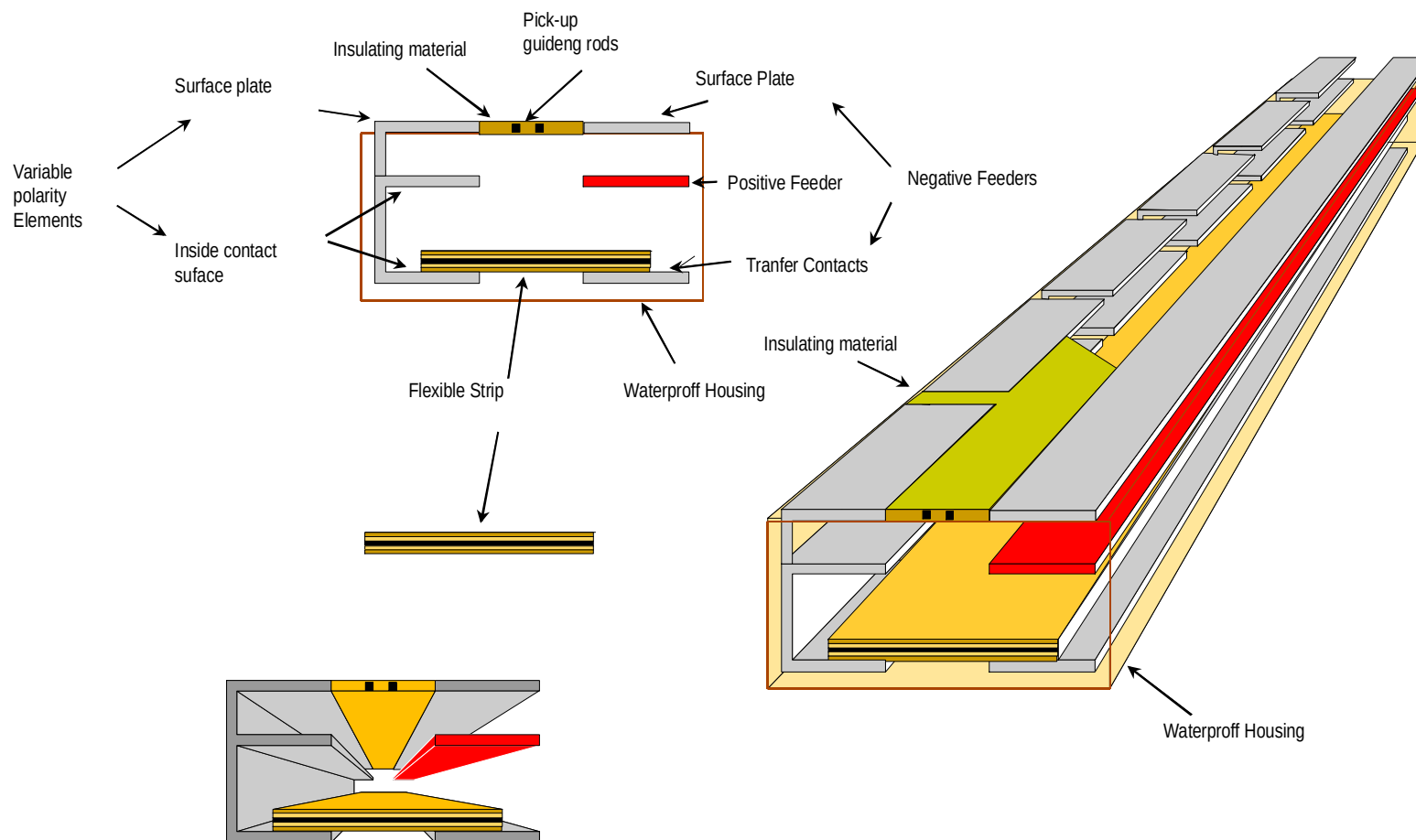


The vehicle is ready to run, powered by the line.

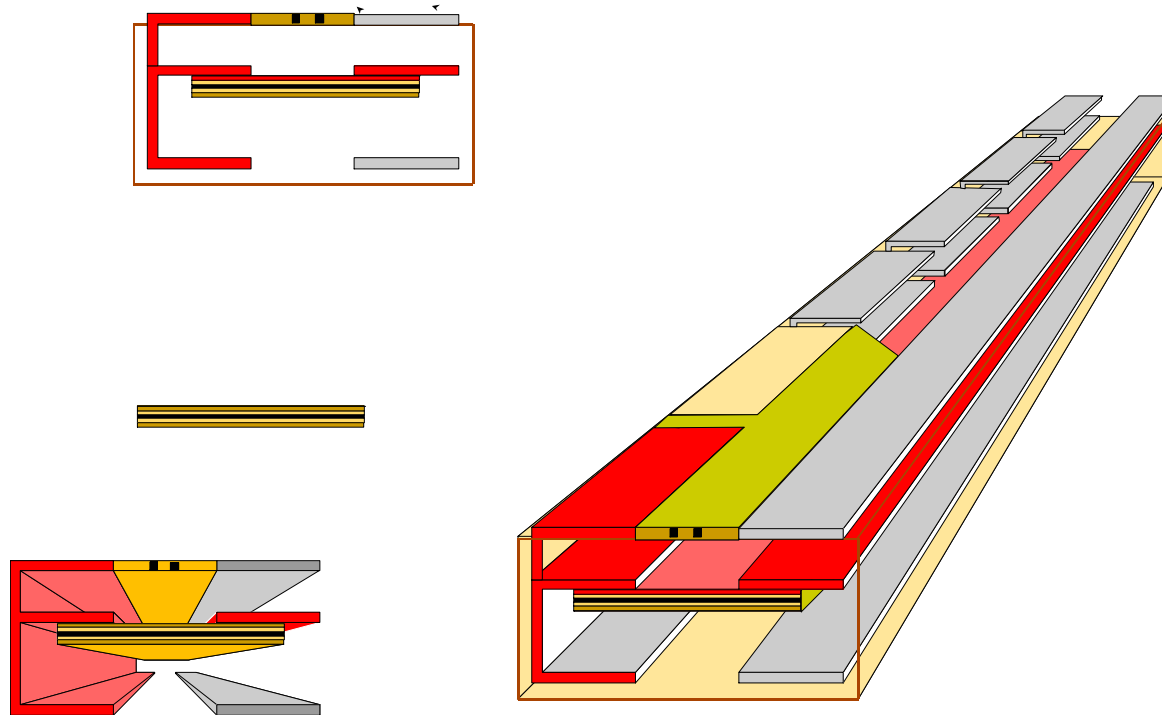
Operating principles



Concept

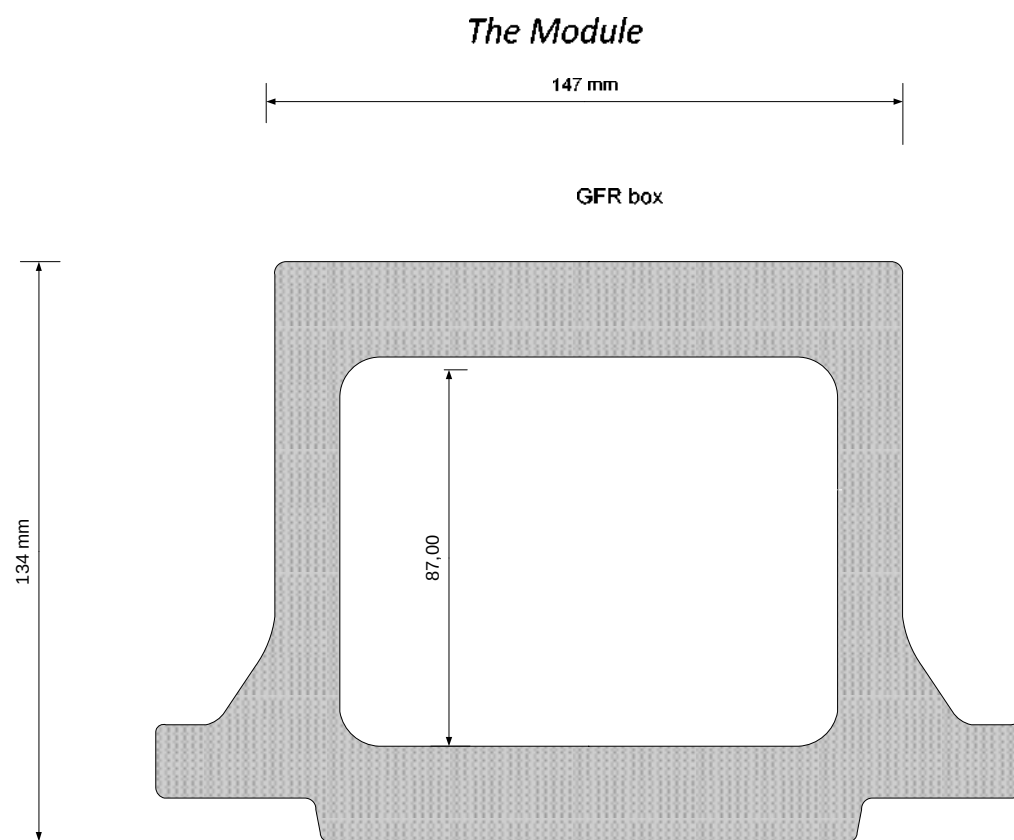


Concept

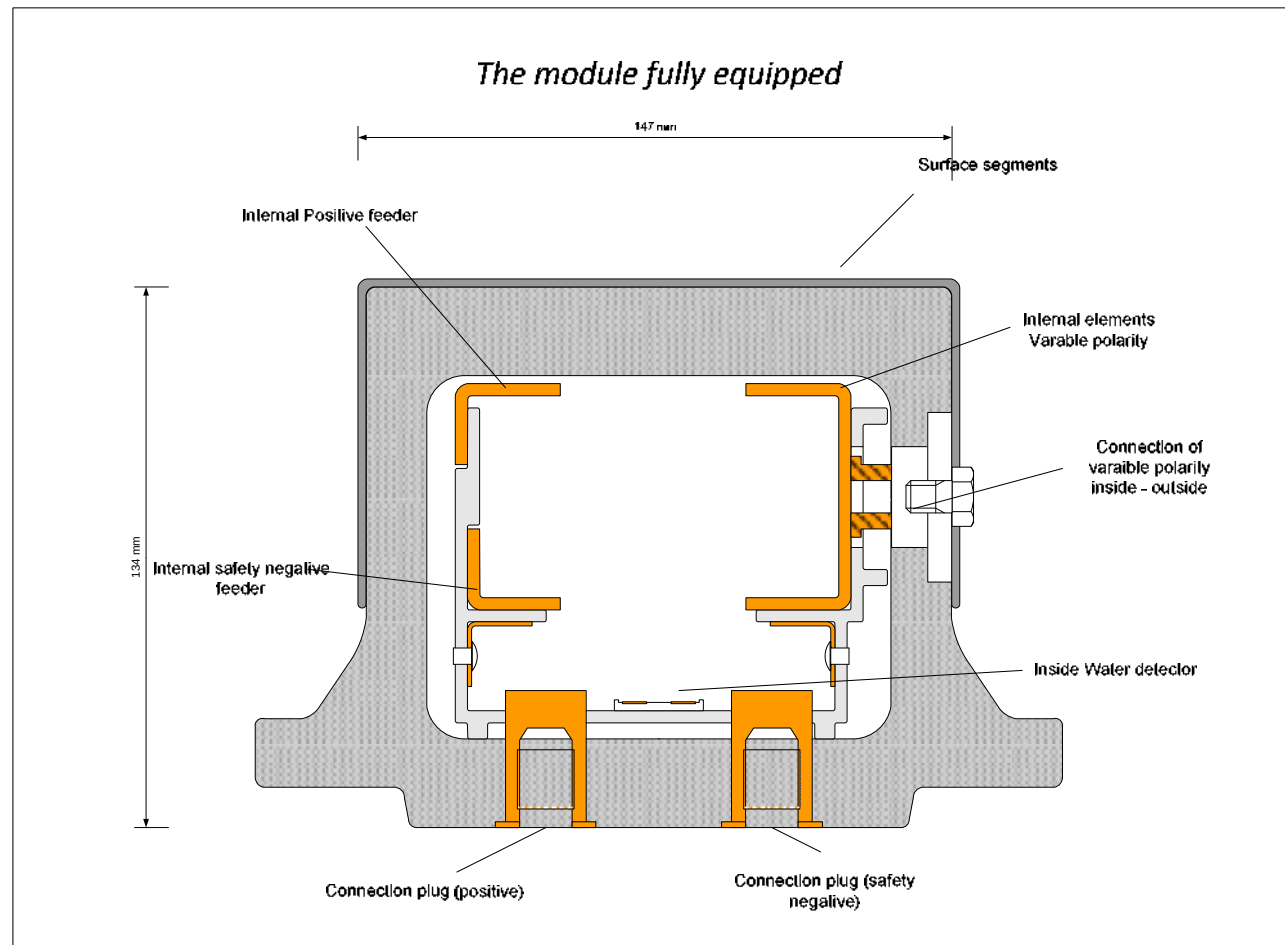


Main components

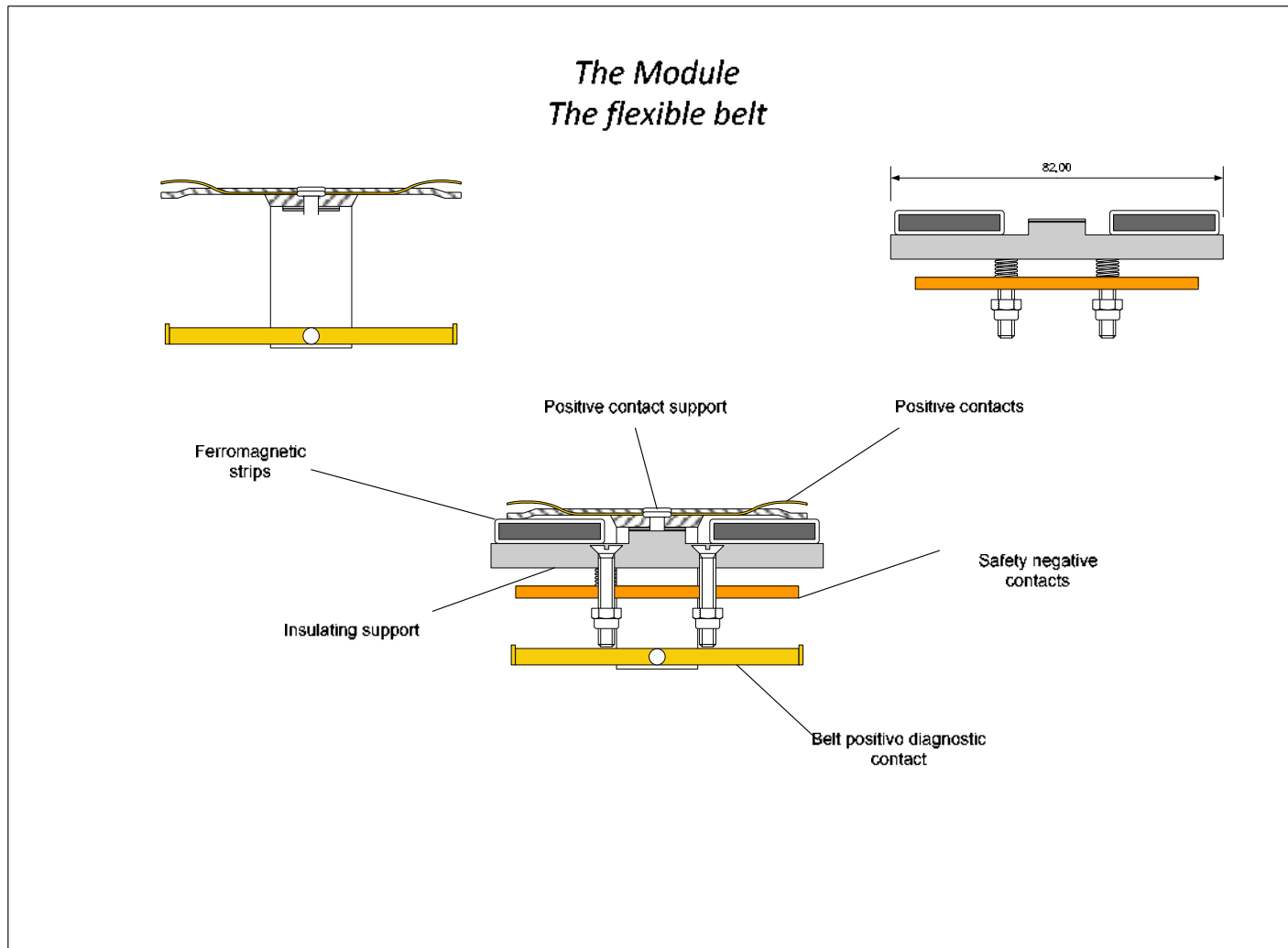
Module section



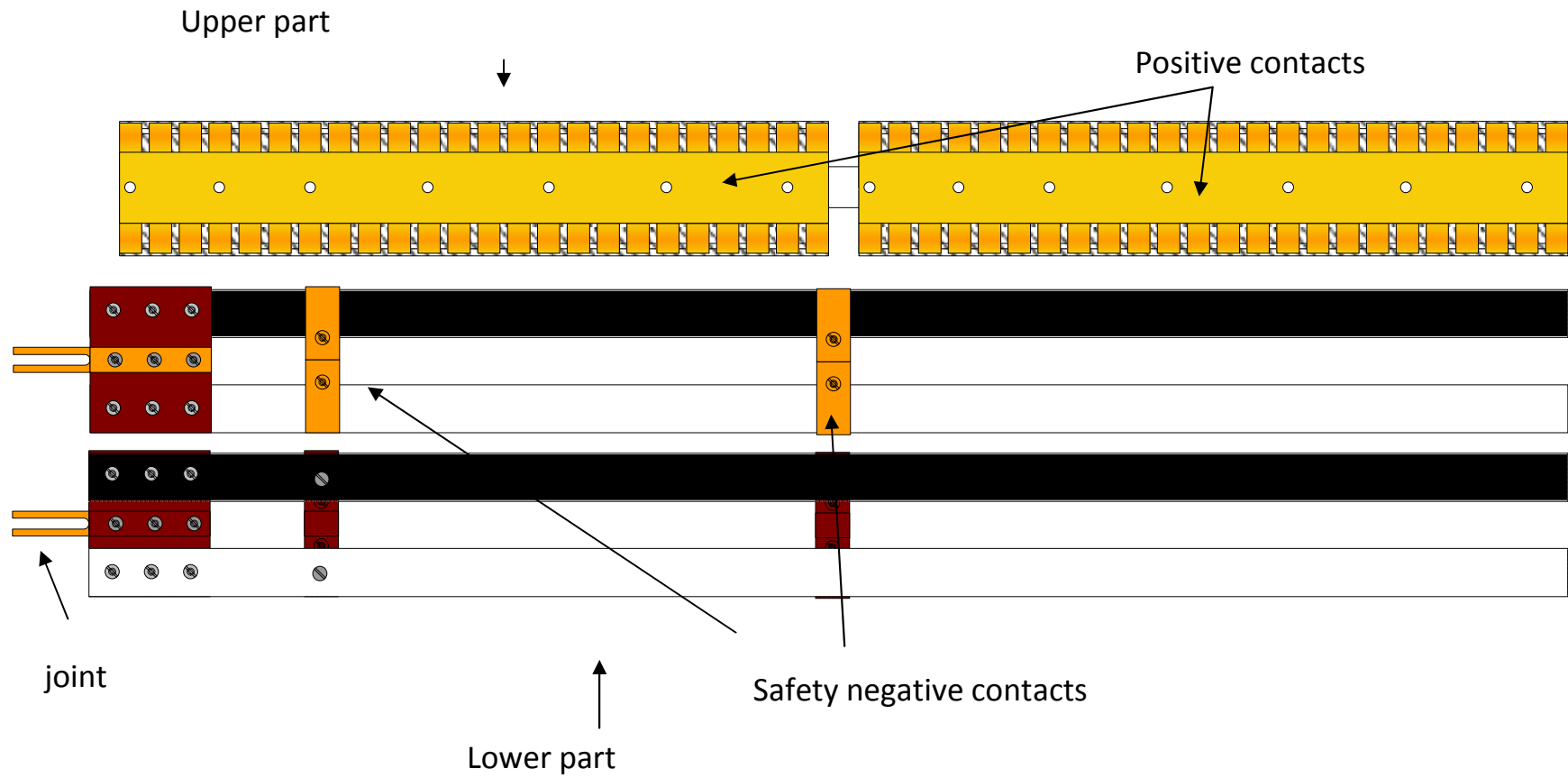
The module: Internals – Fixed elements



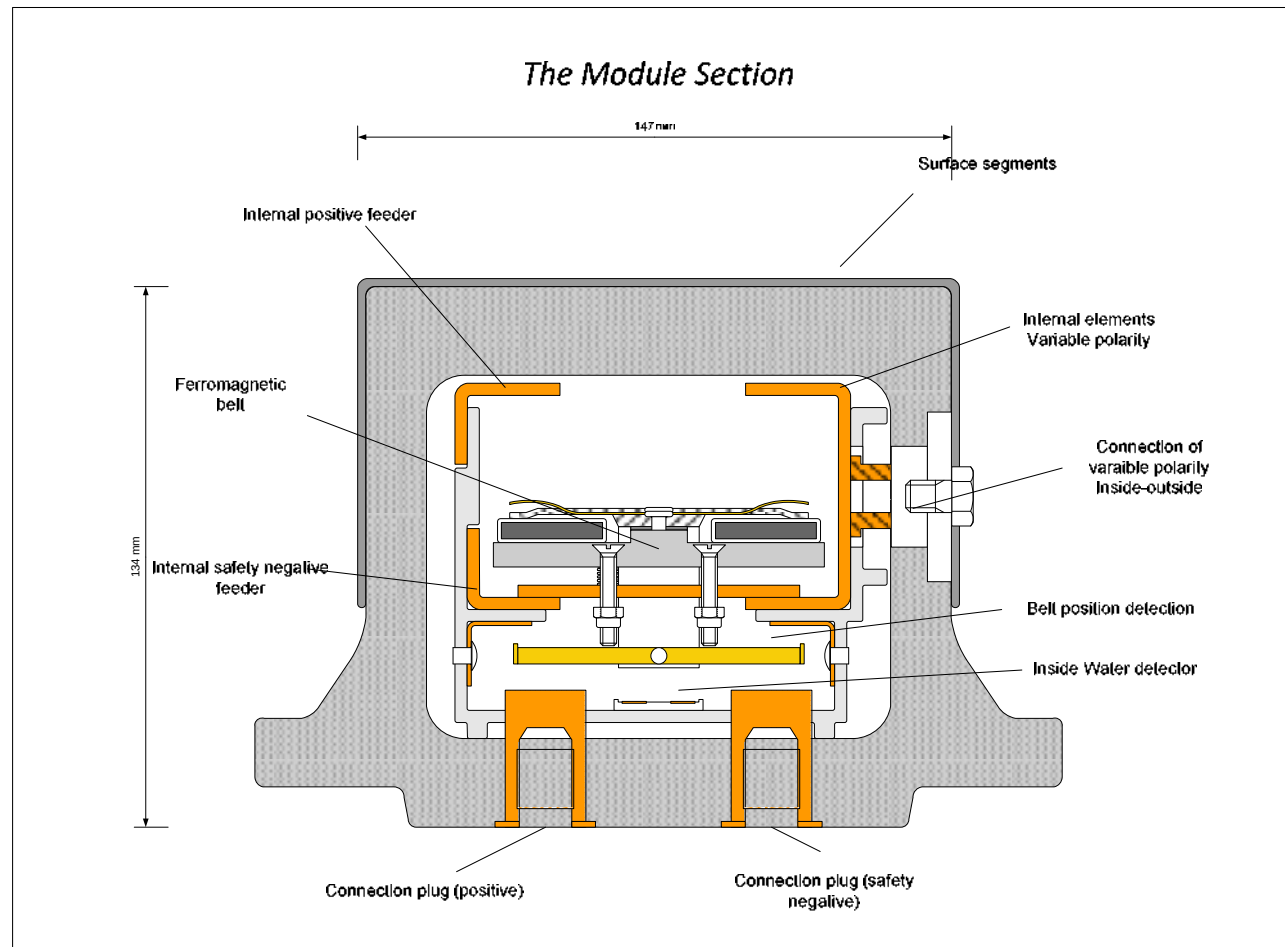
The flexible belt and contact carrier



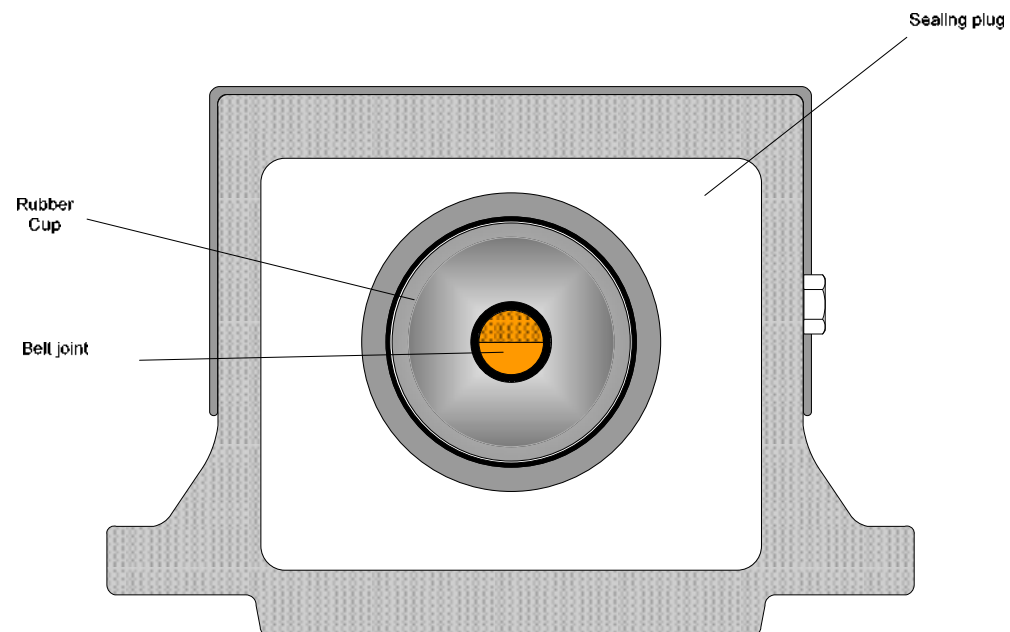
The flexible belt and contact carrier



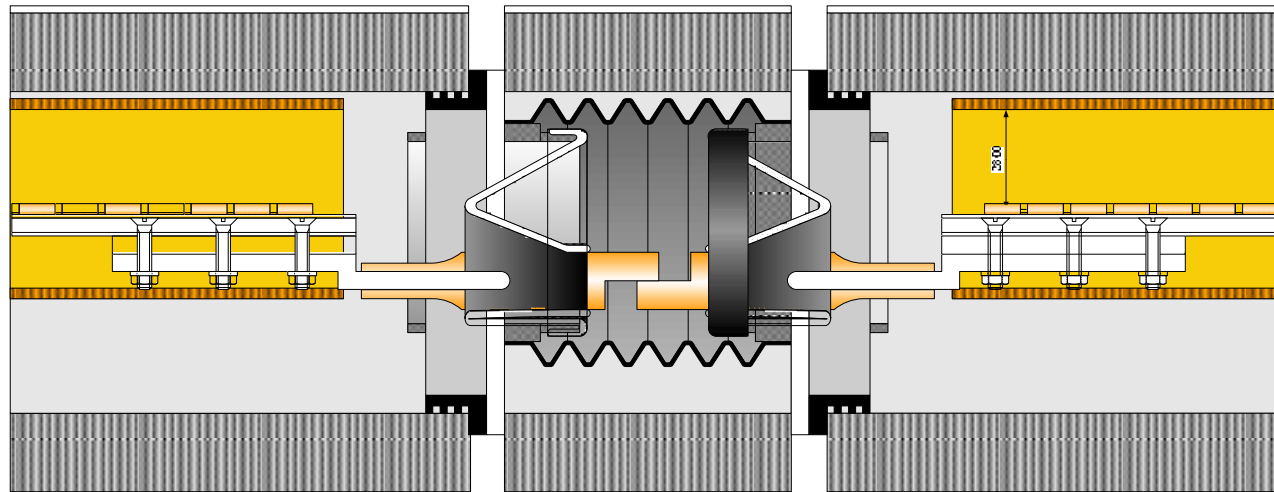
The module: global section



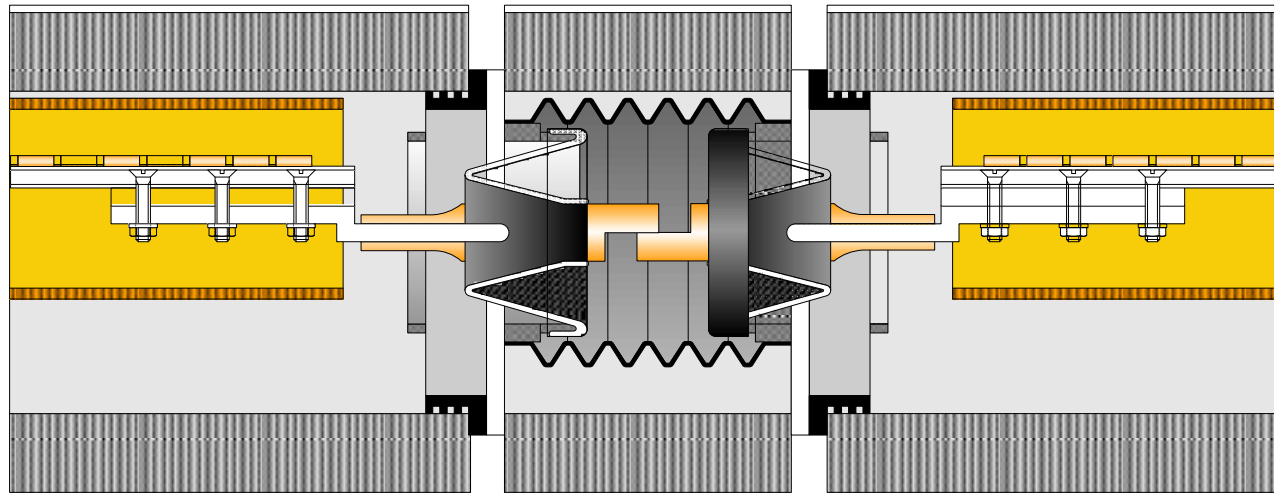
*The module
End terminations*

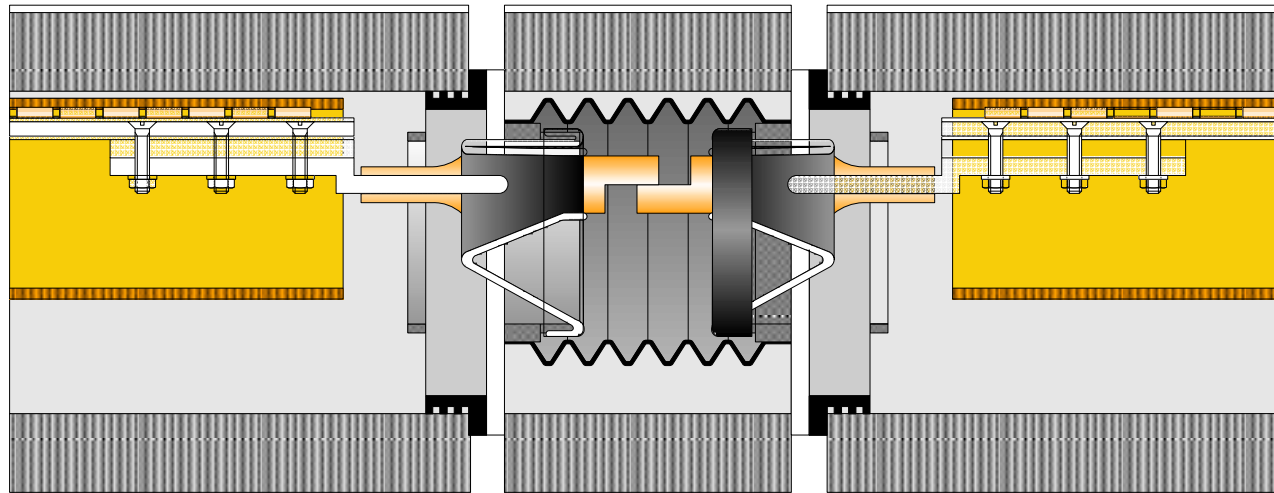


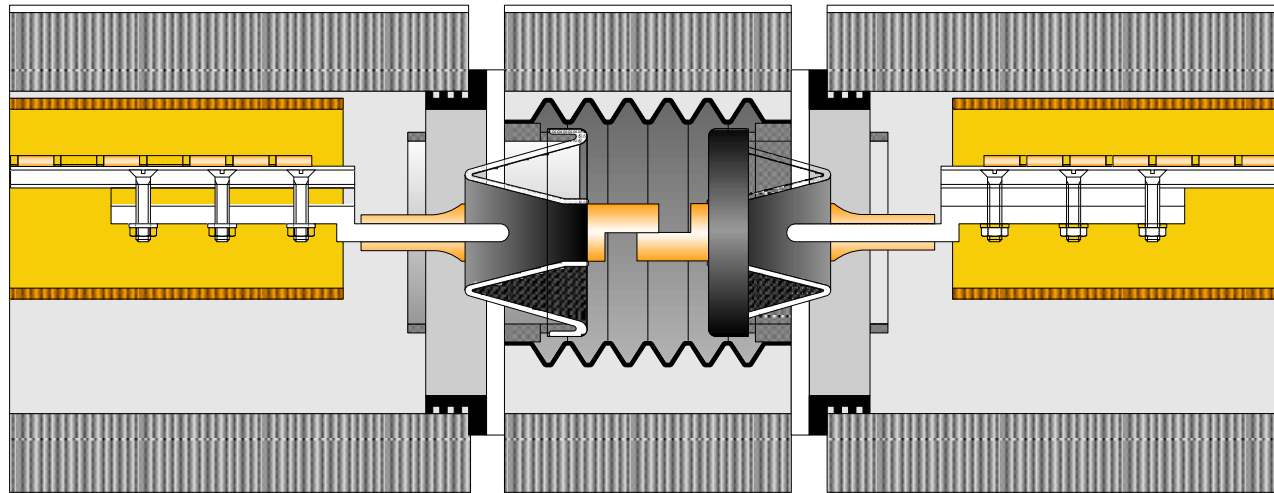
Joints between adjacent modules

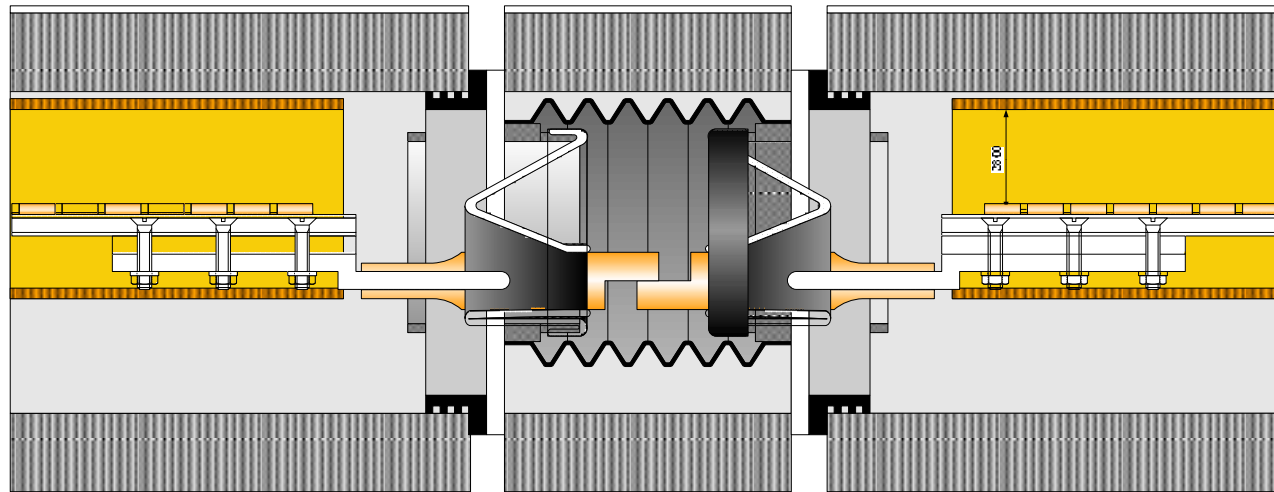


Rest condition

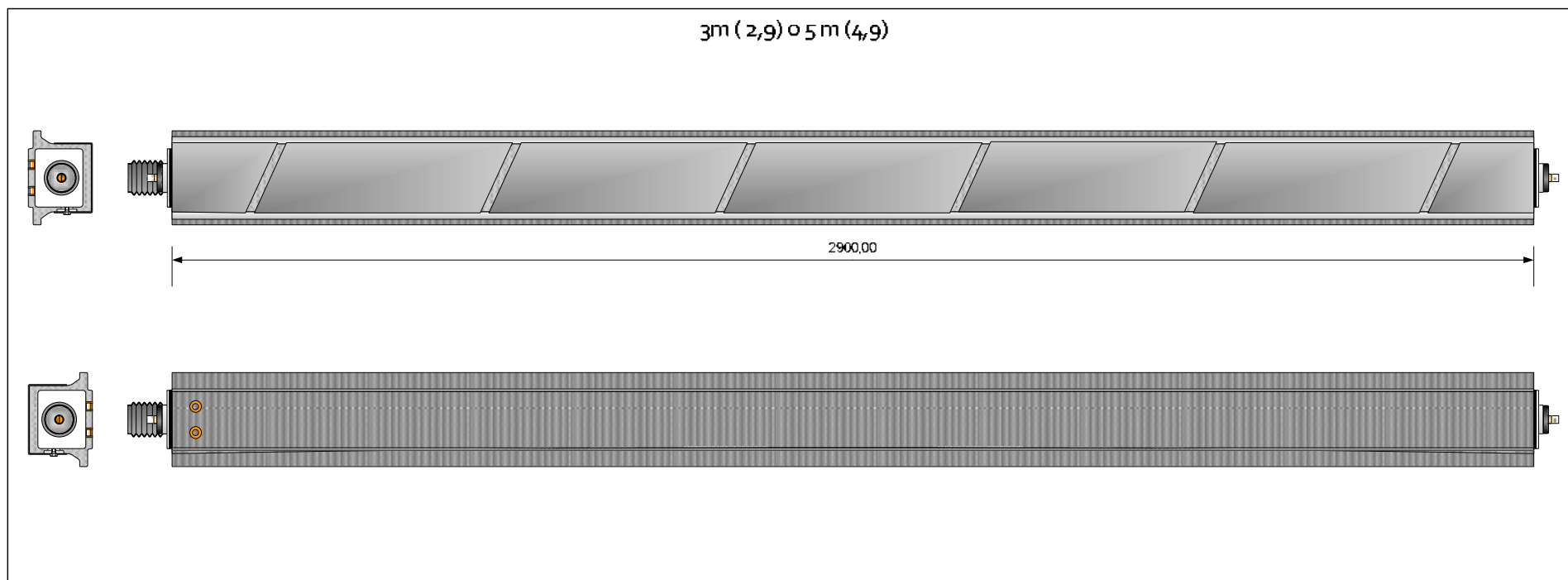




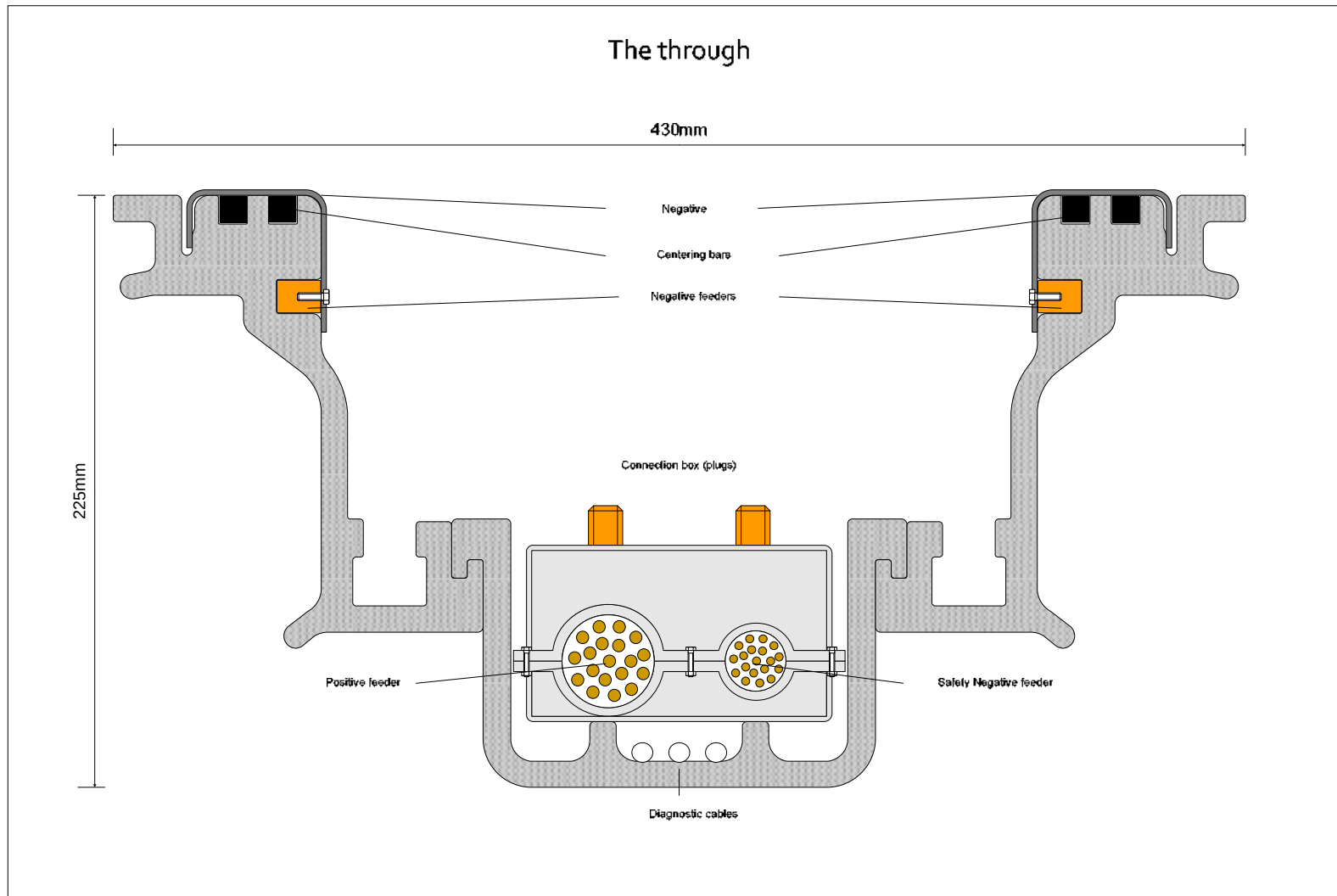




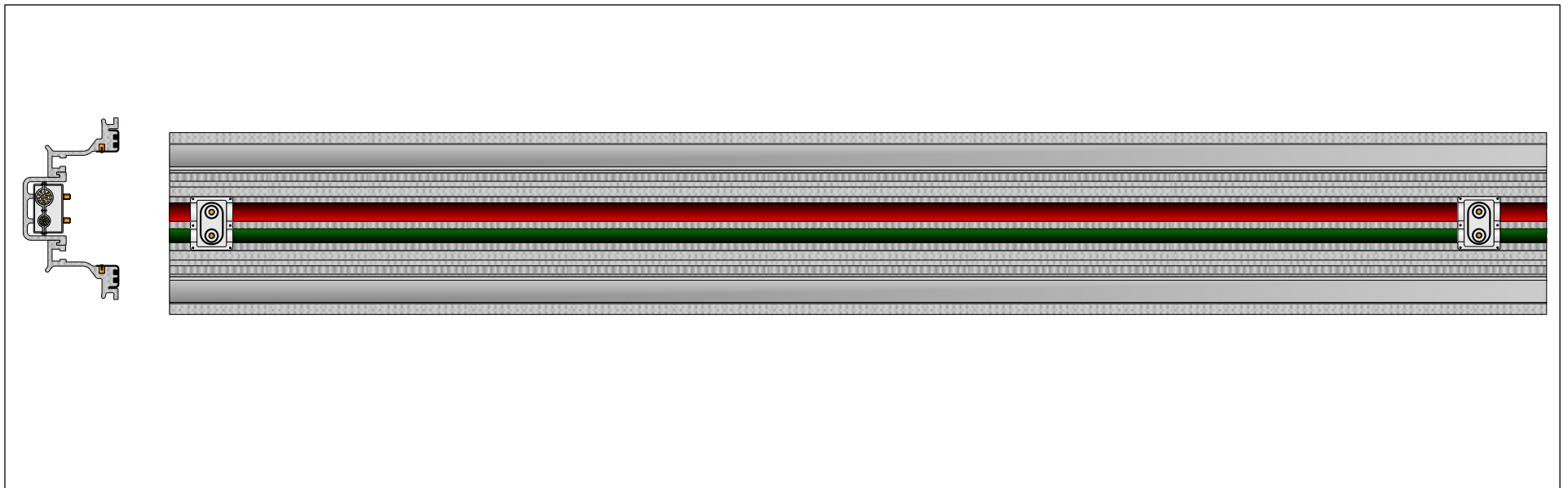
The module fully assembled



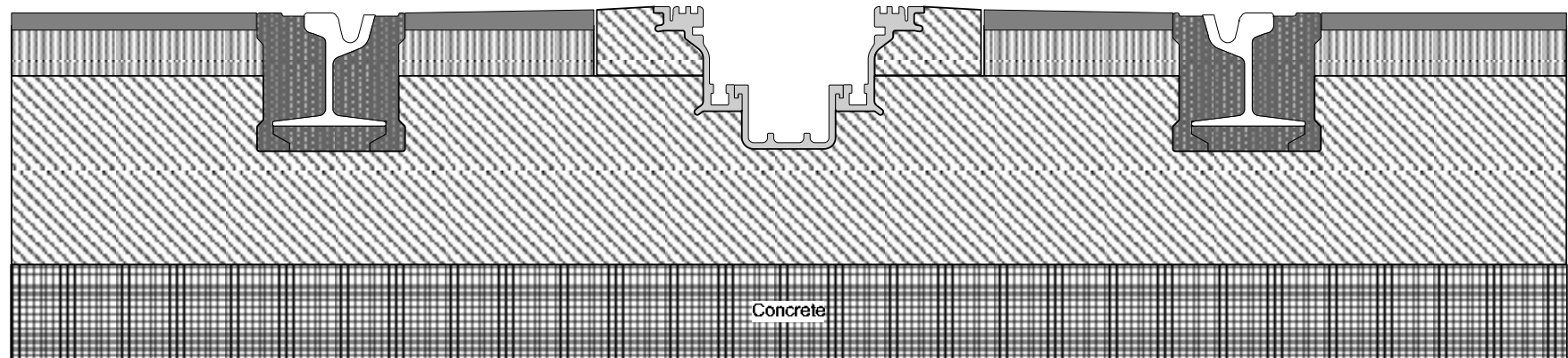
The open conduit (the trough) Section



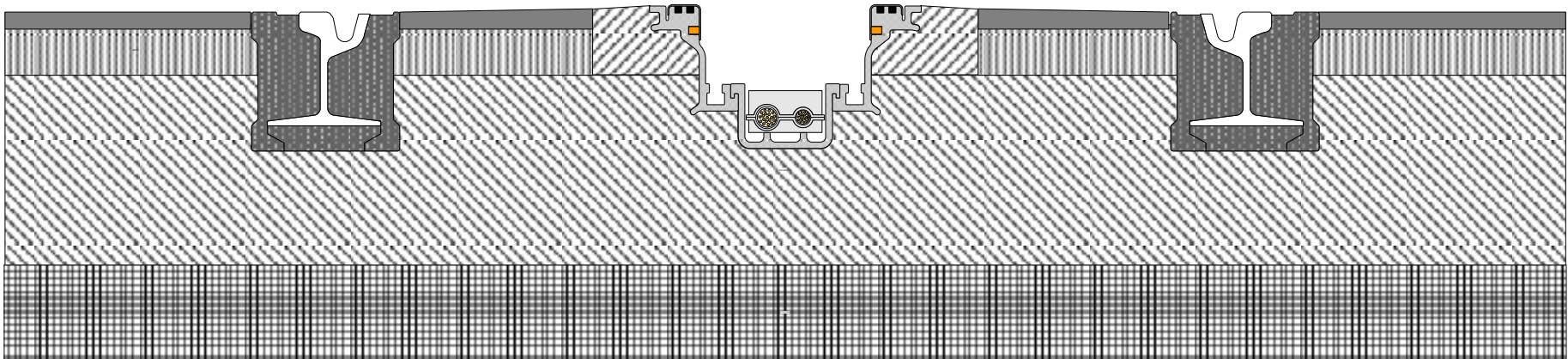
The open conduit (the trough) Top View



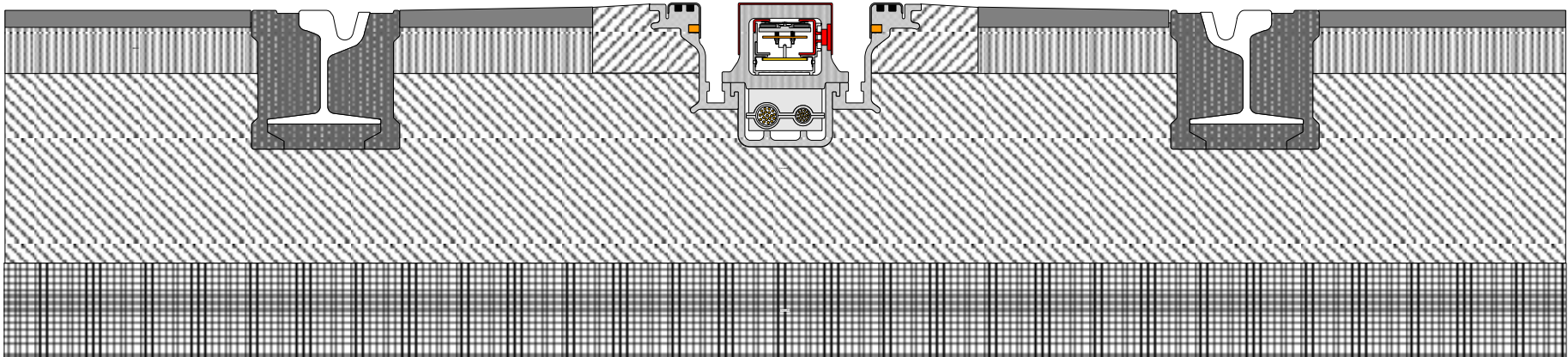
Example of trough insertion in the track



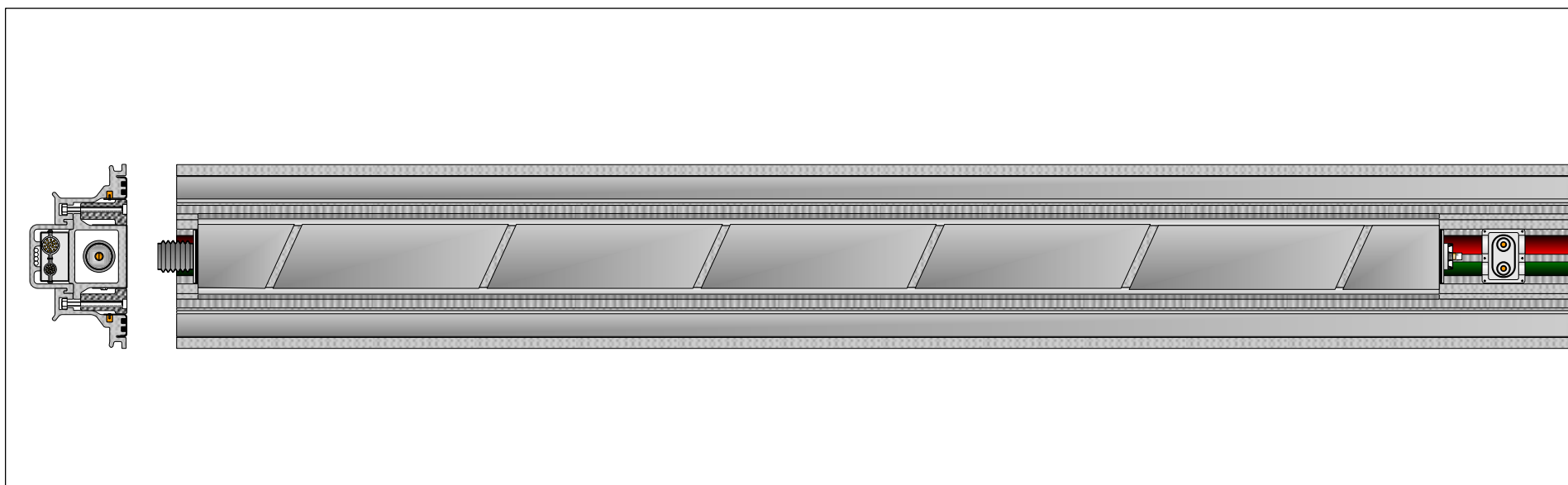
The power line ready for insertion of the modules



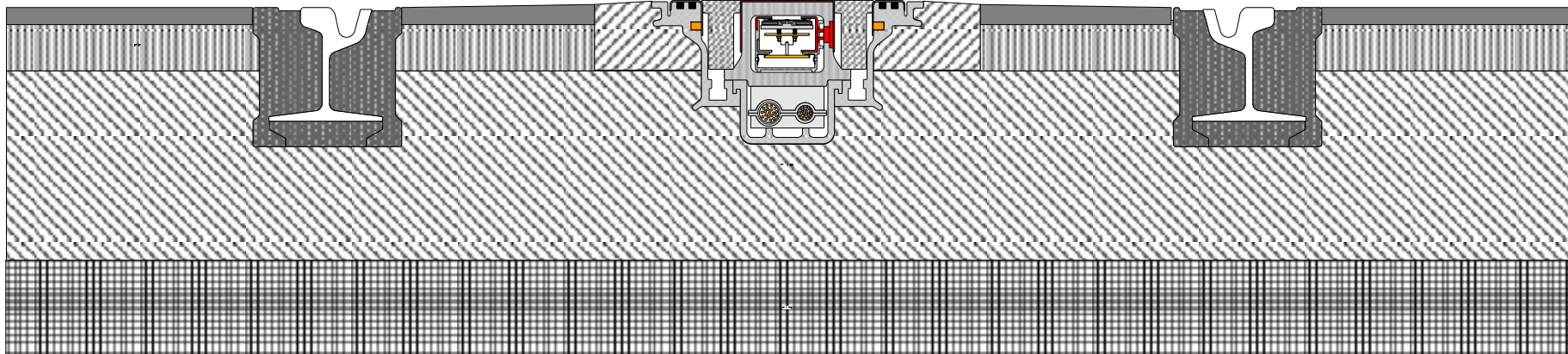
The module in the trough (section)



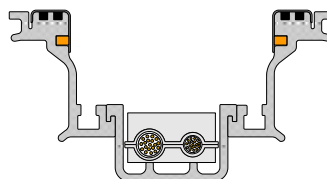
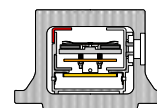
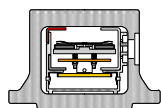
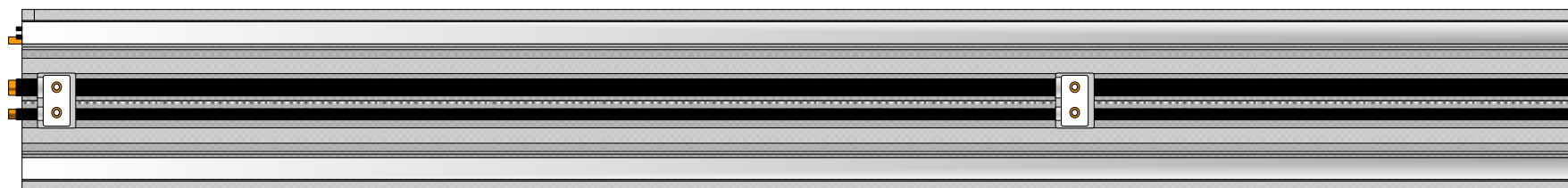
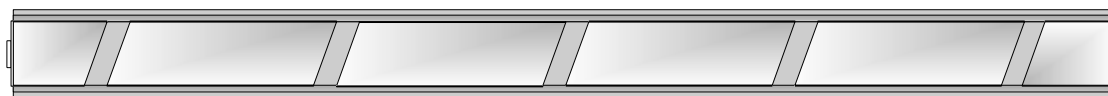
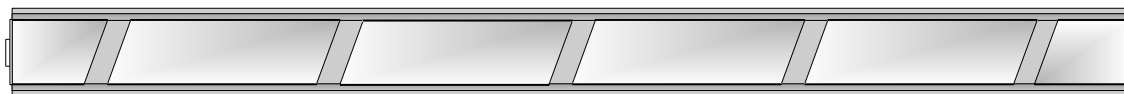
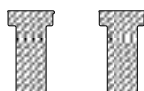
The module in the trough (top view)



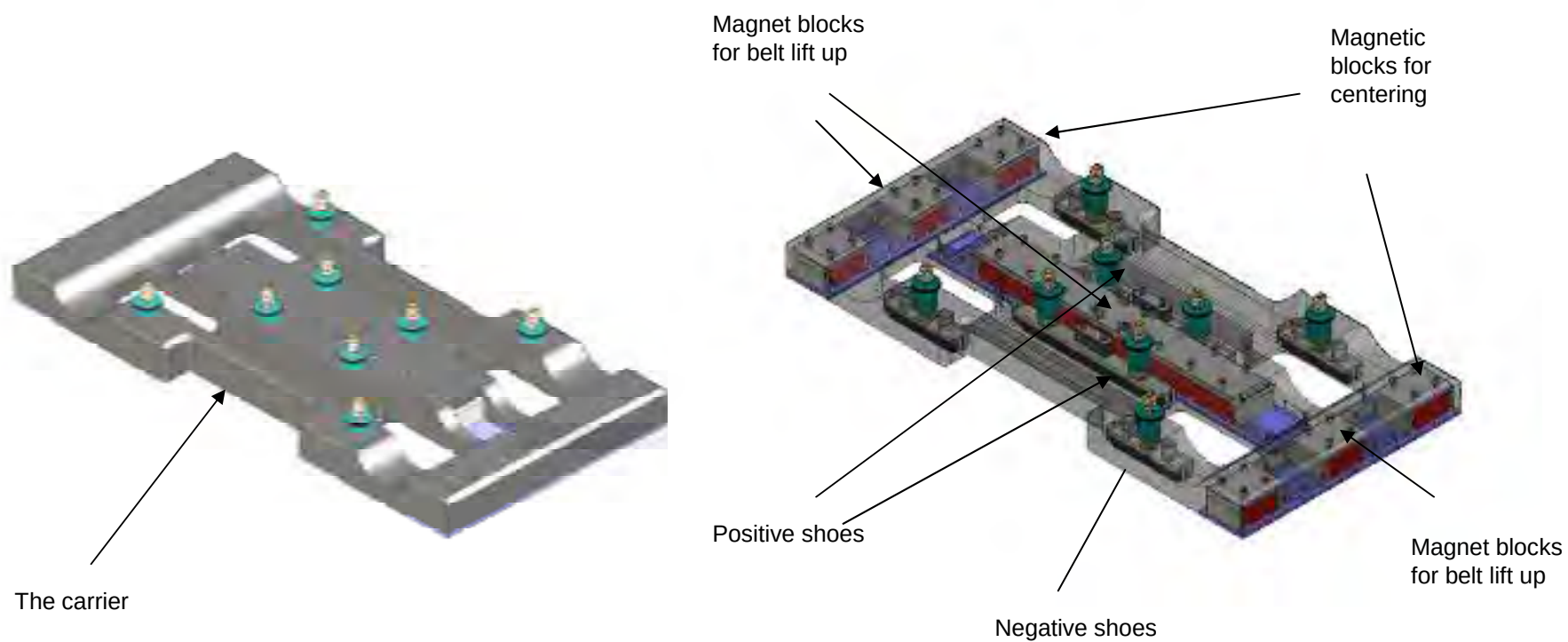
The line fully equipped
(section)



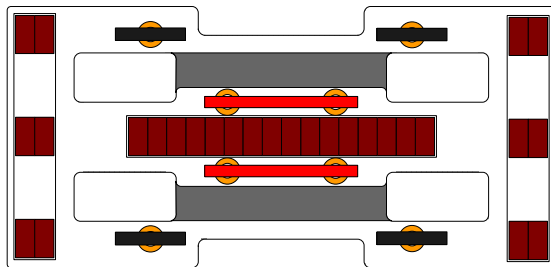
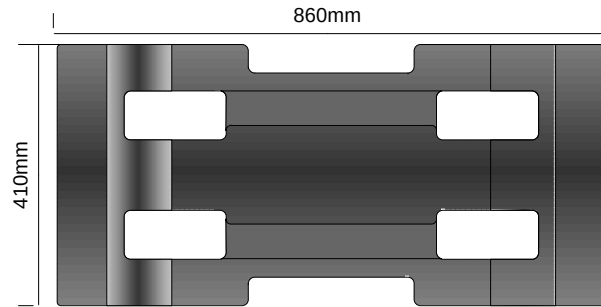
The mounting
sequence



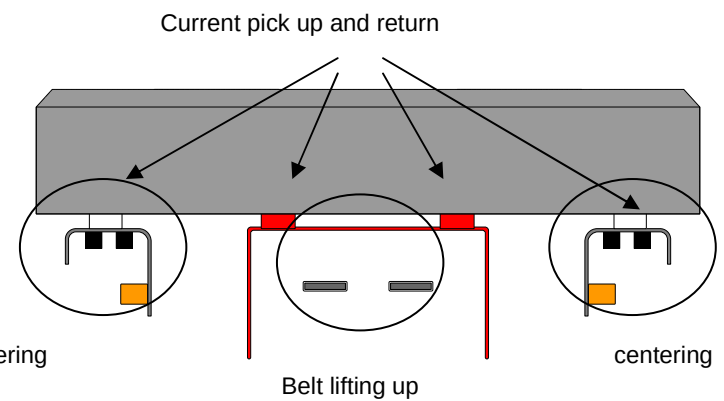
The magnetic power collector



The magnetic power collector



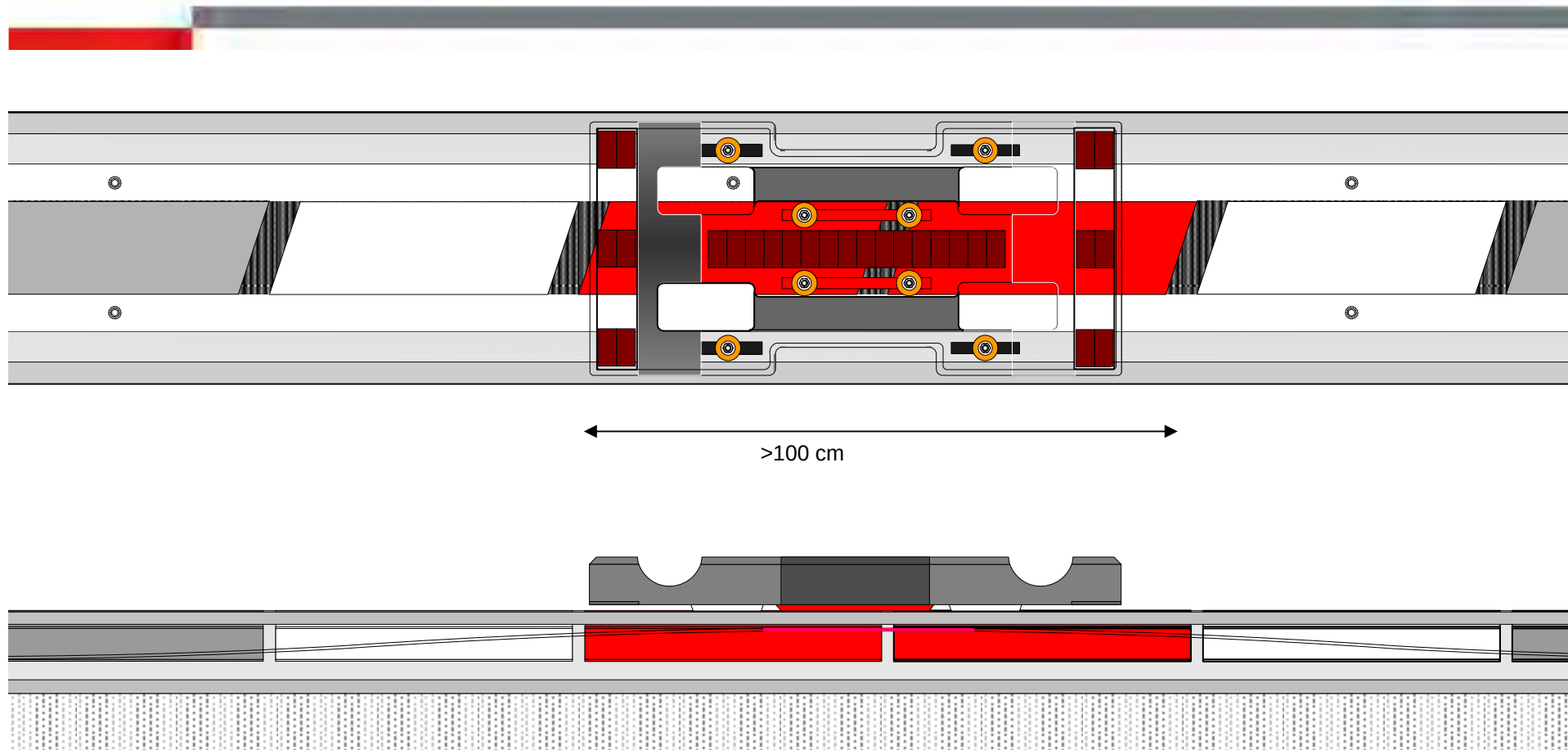
- Three main function
- Activation of line segments
 - Current pick up and current return
 - Guide the power collector over the line



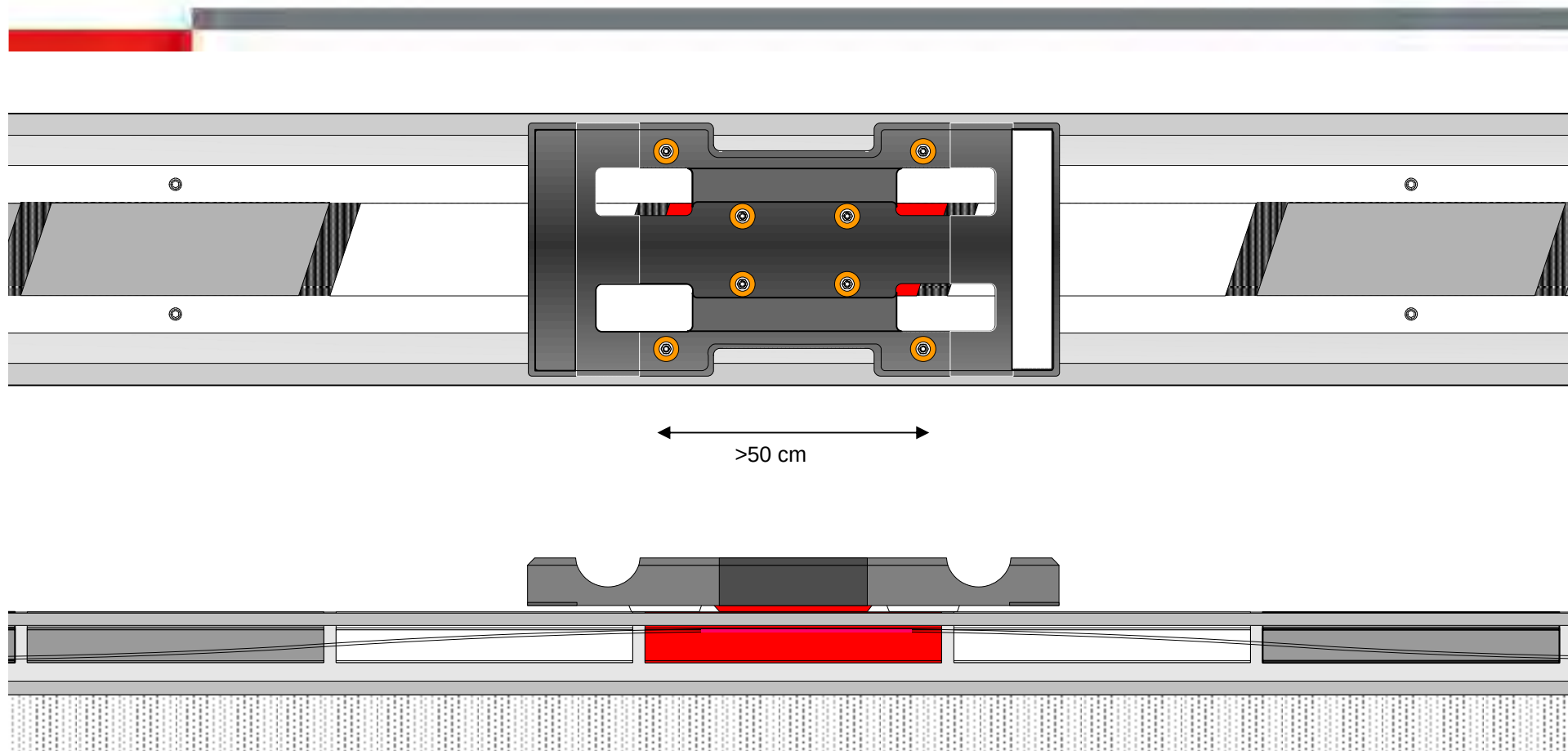
- The length of the magnet, the pulling force, the characteristics of flexible belt (allowed internal gap, rigidity, weight) are designed to assure:
 - *Adequate inner contact length for necessary current in any static or dynamic conditions.*
 - *The correct sequence of activation of segments.*
- The total length of the “wave”, is no more than 3 meters
 - *No constraints for the position of the power collector on the bogies*
 - *No limits to place two or three power collector on the vehicle*
 - *The area to be protected is very limited (less than 1 m x 270 mm)*
- The inner contacts are segmented for a better insulation of non activated segments.

Top view of operation

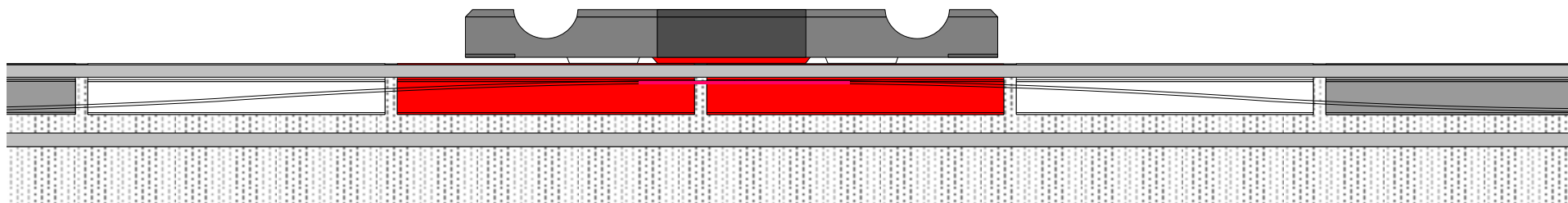
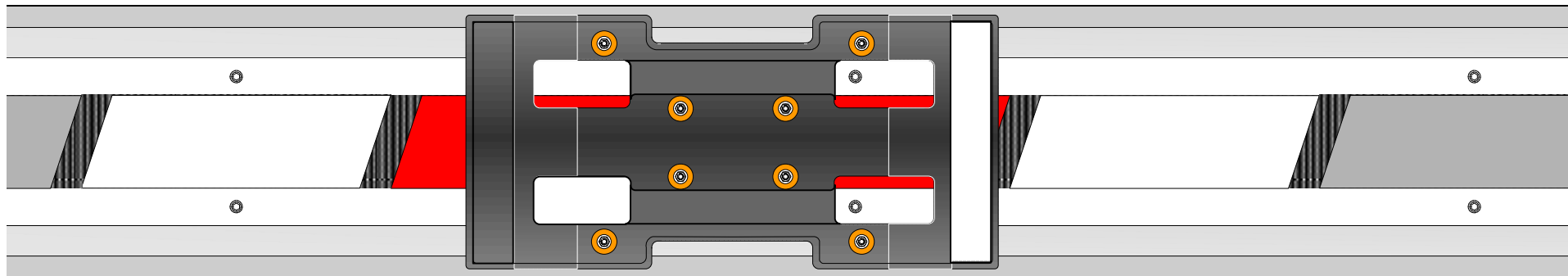
TramWave



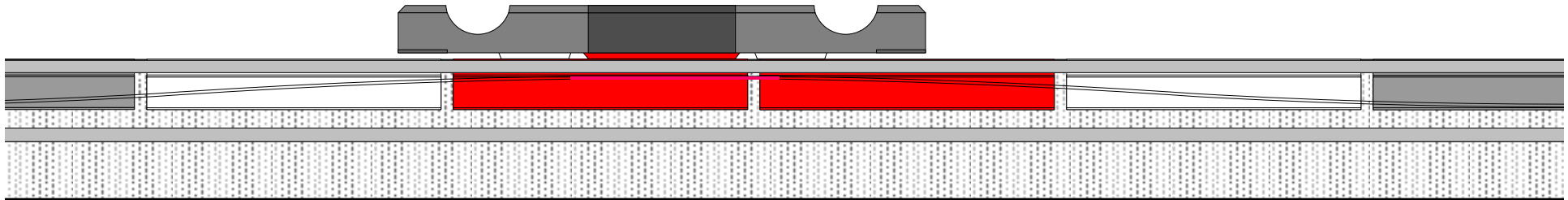
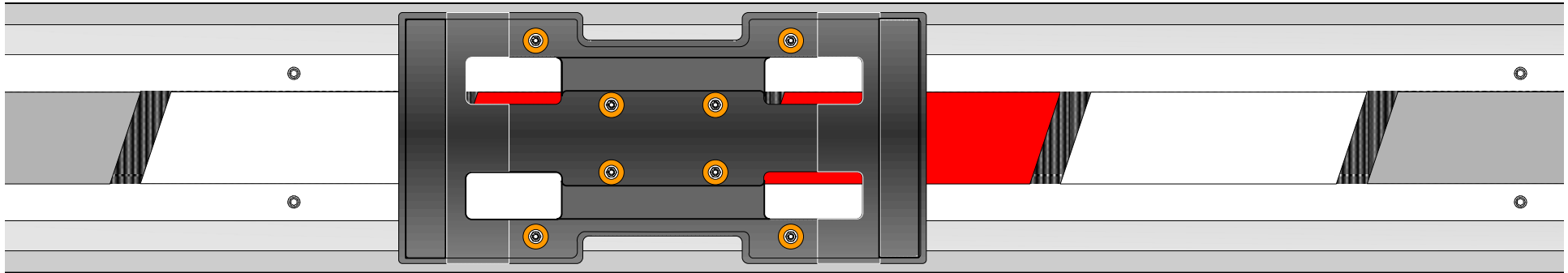
TramWave



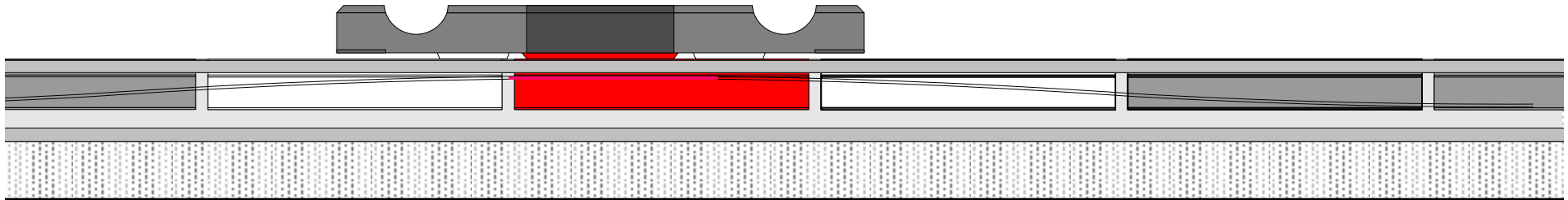
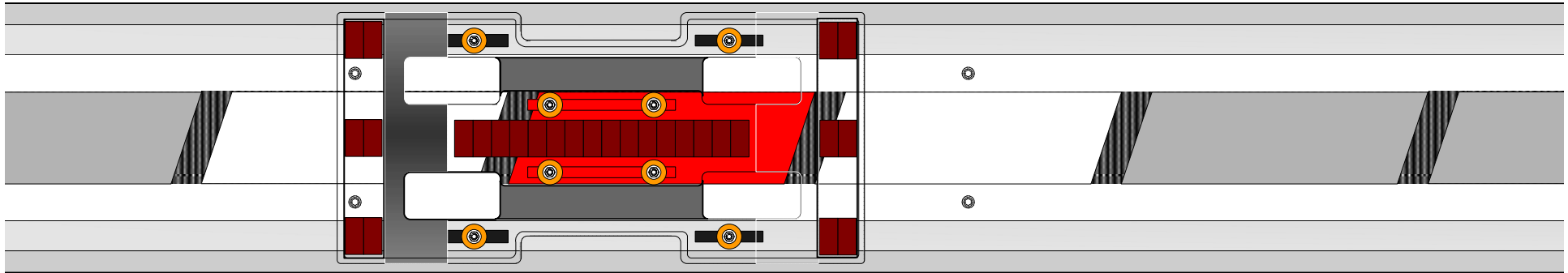
TramWave



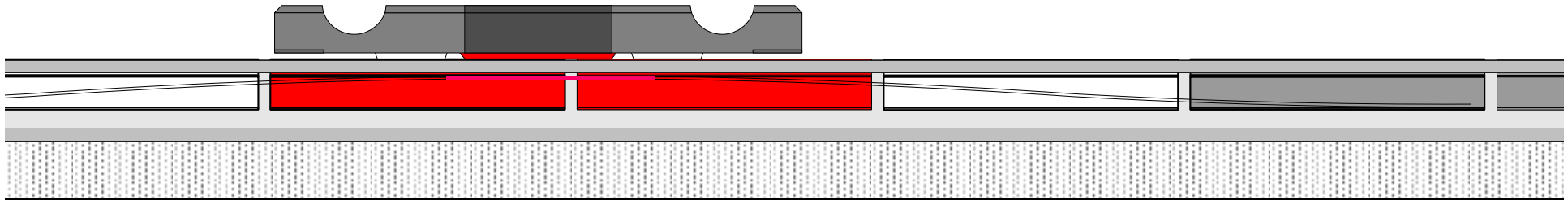
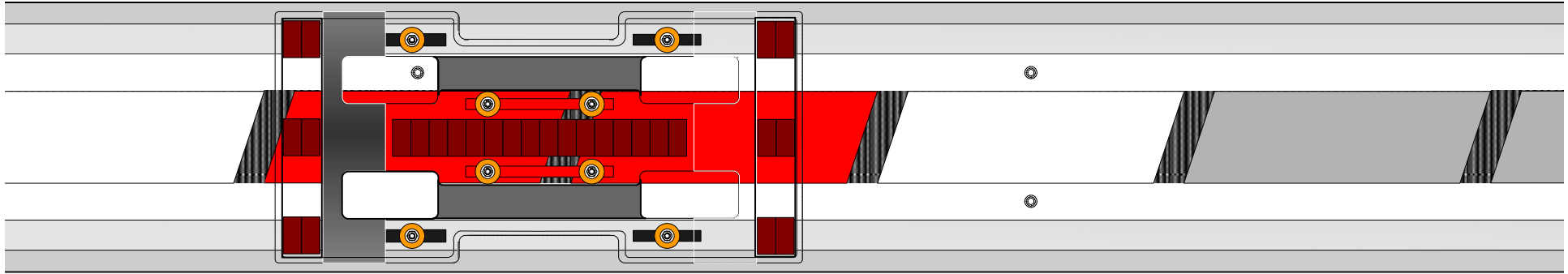
TramWave



TramWave

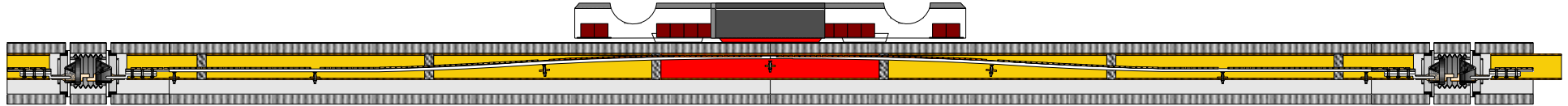


TramWave

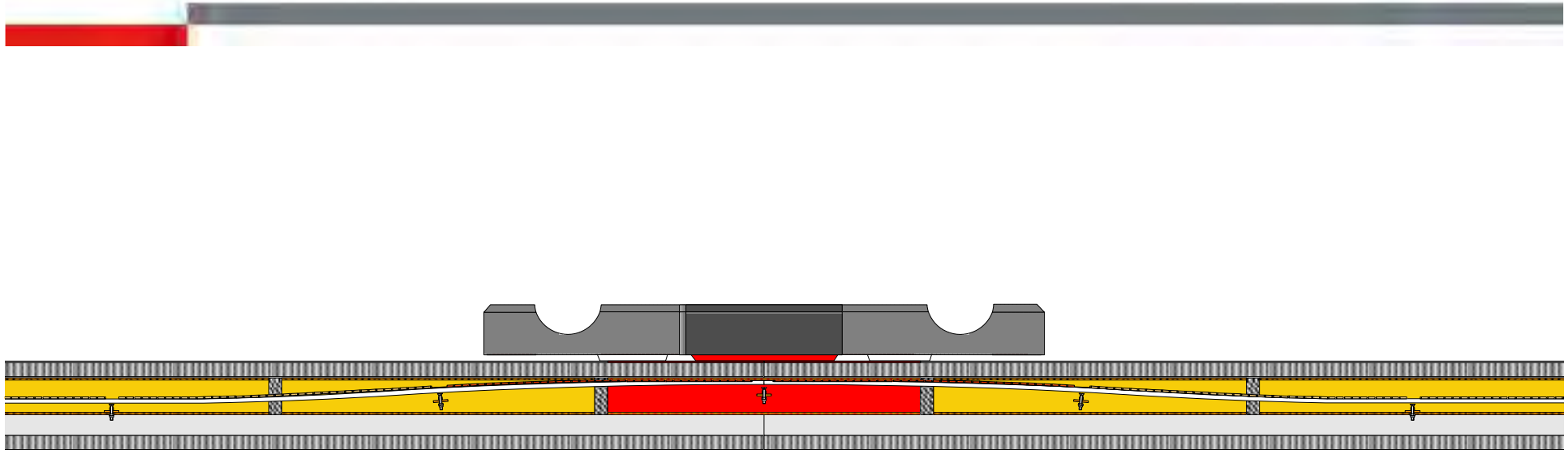


More details of operation

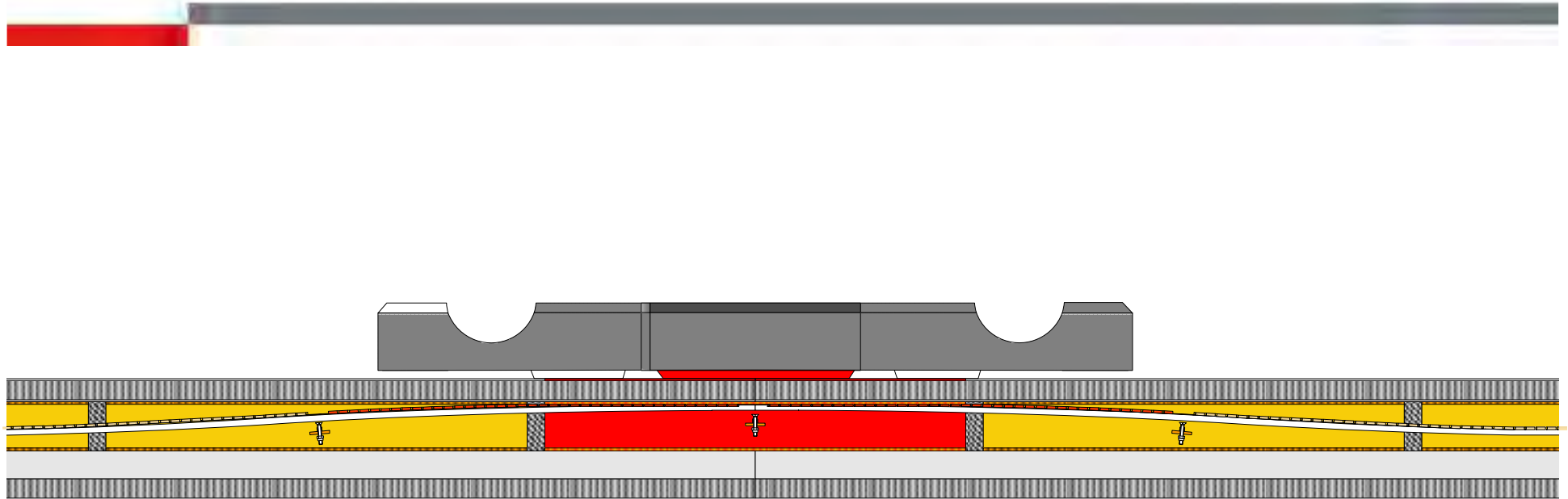
TramWave

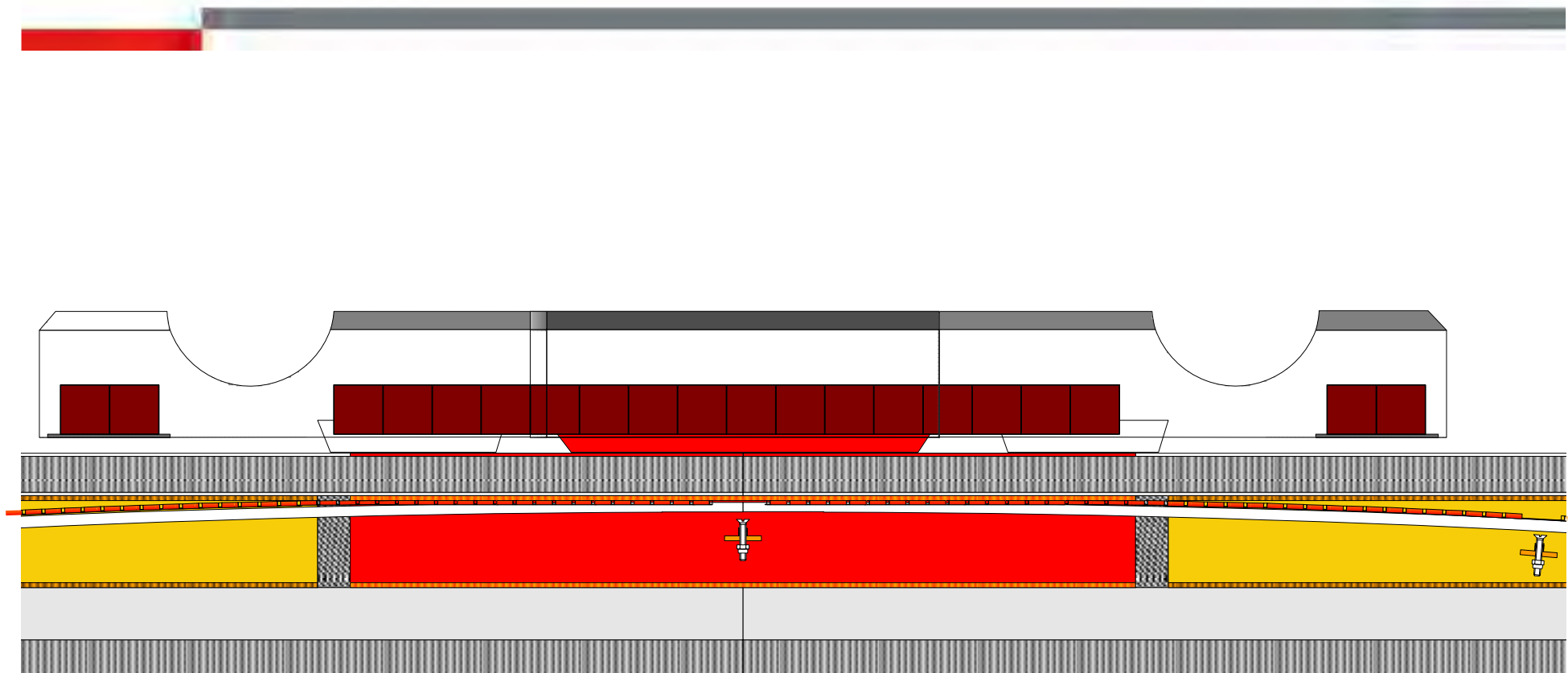


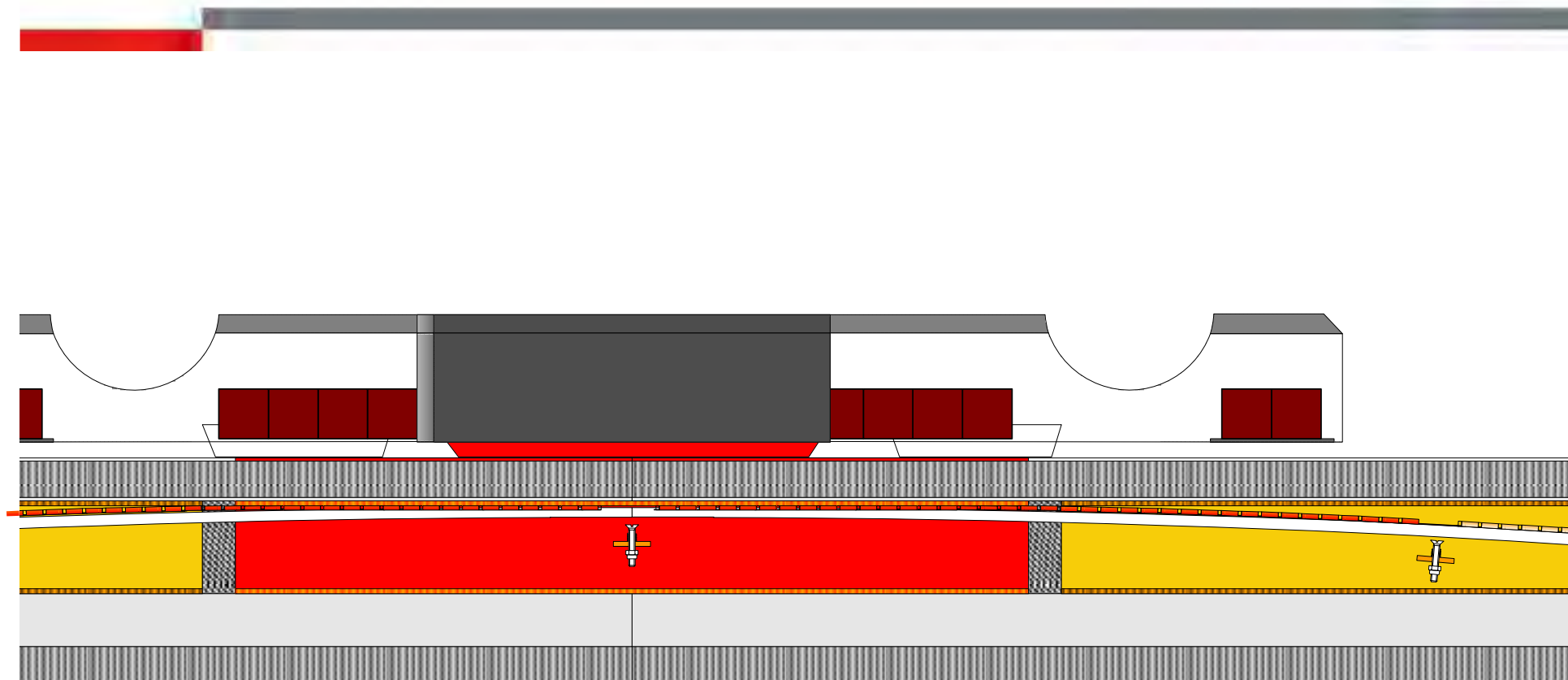
TramWave

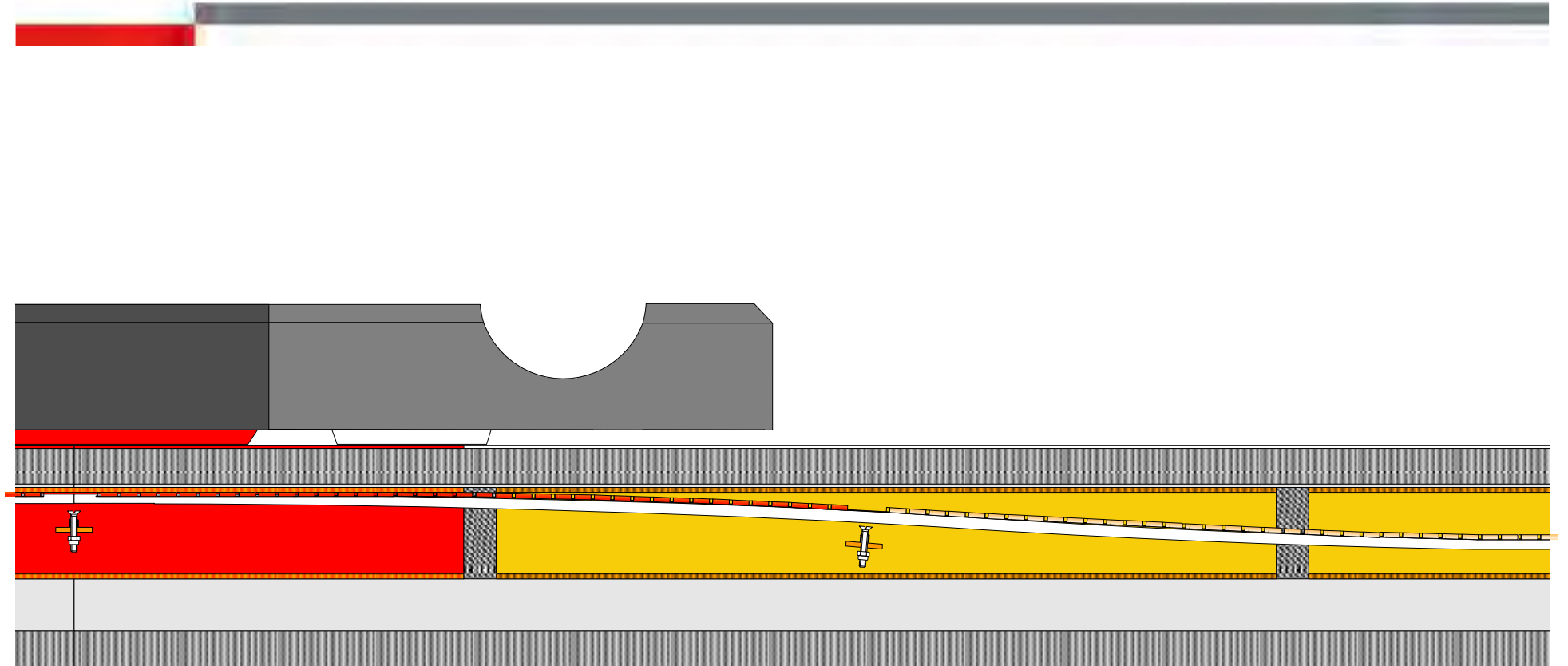


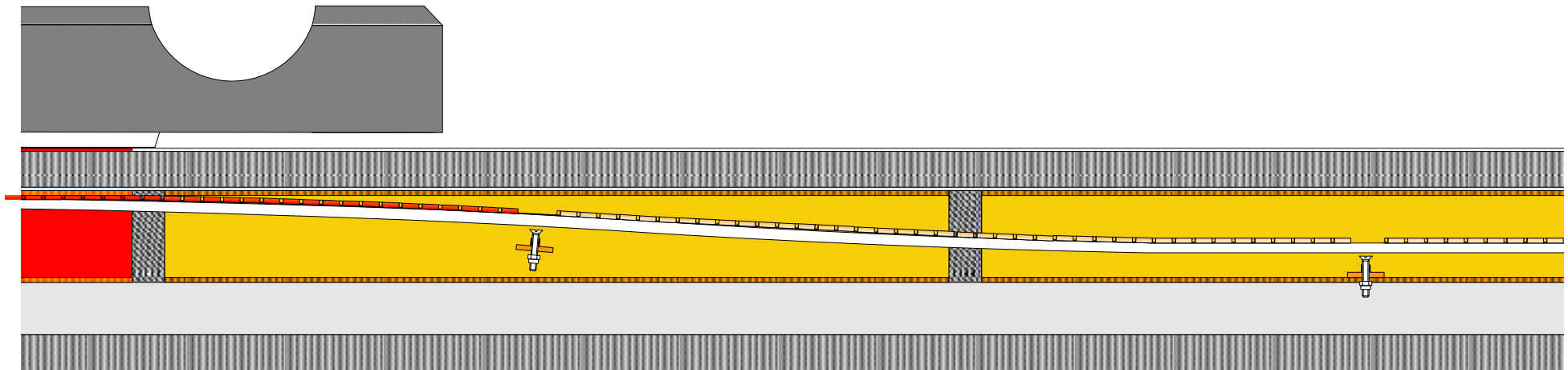
TramWave

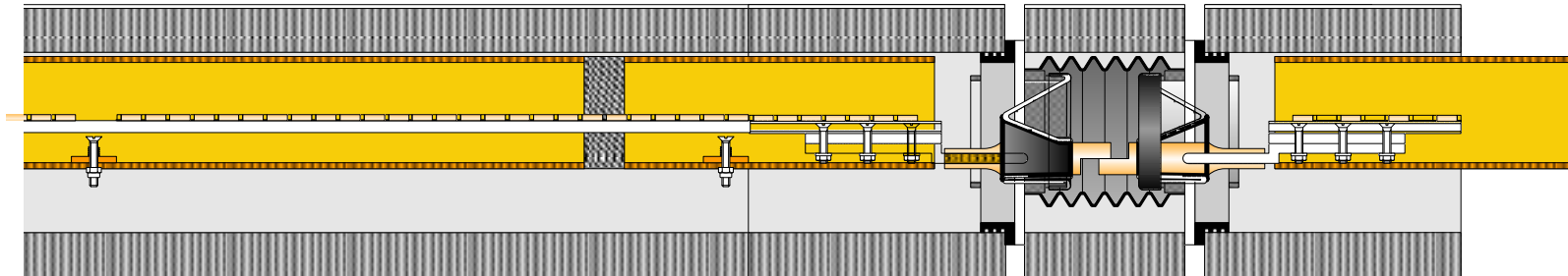






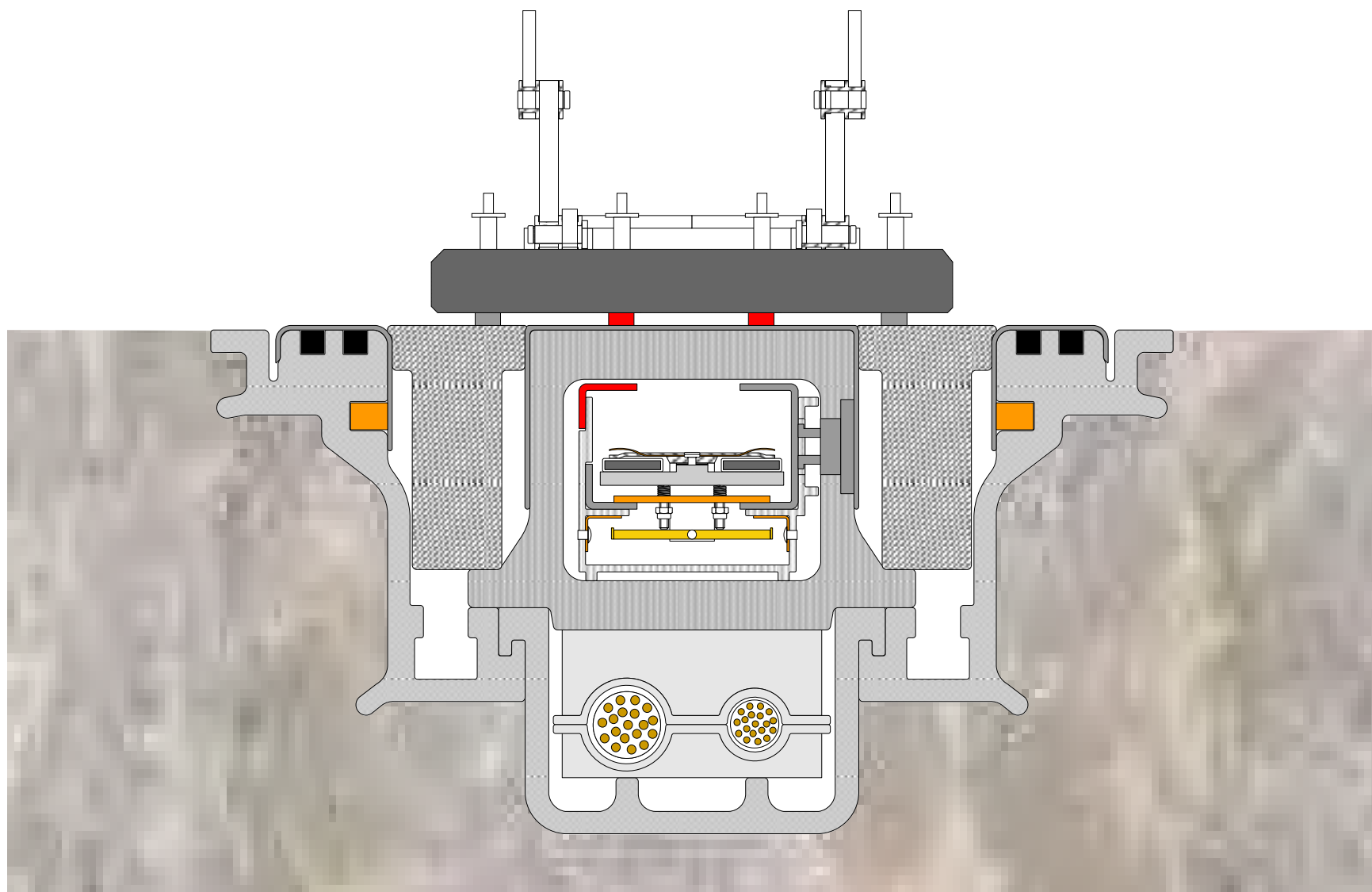




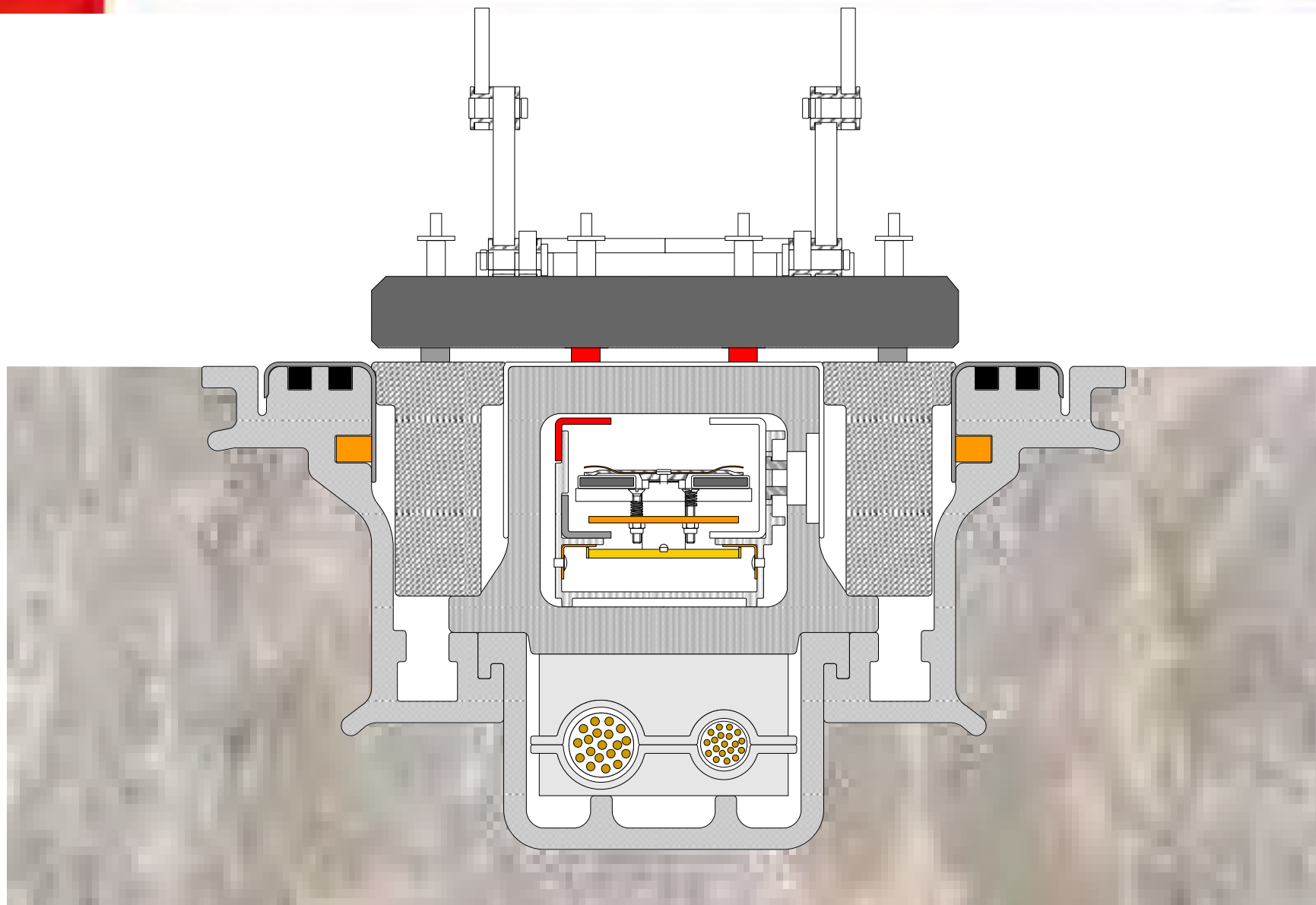


A full line section: view of operation

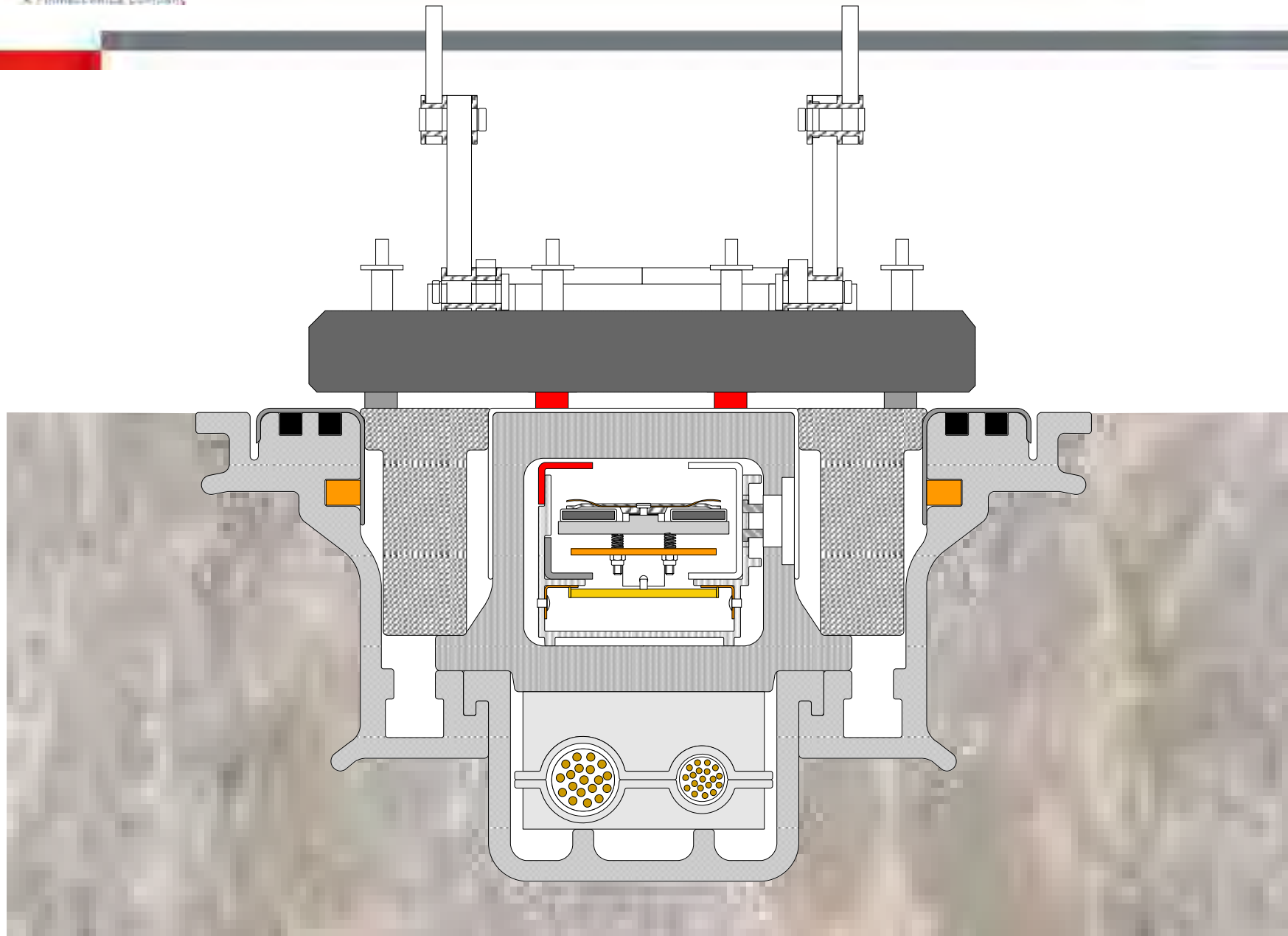
TramWave



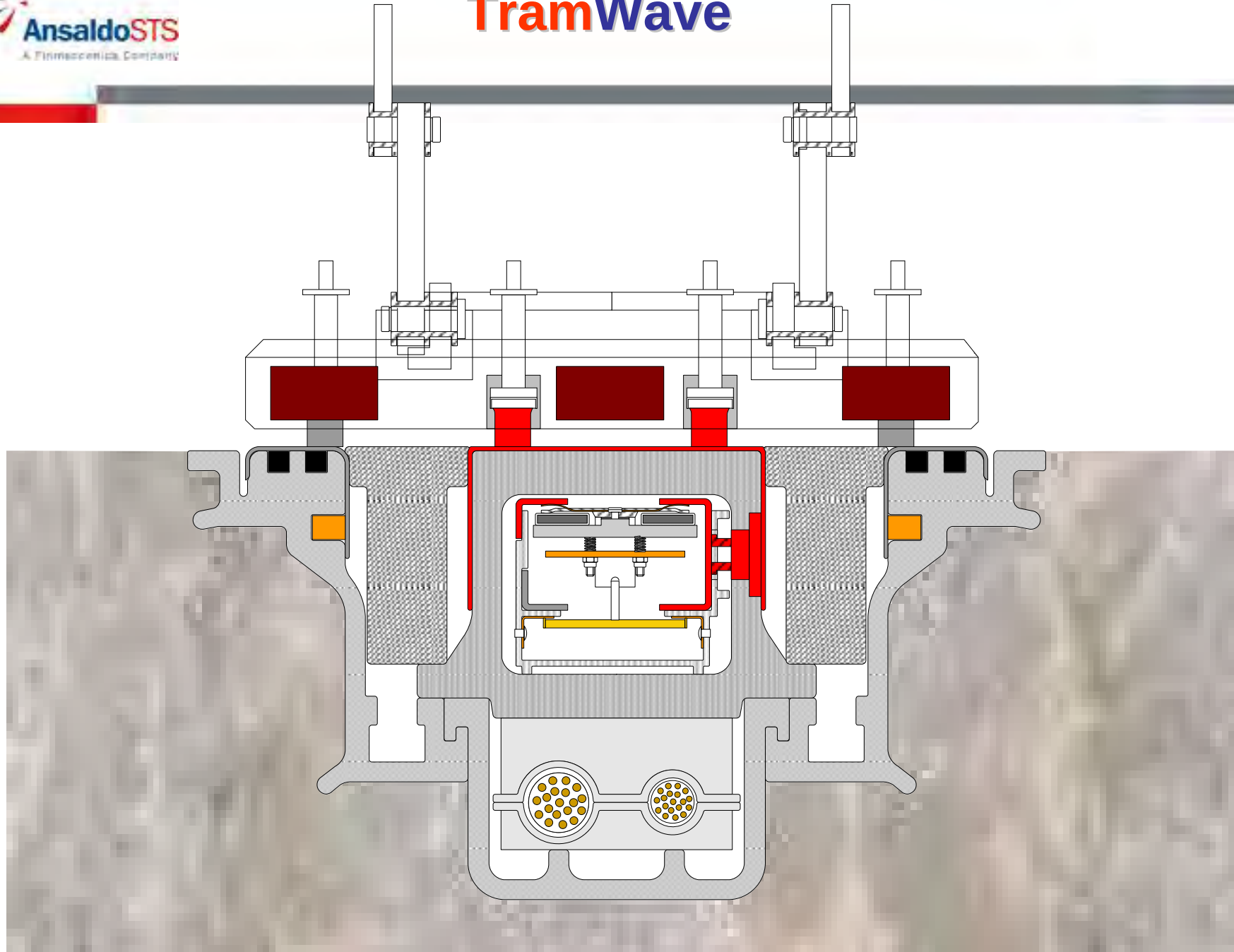
TramWave



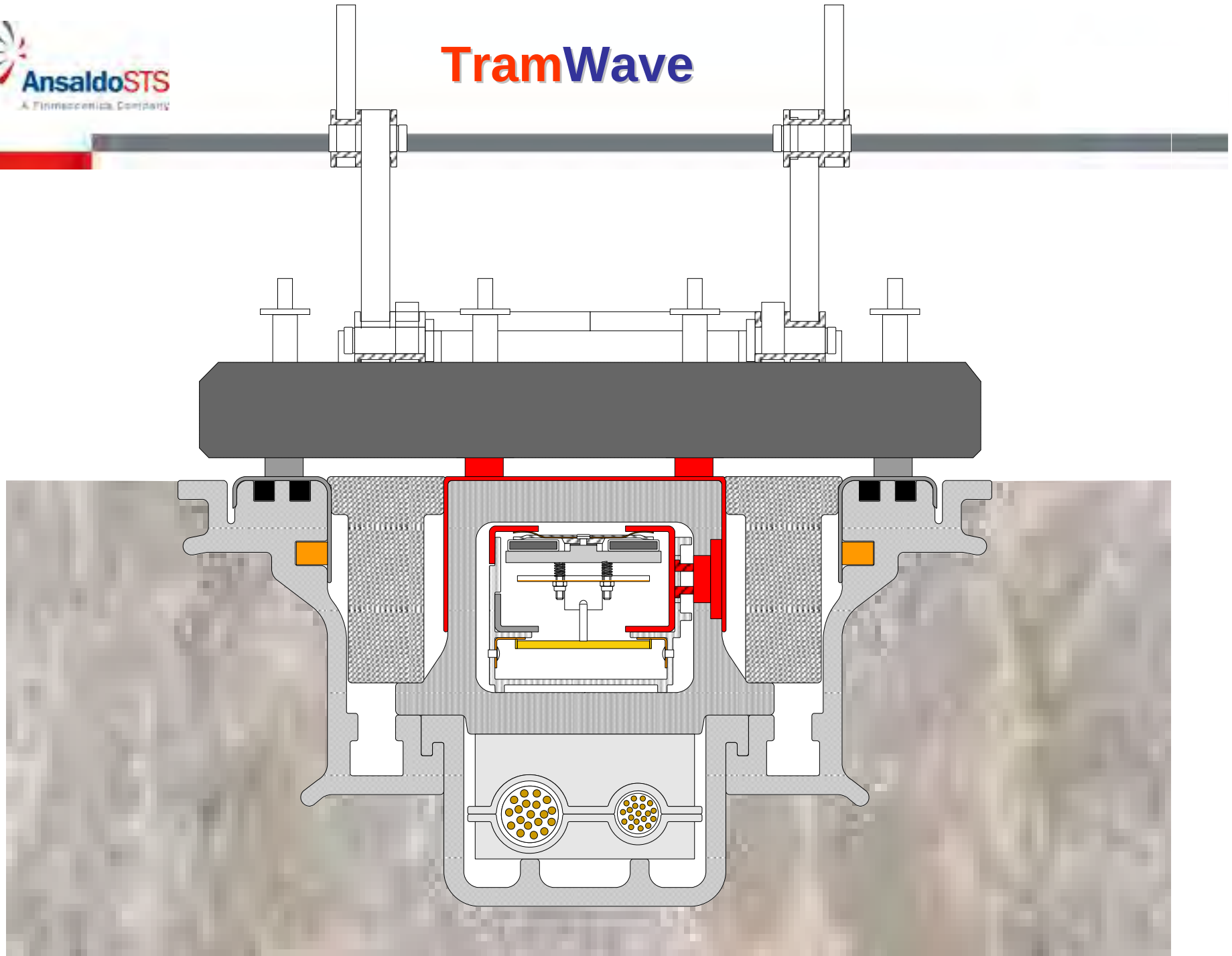
TramWave



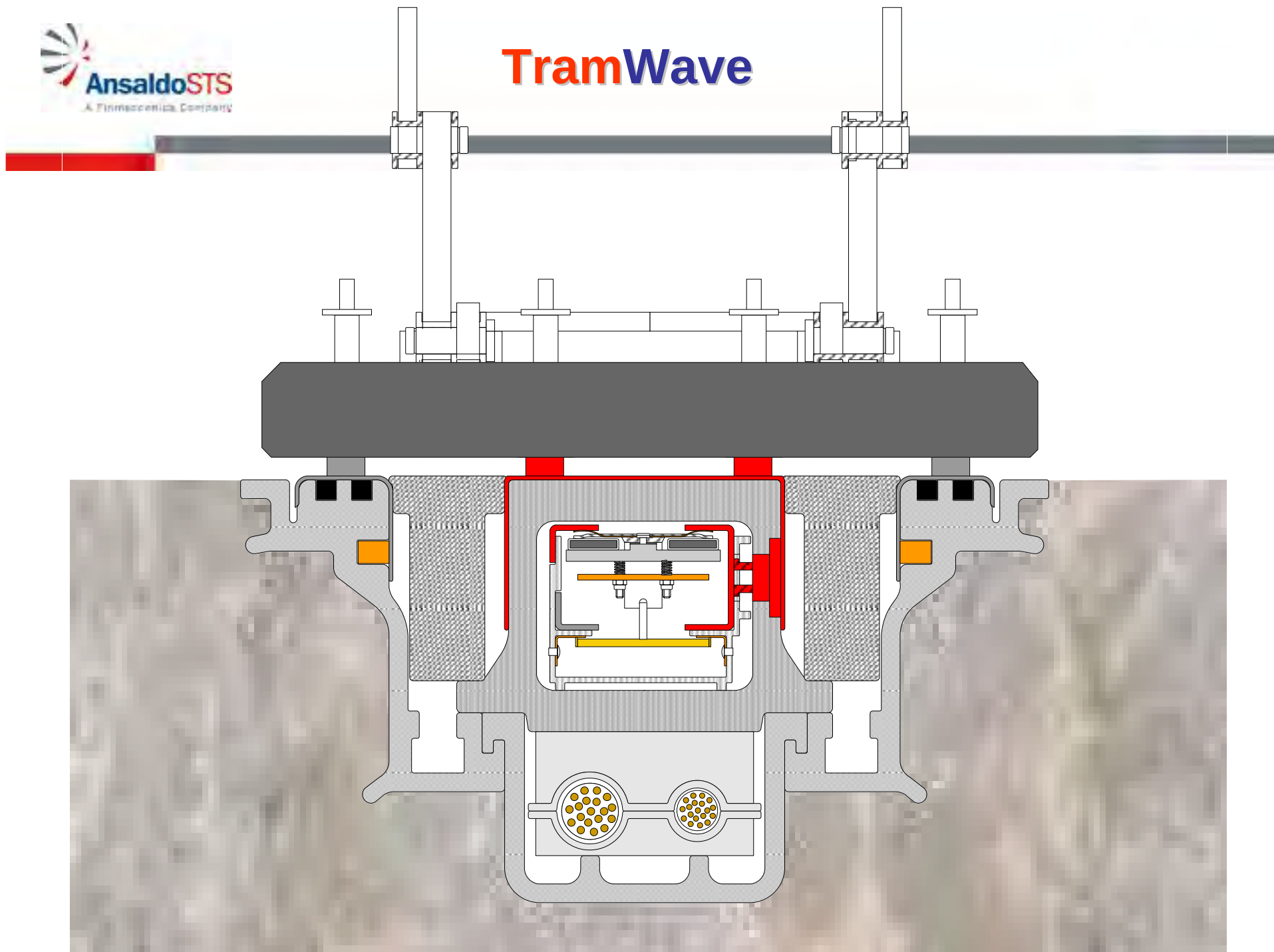
TramWave



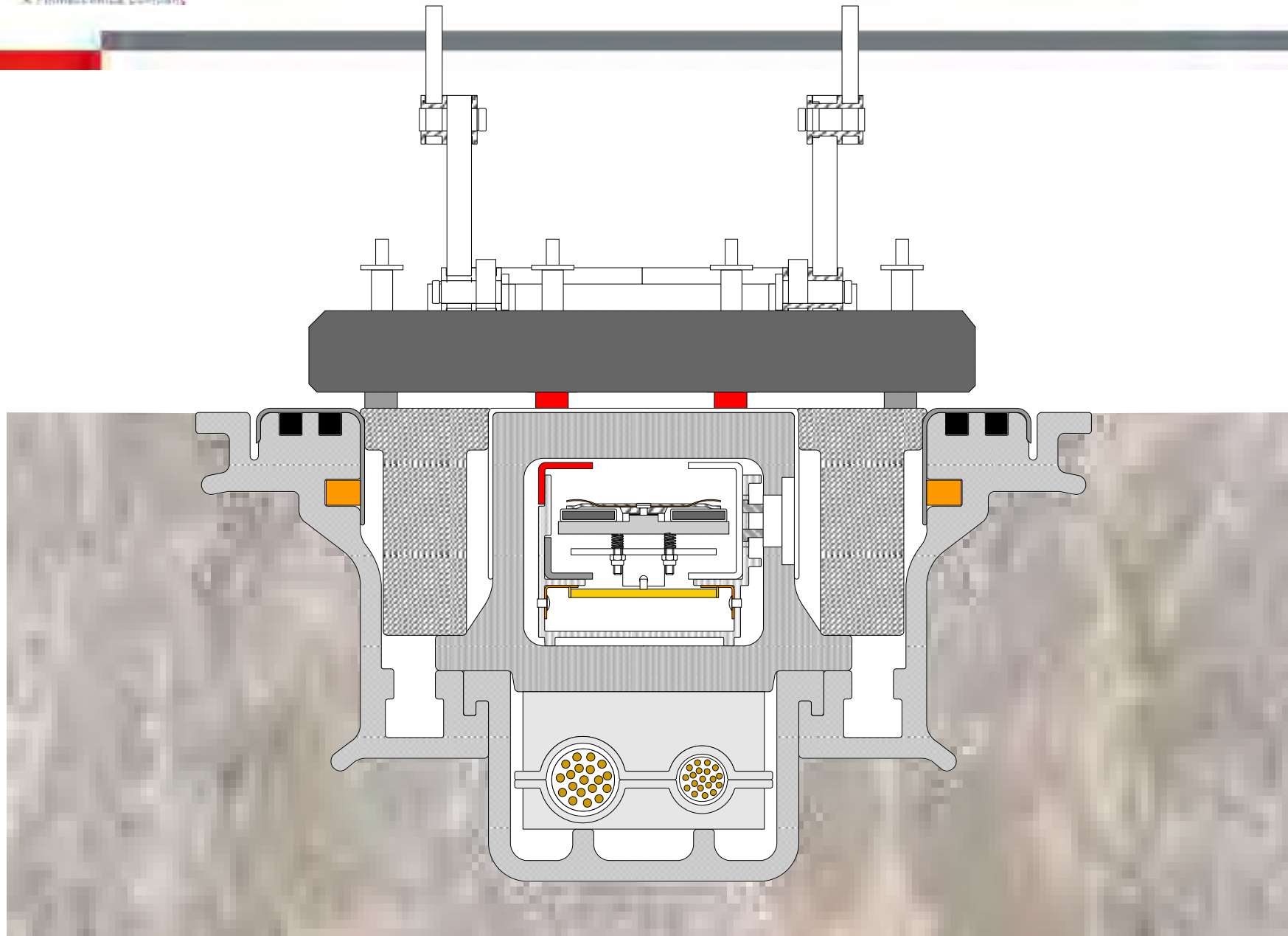
TramWave



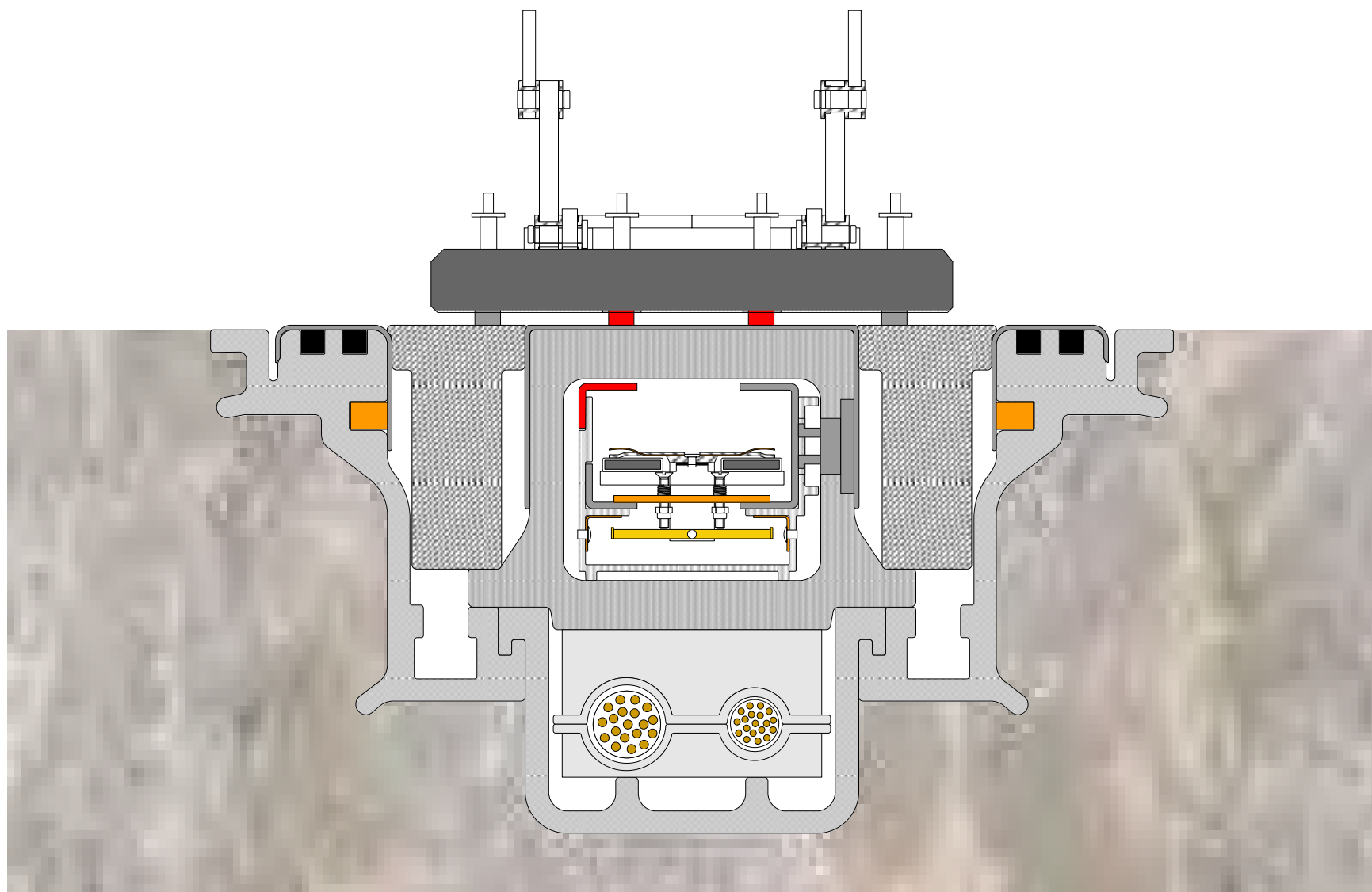
TramWave

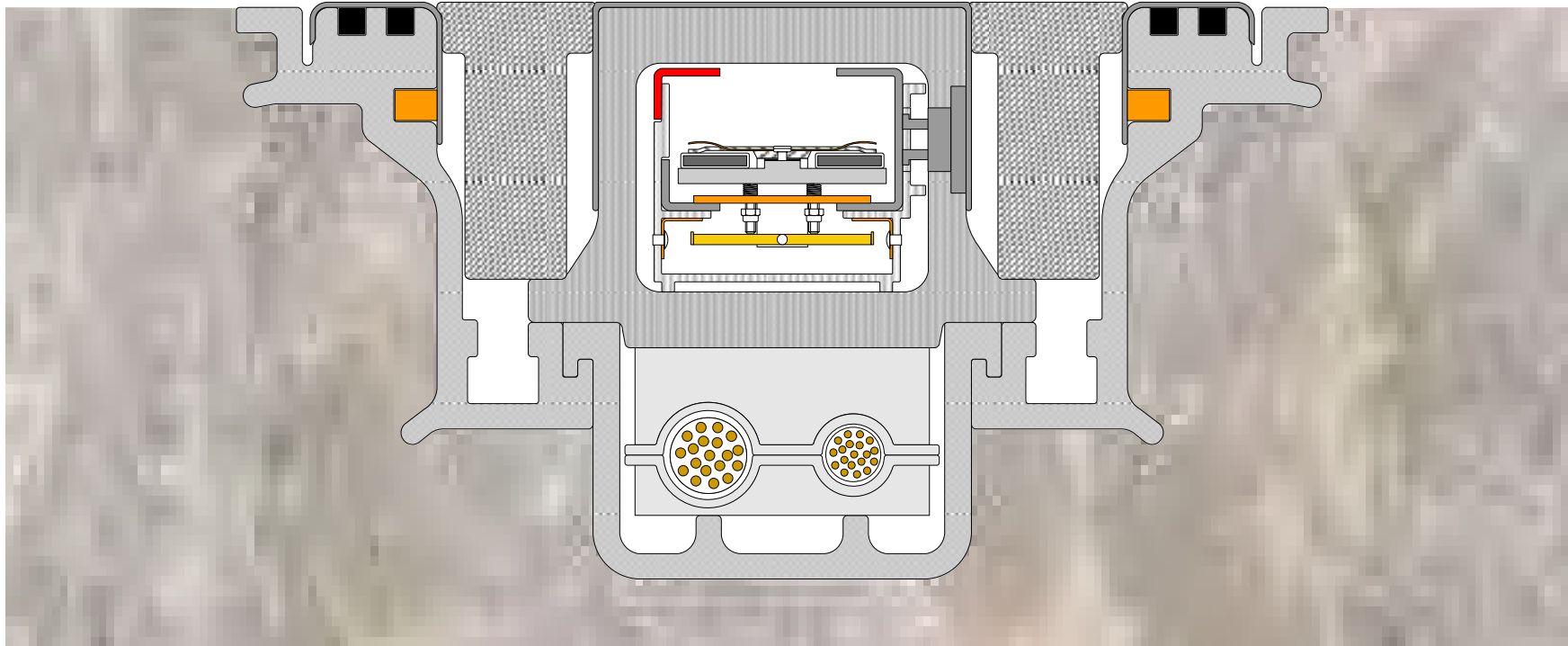


TramWave



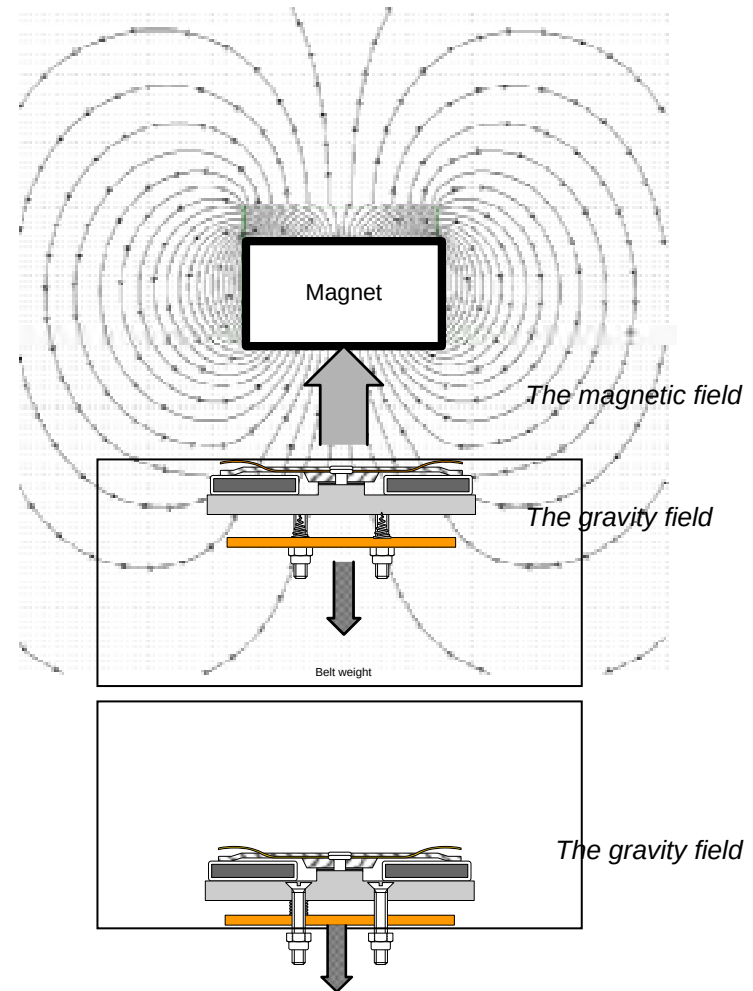
TramWave



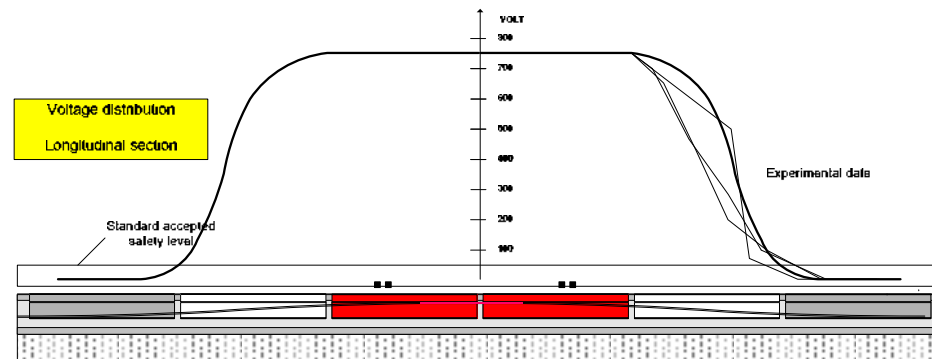
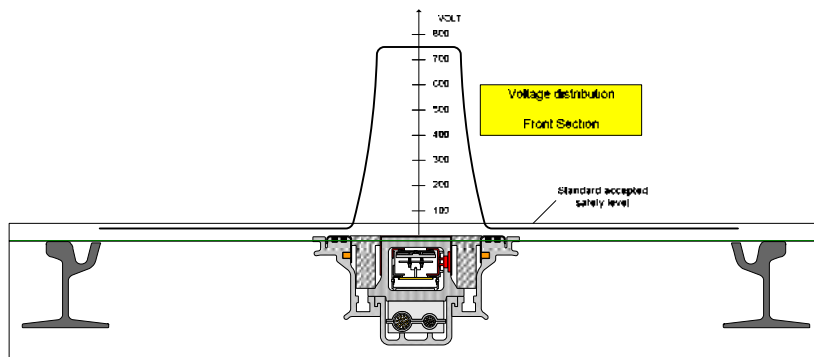
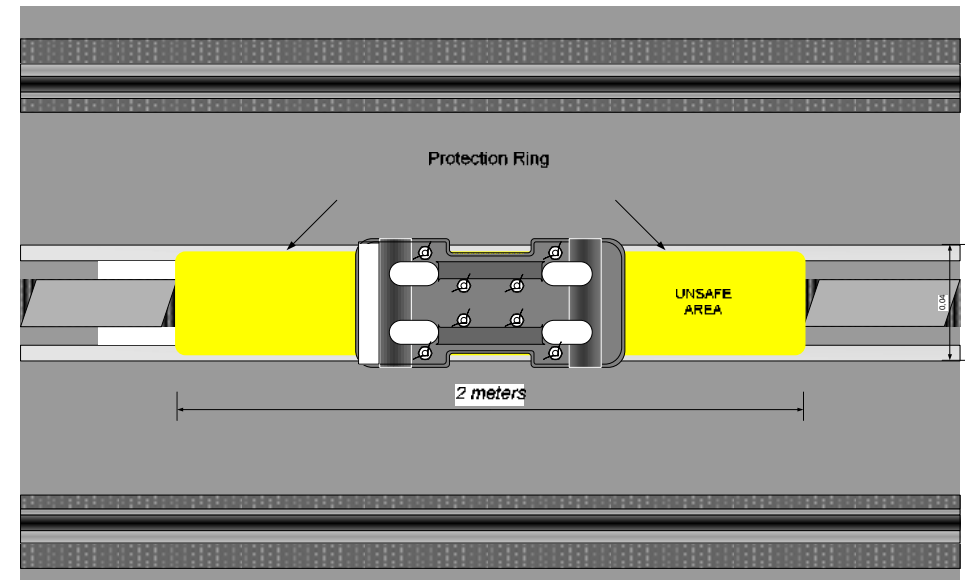


Main Safety Issues

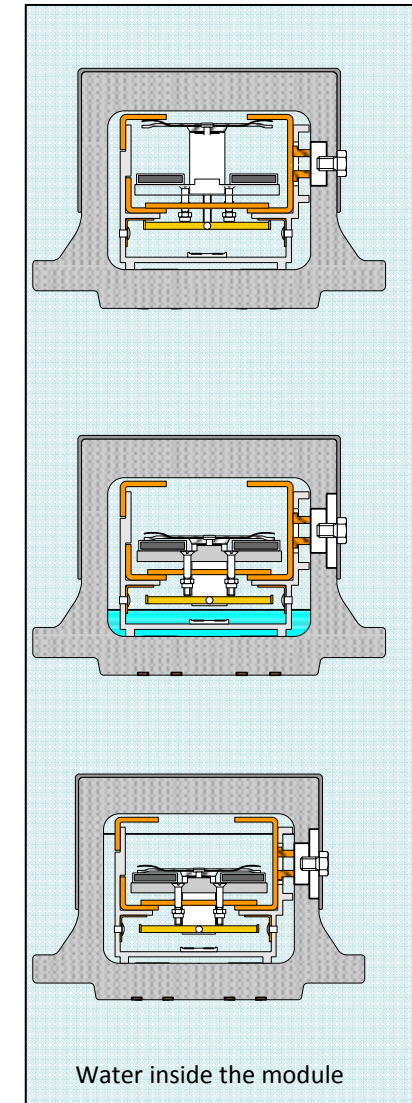
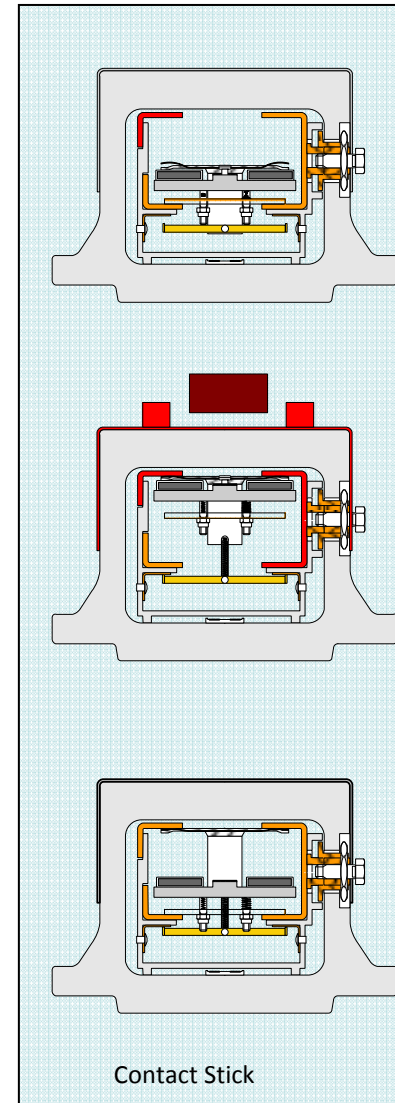
- The concept and the implementation of the safety requirements ensure the safety of the system in any normal operational condition as well as in any possible fault condition or accident.
 - The system goes “naturally” in the condition of safety
 - The absence or incorrect position of magnetic power collector over the line causes the drop of the flexible belt to the rest condition, connecting all the segment involved to the negative.

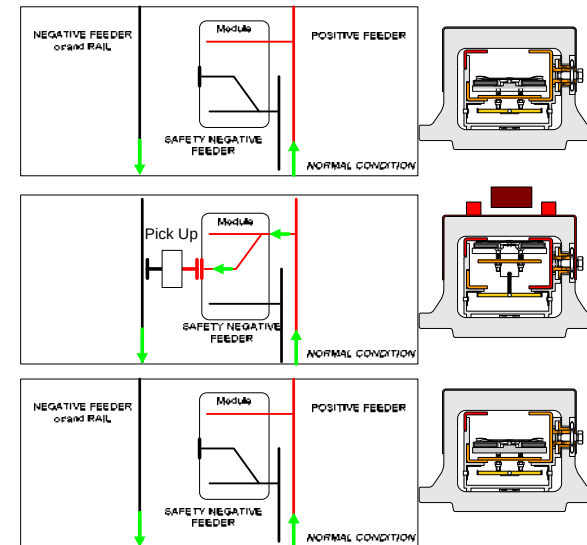
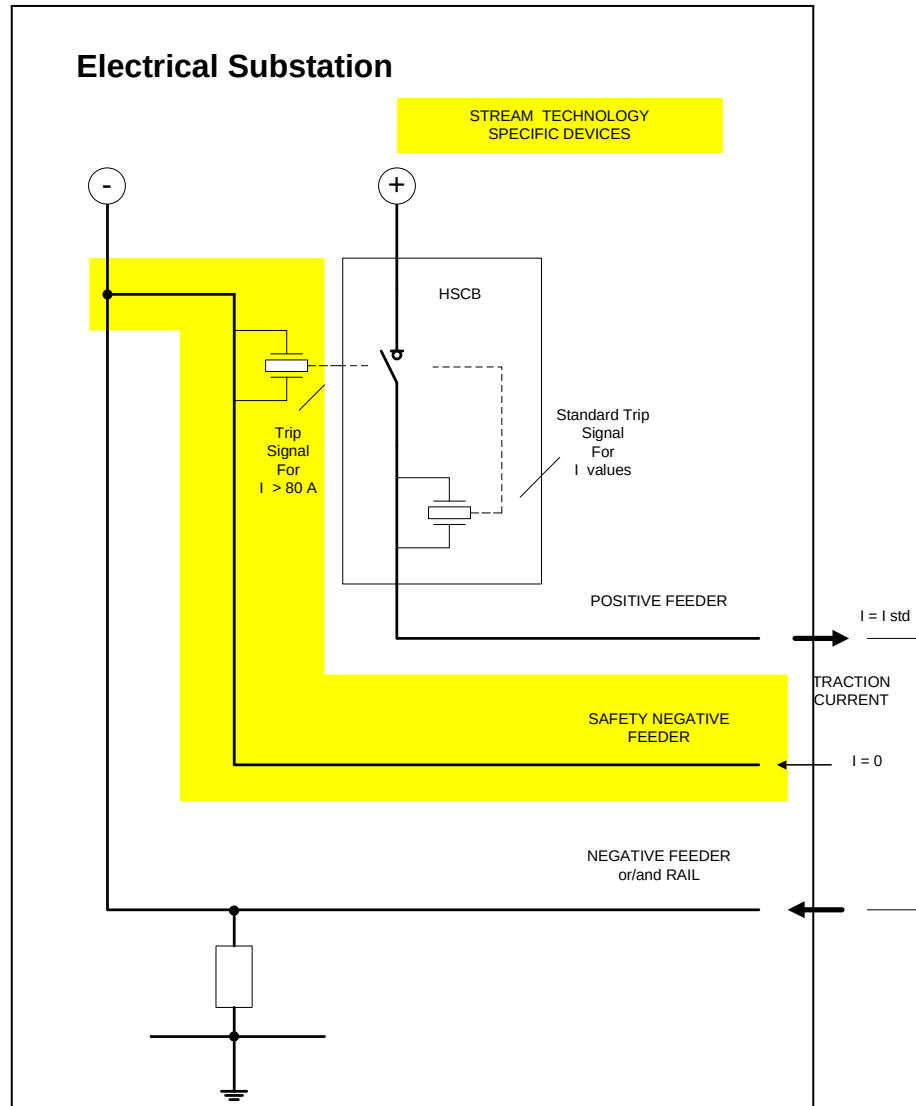


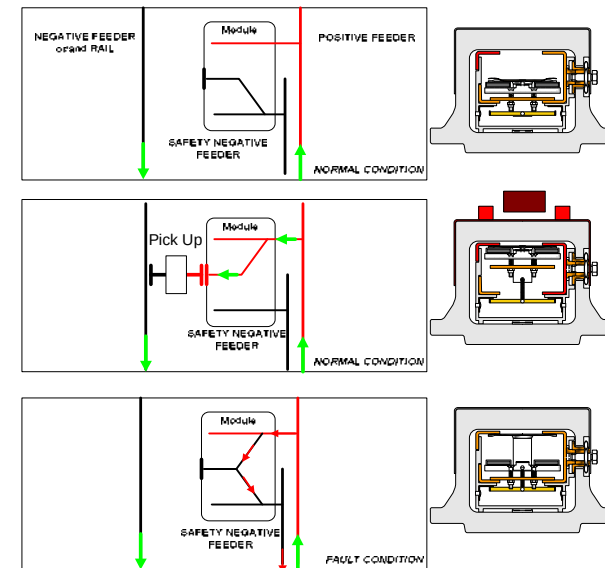
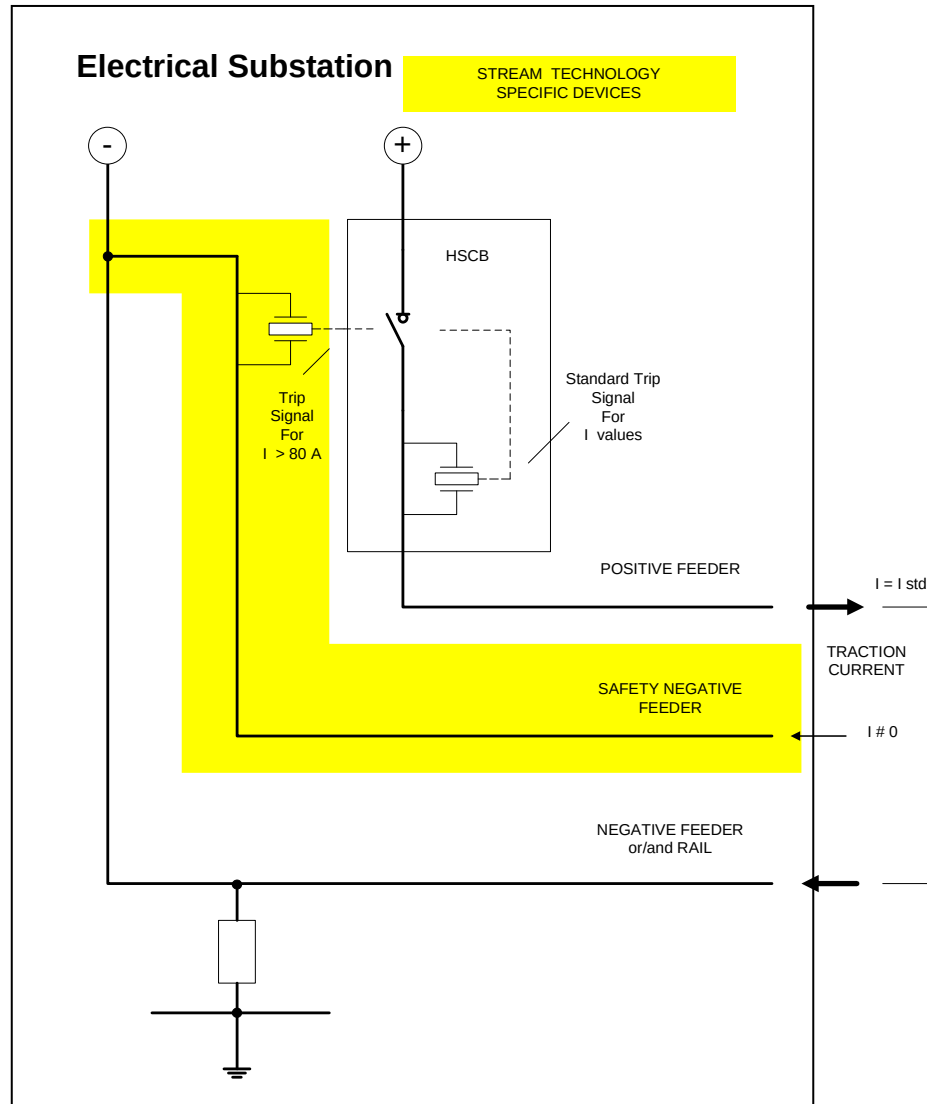
- The activated part of the line is always enclosed by elements connected to the negative.
 - These element act as a “Virtual Protection ring”
 - The protection ring follows the power collector .
 - Safety is always assured even in case of water puddles .
 - The running rails act as a second barrier
- The voltage level all around the activated parts remains in any condition lower than the standard requirements.



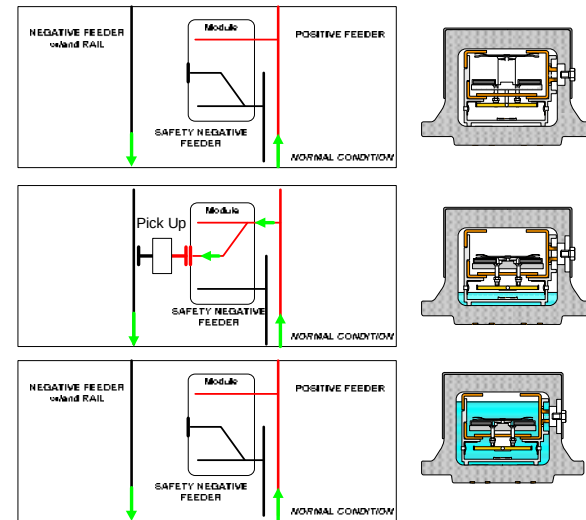
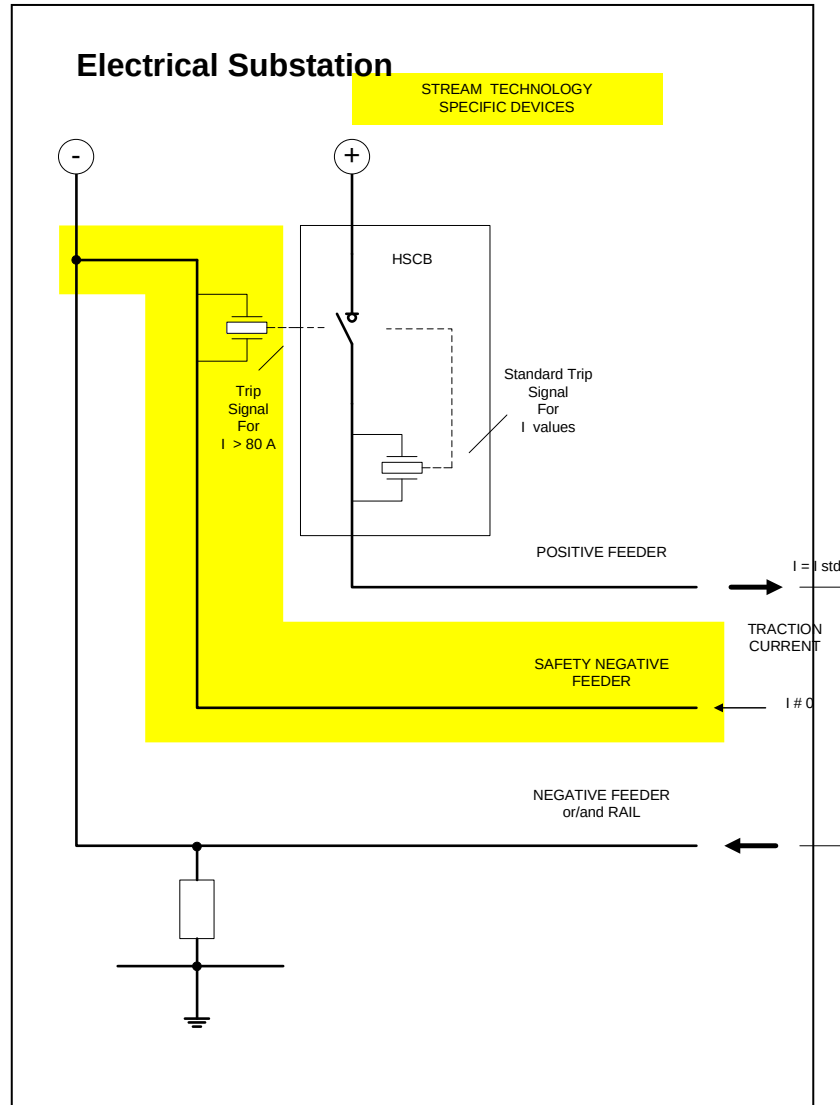
- The design and the realization of the flexible belt and the safety negative concept assures the safety condition in the most severe conceivable accident conditions.
 - The “stick” of a positive contact
 - Loss of sealing and presence of a large quantity of water inside a single module.
- The diagnostic system allows a fast detection of the faulted module.







Event: Contact Stick to positive



Event: water inside the module

MAIN PERFORMANCE HIGHLIGHTS

- The technology can be used different type of rail vehicles in a wide range of power
- The system allows to cut many concern about stray currents, saving related installation and maintenance costs
- The technology can be used without any modification for a multi-modal use.
 - The power line could shared with rubber tyred electric vehicles
- The system could take profit and be integrated with energy storage on board.
 - Management of particular situation or singularities
 - Emergency situations
 - Fast recharge area (static or dynamic).
- The integrated diagnostic allows:
 - A fast identification of the module that presents operational disturbance (even transitory for an early warning)
 - Localizing the vehicle on the line
 - A useful support for operation and maintenance.

- The maintenance level could be equal or better than a conventional overhead catenary.
- Any fault or operational problem remains confined in the affected module
- The maintenance activities consists in the change of the module:
 - 30 minutes is the mean time on site to change a module
 - Few persons could complete the operation without special or heavy tools.
 - The maintenance could be postponed at the end of the day.

Thank you for your attention

Bovenleidingsloze tractie

Techniek ten dienste van duurzaamheid en behoud
van het historisch karakter van stadscentra

KVIV Spoortechnieken

Yves Carels

17 February 2011

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ALSTOM

Agenda

1. Why wireless trams ?
2. Wireless systems in operation & projects
3. How does APS work ?
4. APS evolutions

Why wireless trams?

To preserve urban environment



P 3



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Why wireless trams?

To share restricted space in urban environment - no catenary posts



P 4

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Why wireless trams?

To facilitate access in narrow streets
– fire brigade, facade renovation, ...



P 5

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Why wireless trams?

To preserve nature in cities



P 6

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Agenda

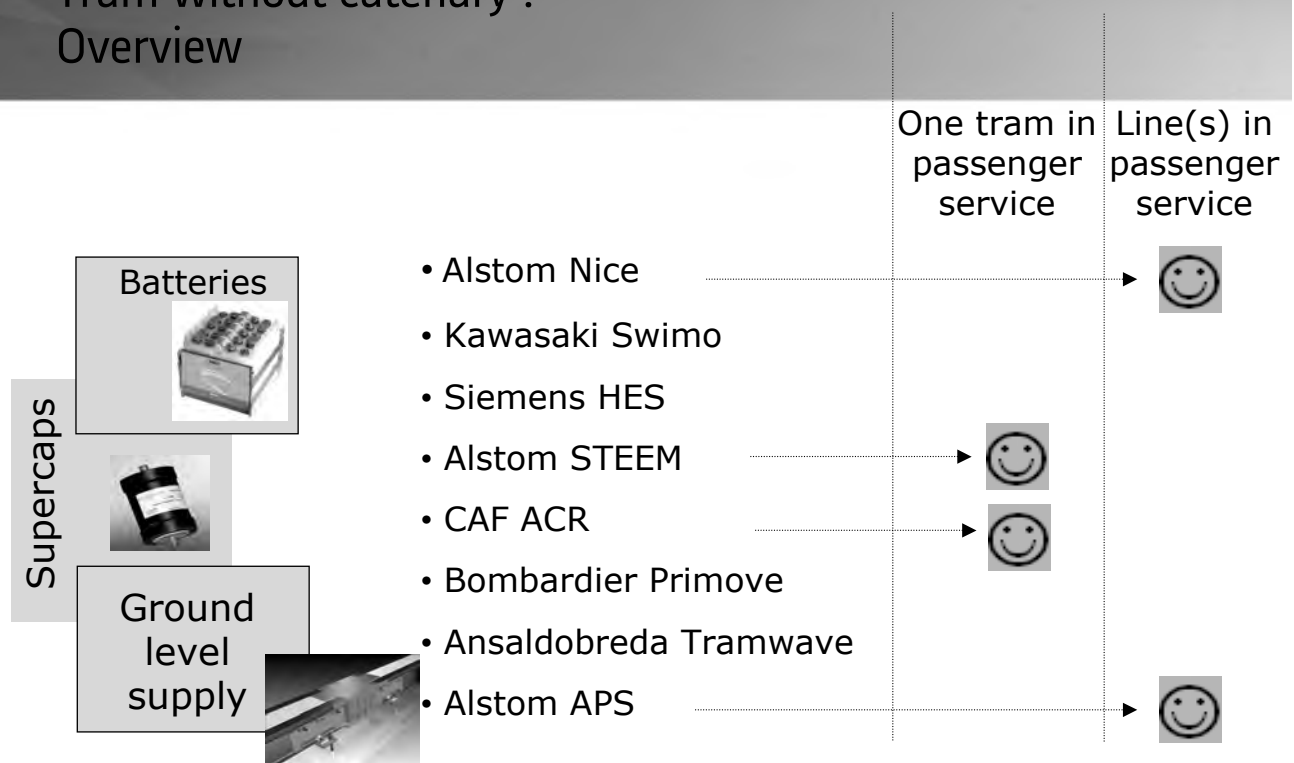
1. Why wireless trams ?
2. Wireless systems in operation & projects
3. How does APS work ?
4. APS evolutions

P 9

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Tram without catenary : Overview



P 10

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Tram without catenary : Batteries



- Tramway service in Nice city since 2007
- Two 450m sections run at 30 km/h without catenary
- NiMH battery technology, with slow recharge under catenary sections : guaranteed lifetime 5 years at 25°C operation temperature
- Battery box internal temperature regulated @ 25°C
- Return on experience on all operating scenarii, battery & tram handling, etc
- 30m tramway solution, extendable to 40m

P 11

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Wireless solutions: a full service proven range

APS and batteries available for optimal, specific adaptation to local needs



P 12

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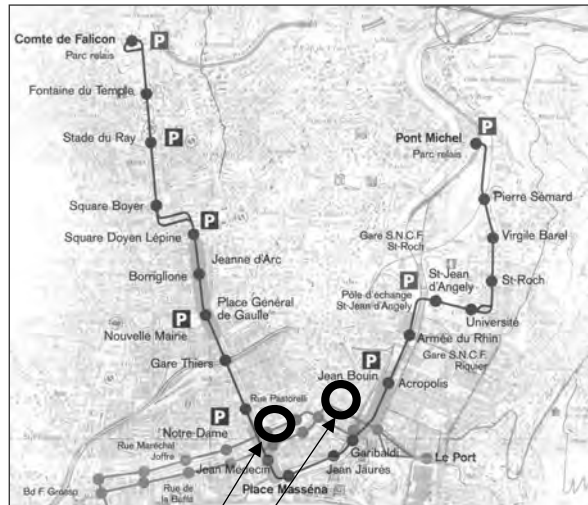
1. Short wireless sections: Nice

Batteries



- NiMH-Batteries
- The solution for short wireless sections
- Acceleration and max. speed adapted to city centre

P 13



- Commercial service in 2007
- No overhead wires on 2 squares
 - ▶ Place Masséna: ~435 m
 - ▶ Place Garibaldi: ~485 m

TRANSPORT

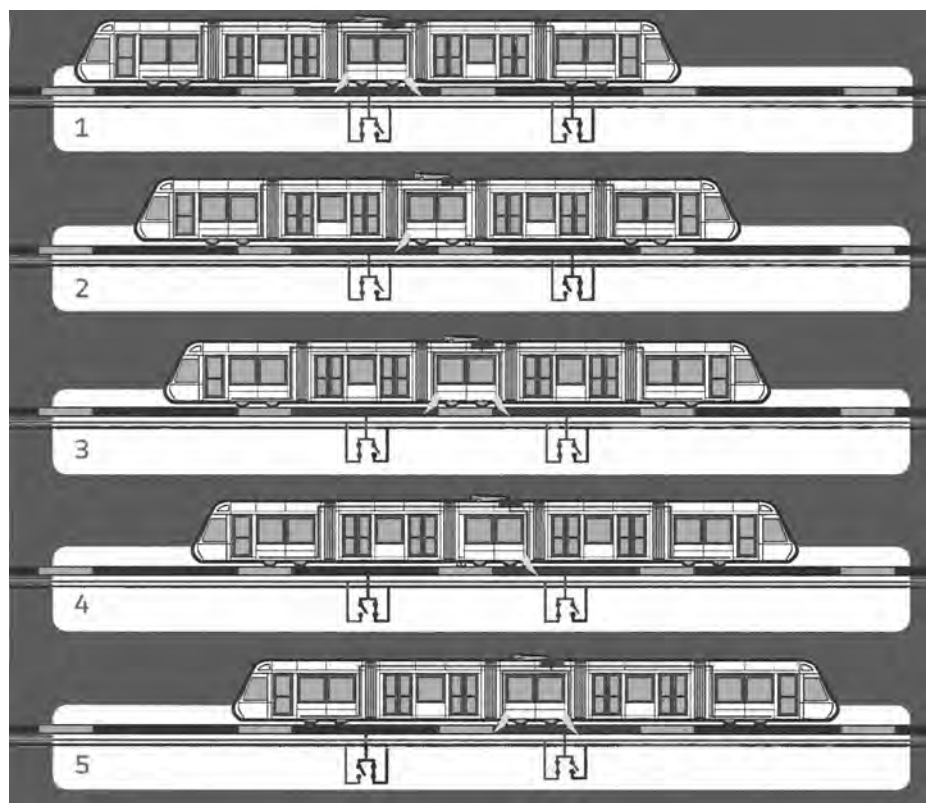
ALSTOM

Tram without catenary : APS

*Alimentation par
le Sol
Ground-level
Power Supply*



P 14



Tram without catenary : APS



Bordeaux



Reims

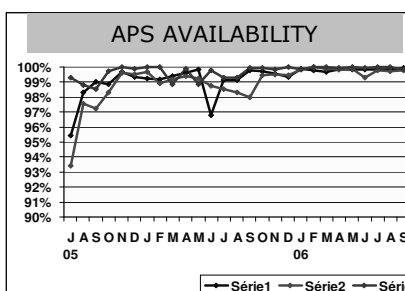
- Proven solution : Bordeaux network in passenger service (13.4 km)
- Return on experience and extensive product improvement process
- No power restriction - full speed and acceleration, possibility to use continuously reinforced HVAC for hot climate
- No risk of "empty tank"
- Complete intrinsic safety
- Customer confidence :
 - contracts in 2006 for Reims / Orléans / Angers,
 - followed by Dubai / Brasilia (hot climate version)
 - recently signed (Sept '10) in Tours

P 15

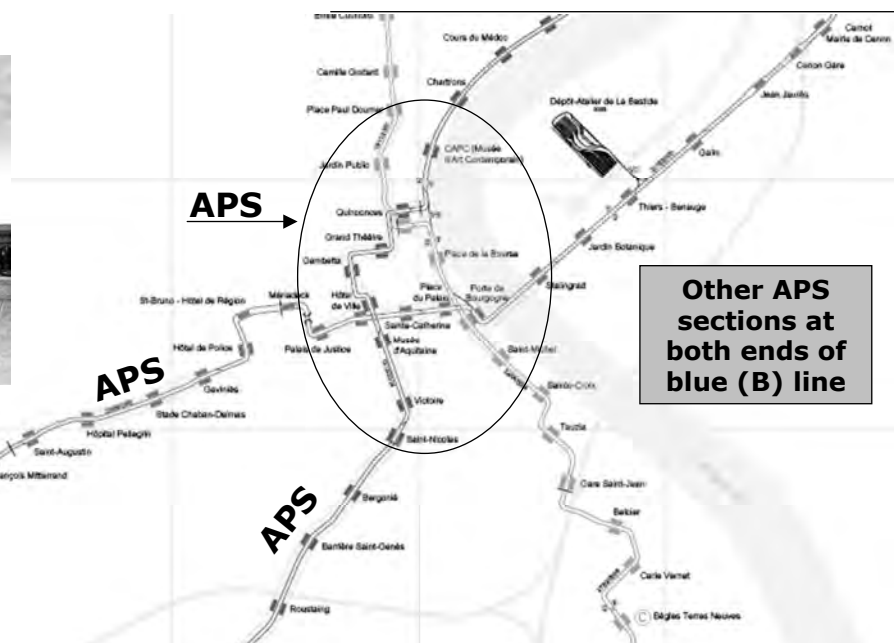
TRANSPORT

ALSTOM

Tram without catenary : APS Bordeaux



P 16



- 3 Lines in service (2004): 24,3 km with 10,85 km twin-track APS
- Second phase (end 2007) : 19,6 km incl. 2.2 km APS
- Final Network : 43.9 km with 13,4 km twin-track APS

Reims

- New LRT line 10 km in 30 years concession
- Alstom scope: 18 Citadis, APS, infrastructure, system
- APS scope: Design, Supply, Installation and Testing :
 - 3,92 km of APS single track
 - 9 APS Turnouts
 - 18 on board Equipment



- Project start in July 2006
- APS install start in June 2009 (compl. June 2010)
- APS T&C start in July 2010 (compl. August 2010)
- PTO : 18/04/2011 (1 year warranty)
- Testing in progress and successful

P 17

TRANSPORT

ALSTOM

Angers

- New LRT line 12 km
- Alstom scope : APS and 17 Citadis
- APS scope: Design, Supply, Supervision of Installation and Testing :
 - 2,82 km of APS single track
 - 5 APS Turnouts
 - 17 on board Equipment
- Particularity – **8%** gradient



- Project start in November 2006
- APS install start (June 2009)
- APS T&C start in Nov 2010 (compl. June 2011)
- PTO: June 2011 (14 months warranty)

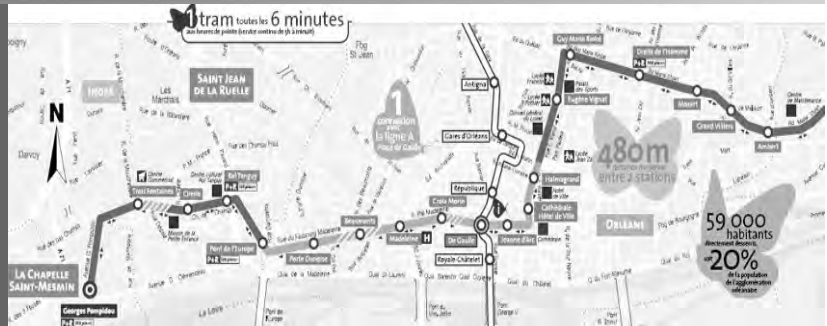
P 18

TRANSPORT

ALSTOM

Orléans

- New LRT Line: line 2
- Alstom scope: 21 Citadis, APS, tracks, railway signalling, system
- APS scope: Design, Supply, Installation and Testing :
 - 4,2 km of APS single track
 - 6 APS Turnouts
 - 21 on board Equipement



- Project start in Sept 2006
- APS install start in Oct 2010 (compl. June 2011)
- APS T&C start in August 2011
- PTO : 30/06/2012 (12 months warranty)

Tours

- New LRT line : 21 tramways, 15 kms track, 30 stations
- Alstom scope: 21 Citadis, APS
- APS scope: Design, Supply, Installation and Testing :
 - 3,6 km of APS single track
 - 4 APS Turnouts
 - 21 on board Equipement



- Project start in September 2010
- APS install start in Nov 2011 (compl. nov 2012)
- APS T&C start in November 2012
- Forecasted PTO : 2013

Dubai



- New LRT line : 11 tramways, 10 kms track, 13 stations
- The first city in the Gulf region to be equipped with a tramway transit system
- Alstom scope: 11 Citadis, APS, infrastructure (track, SST, E&M), system
- APS scope: Design, Supply, Installation and Testing :
 - 18,96 km of APS single track
 - 41 APS Turnouts
 - 11 on board Equipement



- Project start in June 2008
- 5 years warranty

P 21

TRANSPORT

ALSTOM

Brasilia

- New LRT line : 39 tramways, 22 kms track, APS on 1,2 kms platform
- The first city in the Latin America to be equipped with a modern tramway system
- Alstom scope: 39 Citadis, APS, track on APS section, ticketing, signalling, OCC, system
- APS scope: Design, Supply, Installation and Testing :
 - 2,4 km of APS single track
 - 2 APS Turnouts
 - 39 on board Equipement



- Contract September 2009

P 22

TRANSPORT

ALSTOM

Tram without catenary On-board Solution : STEEM



P 23

- Recovery of braking energy
- Running without pantograph
- Tramway length 44 m, width 2.65m, 86 tons max @ 6P/m² i.e. 417 Passengers
- Supercapacitor solution
- Operation in passenger service including a 300m interstation wireless section



TRANSPORT

ALSTOM

On-board Solution : STEEM

*STEEM : Système Tramway à Efficacité Energétique Maximisée
Maximized Energy Efficient Tramway System*

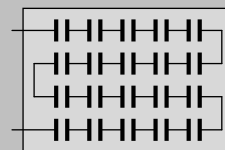


• U = 2,5 V

• a single 2600F cell



• 1 module = 20 cells connected in serial mode



• U = 50 V

• STEEM supercaps box :
branches in parallel,
modules in serie

E = 1,62 KWh

$P_{soc 0} = 350 \text{ KW}$

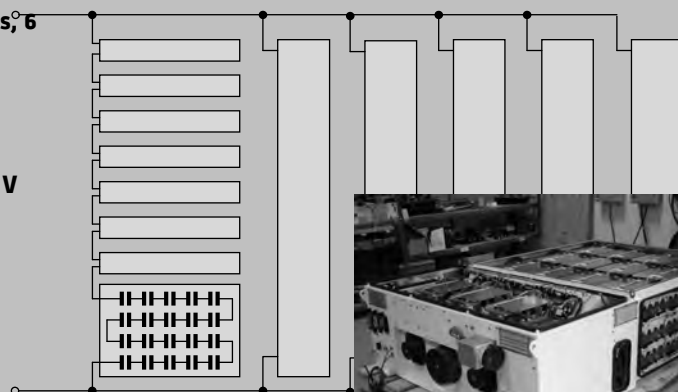
$P_{soc 1} = 500 \text{ KW}$

Msc=720 kg

Recharge time 20 s min

48 modules, 6
each of 8

• U = 400 V

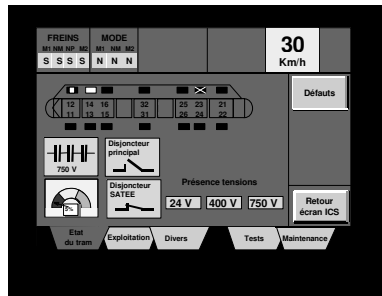


P 24

TRAN

On-board Solution : STEEM

- Integration in roof layout
- Adapted HMI interface for driver including supercap gauge
- Risk of empty tank on autonomous sections



P 25

Supercapacitors constraints

Extract of MAXWELL supercapacitors data sheet :

PC Family Small energy cells	BC Family Medium power cells	MC Family Large power cells
Features	Features	Features
Over 500,000 duty cycles	Over 500,000 duty cycles	Over 1 million duty cycles
2.5 volt operating voltage	2.5 volt operating voltage	2.7 volt operating voltage

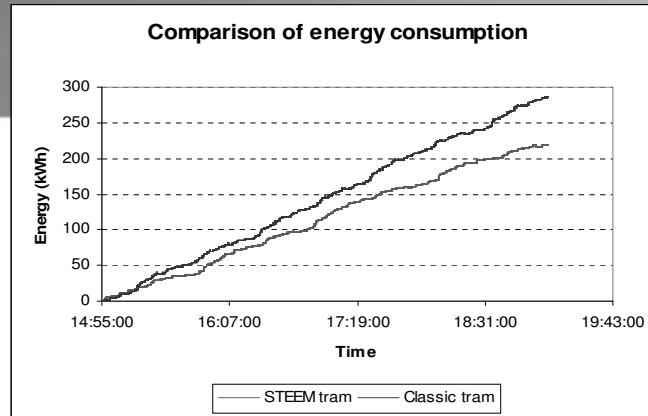
- Average cycles per year : between 150 000 and 200 000, therefore :
Lifespan : between 5 and 7 years for a 25°C operation ambient temperature
- **BUT lifespan is halved for each 10°C above the nominal temperature of 25°C and each 100 mV above nominal voltage (source : Supercapacitor traction system concept evaluation by Ing Frederik van Mulder)**
- **=> Supercapacitors refrigeration is compulsory !**

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TRANSPORT

ALSTOM

On-board Solution : STEEM



Energy saving effect depending on :

- number of trams-on-line
- heating and cooling (HVAC)
- Measured in spring 2010 : 13% average
- minimum 10%, maximum 18%
- highest savings : off-peak hours

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TRANSPORT

ALSTOM

Agenda

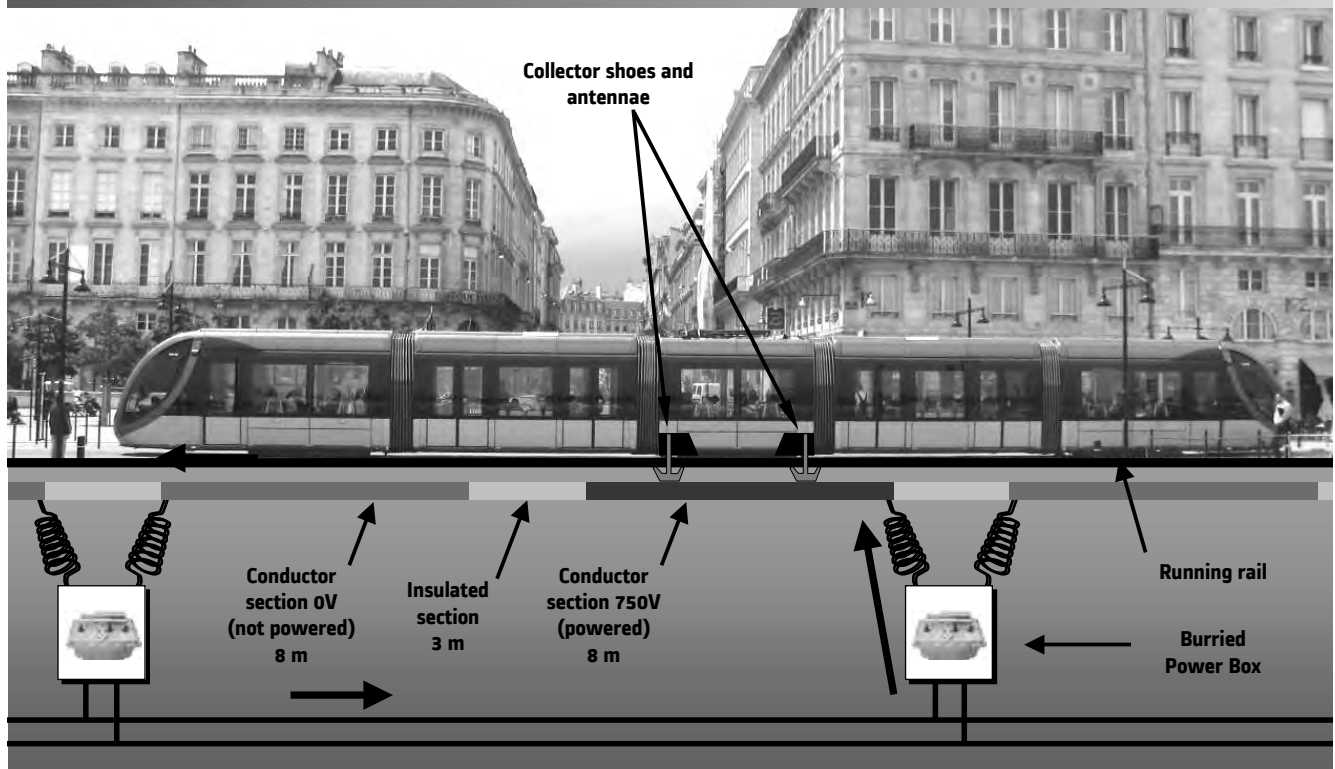
1. Why wireless trams ?
2. Wireless systems in operation & projects
3. How does APS work ?
4. APS evolutions

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APS system: principles

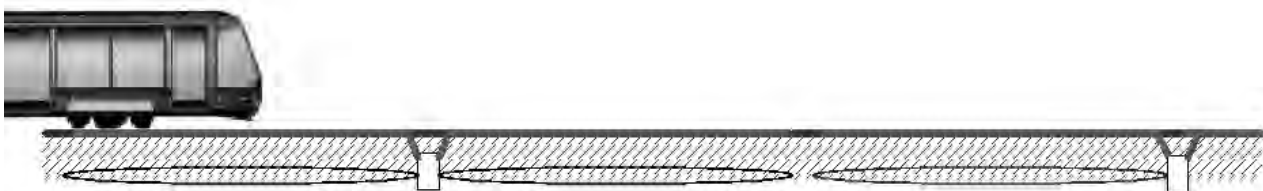


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APS system: principles



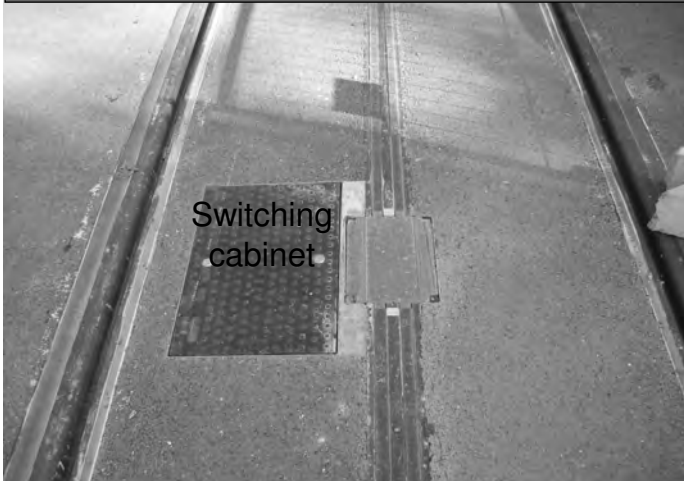
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APS: Aesthetic Power Supply

- Segmented street-level power rail
- Conductive segments Switched off-on-off as tram progresses
- Safety rule: Conductive segments energized under tram only.



- Safety rule consequence: All segments outside tram at 0 Vcc

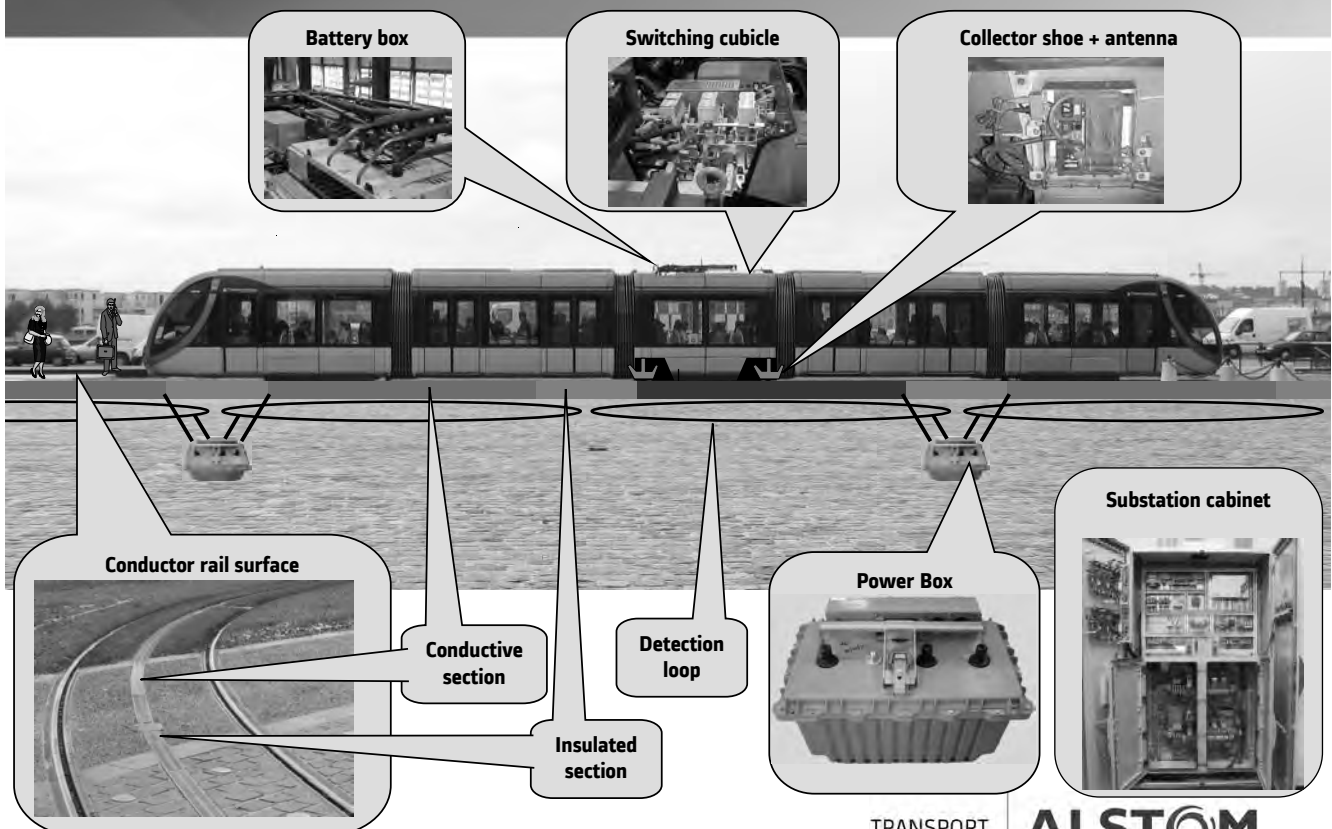


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APS system: main components



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Agenda

1. Why wireless trams ?
2. Wireless systems in operation & projects
3. How does APS work ?
4. APS evolutions

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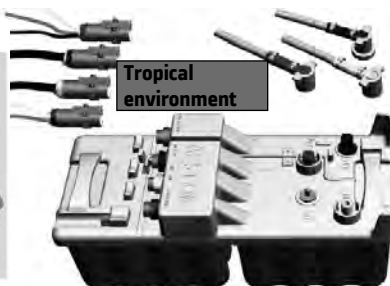
APS adaptation for hot climate

- **Objectives**
 - Tropical environment (hot, humid, sandy)
- **Technologies**
 - Thermic design of power box

Standard



Tropical environment



- Deep cable ways
- Air con substations
- Hot humid air: cooled roof equipment
- Sand and dust: brushes under tram, onboard cabinets sealed with internal heat exchangers or lightly over pressured

- **References** : Dubai & Brasilia



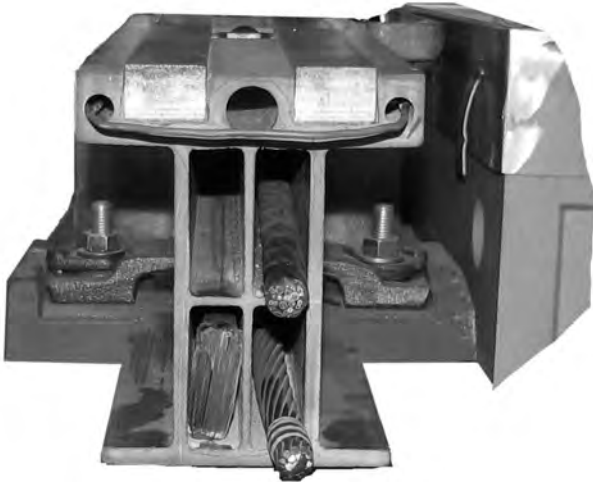
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APS rail evolution

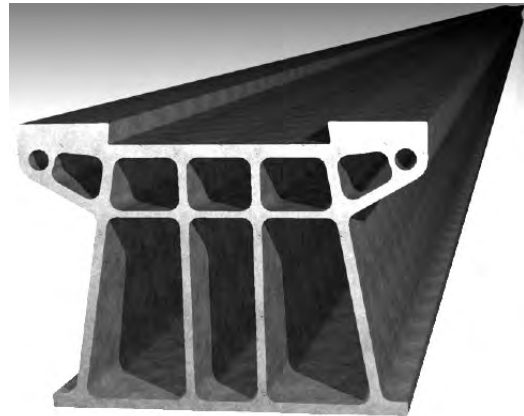
APS Bordeaux



P 35

Other APS projects

- wider rail for surface insulation
- wider loop for better train detection
- power cables centered (harmonics)
- stronger and better for installation



TRANSPORT

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Running Rails

Keeping the Rail Free of Sand : A Proven Solution

- Purpose
 - Remove the sand from the grooved rail
- Solution
 - The Rail Vacuum Cleaner Vehicle



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APS Rail

- Purpose
 - Remove all objects and pollutants from the APS rail surface
- Composition
 - A heavy duty shield to remove objects greater than 60 mm
 - A brush to remove lighter pollutants, **particularly dust and sand**

Design to handle acceleration levels of 30 g's in all directions

- Mounting
 - The device is mounted at each end of the tram
 - Activation is linked to the direction of travel

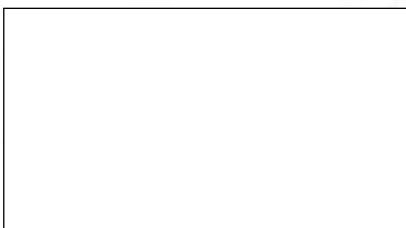
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Keeping the APS Rail Clean/ A Robust Solution

INSTALLATION ON THE VEHICLE



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Dust and Sand protection

IN OPERATION in
BORDEAUX



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Dust and Sand protection

Keeping the APS Rail Clean

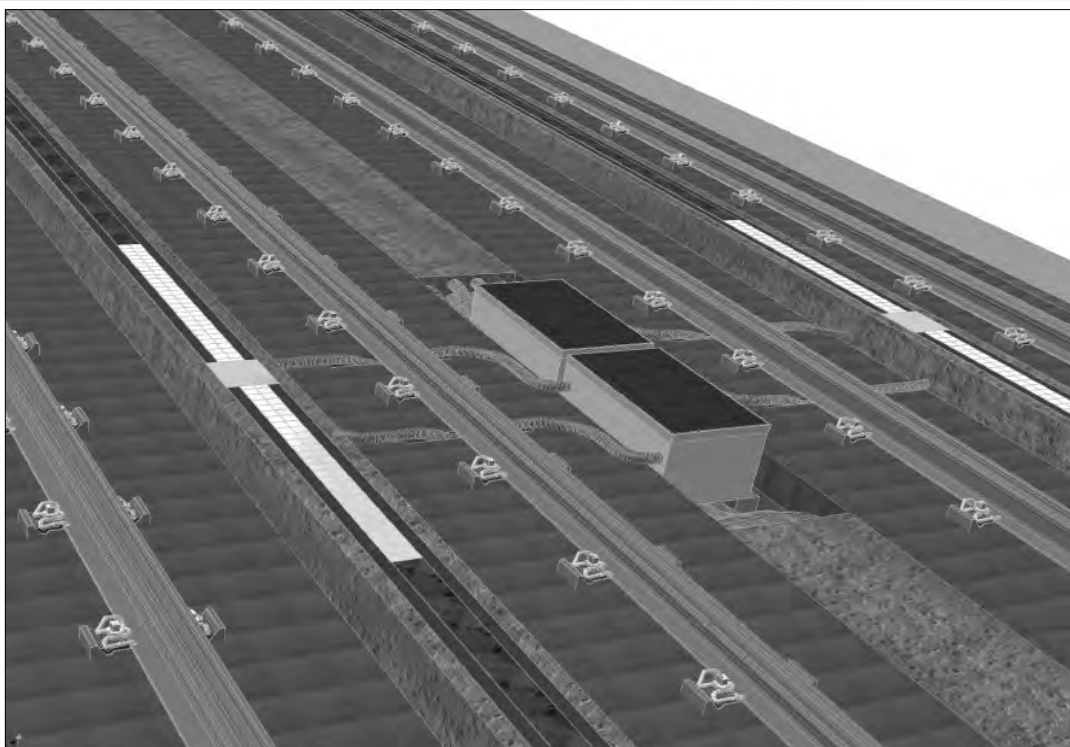
- Test Program completed
 - Shock Tests @ 20 kph with :
 - 1 kg metal chunk
 - 0.6 kg piece of wood
 - 4 kg concrete block
 - Stones & brick
 - Max acceleration recorded less than 20 g in all direction
 - Brush Test @ 15 & 18 kph with
 - Sand and gravel
 - Paper,
 - Plastic Bags
 - Wrappers

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Power boxes arrangement

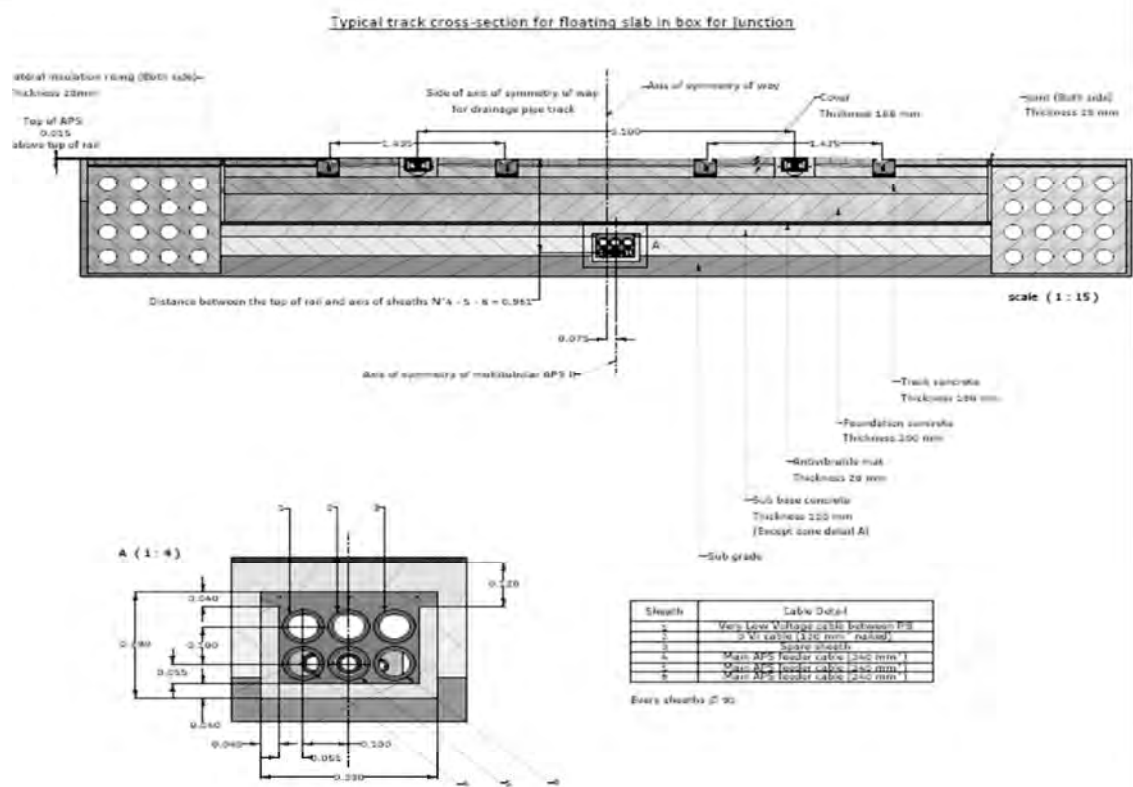


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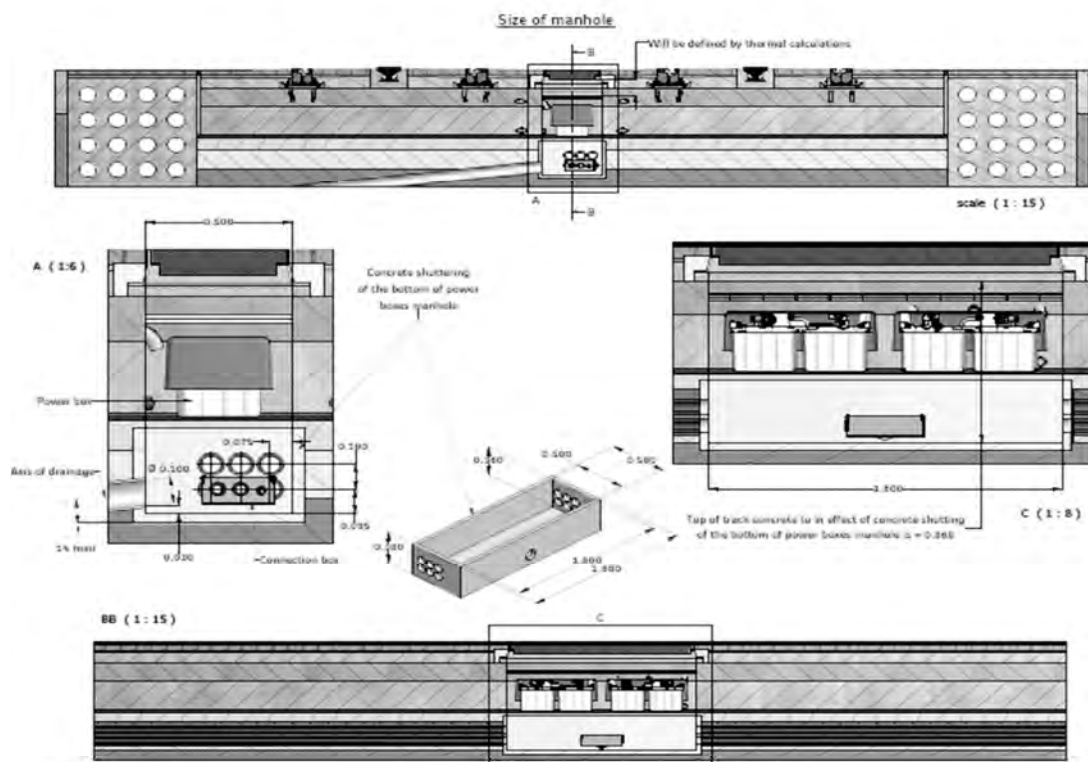
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TYPICAL TRACK CROSS SECTION



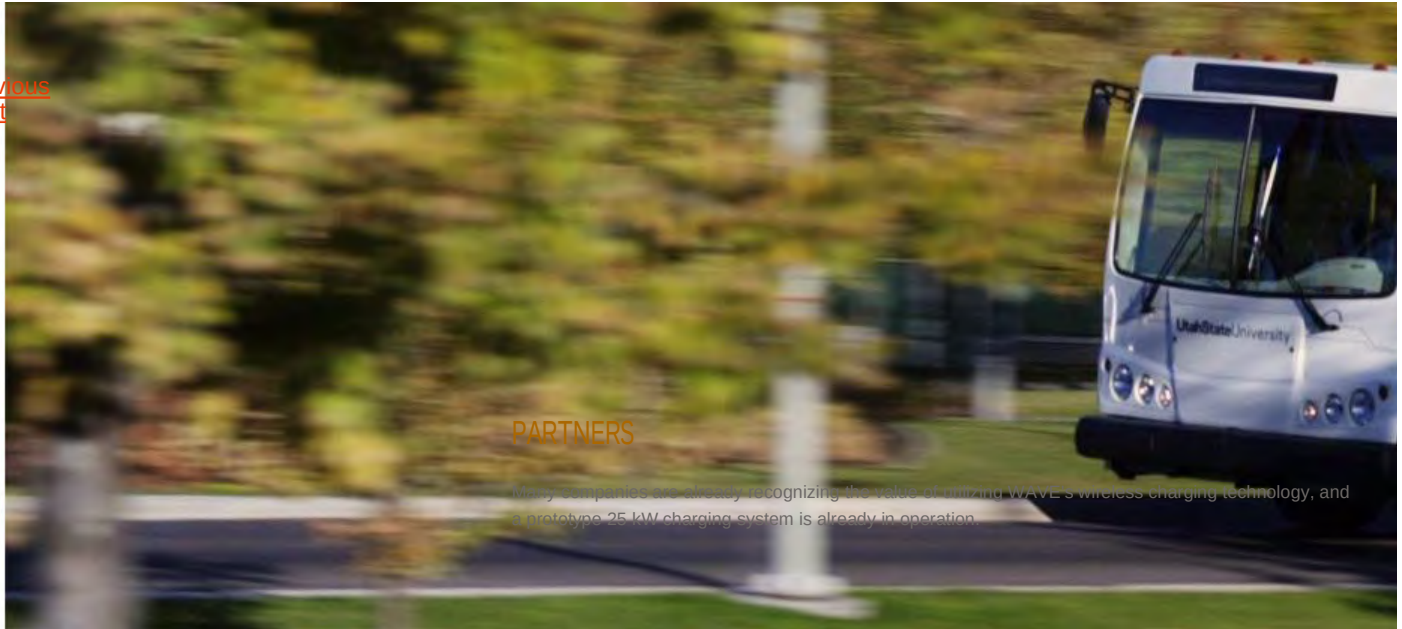
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TYPICAL APS TRACK CROSS SECTION



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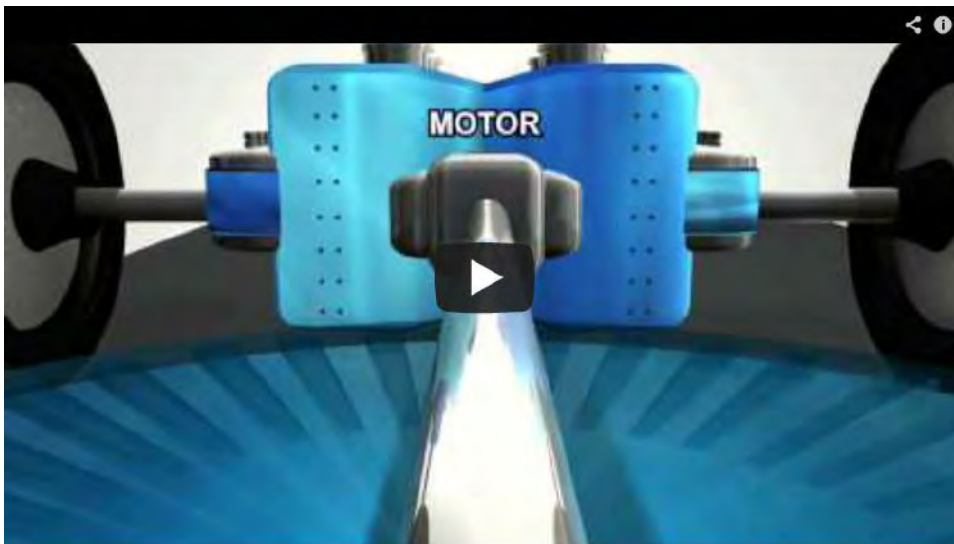
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PARTNERS

Many companies are already recognizing the value of owning WAVE's wireless charging technology, and a prototype 25 kW charging system is already in operation.

Watch Our Video



What Others Are Saying

What attracted us to this technology is the ability for us to power on the go and to have smaller batteries that allow us to get in and out of traffic throughout the day without a constant need for repowering.

Carl Sedoryk, General Manager,
Monterey-Salinas Transit

With WAVE's wireless power transfer technology we're able to use fewer batteries, and get a lighter vehicle, which means that [wireless power transfer] can be economically viable and competitive with diesel.

Alma Allred, University of Utah
Commuter Services

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Induction Charging Comes to Public Transit



by Keith Barry

Wired

12.03.12

Say goodbye to catenary wires. Utah State University has unveiled an electric bus that charges through induction, topping off its batteries whenever it stops to pick up passengers.

Designed by USU's Wireless Power Transfer team and the Utah Science Technology and Research initiative's Advanced Transportation Institute, the prototype Aggie Bus is already on the road. It uses the same wireless charging principle as an electric toothbrush or a wireless smartphone charger, except optimized for a massive public-transit vehicle.

As in all modern inductive-charging setups, a transformer is "split" between the bus and a charge plate under the bus stop. When the bus drives over the charging plate, current flows with no physical contact required. Engineers at USU designed their system so that the Aggie Bus can be misaligned up to 6 inches from the charge plate and still get 25kW of power and 90 percent efficiency from the power grid to the battery.

Because of the fixed routes they run and frequent stops they make, induction charging is ideal for buses. Instead of charging up a massive battery overnight before a route, the Aggie Bus features a smaller battery setup that recharges every time the bus reaches a predetermined stop. The smaller batteries free up interior space, reduce downtime and lower battery costs — although induction plates must be added to bus stops.

Though the Aggie Bus is a working prototype, USU is working with Wireless Advanced Vehicle Electrification (WAVE) — a company spun-out from USU — in order to bring a commercialized bus to market. In mid-2013, WAVE and the Utah Transit Authority are planning to unveil a 40-foot induction-charged transit bus on the USU campus that's capable of taking a 50kW charge. The project was funded by USU, who will purchase the bus, and a \$2.7 million grant from the Federal Transit Administration.

Charging a bus through induction may be a new idea in the U.S., but bus routes with similar wireless charging systems have been in place in Torino, Italy, since 2003 and Utrecht, the Netherlands, since 2010. Ideally, induction charging would be used in city centers to replace noisy, smoky diesel buses. It would also work on already electrified routes, allowing cities to take down unsightly hanging catenary wires.

wired.com

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PRIMOVE: Game-changing turnkey solution for tram

[systems](#)



primove light rail

Liberating trams from overhead lines

In many ways, light rail vehicles are the ultimate form of eMobility. Yet despite being clean, silent and convenient, they have always been hampered by one disadvantage – catenaries. Catenary power systems are complex to install, demanding to maintain and clutter the urban space with unattractive infrastructure.

Thanks to PRIMOVE contactless charging, trams can now run without any need for unsightly poles and overhead cables. The energy source is moved underground and charges the vehicle via inductive power transfer. It now becomes possible to integrate light rail systems into urban areas where conventional catenary networks are prohibited or unwelcome – such as city centres, parks, gardens and protected heritage sites. The cityscape is left untouched, minimising visual pollution and improving the overall appeal of the city.

[Key benefits](#)

[System overview](#)

[Component features](#)

Key benefits

Minimised visual pollution

- Elimination of wires and poles – all components are hidden under the vehicle and beneath the track
- Installation is possible even in previously unsuitable areas such as heritage-protected sites

Operational under all conditions

- Reliable even under adverse weather and ground conditions such as sand, snow or ice
- Compatible with all road surfaces or tracks

Reduced infrastructure

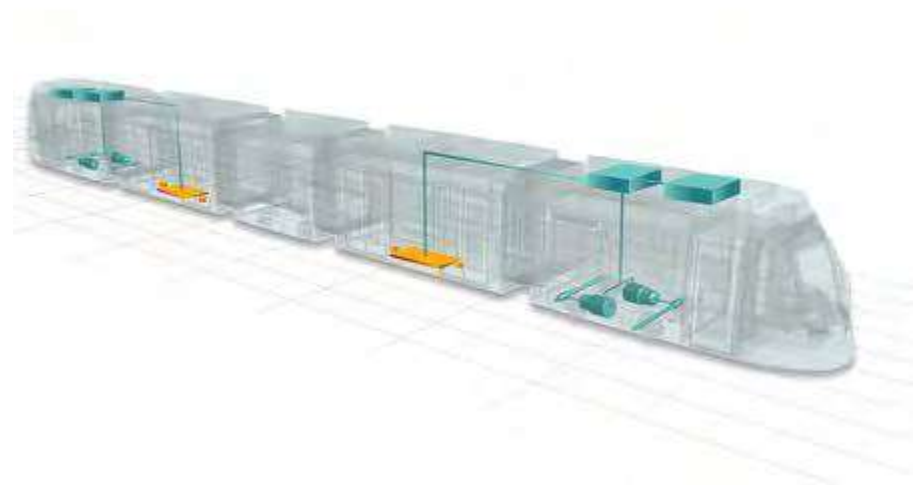
- Less land take needed than for catenary systems
- Less maintenance: no wear of pantographs and overhead lines, no risk of vandalism

No compromise on performance

- Same great performance as with catenary systems
- Reduction of energy consumption by up to 30% when combined with an energy storage solution

System overview

Because PRIMOVE is a contactless energy transfer solution, the system operates reliably under all circumstances – even in adverse ground conditions involving sand, snow or ice. Its liberation from the constraints of overhead cables also gives urban planners and public transport operators more freedom and flexibility in designing their transport solutions.



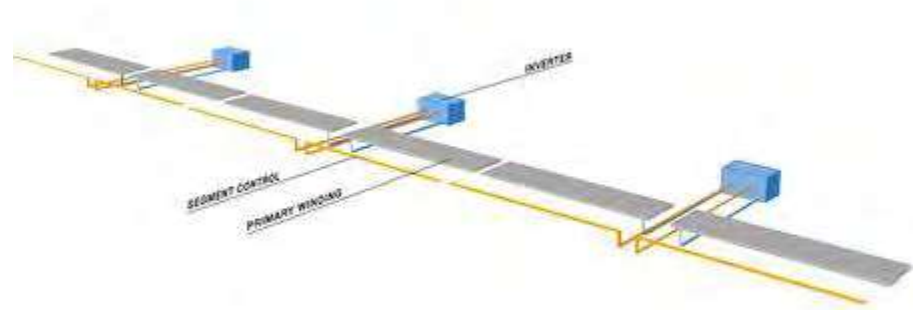
Beyond dispensing with overhead infrastructure, the PRIMOVE system also offers a whole range of further advantages. The technology is simple to install in both new and existing lines as the components easily fit between the rails. Initial investment and maintenance costs are lowered, making the overall system highly competitive and efficient. The

charging system could even be made compatible with road vehicles, enabling the same underground infrastructure to be used for recharging multiple modes of public transport.

For even higher levels of efficiency and performance, PRIMOVE technology can be combined with an energy storage solution. When mounted on a light rail vehicle, this device stores the energy released when braking for later use. The system reduces energy consumption by up to 30%, lowering both electricity costs and greenhouse gas emissions. Over short distances, PRIMOVE-equipped trams can also operate without having to recharge, further minimising infrastructure and installation costs.

Component features

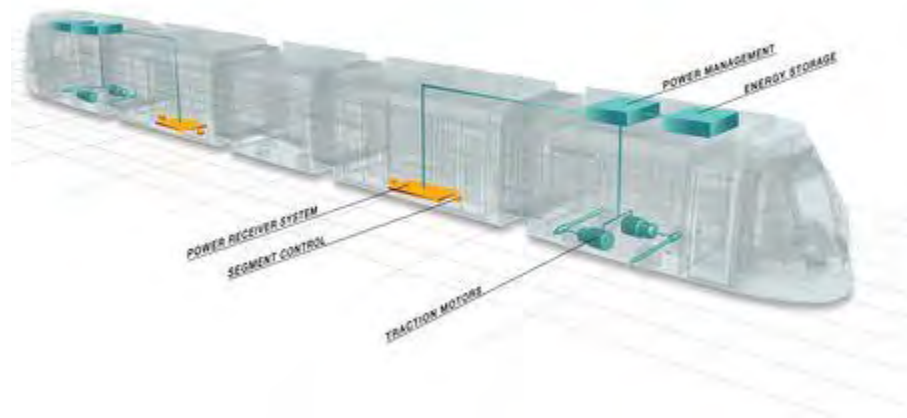
PRIMOVE wireless charging technology comprises two sets of components – wayside components that are buried underground and onboard components that are fitted onto the vehicle frame. Both sets are designed to enable maximum structural integration, as well as for energy transfer at high power and efficiency.



Wayside components

- Fully buried underground and can be covered with different materials like asphalt or concrete
- Primary cable segments provide the actual power transfer to the vehicle and are installed just under the road surface
- Magnetic shielding under the primary winding (magnetic layer) prevents electromagnetic interference
- The Vehicle Detection and PRIMOVE Segment Control (VDSC) cable senses when a PRIMOVE-equipped vehicle is above the segment and switches the segment on. Segments otherwise remain inactive to comply with electromagnetic interference protection requirements
- The Supervisory Control and Data Acquisition (SCADA) interface provides information for system control and diagnostics

- Inverters convert the DC supply voltage to the AC voltage used in the system.
- DC feed cables supply power to the inverters



Onboard components

- The PRIMOVE Power Receiver System consists of the pick-up together with a compensation condenser, which are both installed underneath the vehicle. They convert the magnetic field from the primary winding into alternating current
- Inverters convert the alternating current from the pick-up into direct current that powers and charges the vehicle
- Energy storage solution
- The Vehicle Detection and PRIMOVE Segment Control (VDSC) antenna detects cable segments and coordinates the on/off switching



More information

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PRIMOVE: High power transfer for electric buses

The technology behind primove

Based on the principle of inductive power transfer, PRIMOVE technology allows energy to be wirelessly transmitted between components buried underground and receiving equipment installed beneath the vehicle.

The inductive principle functions as follows: an electric conductor creates a magnetic field, which generates an electric current in another conductor placed within that field. When applied in conjunction with the PRIMOVE system, this electric current generates energy that is then used to propel vehicles forward in a clean, efficient way.

In order to power vehicles through inductive power transfer, an induction coil under the road or track carries high-frequency alternating current (AC), thereby creating a magnetic field. This field induces a voltage in the vehicle-side inductive power receiver (pick-up), which is used to charge and power the vehicle. Wayside components “communicate” with the vehicle to ensure that charging segments are only switched on when the vehicle is positioned directly above them.



Electric current in a primary coil (winding) creates a magnetic field, which induces current in a secondary coil.



This power transfer occurs even if there is a gap in the iron core, enabling the process to be contactless.



If the primary coil is extended in a loop, the secondary coil can receive power anywhere along this loop.

This principle is used in a huge range of applications from electric toothbrushes that charge inductively when placed on their base to electric generators in power plants.

The charging process

When charging statically, the electric vehicle simply drives to a charging point; once the vehicle is positioned over the charging segment, energy transfer can begin. The PRIMOVE system allows for energy transfer at high levels, minimising both charging time and frequency. The driver does not have to follow any special procedure, nor does he require extra qualifications or training to operate the system. Furthermore, there is never any physical contact with electricity, ensuring that the charging process is both safe and driver-friendly.

When charging dynamically (in motion), the rail or road vehicle recharges by driving over the inductive segments. These are automatically switched on as the vehicle is activated by the wayside detection system.

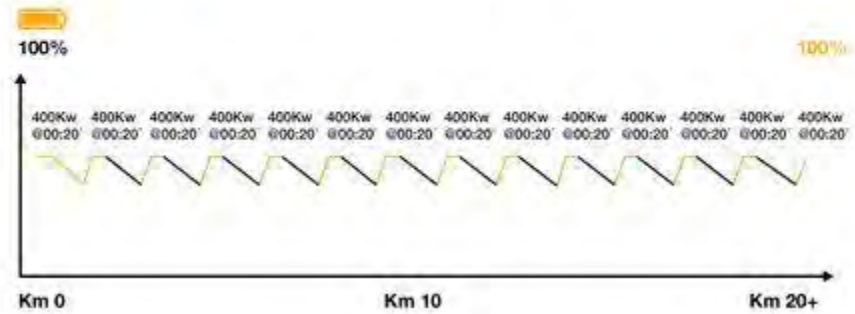
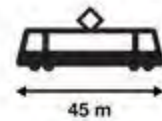
Introducing high power opportunity charging

Range and recharging constraints are the key concerns when it comes to converting an entire delivery fleet or bus network to electric power. In order to address these issues while offering a solution that is light, easy to integrate and competitive, the PRIMOVE system combines a charging pattern at regular intervals with energy transfer at high power levels. The charging process is seamlessly integrated into existing operations, thereby ensuring uninterrupted service without any need for additional fleet vehicles or batteries.

A precise energy flow simulation helps define the optimal infrastructure to maximize efficiency while keeping charging frequency (and infrastructure) to a minimum. It defines the ideal positioning of charging points that match the existing route so that the vehicle never has to change its course or extend dwell time to recharge.

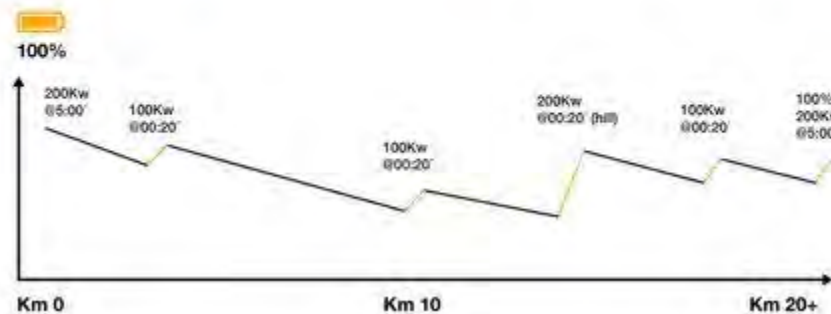
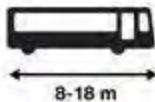
Light rail

Charging segments are integrated at every tram stop and the subsequent few metres to enable recharging while letting passengers on/off and during acceleration.



Bus

Charging stations are positioned in the depot and/or en route at bus stops for recharging while letting passengers on/off without extended dwell times.



Automotive

Charging stations are installed at strategic points (e.g. loading docks for delivery vans, taxi ranks in airport waiting areas, supermarket parking

spaces) to allow fast charging at convenient times when the vehicle is periodically not in use.

Wednesday, August 15, 2012

Induction in action

Written by [Keith Barrow](#)

4



Emerging technologies are helping light rail operators to escape some of the visual, operational and financial restrictions of overhead catenary. Keith Barrow reports from Augsburg on the development of Bombardier's induction-based Primove system.

ONE of the defining trends in light rail technology over the last few years has been the emergence of catenary-free systems.

Advances in supercapacitor and battery technology have

spawned an array of catenary-free solutions and almost all of the major LRV manufacturers have developed their own products, many of which are now being offered commercially.

Bombardier's Primove system draws electrical energy through induction, using the same principles of power transfer used in an electric toothbrush. Primove LRVs draw power from a cable buried beneath the running rails which forms part of a primary circuit. This produces a magnetic field, which is converted back to electrical energy by a pick-up coil mounted underneath the vehicle. A short section of the cable, or primary winding, is only energised as the vehicle passes overhead, and can be safely laid under any surface, including tarmac, concrete, and grass.

A typical low-floor LRV would be equipped with two underfloor power receivers, each feeding roof-mounted power management and energy storage units at either end of the vehicle, which are also fed by the regenerative braking system. The power management unit feeds energy back to the traction motors as required.

Primove can operate with a supply voltage of 400-600V ac or 750V dc. The supply is fed to wayside inverters to power the vehicle detection antenna loop, which is laid alongside the track, and the primary winding, which is laid in 9m-long sections between the running rails. The primary winding is energised only when the vehicle passes overhead. Like the primary winding, the inverters and power supply network can be covered with any surface. Depending on the characteristics of the route, 10-25% of a typical light rail line would be equipped with the wayside equipment.

The system has charging power of 200kW, which feeds two 48kWh batteries with a transfer efficiency of up to 95%. Each battery weighs around a tonne - roughly the equivalent of 13 standing passengers - can load fully in 20 seconds, and has a 10-year service life expectancy under normal operating conditions.

The technology allows vehicles to charge dynamically or statically, which means Primove-equipped vehicles continue to draw current while standing at stations but use less power than conventional trams when in motion. This inevitably has an impact on the power supply architecture, and Bombardier says a line operating exclusively with Primove requires fewer substations than a line with standard catenary.

"The key to Primove is energy management," says Bombardier's Primove product director Mr Harry Seiffert. "It's all about achieving a trade-off between stress on the battery and the power supply infrastructure. The fact that there is no return current to the rail is also a key advantage."

Bombardier engineers first conceived Primove in 2003, and following a period of further development including input from the University of Braunschweig, it set up a 1km test track at its Bautzen plant in eastern Germany in 2009. Here a 30m-long Flexity LRV was tested at up to 40km/h on a 6% gradient.

The next step was to test the operating performance and electromagnetic compatibility of the system in an urban environment. In June 2010 Bombardier began installation of Primove on the 800m-long branch of Augsburg Line 3 to the city's exhibition centre, a project implemented in cooperation with the Augsburg Transport Authority (SAV) with grant funding from the German Federal Ministry of Transport Building and Urban Development (BMVBS). Test operation began in September 2010, using a bidirectional Flexity low-floor LRV, and the system was approved for limited passenger use a year later.

During this evaluation phase, Bombardier engineers worked with external assessors such as TÜV Süd to ensure Primove achieved all applicable electromagnetic compatibility standards, including the guidelines of the International Commission on Non-Ionising Radiation Protection.

Bombardier says a new LRV equipped with Primove costs around 10% more than a standard vehicle, although it aims to achieve equivalent operating performance and cost to catenary-based systems on a life-cycle basis, and even exceed the capabilities of overhead electrification in areas such as energy consumption. "It's clear trams won't run on Primove unless we are competitive on cost, so we need to be in the same range as conventional vehicles because cost is important to the market," explains Bombardier Transportation CEO Mr André Navarri. "You also have to factor in the price of the overall system, and the charging strategy for the line. The price of Primove components will decrease over time, and our simulations have demonstrated the system is cost-effective on a whole-life basis."

In addition to the elimination of unsightly catenary masts, Primove can also reduce the land area required for light rail projects. A double-track line with Primove requires a 7.05m-wide corridor, compared with the 7.6m footprint of a line equipped with overhead catenary.

Bombardier is pitching Primove as a system that completely obviates the need for catenary, while maintaining or improving on the performance of overhead electrification. The system is totally weather independent, and the Primove demonstrator has been successfully put through its paces in heavy snow and over sand-covered track with no loss of performance.

But what really sets Primove apart from competing catenary-free technologies is the potential of the system beyond light rail. A 125m-long section of public road in the Belgian town of Lommel has been equipped with Primove, and tests are underway with a bus and a car. In June Bombardier and Braunschweig Transport launched a BMVBS-supported project to test two Primove-equipped buses on a 12km bus route in the German city. Bombardier is also extending the technology to commercial vehicles and is testing a van with a new prototype power receiver for smaller road vehicles at its eMobility facility in Mannheim.

Bombardier anticipates that the global electric bus market will represent 235,000 new vehicles over the next decade, and the value of the electric bus/taxi market is expected to increase from \$US 6.24bn to \$US 54.1bn by 2021. As light rail systems are almost universally electrified, the arguments in favour of adopting induction technology are naturally quite different from those for road vehicles. But the extension of Primove to other modes means economies of scale and the commonality of components could help to make this innovative technology even more accessible for future light rail projects.



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**Innovative Technologies for Light Rail
and Tram:
A European reference resource**

**Briefing Paper 2
Ground-Level Power Supply -
Alimentation par le Sol
September 2015**



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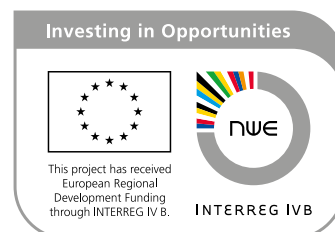
5.2



Sustainable transport for North-West Europe's periphery

Sintropher is a five-year €23m transnational cooperation project with the aim of enhancing local and regional transport provision to, from and within five peripheral regions in North-West Europe.

INTERREG IVB



INTERREG IVB North-West Europe is a financial instrument of the European Union's Cohesion Policy. It funds projects which support transnational cooperation.



Working in association with the POLIS European transport network, who are kindly hosting these briefing papers on their website.



Report produced by University College London

Lead Partner of Sintropher project



Authors: Charles King, Giacomo Vecia, Imogen Thompson, Bartlett School of Planning, University College London. The paper reflects the views of the authors and should not be taken to be the formal view of UCL or Sintropher project.

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Background

This briefing paper is one of a series that together comprise a European reference resource for innovative technologies rail-based systems, with particular reference to light rail and tram-based schemes in cities and regions. The approaches are also relevant, in many cases, to heavy rail and even other forms of public transport for example bus.

The resource is one of the Investments undertaken for the Sintropher project funded under the INTERREG IVB North West Europe Programme for transnational co-operation. The overall aim of Sintropher project is to develop sustainable, cost-effective solutions to improve connectivity to, from and within poorly connected regions in North-West Europe - to use innovative transport links to connect peripheral regions of NWE with the core European transport network of high-speed trains, via effective interchange hubs.

There has been a particular focus on tram-train systems which allow local trams to run on to national rail networks, pioneered in Germany, firstly in Karlsruhe and developed in Kassel, which allow urban tram systems to extend over national rail tracks to serve extensive city regions. The project has also looked at other innovative forms of tram systems such as single-track tramways, as well as high-quality transport interchanges that link such systems to major national or transnational rail or air hubs.

The project began in late 2009, with fourteen partner agencies in five EU Member States, and lead partner University College London (UCL): Valenciennes (France); the Fylde Coast (UK); West Flanders (Belgium); North Hesse (Germany); and Arnhem-Nijmegen (Netherlands). Participants included public transport operators, local authorities, regional transport agencies, and universities.

They have worked together on a series of feasibility evaluations, pilot investments and demonstration projects, as well as comparative analyses of EU best practice. The total budget is more than €23m, with funding part-financed by the EU's INTERREG IVB Programme.

A €1.5m project extension in 2014, covers follow-on work to capitalise on results from the initial project, and added a fifth objective: to test technologies for low cost transport links in different territorial contexts, plus integrated territorial corridor plans that help these links unlock wider economic and regeneration benefits; and better recognise these in business cases. This included two new partners (total now 16) and two extra demonstration regions (total now 7) in West Flanders Brugge-Zeebrugge (Belgium) and Saar-Moselle (a cross-border region France-Germany).

Innovative technologies for light rail and tram – developing opportunities

Previous results from Sintropher show that low-cost systems, such as tram-train, tram-rail, and single-track tram systems, have clear potential but there is no single “best” solution and these opportunities must be assessed and adapted to city/regional circumstances. (Sintropher Report *Connecting European regions using Innovative Transport. Investing in light rail and tram systems: technological and organisational dimensions*. See references at end.)

Additionally over the 5 years of Sintropher, there have been dramatic developments in relevant transport technologies. The most important are (a) very long-life batteries that allow electric trams and trains to operate over substantial distances “off the wire”; (b) charging devices that boost battery life by recharging at stops en route – e.g. the supercapacitor technology demonstrated at the 2010 Shanghai Expo, or the induction system employed by Bombardier in their Remove trams and buses; (c) discontinuous

electrification that allows electric trains and trams to “coast” under bridges and through short tunnels where it would be impossible or prohibitively expensive to install overhead catenary.

Also, a recent Report by UK Network Rail “*Network RUS: Alternative Solutions*” (July 2013) - an input to its Route Utilisation Strategy for long-term planning of the national rail network - has reviewed these developments. This work followed a remit to think imaginatively about cost effective solutions for accommodating growth in UK passenger demand, and operating services more efficiently. The solutions which are considered in the UK context are generally over and above the conventional solutions such as types of rolling stock and 25kV AC overhead line electrification. It looked at tram-train, tram systems, battery-powered vehicles, hybrid light rail, personal rapid transit, bus rapid transit and guided bus, and electrification solutions for lightly-used routes. Its main focus is existing rail lines in the UK network, but it can also be used to consider options for new transport corridors in urban areas.

The Report’s overall comment is “Whilst some of the solutions are close to an appropriate stage of development (or adaption) for introduction onto the UK rail network, others will require more attention, for example on battery technology. It is important to be aware that, by definition, a process of innovation is a process of change and that some technologies that are not listed as appropriate at present may become appropriate after further development work. It is possible that over the next 30 years there may be some significant technological developments that could reshape the market for public transport and how it is powered.”

So within the project’s partner regions, there has been further feasibility work to test these kinds of innovative low-cost solutions in different city/regional contexts, including new developments in technical solutions.

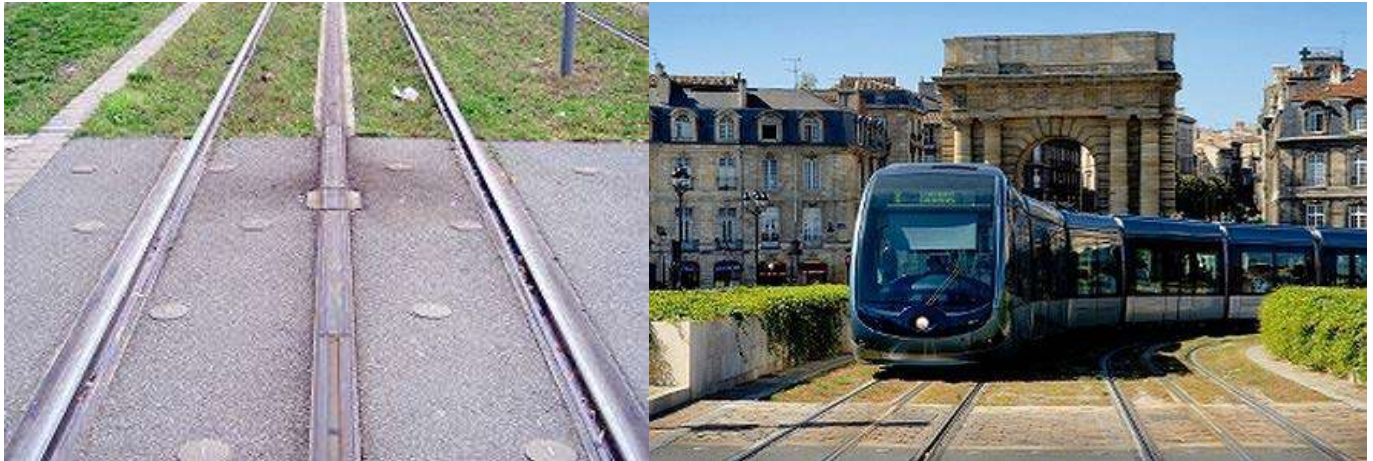
The European reference resource informs project partners’ work, and is also intended to be of relevance to much wider audiences especially. Particular target audiences are governmental authorities and transport agencies at city, regional, national and EU levels; and transport professionals and practitioners who may be involved in the initiation and implementation of new transport links

The reference resource is a snapshot in time (September 2015) and obviously the field of technologies is developing on an ongoing basis - it is hoped to update the briefing papers periodically as necessary.

Alimentation Par le Sol (APS)

Literally meaning ‘feeding via the ground’, Alimentation Par le Sol (APS) is a modern third-rail electrical pick-up power supply mode pioneered in France in 2002 and used in selected urban tramways globally. APS systems boast high standards of safety and efficiency, and are minimally invasive aesthetically, which makes them especially suitable for urban settings.

Overall infrastructure costs relative to catenary installation remain higher and APS systems can experience problems when operating in extremely wet and rainy conditions. But despite this, many cities around the world are currently adopting APS and the system is experiencing a renaissance with recent improvements in reliability delivered through advances in technology.

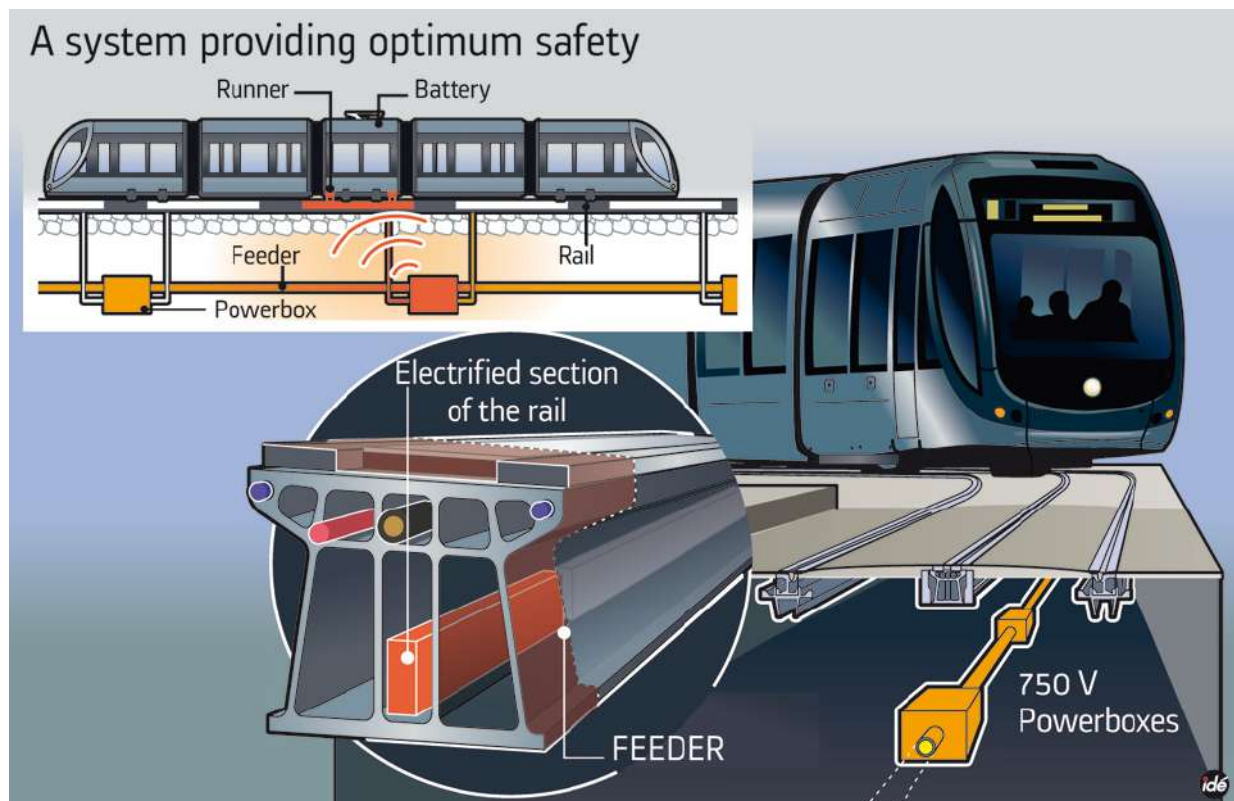


Left: APS track sections showing third rails, powered segments, and neutral segments. Right: An Alstom Citadis train running on the Bordeaux APS network.

Technology

APS rail technology is distinct from most other methods of supplying power to trams. Instead of picking up power from a conventional overhead wire, the system uses a third rail placed centrally between riding rails to transfer power to the tram. The rail is broken into two types of segments: *neutral segments* (~3m) and *powered segments* (~10m).

The trams riding over these third rails utilise *power shoes* or *skates* to collect electricity from the powered rails, which are only activated when special radio antennae under the tram signal these rail segments to energise. Thus, only the segments directly under the moving tram which have been signalled by the undercar antennae will be electrified at any one time. This system is visualised below.



Above: APS track/tram interaction and visualisation of the electrified section of the rail.

Attractiveness

- APS is compatible with all types of road surfaces and can be extended relatively easily along existing rail, making it suitable for retrofitting.
- It offers safety benefits where other electrification processes would pose safety risks to pedestrians and road users.
- Advances in shoe collection technology allow greater line energy transfer efficiencies and reliability (up to 99%) relative to other catenary and non-catenary operations.

Risks

- APS tramways experience problems operating in extremely wet environments or on roads with poor drainage.
- Heavy rains on small urban streets with old stormwater systems have posed significant barriers to reliability in cities such as Bordeaux.
- Technology remains expensive and significant reductions in capital costs not anticipated with further development.

Track Record

Despite most historic ground level power supply systems being replaced by overhead wires or buses over the 20th century, a number of cities have announced new APS tramways over the past decade.

France was originally the largest adopter of this technology with three networks using APS in Bordeaux, Reims, Angers, and two more proposals under consideration in Marseille and Tours. In addition the UAE, Australia, China, Brazil, Spain, the USA, and Italy are all considering or have prepared proposals for APS tramways.

APS Case Study: Bordeaux Tram



System Specifications:

Line	Length ^[1]	Stations ^{[1][2]}	Route
A	20.6 km	41	Mérignac Centre - La Gardette Bassens Carbon Blanc and Floriac Dravemont
B	15.2 km	32	Pessac Centre - Berges de la Garonne
C	8.1 km	17	Terres Neuves - Berges du Lac
-	-	-	14km total APS tramway between lines

Rolling Stock: Alstom Citadis Trams with specifications shown below.

Citadis for Bordeaux		
The standard-gauge, double-ended Citadis 100% low-floor trams are built by Alstom, at their factory at Aytré, near La Rochelle. The 5-section vehicle, type Citadis 302, has a length of 32 m and a capacity of 200 passengers. The 7-section vehicles for Bordeaux are of type Citadis 402, with a length of 44 m and a capacity of 300 passengers. Alstom has just decided to drop the numerical model designations for Citadis, but they are retained here for clarity.		
	Citadis-302	Citadis-402
Length (m)	32.90	44.00
Width (m)	2.40	2.40
Height (m)	3.27	3.27
Entrance level (mm)	320	320
Passengers seated	48	70
Standees	170	230
Total capacity	213	300
Motors (9kW)	4x120	6 x 120
Axles	6	8
Max. Speed (km/h)	60	60



Status: Line B: extension under construction, completion summer 2015.

Line C: extension under construction, completion April 2015

New tram-train: 7.5km branch from line C, completion 2015

New Line D: 9.8km, under planning, expected delivery 2017

Line A completed 21 December 2003; extended Sept 2005, Feb 2007, and May 2008

Line C completed 24 April 2004

Line B completed 3 July 2004; extended May 2007, October 2008

Cost: EUR 1.2bn. Phase 1: €690m 2003-4; and phase 2: €560m 2006-8

Ridership: 117 million passenger journeys in 2012

Why was the technology chosen in Bordeaux?

Urban aesthetics: overhead wires were considered by the French Ministry of Culture and the public as invasive and irreconcilable with the urban form of the dense city centre.

Safety: Traditional conduit systems were deemed unsafe by government to use in the conditions of Bordeaux.

Solution 'of the times': Innorail (alongside Electricité de France) was commissioned to develop APS as a method to deliver a catenary-free, non-electrified third rail system.

Benefits

- The system has received acclaim for eliminating the need for overhead wires and preserving the aesthetic form of the dense urban centre.
- Safer alternative to conduit power systems as APS track electrification occurs only on track segments directly underneath each tram.

Drawbacks

- The system has faced difficulties on some streets with poor drainage where heavy rains can lead to short-term flooding and severe delays. This led the city to replace roughly 1km of APS tramway on streets with chronic flooding with overhead wires.
- Maintenance costs greatly exceeded initial estimates leading Bordeaux to initially spend more on the small portion of APS track than on the rest of the conventional tram network combined.

Assessment

Over the first two years of APS being rolled out in Bordeaux, tram ridership increased by roughly 25 per cent. While originally susceptible to cancellation due to heavy rain or flooding, improvements in drainage along tracks alongside better planning around extreme weather events has increased tram reliability along the APS to 99 per cent.

Additionally the implementation of APS has seen the removal of a number of overhead wire “webs” in the urban core allowing Bordeaux to preserve many of its historical sights and vistas. While it is difficult to argue whether the cost of APS justified its use, different judgements on the value of urban form and heritage preservation may make the system appear worthwhile. In general, France places significant emphasis on preserving urban “beauty” with often greater engineering costs. Thus, in contexts where such value is placed on urban form such as Bordeaux, the system can provide “return” on investment.

Future Prospects and Transnational Relevance

APS technology has demonstrated itself as a viable catenary-free alternative. While engineering costs are still high when compared to conventional trams the cost of implementation is expected to decrease somewhat with time as the technology becomes more popular. Indeed even if costs remain high many cities are placing a greater emphasis on preserving urban form and may benefit from APS systems.

Future improvements for APS technology include: increasing energy efficiency as it is still less efficient when compared to battery and super-capacitor trams; reducing engineering and maintenance costs; and increasing current capacity to allow longer trams on steeper gradients.

While APS technology has been pioneered by the French, the system has significant application in many other contexts. Indeed any city with a desire to explore third-rail systems can benefit from APS technology. In June 2013 Rio de Janeiro placed an order with Alstom for Citadis trams designed to run simultaneously with APS and super-capacitors demonstrating both a more global demand for the system alongside the potential for APS incorporate other catenary-free technologies.

Transnational relevance

The technologies and approaches and city/region case examples on the reference resource are context-specific and reflect:

- the geographical context: for example the extent of the urban or regional rail (and/or tram) network and degree of electrification or non-electrification; density of traffic; extent of urban and rural areas; and physical urban conditions such as street width, environmental conditions, historic areas.
- the technical context: the national regime of technical standards for rail or tram infrastructure, rolling-stock vehicles, rail electrification power supply.
- the regulatory context: the national regime for matters especially safety standards, CO₂ emissions, environmental impact.

Some of the technical and regulatory matters are EU-wide. A Sintropher Report on the technological and organisational aspects of innovative tram-based systems looks at the desirability of greater harmonisation across Member States where different standards exist (see references).

These potential low-cost solutions now need to be tested in different regional cases in EU Member States. There are some distinct physical differences:

- rail systems in most Member States were built at lower cost than in the UK, with fewer over-bridges and more at-grade road/rail crossings, which may reduce the benefits of some technological alternatives (e.g. discontinuous electrification).
- many areas have historic towns where conservation considerations make overhead catenary undesirable, increasing the advantage of battery-based solutions.
- in many European countries, in contrast to the UK, many urban tram systems have been maintained, or even constructed in the last 20 years, making tram-train solutions more relevant.

Even though the various approaches and case examples are context-specific, their transnational relevance is strong:

- the approaches offer a stimulus and possibilities for wider thinking by cities and regions in other European countries
- some or all of the various approaches might be potentially adaptable within the particular organisational and governance regime of another country, and technical and regulatory regime. For example the Governments' UK tram-train trial in Sheffield, Network Rail's UK trial with battery power for trains on a non-electrified heavy rail line in East Anglia, and (in Sintropher) Province Gelderland's feasibility studies for battery power to enable electric trains to operate on non-electrified routes in their regional network..

The reference resource should be seen from this perspective, as a means to promote knowledge transfer and learning across different NWE countries and regions.

Sources

http://en.wikipedia.org/wiki/Ground-level_power_supply

<http://www.railengineer.uk/2012/11/28/trams-without-wires/>

<http://www.railway-technology.com/projects/nice-trams/>

<http://citytransport.info/Bod.htm>

http://vicito.jigsy.com/files/documents/Bordeaux_Fronting_the_French_Tramway_Revolution.pdf

<http://www.alstom.com/products-services/product-catalogue/rail-systems/Infrastructures/products/aps-ground-level-power-supply/>

<http://www.alstom.com/Global/Transport/Resources/Documents/brochure2014/Tours%20tramway%20-%20Case%20study%20-%20EN%20-%20LD.pdf?epslanguage=en-GB>

<http://www.theguardian.com/edinburgh/2010/jul/30/edinburgh-trams-bordeaux-city>

http://en.wikipedia.org/wiki/Bordeaux_tramway

<http://www.railengineer.uk/2012/11/28/trams-without-wires/>

References

Network RUS - Alternative Solutions. (July 2013) Report by Network Rail, London. www.networkrail.co.uk

Connecting European regions using Innovative Transport. Investing in light rail and tram systems: technological and organisational dimensions. (September 2015) Sintropher Integration Report 1, University College London. www.sintropher.eu/publications

Further information

This paper was produced by UCL Bartlett School of Planning (Sintropher team members Charles King, Giacomo Vecia, Imogen Thompson) using desk research and expert comment. The paper reflects the views of the authors and should not be taken to be the formal view of UCL or Sintropher project

The European reference resource can be accessed on the following:

Sintropher project website

<http://www.sintropher.eu/publications>

POLIS website

<http://www.polisnetwork.eu/sintropher> or <http://www.polisnetwork.eu/res/resources>

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01

Railway systems





Light rail evolved from the traditional tram to become a groundbreaking, user-friendly, green, extremely safe method of public transport.

Within metropolitan railway systems, it is trams and light rail that currently arouse most interest with respect to their deployment in medium-sized cities with an average population density and metropolitan areas.

1.1 Light rail, a cosmopolitan transit system

Light rail evolved from the traditional tram to become a groundbreaking, user-friendly, green, extremely safe method of public transport.

Light rail runs on a reserved but not exclusive track, enabling it to operate overground sharing traffic with other vehicles. Although this reserved platform separates it from private vehicles, it allows for level crossings with pedestrians and the rest of the traffic, fitting seamlessly into the city. The incorporation of new technologies enables it to benefit from priority at traffic lights, to offer real time information and to offer greater passenger safety.

1.2 The advantages of cutting-edge transport

INTEGRATED

Designed to save space in cities and to improve quality of life, winning back space for pedestrians and public transport.

INTERMODAL

It allows passengers to link up easily with all the methods of transport in the Autonomous Community of Madrid during its operating hours from 6 a.m. to 1.30 a.m.

PUNCTUAL

It avoids traffic congestion and saves time of looking for a parking space. Its transit signal priority also guarantees timetable reliability.

SAFE

For a substantial portion of the journey, it travels along a platform that is separated from road traffic, its operation is monitored and managed from a Central Control Centre (CCC) and it is programmed to adapt its speed to the section it is running in.

USER FRIENDLY

The vehicles are adapted to ensure they are easy to access and safe, making them suitable for persons with reduced mobility, baby strollers and bicycles.

GREEN

It does not emit gases and its direct contamination is very low. In figures, one single light rail train moves the same number of people as 170 private vehicles.

AFFORDABLE

Passengers can use the Public Transport Pass of the Autonomous Community of Madrid fare system whose prices are very reasonable.



02



Metro Ligero Oeste

as a concessionary company



In July 2006, the company was awarded the public works concession contract for a period of 30 years.

In July 2006, the company was awarded the public works concession contract for a period of 30 years.

Since 2007, Metro Ligero Oeste (MLO) has been managing the operations of the entire light rail system in the western area of Madrid.

2.1 The concession

MLO is a concession awarded by the Autonomous Community of Madrid, which, since July 2007, has linked the municipalities of Boadilla del Monte, Alcorcón, Pozuelo de Alarcón and Madrid up to the Metro, Suburban Rail and City and Intercity bus network managed and coordinated by the Regional Transport Consortium of Madrid.

In July 2006, the company was awarded the public works concession contract for the light rail lines between Colonia Jardín and the stations of Aravaca (ML2) and Colonia Jardín and Puerta de Boadilla (ML3) for a period of 30 years.

The MLO network is formed of two lines, with a total length of over 22 kilometres, 28 stops and a fleet of 27 vehicles.

Since July 2007, MLO has managed the operating (operations and maintenance) of the entire system: works, facilities and rolling stock, employing a workforce of around 231 people. The project represented an initial investment in rolling stock, works, facilities, and technical and human resources of almost 673 million euros.

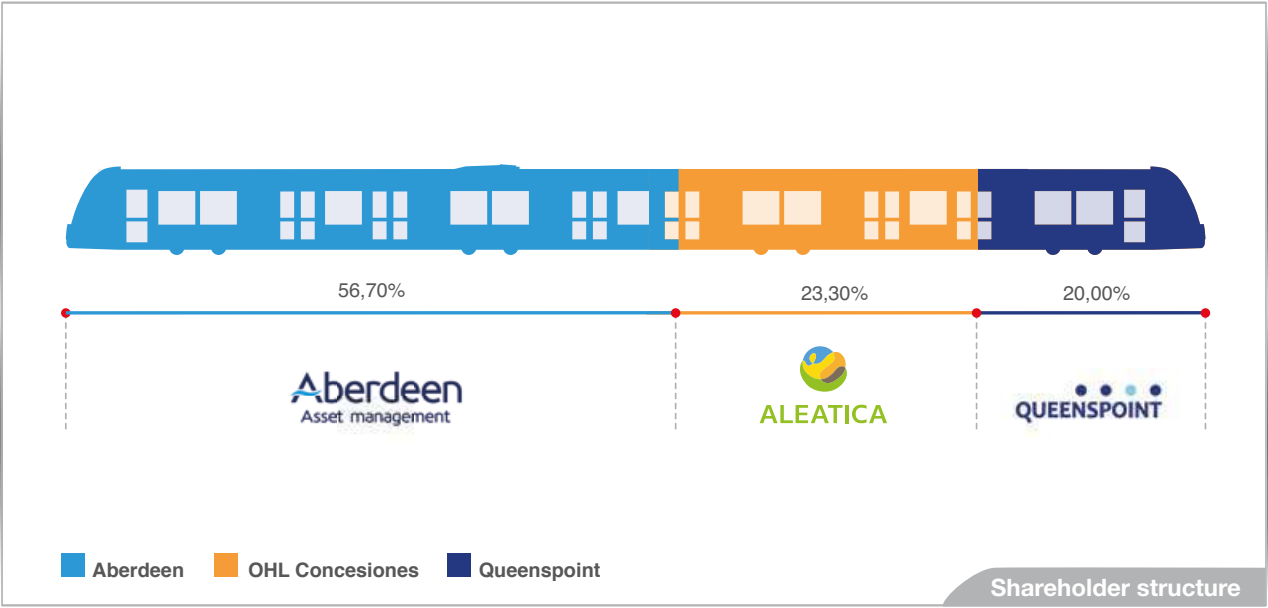
2.2 Shareholder structure

MLO's shareholder structure is comprised of three companies of recognised standing in their respective business areas:



Aberdeen - 56,70%

- Aberdeen Asset Management is one of the world's largest investment companies. It has a significant global presence and the scale and expertise to help clients meet their investment goals.
- As a leading global asset manager, Aberdeen Standard Investments is dedicated to creating long-term value for their clients. They offer a comprehensive range of investment solutions, as well as the very highest level of service and support.



ALEATICA - 23,30%

- ALEATICA is a new breed of transportation company. Its fit-for-purpose structure as a pure operator of transportation assets allows it to focus exclusively on conceptualizing and operating roads and other transportation assets in Spain and Latin America.

QUEENSPPOINT - 20%

- A joint venture formed of Allianz Capital Partners and Bastion Infrastructure Group.
- Queenspoint is a long term investment vehicle and asset manager which acquires, holds and actively operates middle market core infrastructure assets -in fields such as transport, energy, telecommunications, waste, water and others- largely under PPP contractual and risk allocation structures.



2.3 Cronología de hitos históricos

2004	• August: Construction MM	
2005	• February: Construction OC	
2006	• 20 April: Bid publication • 25 June: Bid submission • 18 July: Award	• 30 August: Company incorporation • 15 September: Concession contract • 12 December: Financing contract
2007	• May: End of construction • 27 July: Commercial service	
2008	• 19 April: 5 million users • September: ISO 9K, 14K and OSHAS 18K certification	• 5 December: 10 million users
2009	• 15 July: 15 million users • September: ISO 27K certification	
2010	• 5 March: 20 million users • October: diMLO launched • 28 October: 25 million users	• October: Association with OHL in preventive management • November: UITP Award
2011	• 28 May: 30 million users • June: MLO takes over preventive maintenance of permanent fixtures and rolling stock	• July: ISO/OSHAS recertification • October: OHL Health & Safety Award
2012	• 27 January: 35 million users • March: Inauguration of Express Service • May: Activation of 'Salida Oeste' App	• April: CRTM Award for the Promotion of Sustainable Mobility and Public Transport • October: 40 million users diMLO launched
2013	• January: Passenger Wi-Fi service • June: 10 million km travelled	• November: Award for the best European Light Rail Operator of the year
2014	• January: Award for the CSR educational project II Awards for the Promotion of Sustainable Mobility and Public Transport	• November: 3rd place in international tram drivers contest • December: Award for three innovative initiatives in the 1st edition of the Innova Awards
2015	• November: Excellence Award in Maintenance Management 2015, in Infrastructure category	• December: Most innovative enterprise in 2nd edition of the Innova Awards
2016	• May: Launch of new website and MLO App • June: 60 million users	• October: Installation of USB charging points inside vehicles
2017	• April: 65 million users • 27 July: MLO 10th anniversary	• September: Change maintenance vehicle fleet for electric cars
2018	• February: 70 million users • November: 75 million users	• December: Project for smart regulation of platform lighting
2019	• May: certified in conciliation, MLO is a family responsible entity. • December: 83 million users	• AENOR certified us of the Operational Railway Safety Management System.

Chronology of historic milestones



03



The Metro LigerO Oeste network





Since 2007, the public transport system of the Autonomous Community of Madrid has incorporated into its transit network 36 km of light rail divided into four lines.

Almost 200,000 people who live and work in the municipalities of Madrid, Boadilla del Monte, Alcorcón and Pozuelo de Alarcón can use the light rail network managed by MLO.

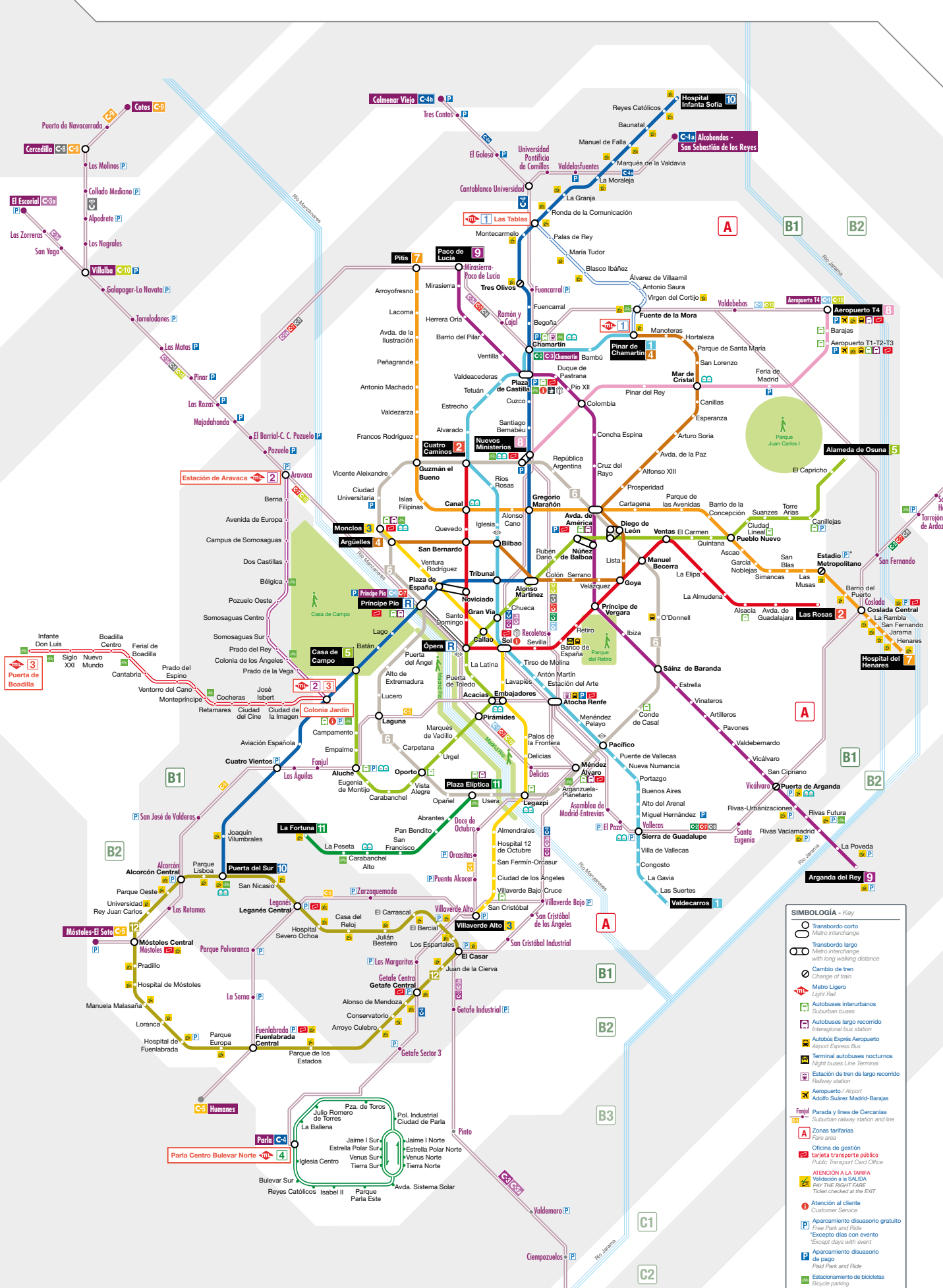
3.1 MLO zone plan

Since 2007, the public transport system of the Autonomous Community of Madrid has incorporated into its transit network 36 km of light rail divided into four lines.

Since the month of July of that same year, MLO has managed two of them, linking the municipalities of Boadilla del Monte, Alcorcón and Pozuelo de Alarcón up to the Metro, Suburban Rail and City and Intercity bus network managed and coordinated by the Regional Transport Consortium of Madrid.

- Areas serviced ML2**
 - 1 Colonia Jardín
 - 2 Quirón Hospital
 - 3 RTVE
 - 4 La Finca Business Estate
 - 5 Zoco de Pozuelo Shopping Centre
 - 6 Somosaguas University Campus
 - 7 Aravaca Renfe-Suburban Rail Station
- Areas serviced ML3**
 - 1 Colonia Jardín
 - 8 Ciudad de la Imagen / Carrefour
 - 9 Kinépolis Leisure Centre
 - 10 San Pablo CEU University
 - 11 Ventorro del Cano and Prado del Espino Industrial Estates
 - 12 Santander Group Financial Hub
 - 13 Boadilla del Monte town centre





SIMBOLOGÍA - Key

- Transbordo corto / Metro interchange
- Transbordo largo / Metro interchange with long walking distance
- Cambio de tren / Change of train
- Metro Ligero / Light Rail
- Autobuses interurbanos / Suburban buses
- Autobuses largo recorrido / Interregional bus station
- Autobús Exprés Aeropuerto / Airport Express Bus
- Terminal autobuses nocturnos / Night buses Line Terminal
- Estación de tren de largo recorrido / Railway station
- Aeropuerto / Airport Adolfo Suárez Madrid-Barajas
- Parada y línea de Cercanías / Suburban railway station and line
- Zonas tarifarias / Fare areas
- Oficina de gestión tarjeta transporte público / Public Transport Card Office
- ATENCIÓN A LA TARIFA / Validación a la SALIDA / For the ticket raise / Ticket checked at the EXIT
- Atención al cliente / Customer Service
- Aparcamiento disuasorio gratuito / Free Park and Ride
- Aparcamiento disuasorio de pago / Paid Park and Ride
- Estacionamiento de bicicletas / Bicycle parking
- Biblioteca / Metro library
- Espacio Histórico de Metro / Metro Historic Space
- Objetos perdidos / Lost and found
- Productos oficiales Metro / Official Metro merchandising

3.2. Integrated system of railway networks of the Community of Madrid



Oficina de gestión
tarjeta transporte público

Administration offices

Ver relación y horarios en www.crtm.es

See at www.crtm.es



RENFE-CERANÍAS LÍNEAS DE FERROCARRIL - SUBURBAN RAILWAY LINES

C-1

Príncipe Pío - Atocha - Recoletos - Chamartín - Valdebebas - Aeropuerto T4

C-2

Guadalajara - Atocha - Recoletos - Chamartín

C-3

Aranjuez - Atocha - Sol - Chamartín - El Escorial

C-4

Parla - Atocha - Sol - Chamartín - Alcobendas - San Sebastián de los Reyes / Colmenar Viejo

C-5

Móstoles - El Soto - Atocha - Fuenlabrada - Humanes

C-7

Alcalá de Henares - Atocha - Recoletos - Chamartín - Príncipe Pío - Atocha - Chamartín - Fuente de la Mora

C-8

Atocha - Recoletos - Chamartín - Villalba - Cercedilla

C-9

Cercedilla - Cotos

C-10

Villalba - Príncipe Pío - Atocha - Recoletos - Chamartín / Fuente de la Mora



LÍNEA METRO - METRO LINES

1

Pinar de Chamartín - Valdecarros

2

Las Rosas - Cuatro Caminos

3

Villaverde Alto - Moncloa

4

Argüelles - Pinar de Chamartín

5

Alameda de Osuna - Casa de Campo

6

Circular

7

Hospital del Henares - Pitis

8

Nuevos Ministerios - Aeropuerto

9

Paco de Lucía - Arganda del Rey

10

Hospital Infanta Sofía - Puerta del Sur



LÍNEA METRO LIGERO - LIGHT RAIL LINES

1

Pinar de Chamartín - Las Tablas

2

Colonia Jardín - Estación de Aravaca

3

Colonia Jardín - Puerta de Boadilla

4

Tramvía de Parla: línea circular



3.3 Main features of the MLO network

The MLO network is formed of two lines: on the one hand, ML2, which links Line 10 of the Metro to the municipality of Pozuelo de Alarcón, has 13 stops from Colonia Jardín to Aravaca station and a length of 8.7 kilometres; and on the other, ML3, which runs between Colonia Jardín and Boadilla del Monte, and has 16 stations and a total length of 13.53 kilometres.



All our stations can be easily accessed by people with reduced mobility

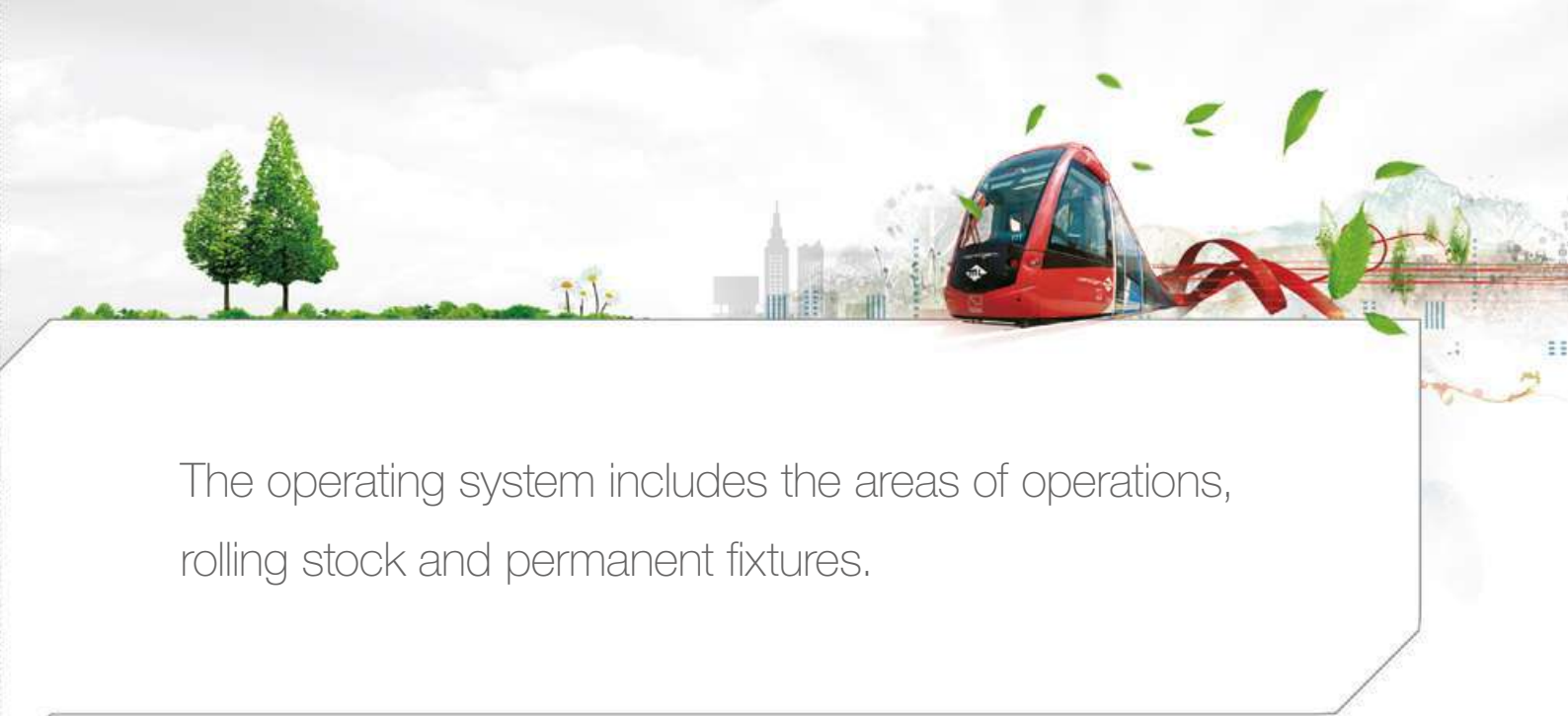
		
Commencement of works	February 2005	
Commissioning	July 2007	
Length	8.63 km	13.53 km
Stations or stops	13 (3 underground)	16 (2 underground)
Interchange stations	2	2
Average distance between stops	720m	900m
Total route time	22,5 minutes	32 minutes
Maximum operating speed	50km/h (urban), 70km/h (suburban), 20km/h (pedestrian)	
Average commercial speed	23,01km/h	25,36km/h
Vehicle availability at rush hour	10	13
Frecuency at rush hour	6 minutes	
Track gauge	1,435m	
Standard platform width	7.80m	
Average platform length	45m	
Electrical service connections	3	
Structures	2 bridges and 8 tunnels	4 bridges and 5 tunnels
Traction substations	4 underground/ 1 surface	4 underground/ 3 surface
Longest tunnel length	1,150m	880m
Road crossings	13	49

04

Metro Ligerio Oeste

Operating System





The operating system includes the areas of operations, rolling stock and permanent fixtures.

MLO is a company structured into five operating areas, centred directly on production, and two for support, which play a key role in the development of the company.

The General Management are supported by an Integrated Management System, which enables them to monitor business performance from different perspectives, ensuring correct strategic decision-making.

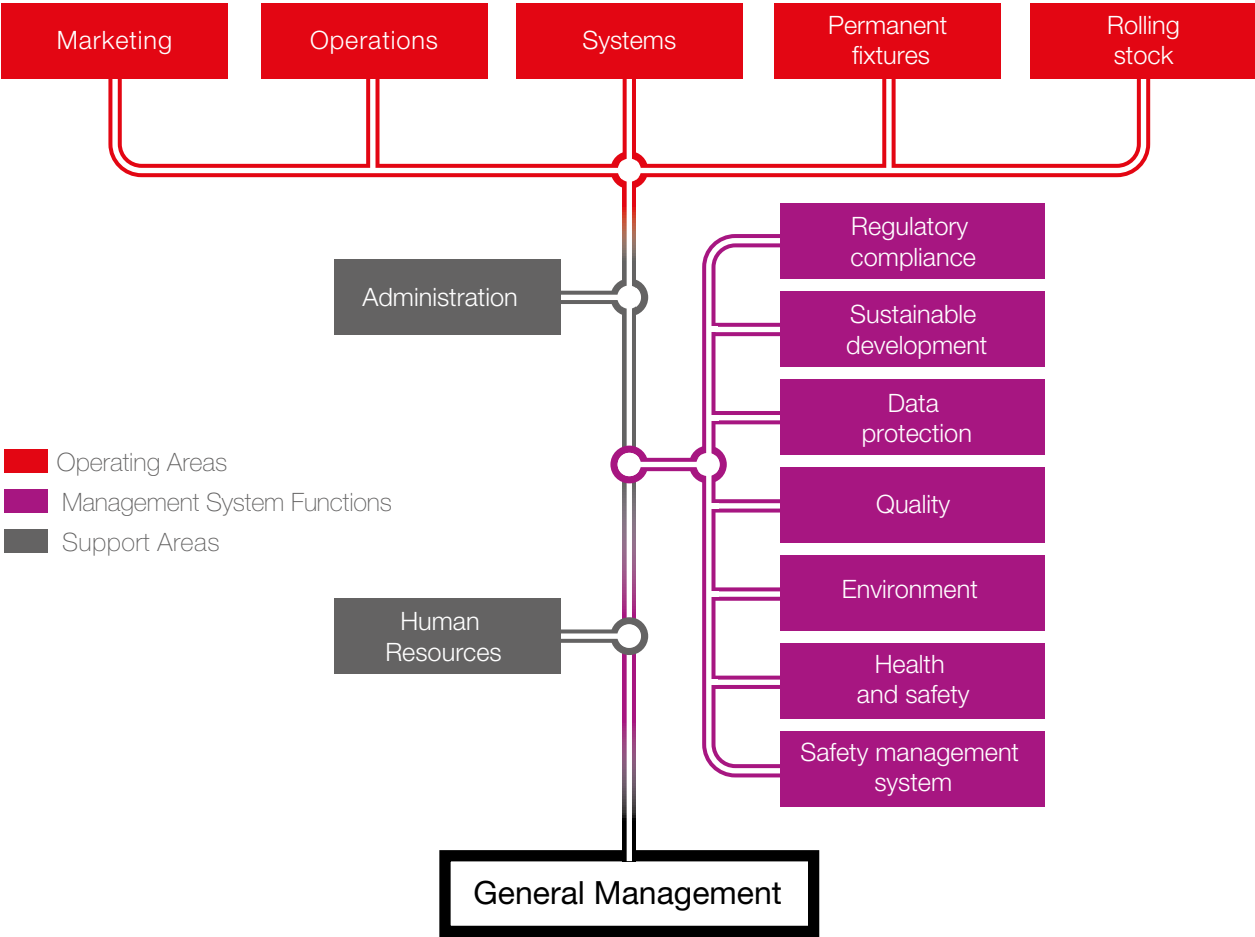
The operating system (operations and maintenance) is managed in its entirety by MLO: works, facilities and rolling stock and currently employs a workforce of around 230 people.

Mission
To offer a safe, punctual, user-friendly, sustainable mobility service.

Vision
To become a national benchmark in the passenger transportation industry and in sustainable mobility, standing out on account of its dedicated commitment to its stakeholders.

Values
Professionalism, motivation, integrity, teamwork, respect, pride in belonging to the organisation, the quest for excellence, stakeholder centricity, social responsibility and compliance.

Organisational structure





4.1 Operations

The Operations division employs around 129 people (drivers, inspectors, CCP (Central Control Center) operators and customer service staff). The scope of its management includes:

THE LINE

TRANSPORT SERVICE PRODUCTION

- Service planning
- Driving and provision of the public transport service
- Inspection and fraud control
- Training and continuous professional development for the corresponding operating positions

SAFETY

- Deployment of a Safety Management System (SMS) that serves to monitor regular risk factors, to prevent or mitigate them, and to guarantee a safe, reliable service.
- Definition and monitoring of a Self-Protection Plan that serves to manage potential emergency situations, coordinating own and external support teams (fire-fighters, police, etc.).

SURVEILLANCE

Control of surveillance service provision

- Preventive surveillance of facilities and their accesses
- User surveillance and support for operating staff
- Management of CCTV circuits
- Collection and transportation of securities

CCC

Control of the operating system and customer information

- Traffic management and real-time information for customers
- Remote control and surveillance of system operating mechanisms
- Coordination of maintenance procedures
- Incident management and coordination for service resumption





TOOLS

The Central Control Centre (CCC) uses the following tools to perform its tasks:

SCADA Supervision and control of the energy system.

OAS Operation Assistance System: vehicle location and frequency management.

CTC Centralised route and railway signalling control system.

Communications (radiotelephony, interphone, public address, telephony).

UTC Road traffic light control.

CCTV Surveillance system.

SRC Station remote control including:

- Lifts
- Escalators
- Fire detection

- Pump wells and tunnel ventilation
- Tunnel ventilation
- Ticketing

MANAGEMENT INDICATORS

- Availability (% of kilometres completed/ planned):
 - 99.76% in 2019
- Punctuality (journeys without delays of over 1 minute):
 - 97.16% in 2019
- Accident rate (collisions):*
 - Average since 2008: 4.0 accidents x 10^6 km
 - Past 12 months: 3.12 accidents x 10^6 km

* This indicator refers to collisions with third parties, in which it is important to note that no serious injuries occurred in any of the cases and none were the result of errors or transgressions by MLO drivers.



Workshops and depots



Storage



Washing tunnel



Parking building





Maintenance workshop



Service building



Office



CCC – Central Control Centre



4.2 Rolling stock

MLO employs a group of around 26 professionals who manage the integrated maintenance of 27 vehicles and the workshop equipment located in the depots.

THE VEHICLES

MLO vehicles belong to Alstom's Citadis range, model TGA 302.

This is a fully low-floor vehicle measuring 32 m long and with a capacity for more than 200 passengers. It has specific areas for persons with reduced mobility and 4 double and 2 single doors on either side. It can reach a maximum speed of 70 km/h, accelerating to 1.20 m/s²,

and braking with a deceleration of 3 m/s² in the event of an emergency stop.

All the vehicles are equipped with an Internet connection for mobile devices thanks to their Wi-Fi network and USB chargers.

THE DEPOTS

MLO depots have the facilities required to carry out the integrated maintenance of the vehicle fleet throughout its useful life, including major inspections.



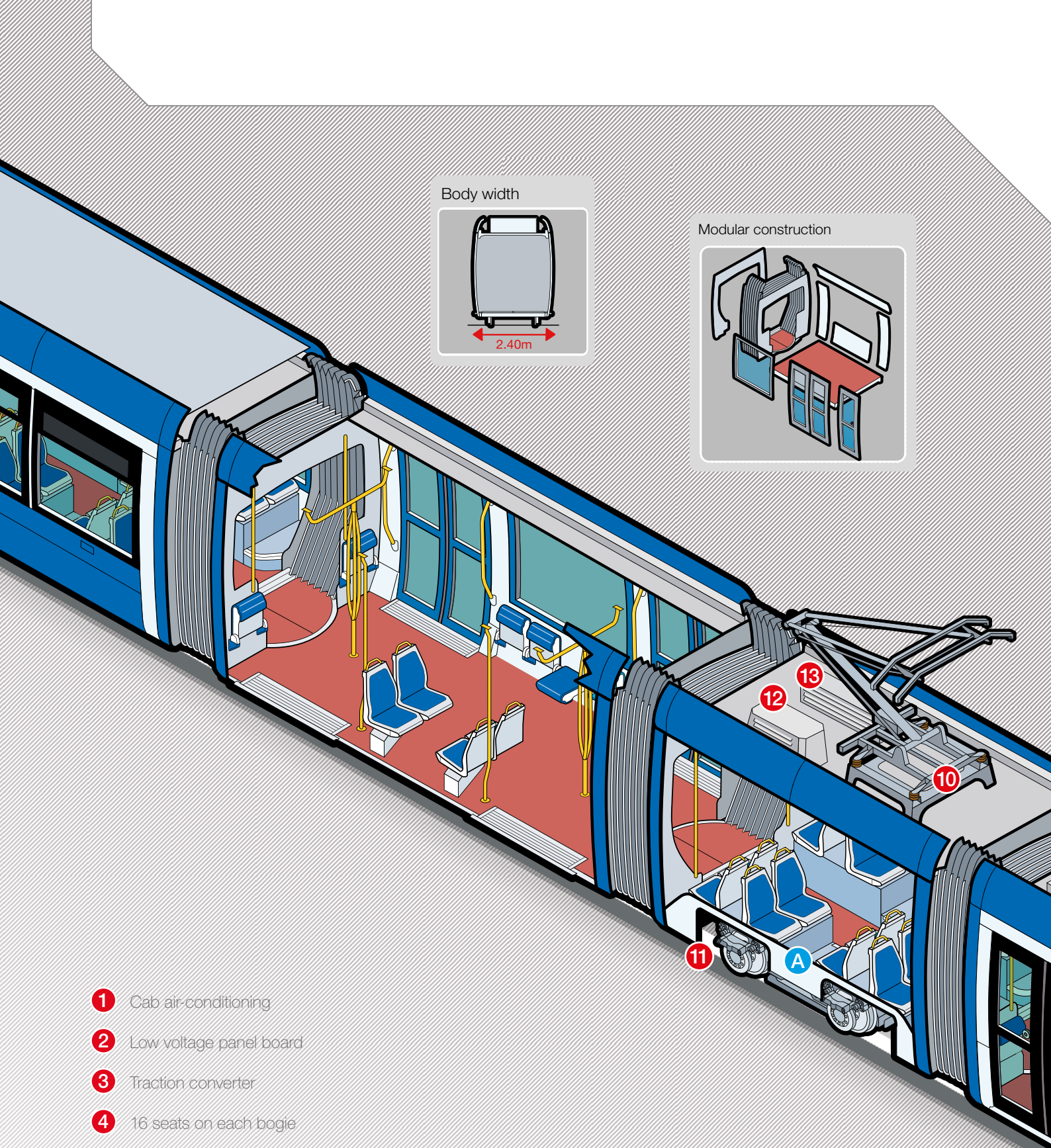
The most noteworthy elements of the facilities are:

- A washing tunnel
- A sand hopper with a 30 mt silo
- A wheel lathe
- Lifting jacks
- Overhead cranes
- Train roof access platforms
- An underside washing area

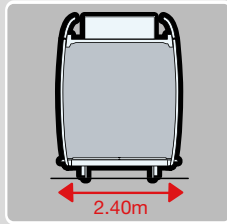
MANAGEMENT INDICATORS

- 99% fleet availability.
- 98% fleet availability.

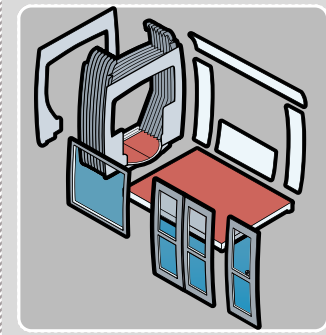




Body width

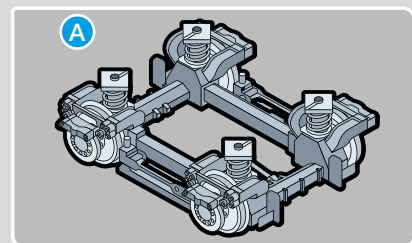


Modular construction

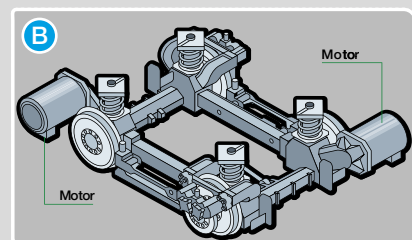


- 1 Cab air-conditioning
- 2 Low voltage panel board
- 3 Traction converter
- 4 16 seats on each bogie
- 5 Motor cooling unit
- 6 Passenger car air-conditioning system
- 7 Double door with a clear width of 1,300 mm
- 8 Breaking resistor
- 9 Static converter and battery box
- 10 Pantograph
- 11 Bogies accessible for maintenance
- 12 High speed circuit breaker
- 13 Lightning arrester

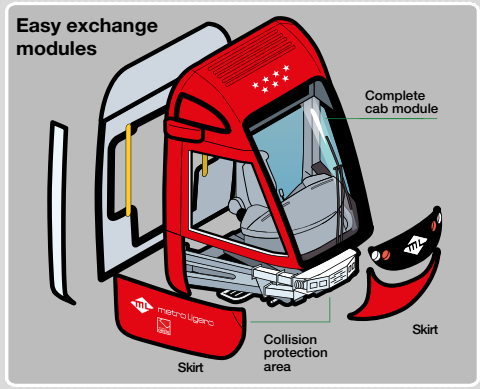
Trailer bogie



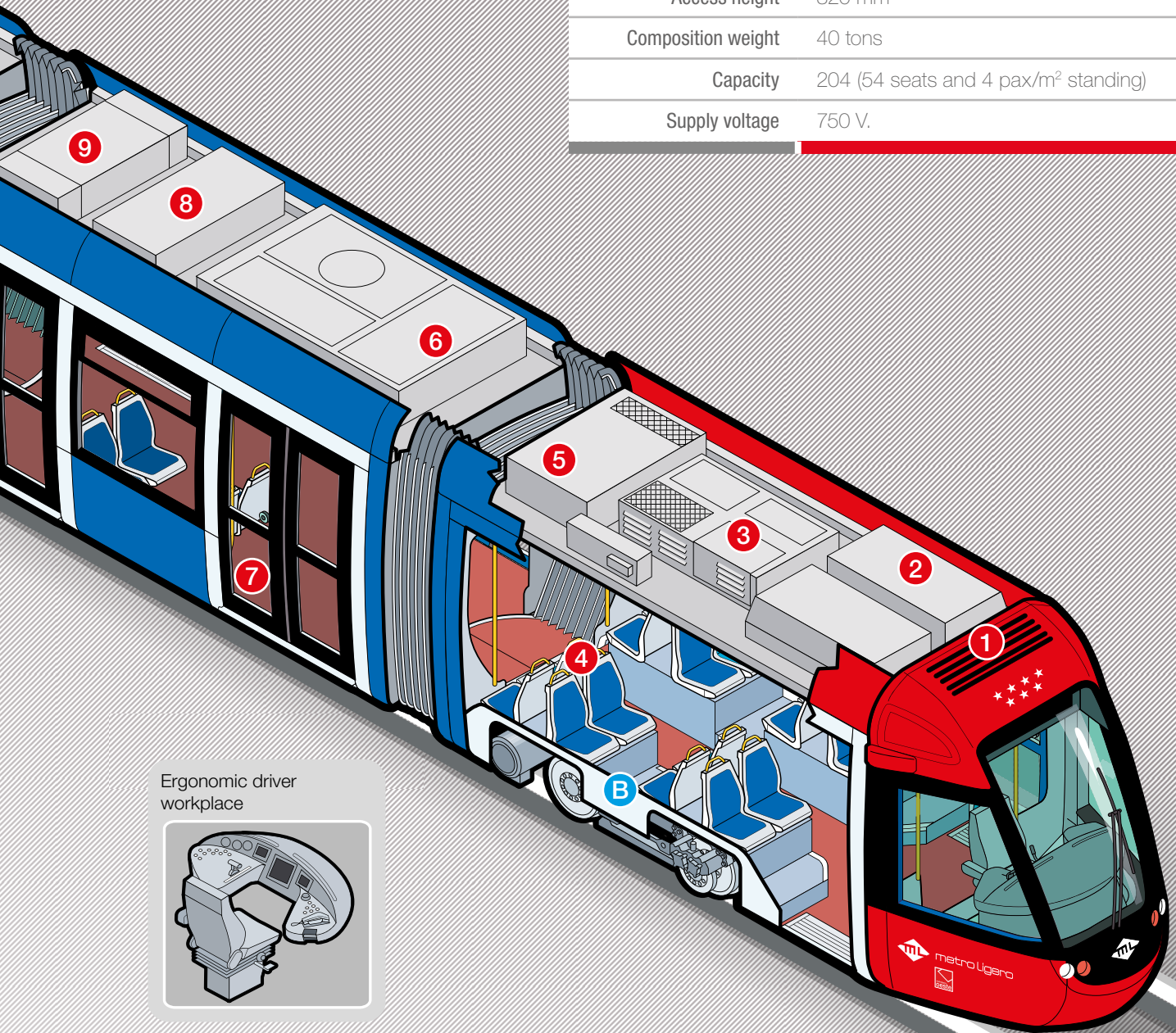
Motor bogie



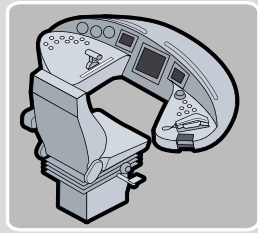
Modular components of the car body for collision safety and easy repair and replacement



Model	ALSTOM CITADIS TGA 302
Total fleet planned	27 units (23 in commercial service, 2 in reserve for operations and 2 in reserve for maintenance)
Bogies	3 bogies (2 motors and 1 trailer NP)
Type	100% low floor
Speed	20 km/h in platform shared with pedestrians, 50 km/h in urban area and up to 70 km/h in suburban section
Length	32,34 m
Line geometric parameters	Capacity to climb inclines of up to 8%
Minimum curve radius	16 m in workshop
Full width	2,40 m
Full height	3,20 m
Access height	320 mm
Composition weight	40 tons
Capacity	204 (54 seats and 4 pax/m ² standing)
Supply voltage	750 V.



Ergonomic driver workplace



4.3 Systems

The running of modern transit networks is based on a core technological pillar where IT systems and communications play a key role.

The communication systems and networks that support MLO lines are divided into:

- Communications systems: they enable data, voice and video communications to be established between the Central Control Centre and the different elements spread across the line and the vehicles.
- Control systems: they comprise the supervision and control of all the facilities and vehicles of both lines.
- Integrated ticketing systems in the Regional Transport Consortium of Madrid system.
- Software packages and management applications required for the operating procedures of Metro Ligero Oeste.
- Safety and recovery systems intended for service maintenance and contingency and recovery plans both for data as well as for systems in the case of incidents.



The Systems Maintenance division is responsible for providing technical support for all these systems and for performing the following tasks for them:

- Configuring and managing operating systems, application and database servers, website servers, network architecture design and communication device administration.
- Securing systems and communications.
- Analysing and developing or deploying software solutions.
- Dealing with hardware and software queries and incident troubleshooting.

The Systems Maintenance division employs a team of around 15 professionals to perform all these activities:

- Systems engineers and administrators, whose task is the management and maintenance of the technical equipment, systems and communications in place.
- A software development analyst-programmer, whose task is application development and deployment.
- Systems technicians and operators, whose task is the maintenance of the technical equipment, systems and communications in place in the DPCs (Data Processing Centres) of the Central Control Centre, the line technical rooms and office and customer service workstations.



MANAGEMENT INDICATORS

The indicators that measure the efficiency of the department are based on the availability of the critical systems with the following breakdown:

- Essential communications:
 - Required limit of 99.98%
 - Availability achieved in 2018: 99.99%
- Control and communications equipment and Central Control Center system.:
 - Required limit of 99.00%
 - Availability achieved in 2018: 99.87%
- Ticketing, sales, validation and oversight equipment:
 - Required limit of 98.50%
 - Availability achieved in 2018: 99.73%



4.4 Permanent fixtures

MLO employs a team of around 43 professionals in a variety of areas, track, electrification and signalling, who carry out the maintenance of the entire infrastructure as well as the engineering of all the modifications.

The MLO system consists of:

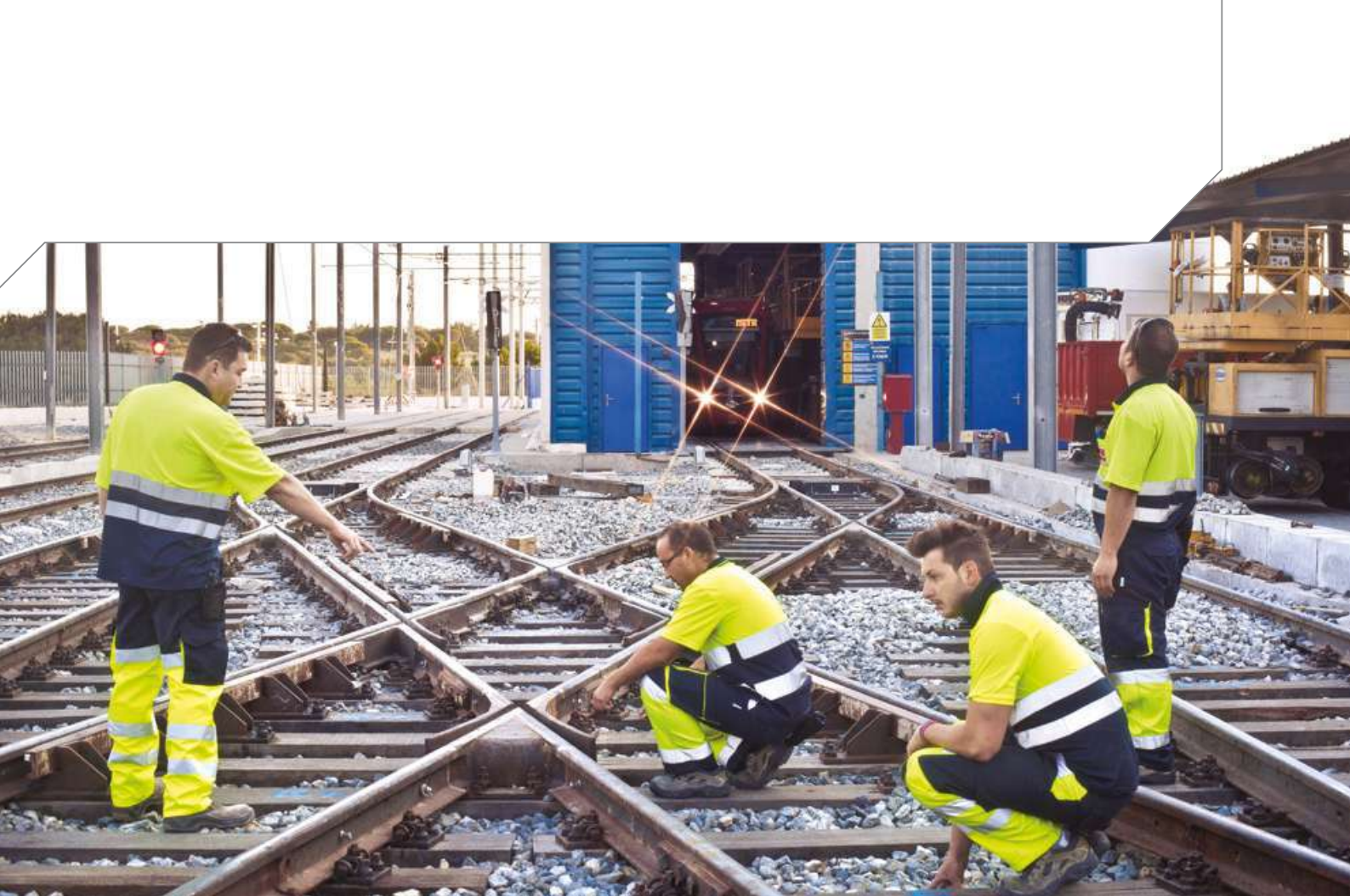
- 22.4 km of double track with grooved embedded rail on an accessible concrete platform. A jacketed rail system.
- 24 stops with 45 metre-platforms, exclusive lighting and a covered shelter.
- Three underground stations and one in a cutting and two terminal interchange stations.
- 750 VCC electrification with tram catenary integrated into the urban areas it operates in.
- 12 traction substations with an installed traction power of 12 MW and 18 transformation centres that form two interconnection rings, respectively.
- 62 road junctions to regulate vehicle and light rail traffic, as well as pedestrian crossings, which give transit priority to light rail over road traffic.
- A railway signalling system that guarantees the traffic safety of light rail vehicles through the use of audio frequency track circuits and electro-hydraulic point motors.

- A fire protection system in all MLO technical rooms, air-conditioning systems, forced ventilation in tunnels, pump wells and rescue systems, as well as generator sets and uninterruptible power supply systems form part of the action area of the permanent fixture department.
- The OAS (Operation Assistance System) informs the control room of the position of the entire fleet, guaranteeing compliance with scheduled frequency in addition to recalculating frequencies should any incidents occur.

INNOVATION

In conjunction with Alstom, the signalling system manufacturer, the department develops the SIDI software tool for the monitoring and remote maintenance of the 6 interlocking machine rooms that form part of the signalling system. Engineering and joint development of the SCADA systems, integrating all the remote systems into Siemens' SCADA WINcc Open Architecture, which allows the equipment in all the technical rooms to be accessed directly and a large portion of incidents to be solved without the need for onsite technical assistance. These new developments will make current systems even smarter, for example, the Tunnel and Platform Smart Lighting Control (CEIPT) and the Tunnel Ventilation Control System (SCVT), which will be used to manage





air quality and temperature in stations and tunnels and to configure ventilation in the event of a fire. The power consumption of the entire network is also managed in real time ensuring its optimisation.

MANAGEMENT INDICATORS

In 2018, the incidents attributed to Permanent Fixtures affecting operations accounted for a monthly average for all journeys of only 0.6 min. delay/ month and 9.1 km lost/ month.



4.5 Marketing

- Customer service
- Market analysis
- Communications and promotion
- Public relations
- Corporate Social Responsibility

MANAGEMENT INDICATORS

- A total of 465 complaints were recorded in 2019, 4% less than the average of recent years.
- An average response time of 4 days in 2019 for complaints and suggestions received from our users.

Technological innovation at the service of users

MLO makes a firm commitment to cutting-edge technology and smart mobility in cities.



- Real-time information (App and website)
- Public Transport Pass (PTP)
- Multi-Card

WEB MLO

www.metroligero-oeste.es



APP MLO

Real time service information



MLO PROFILES

- Facebook: <http://Facebook.com/MLOeste>
- Twitter: <http://www.twitter.com/MLOeste>
- Flickr: <http://www.flickr.com/photos/mlooste/>
- YouTube: <http://www.youtube.com/MLOeste>
- Instagram: <http://www.instagram.com/metroligerooeste/>
- LinkedIn: <http://www.linkedin.com/company/metro-ligero-oeste-s-a->

CORPORATE BLOG

www.blog.metroligero-oeste.es

REAL-TIME INFORMATION DISPLAY SCREENS

Real time service information



4.6 Administration

- Financial
- Accounting
- Legal and insurance
- General services

The Administration and Oversight division is responsible for:

- Performing and executing all the tasks resulting from the budgetary, economic, administrative and accounting management of MLO, analysing on a monthly basis the results obtained and making the necessary budget adjustments for the purpose of ensuring that the company's equity position is sound and that the business is profitable for its shareholders.
- Providing the necessary support for the other MLO departments, overseeing the appropriate provision of goods, services and economic resources requested by these departments so that they can perform their tasks properly and always complying with valid tax, commercial, legal and accounting obligations.
- Monitoring personal accidents and acts of vandalism that occur on the facilities.
- Providing the company with communal services, such as a cafeteria, cleaning, courier services, etc.

4.7 Human Resources

- Staff
- Health and safety
- Internal regulations

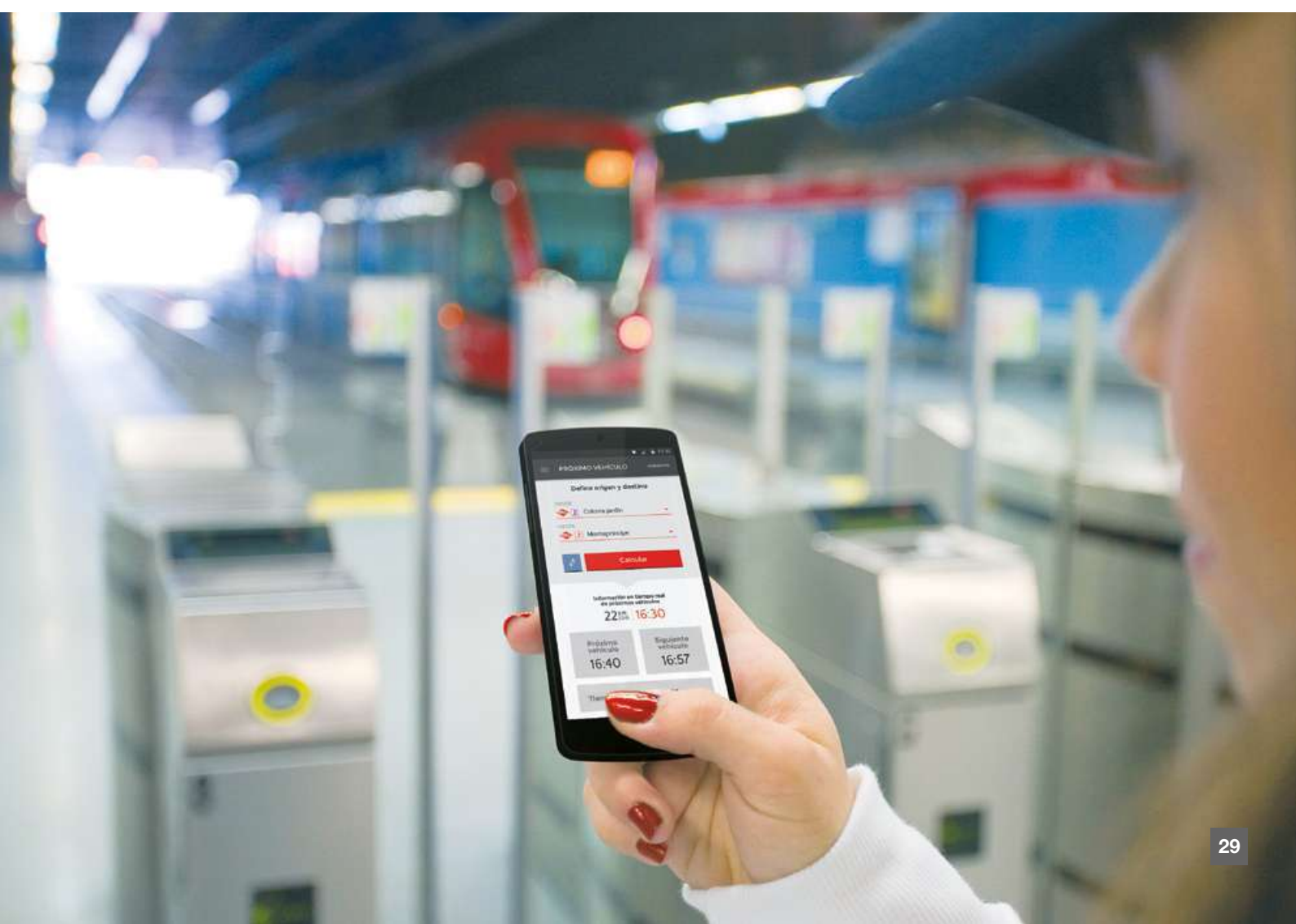
The MLO workforce comprises approximately 230 members of staff with a young, skilled profile.

Key aspects:

- The firm commitment of MLO to professional development.
- The creation of an Internal Health Promotion Plan, guaranteeing the health and safety of employees and users.
- The Health and Safety Management System, started up in 2007/8, has adapted its procedures to the technical specifications of OHSAS 18001, achieving the certificate one year after the business began.

MANAGEMENT INDICATORS

- In 2019, our employees received more than 5.530 hours of professional development, rated with a grade of over 9 out of 10.



05



Certificates

and distinctions awarded
to Metro Ligero Oeste



Firmly committed to ongoing improvement: new Family-Friendly Enterprise and Operating Railway Safety certificates incorporated into our Integrated Management System.

5.1 Recognition of achievements

Recognitions vouch for our commitment, rewarding aspects as important as customer satisfaction and environmental sustainability.

We strive every day to strengthen our commitment to our stakeholders, good governance and environmental sustainability. On this basis, we are firmly committed to improving our Integrated Management System, including new Family-Friendly Enterprise and Operating Railway Safety certificates.

In the distinctions section, MLO has also received:

- The Award for the Best Global Light Rail Initiatives (International Light Rail and Tram Conference – October 2010).
- The Award for the Promotion of Public Transport and Sustainable Mobility presented by the Autonomous Community of Madrid 2012 (Regional Transport Consortium of Madrid for the MLO Marketing and Communication Team).
- The Award for the Best European Light Rail Operator of the Year (Annual Rail Awards - November 2013).
- The III Tria Railway RD Award for Young Railway Engineers (Spanish Railway Foundation - April 2015).
- The Award for Excellence in Maintenance Management, Infrastructure Category - PRISMA 3 (Sisteplant - November 2015).

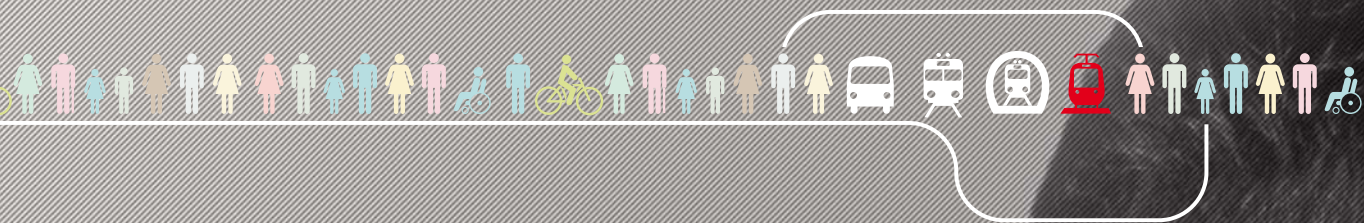


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metroligero
oeste

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Transport information line: 012

metroligero-oeste.es

unimos Personas



Tu sistema de transportes



www.crtm.es



SYDNEY LIGHT RAIL PROJECT

Presentation to the

Bruno PETIN

28 April 2016

ALSTOM
Designing fluidity

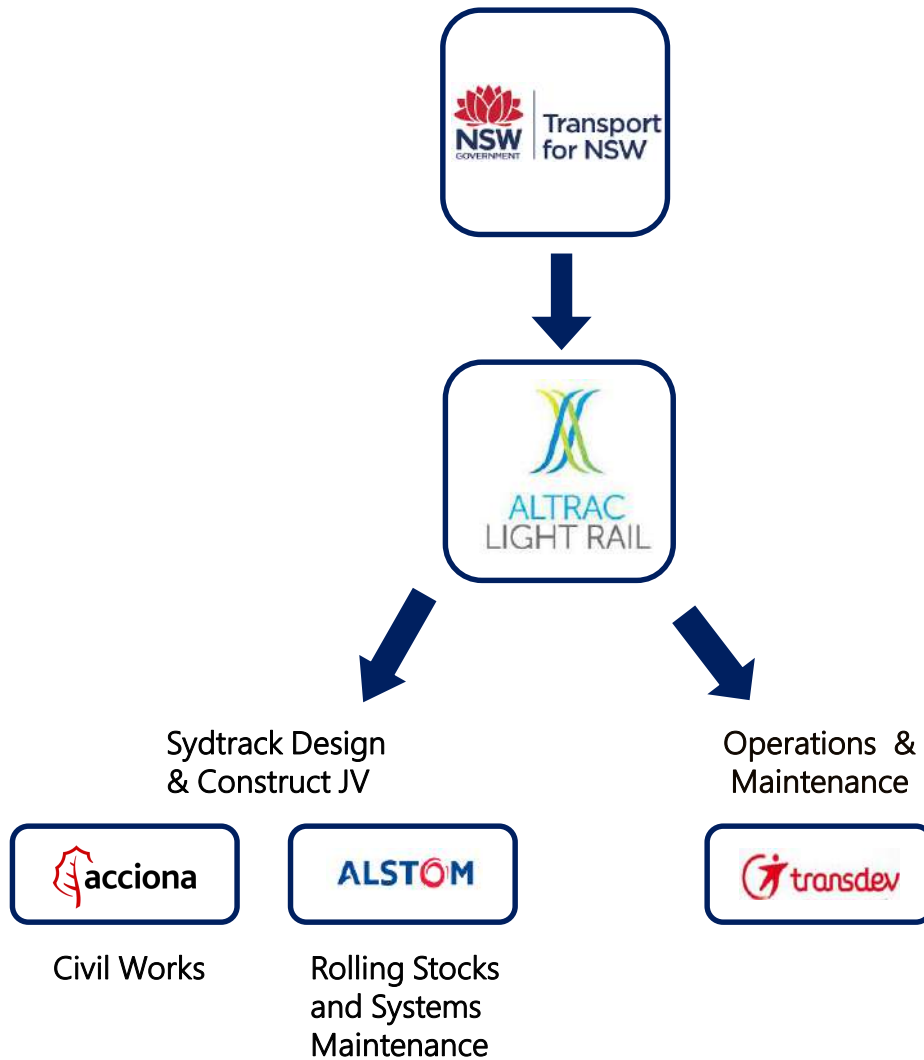
Agenda

- 1. Introduction**
- 2. Project Overview and Organisation**
- 3. Focus on System Engineering**
- 4. Focus on APS**
- 5. Focus on HESOP**
- 6. Focus on Citadis X05**
- 7. Focus on EMC Studies**
- 8. Focus on Sustainability**
- 9. Other Engineering Challenges**

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Project Overview and Organisation



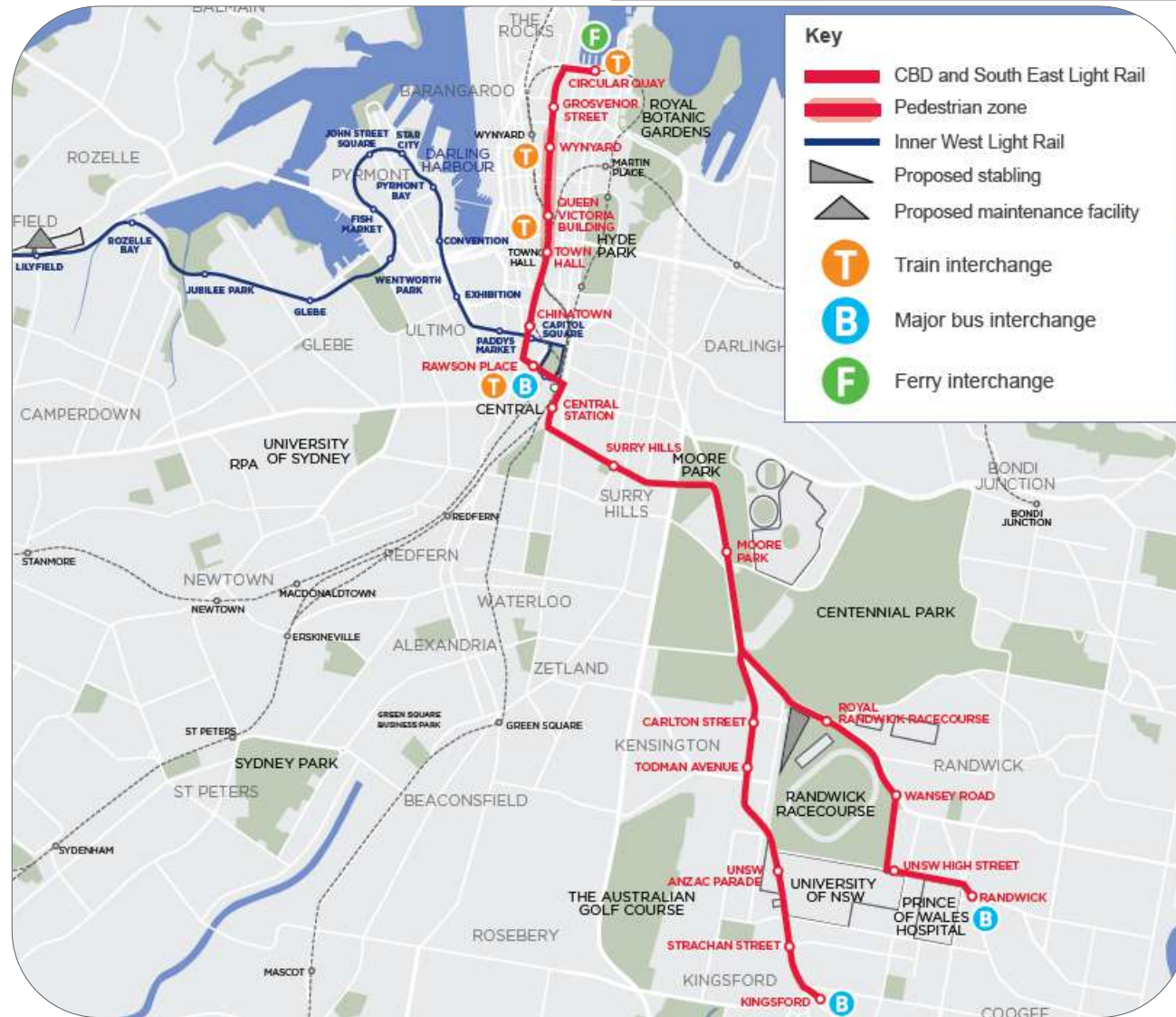
Sydtrac - Acciona and Alstom

- Acciona has been operating in Australia since 2002. Globally it has approx. 32,000 employees in 30 countries and is headquartered in Madrid, Spain
- Acciona's capabilities are focused globally on engineering, financing, constructing and operating solutions. Its core businesses include:
 - Renewable Energy
 - Water
 - Infrastructure
- Alstom has a presence in over 60 countries with approx. 32,000 employees worldwide.
- Global leader in rolling stock manufacturing and rail infrastructure
- Alstom specialise in:
 - The TGV high speed train
 - The Tilting Pendolino trains
 - Citadis trams
 - Hi-tech Metropolis metro trains and world leading signalling technologies



Scope of works

- 12 km :
 - Central : 6 km (CBD + Central to Robertson Road Junction)
 - Two 3 km branches :
 - Randwick
 - Kingsford
- 10 Substations
- 2 x 1600 m of APS
- Depots :
 - Stabling – Randwick
 - Depot – Rozelle (on IWLR)
- One integrated OCC (for both CSELR – IWLR)
- 60x Citadis 305 in double units

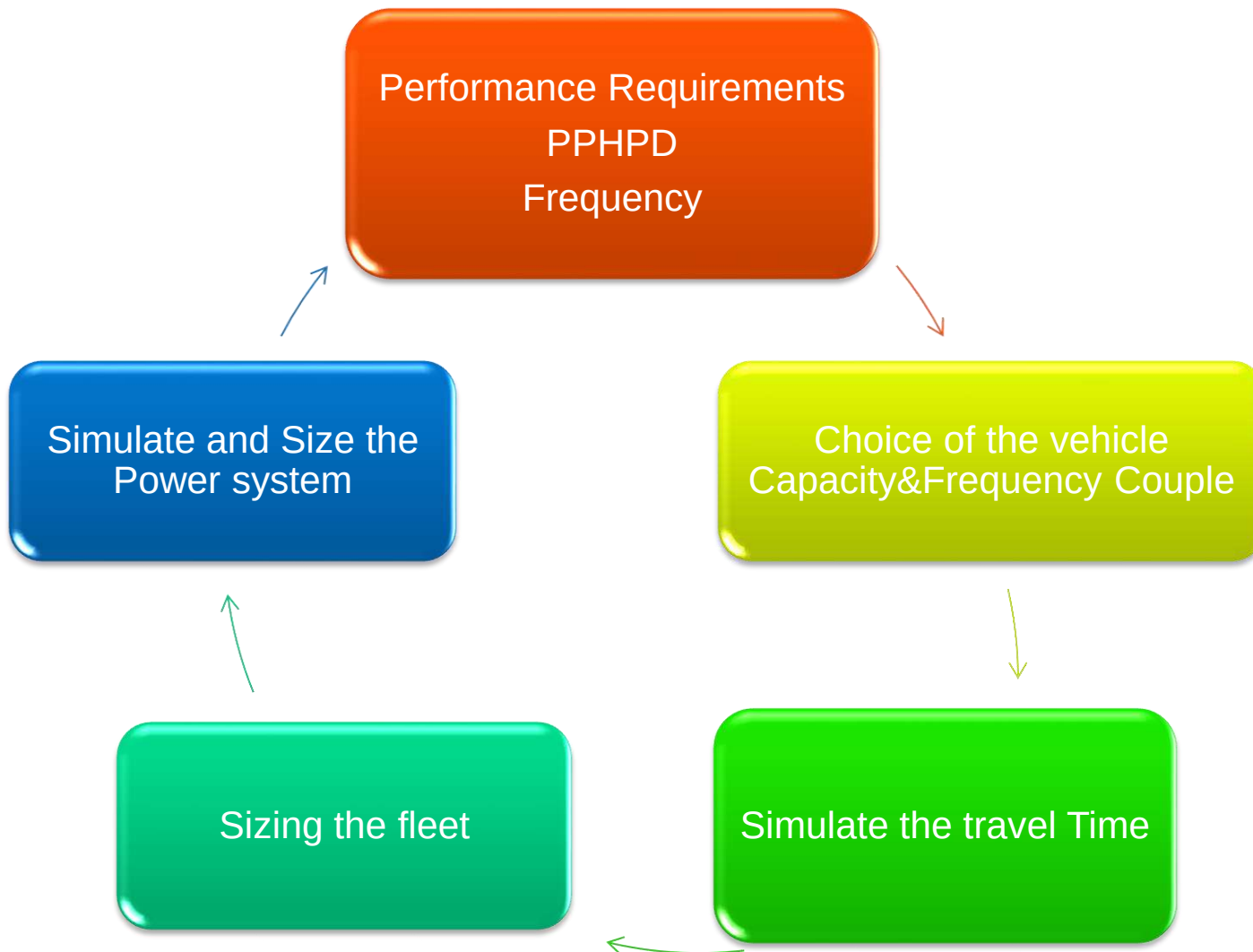


A small video from TfNSW

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- 3. Focus on System Engineering**
4. Focus on APS
5. Focus on HESOP
6. Focus on Citadis X05
7. Focus on EMC Studies
8. Focus on Sustainability
9. Other Engineering Challenges

System Engineering – How do we size a System?



10

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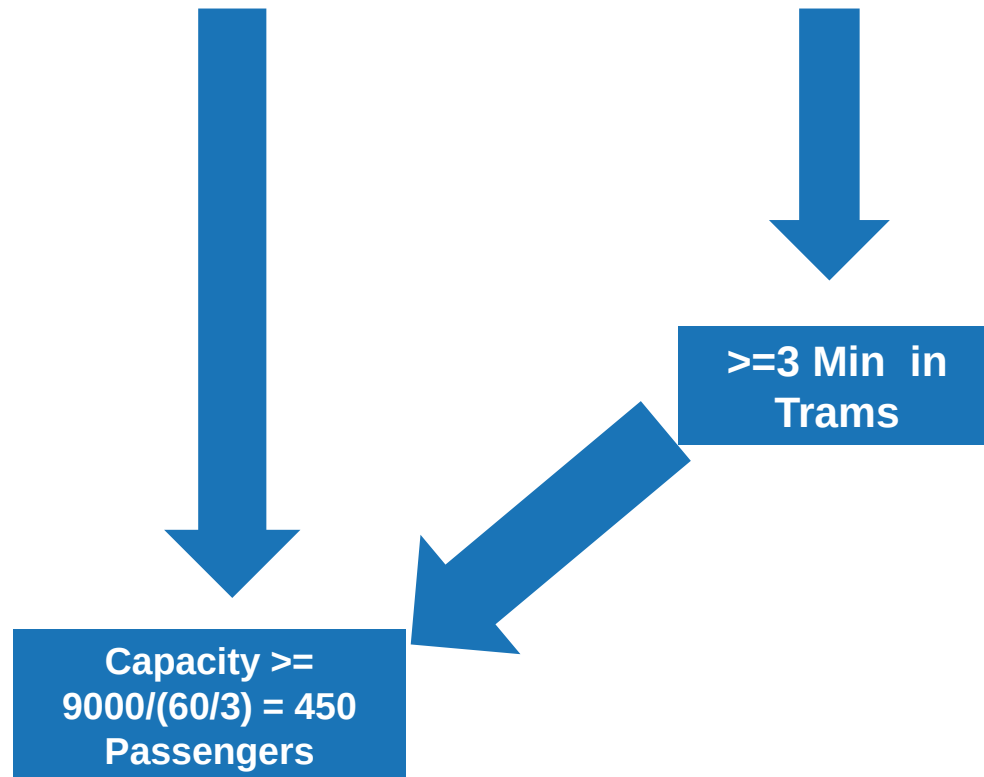
dn

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Crushing the numbers

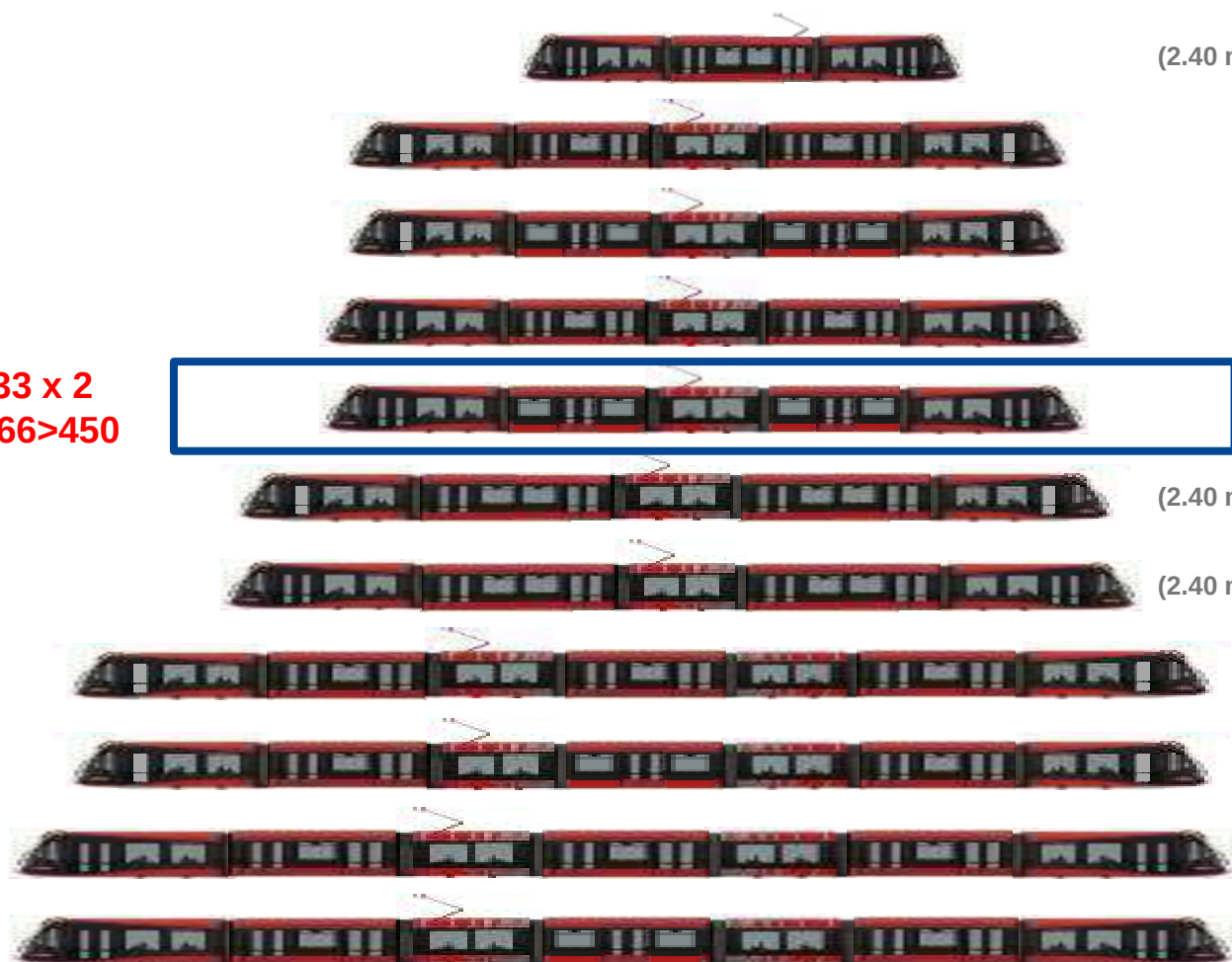
- $9000 \text{ PPHPD} = \text{Capacity of the Tram} \times \text{Number of trams per hour}$



Choice of the right Vehicle

WITH CITADIS X05

$$233 \times 2 \\ = 466 > 450$$



(2.40 m only)

24M VERSION
(CITADIS 205)

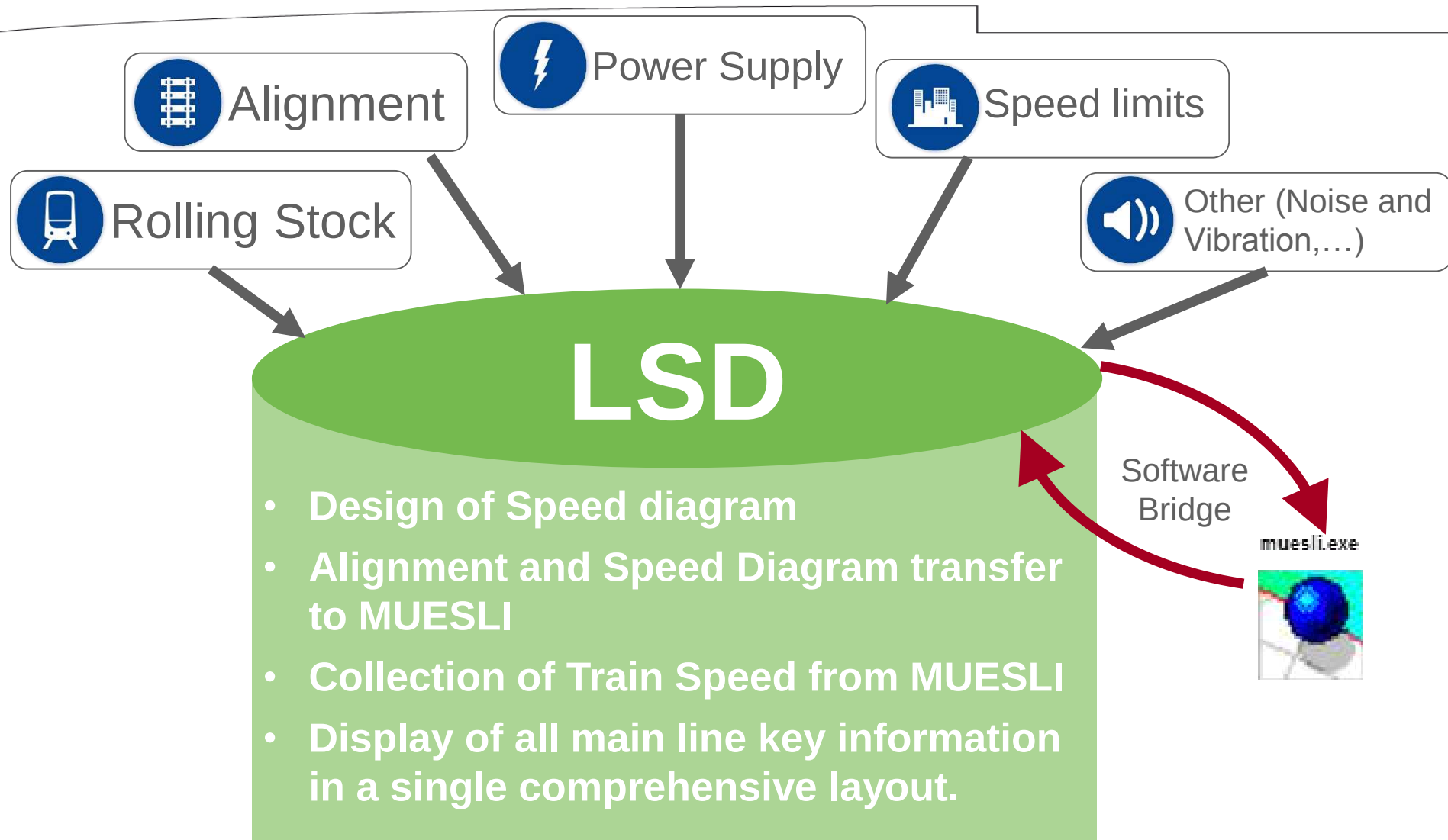
32 TO 37M
VERSIONS
(CITADIS 305)

(2.40 m only)

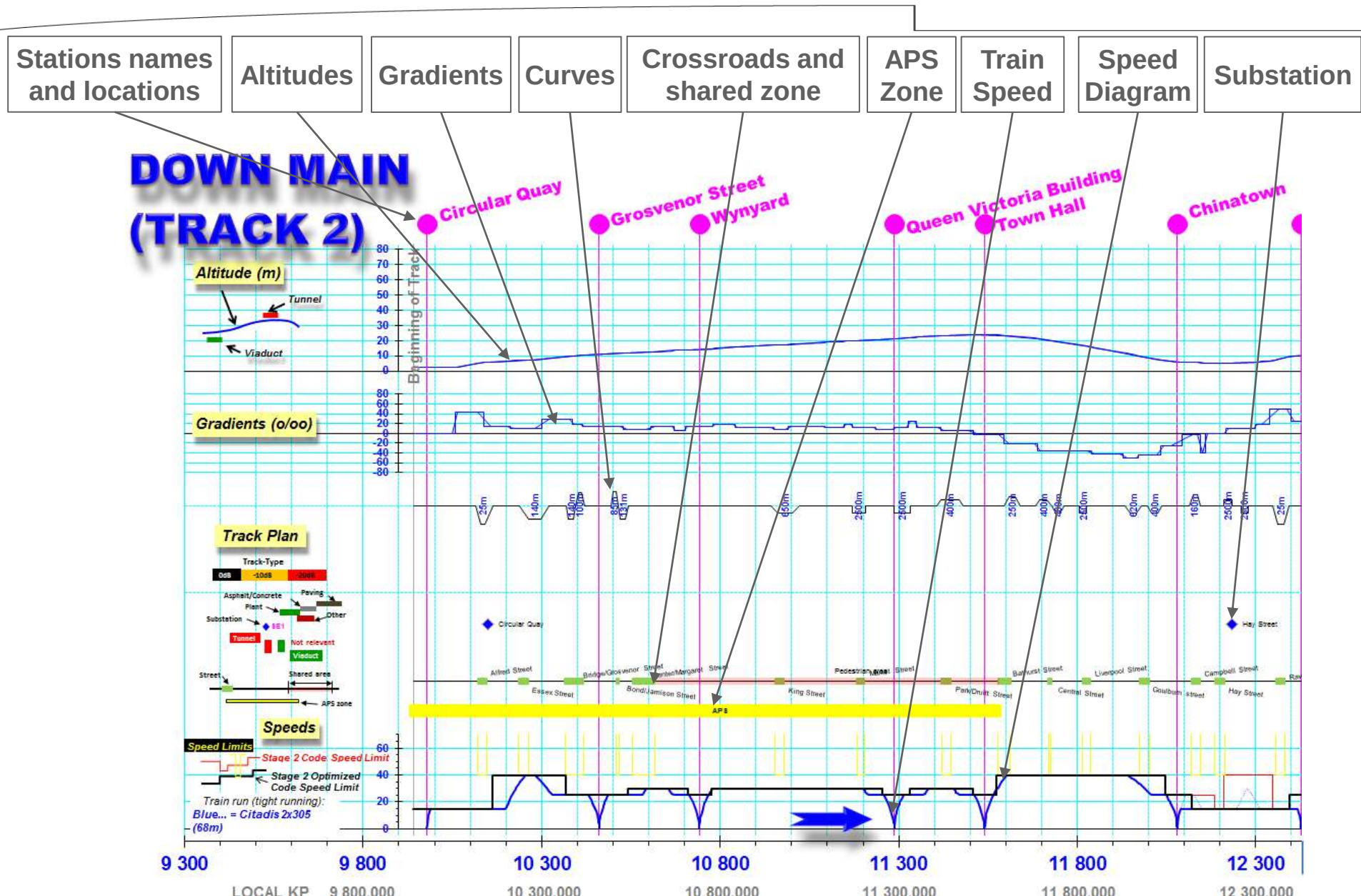
(2.40 m only)

43 TO 45 M
VERSIONS
(CITADIS 405)

Simulating the speed profile and Travel time with Muesli



Simulating the speed profile and Travel time with Muesli



Sizing the Fleet

Round Trip time = Travel Time A to B + Travel Time B to A + Turnback time at A + Turnback time B

Fleet Requirement = Round Trip Time / Headway

Fleet Size = Fleet Requirement + Hot Spare + Maintenance allowance

For SLR :

Round Trip Time = 88min on each branch

Headway = 8 min start (6 min 30 s ultimate) on each branch

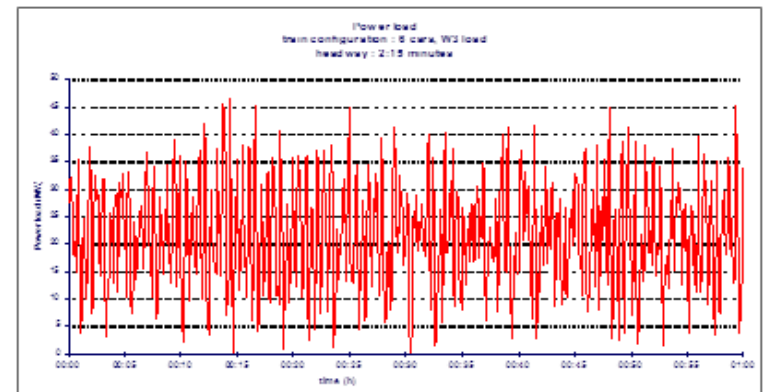
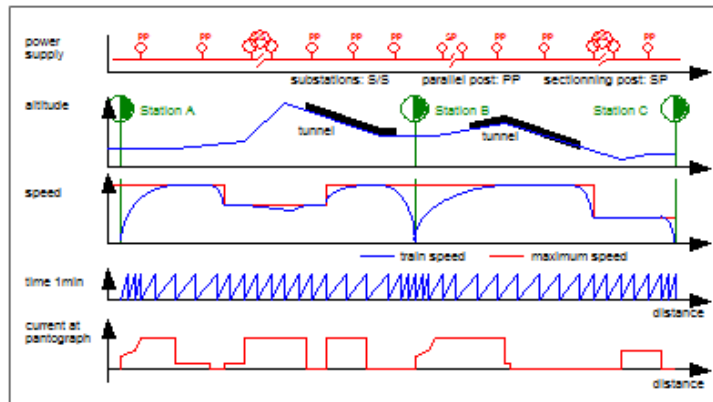
Fleet requirement = 11 per branch

Fleet size = 2 x 11 + 3 = 25 (30 ultimate)

Sizing the Traction Power supply system

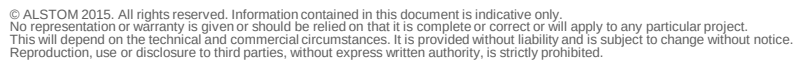
Power supply architecture definition

- Simulations with ELBAS software
- Optimization of Power Scheme
- Analysis of HESOP performance



Simulate to optimize architecture

18



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Wireless trams : no overhead contact line



APS projects locations



George street in a couple of years



Catenary-less solutions: 3 steps to choose

1. PROJECT LOCATION

- Very hot temperature
- Nordic countries with hard winter conditions

Recommended solution: APS

Reason: behavior and reduced life time of on-board energy storage solution with very high temperature

Recommended solution: full on board autonomy

Reason: avoid de-icing product and ice cleaner necessary with APS or other system with collecting shoe

2. SPECIFIC PROJECT REQUIREMENT

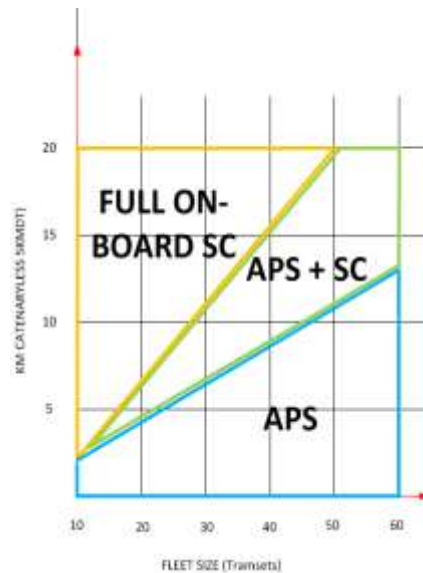
- Severe slopes or long stops due to traffic jams

Recommended solution: APS or APS with on-board supercap

Reason: on-board solutions cannot cope with huge amount of energy

If solution not defined after steps 1 & 2, all solutions are feasible

3. CAPEX AND OPEX COSTS ANALYSIS



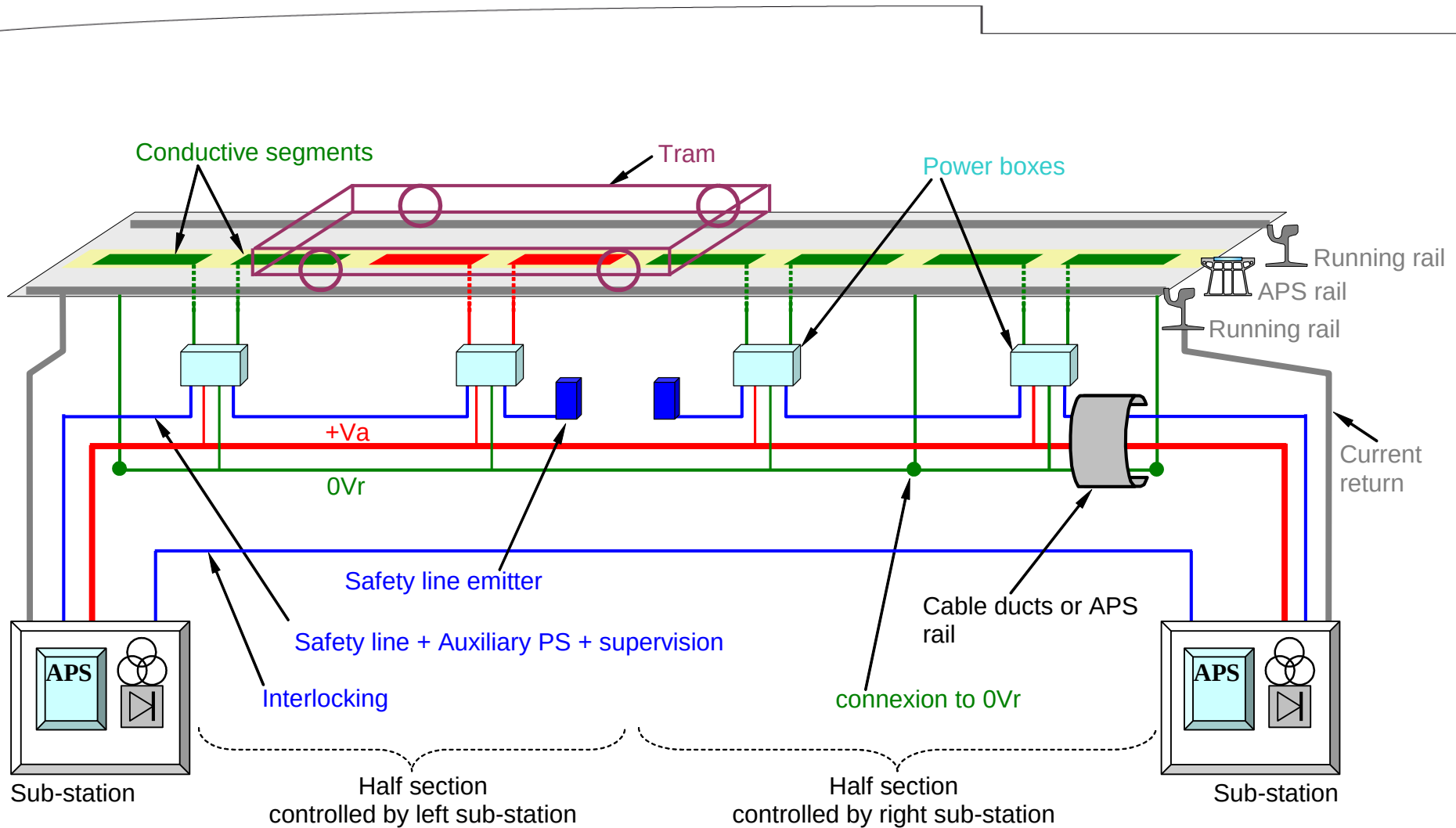
Smaller the fleet size and long catenary-less section: on-board technology is the best solution

Big fleet size and short catenary-less section: APS technology is the best solution

APS basic principles: Movie



APS – Simplified architecture



APS MAIN COMPONENTS

On-board equipment



Battery Cubicle

- Allows train motion in case of loss of power on the APS rail
- Includes a battery charger 6 kVA and the battery (15 A.h)



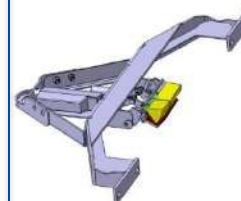
Main Switch Cubicle

- Allows switching the power source from APS rail to OHW or Battery
- Includes the APS safety emitter



Collector shoe

- Collect the traction current from the APS rail (physical contact)
- Include the APS coded signal antennae



Brush

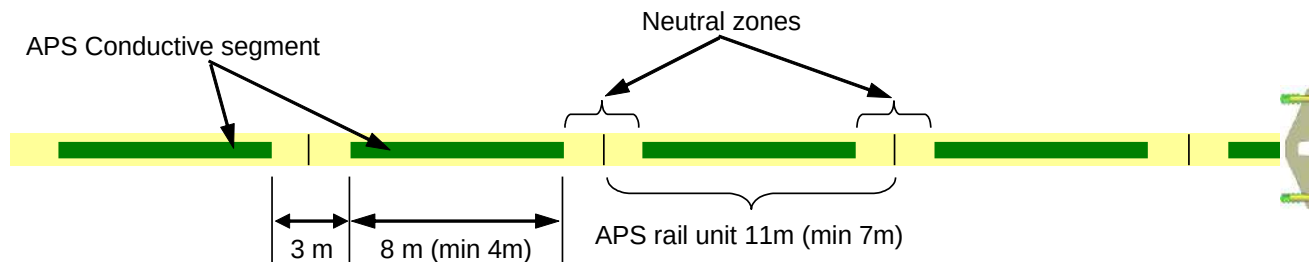
- A bumper to eject objects such as cans
- A brush to clean the rail from sand and smaller objects

APS MAIN COMPONENTS

Mechanical equipment (installed by CW)

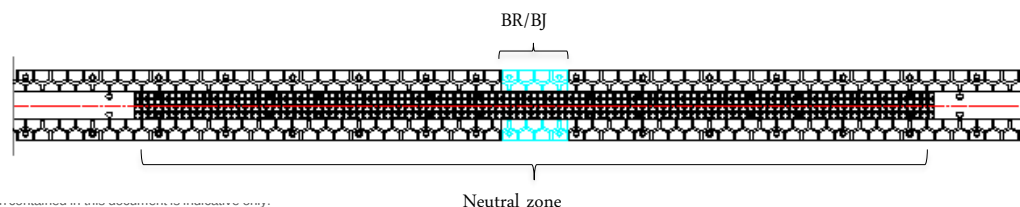
- **APS rail**

- Insulated support frame (rubber beam)
- Conductive segment
- Neutral zone



- **Branching box / Box for Junction**

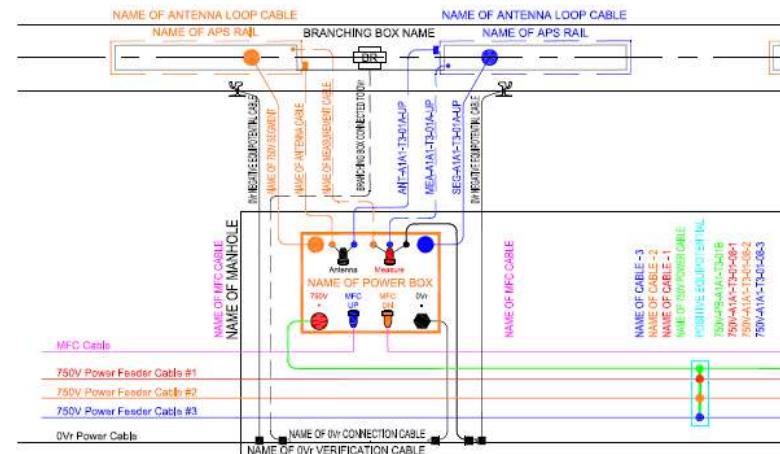
- Box for Junction ensures mechanical connection between two APS rails.
- Branching box ensures the same functions as a BJ but also ensures connections to the electrical equipment inside the APS manhole.



APS MAIN COMPONENTS

Electrical equipment

- **APS cabinet**
 - Installed inside each APS Traction Power Substation and interfacing with the High Speed Circuit Breaker.
- **APS power box**
 - Located in the APS manhole and supplying one or two APS conductive segments.
- **APS rail antenna**
 - Detection loop connected to the PB are embedded in the APS rail support frame in order to receive the coded signal sent by the tramway.
- **Cables**
 - Feeders cables and positive equipotential boxes,
 - MFC cables (Safety line + 230Vac + Communication),
 - 0vr cables,
 - Antenna cables,
 - Safety interlocking line between APS cabinets in TPS
- **End of line emitter**
 - Supply and monitor the safety line.

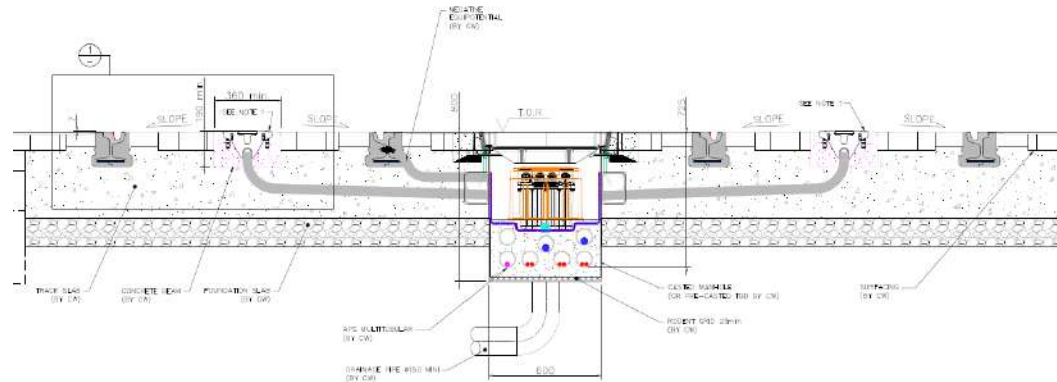


APS MAIN COMPONENTS

Mechanical equipment (installed by CW)

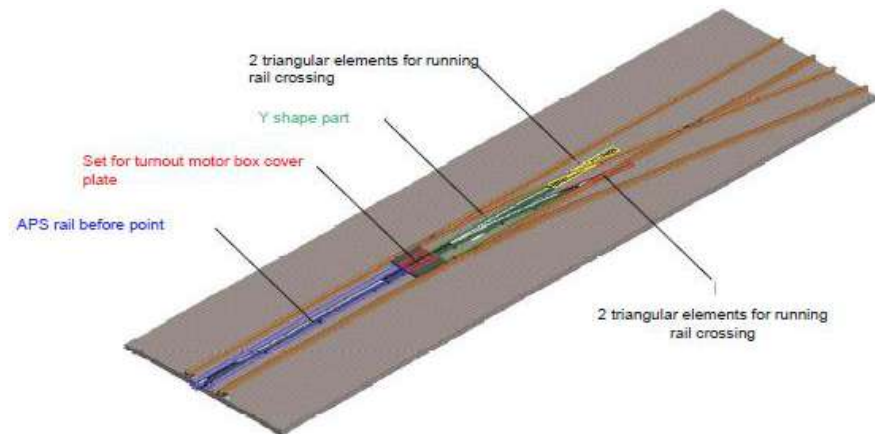
- **APS manhole**

- Pit installed along the track which contains APS trackside electrical equipment.

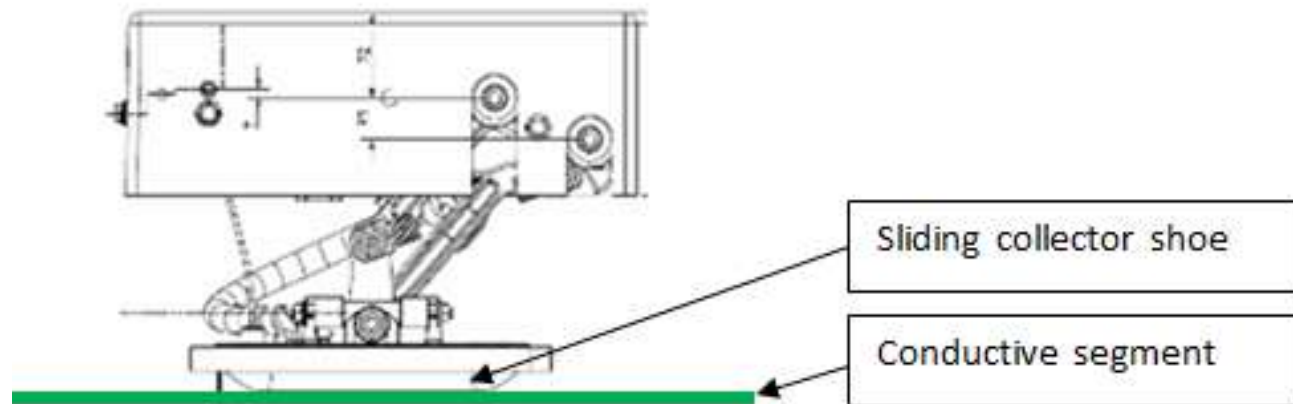


- **APS turnout**

- Specific APS parts designed to fit with turnout configuration.



APS basic principles: Summary



APS basic principles: Summary



✓ The standard APS rail is segmented every 11m: 8m conductive segment / 3m neutral zone.

✓ Spacing between collector shoes is **slightly higher than 3m**:

➔ At least one collector shoe is in contact with the conductive segment.

➔ No power loss while crossing 3m long standard neutral zones.



APS Collector shoes

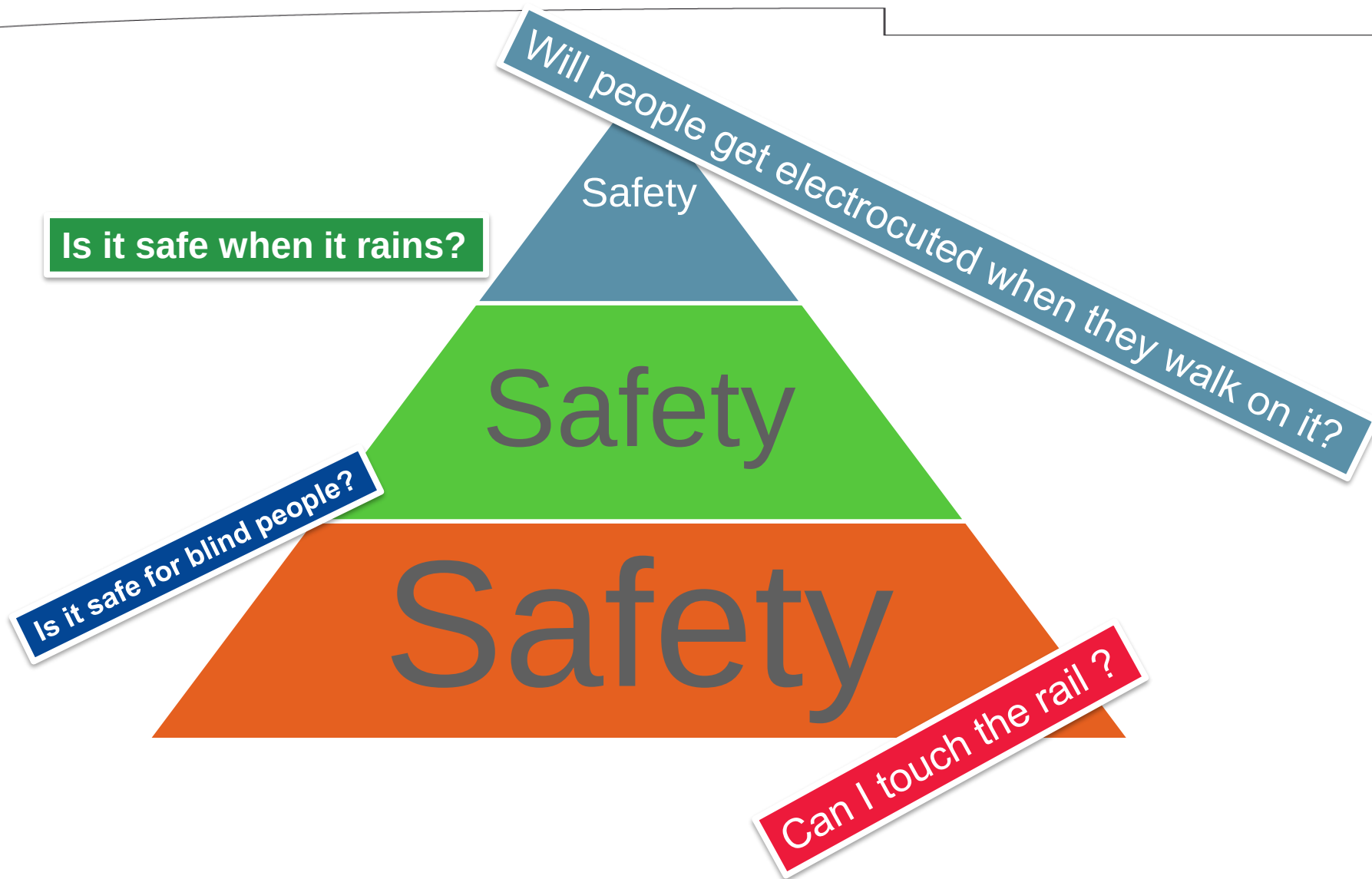
APS basic principles: Summary



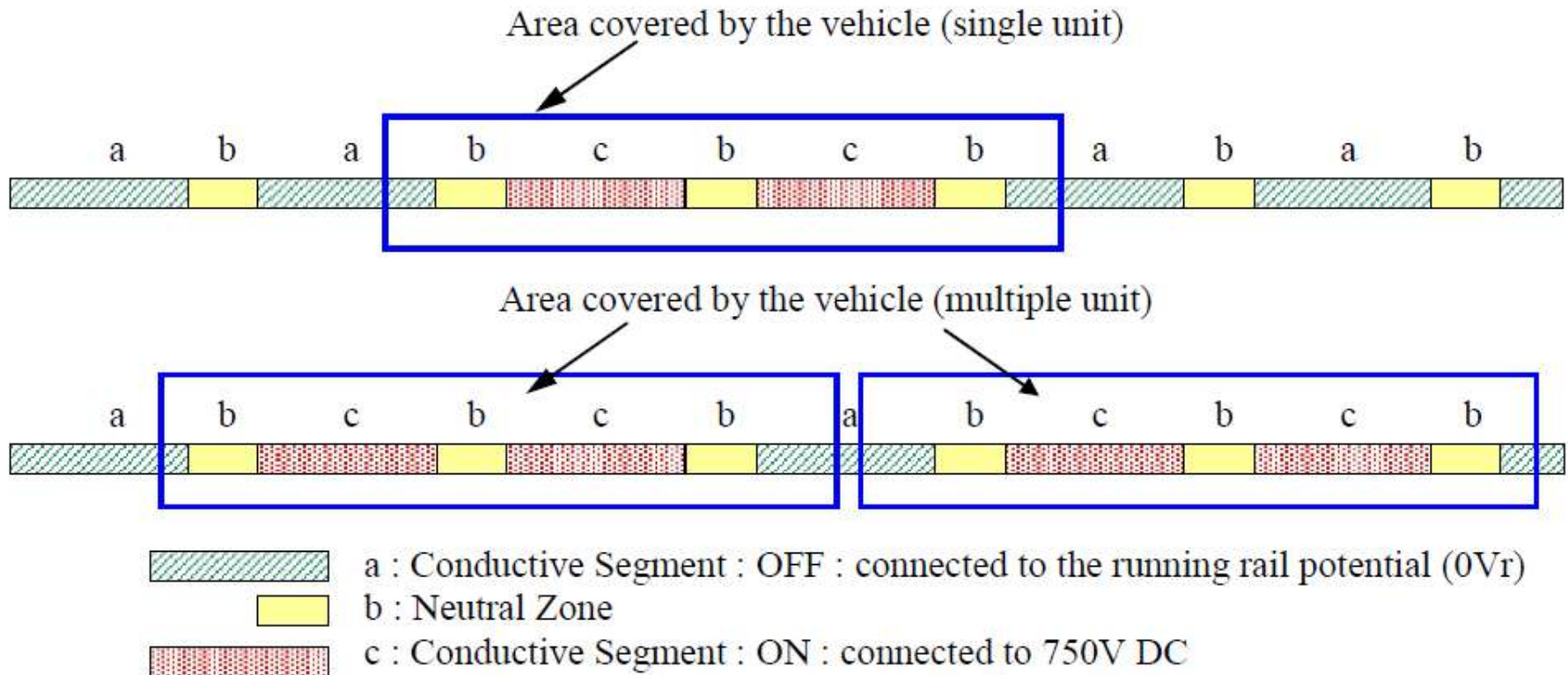
- ✓ The tramway sends a coded signal to the ground to announce its presence.
- ✓ The tramway safe detection is managed by an electronical unit called « Power Box ».
- ✓ Once the tramway is safely detected, the conductive segment potential is set to 750V by the Power Box.
- ✓ After the tram passage, the segment is connected to the running rail potential by the Power Box.
- ✓ Tramways are 33m long, covering every powered segments.



What is APS main Engineering Challenge?



APS basic principles: APS Rail segments

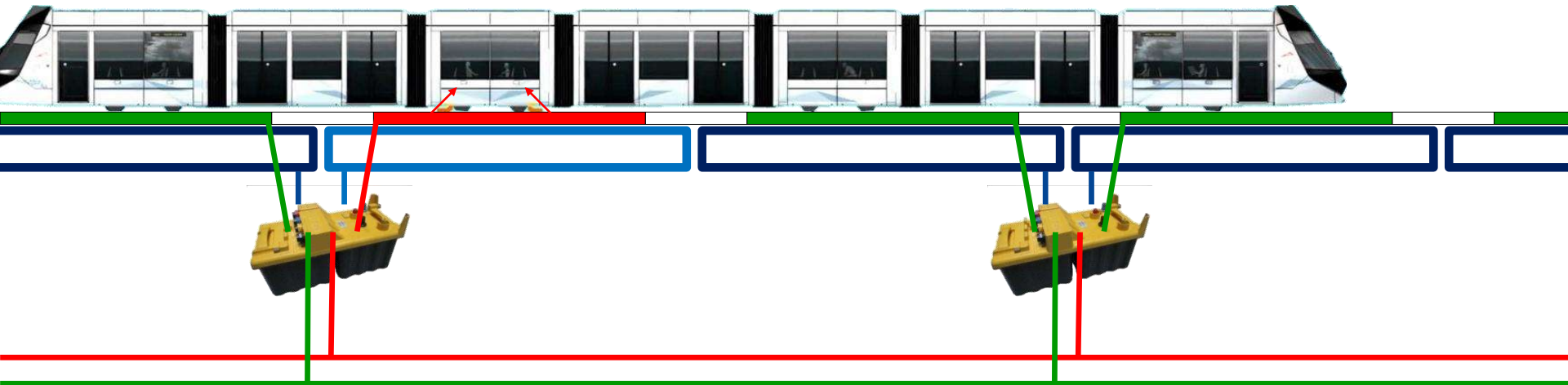


APS Basic Principle: Power Moving Bloc

Both collector shoes are on the same conducting segment

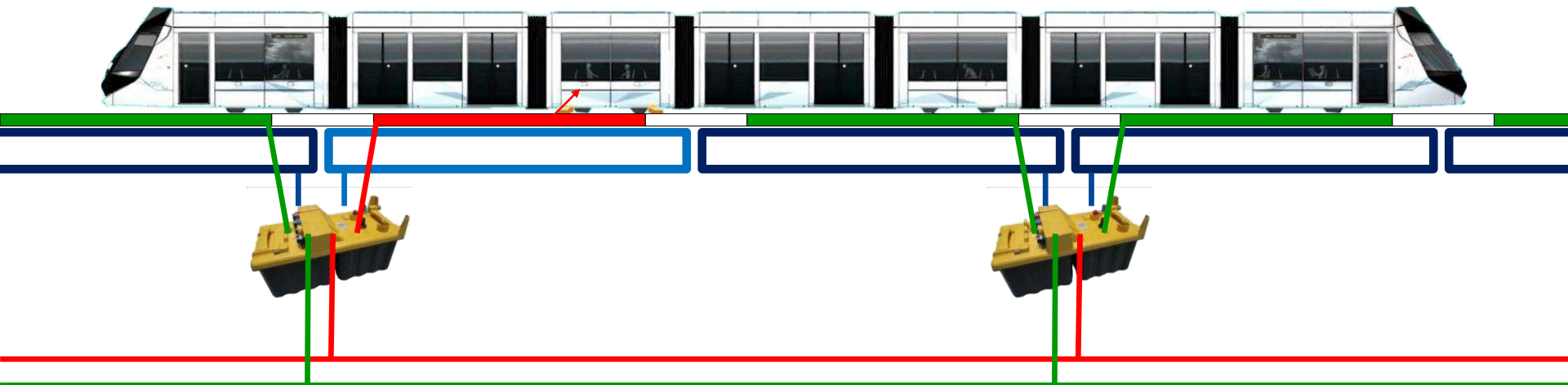
Return current via the running rail

Presence detection loop detects both presence detection signals generated at the level of the collection shoes



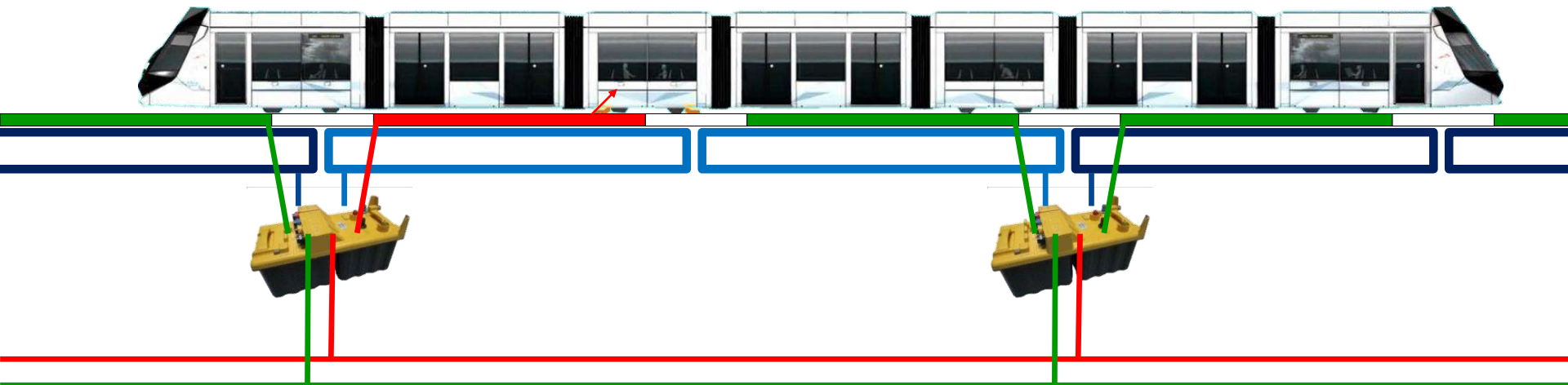
APS Basic Principle: Power Moving Bloc

The leading collector shoe leaves the active conducting rail
The trailing collector shoe is still on the conducting rail and supplies power to the tram
Return current via the running rail



APS Basic Principle: Power Moving Bloc

The leading collector shoes activates the detection loop of the next APS zone
The associated contactor in the APS box is closed at no load



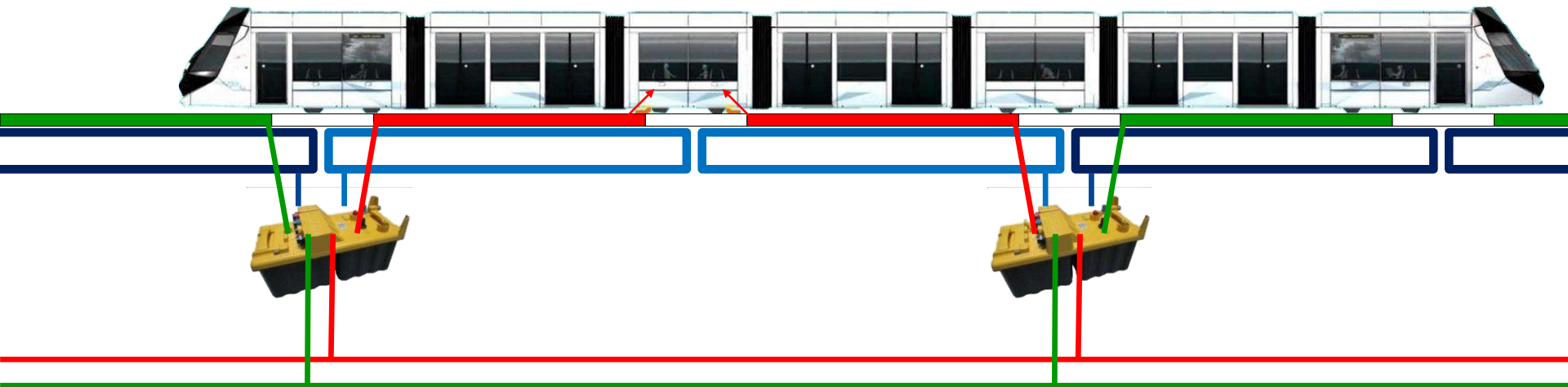
APS Basic Principle: Power Moving Bloc

The next conductive segment is energized at no load



APS Basic Principle: Power Moving Bloc

As the leading collector shoe reaches the energised conducting segment, power flows from the power box to the tram through both shoes



APS Basic Principle: Power Moving Bloc

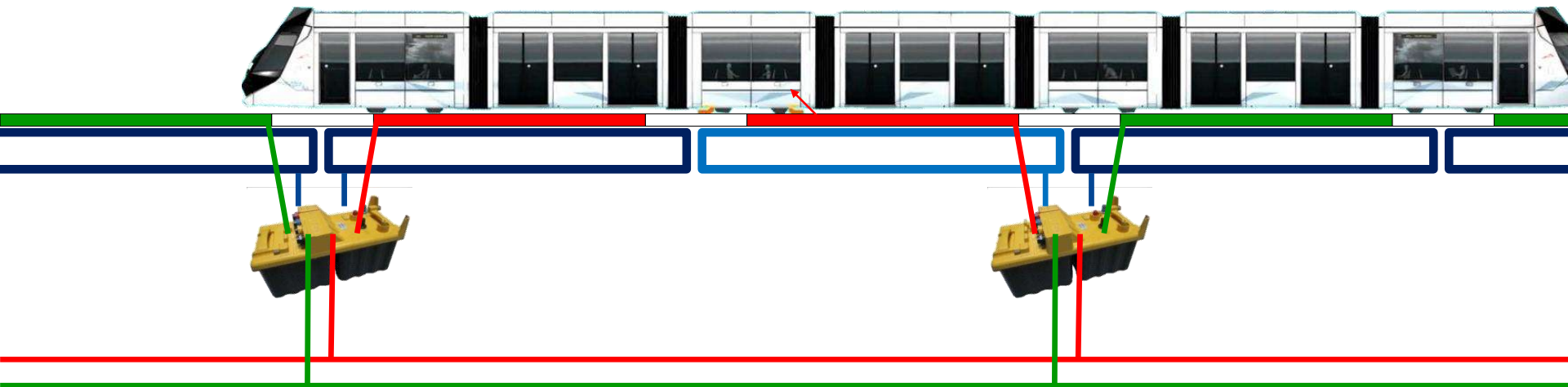
The rear collector shoes leaves the rear conducting segment that stays energized as the rear shoe is still over the associated conducting segment presence detection loop

Power flows only through the leading brush



APS Basic Principle: Power Moving Bloc

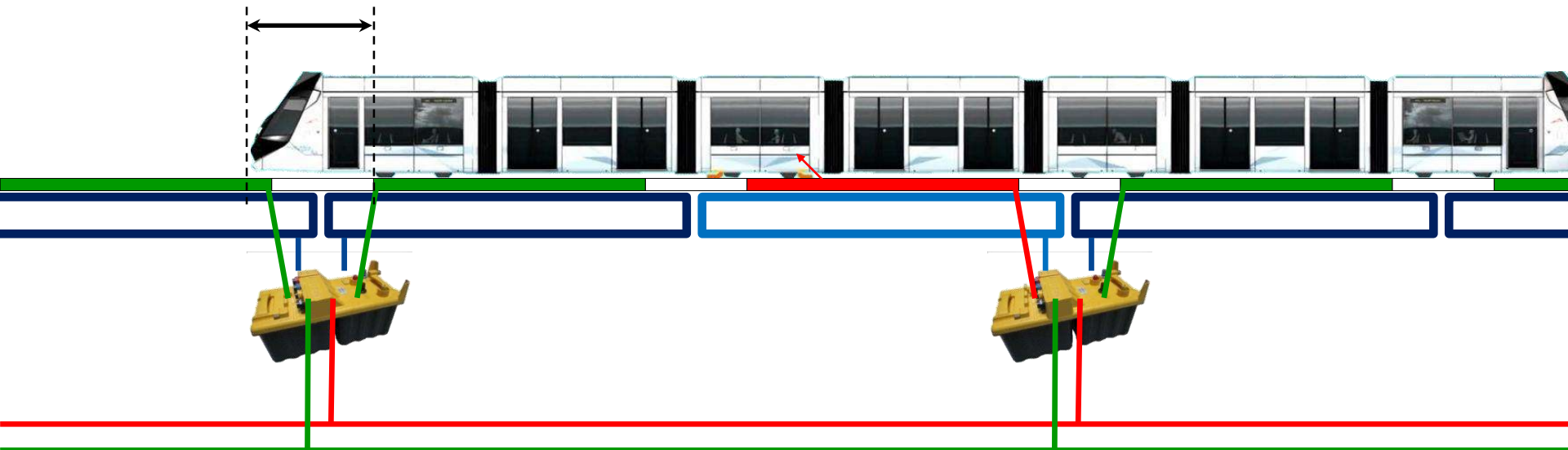
The detection loop associated to the rear segment no longer detects the rear shoes
The loss of detection signal triggers the closing of the associated contactor at no load.



APS Basic Principle: Power Moving Bloc

The rear conducting segment is no longer powered and is connected to the running rail

The tram still protects the segment

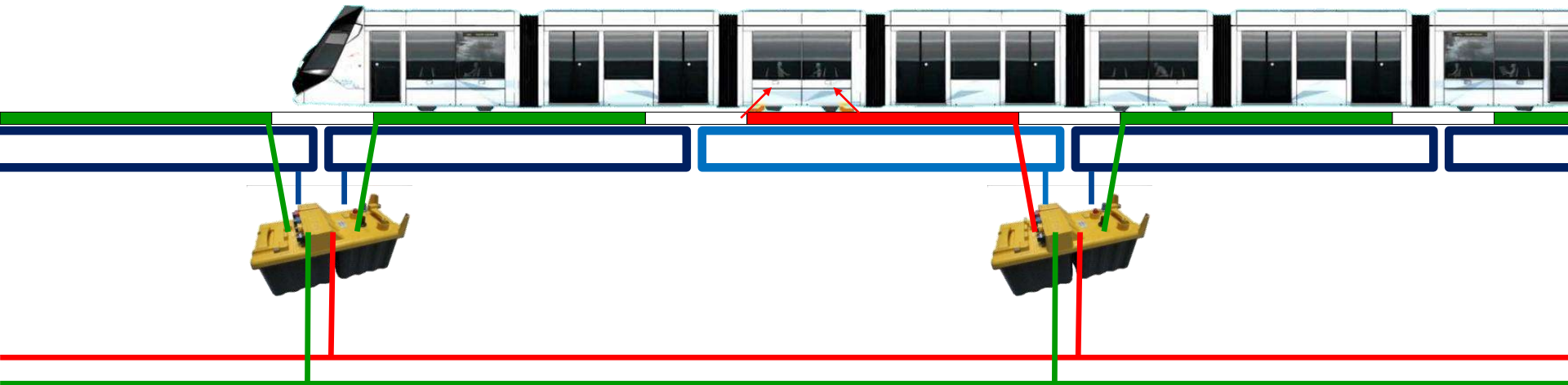


APS Basic Principle: Power Moving Bloc

Both collector shoes are on the same conducting segment

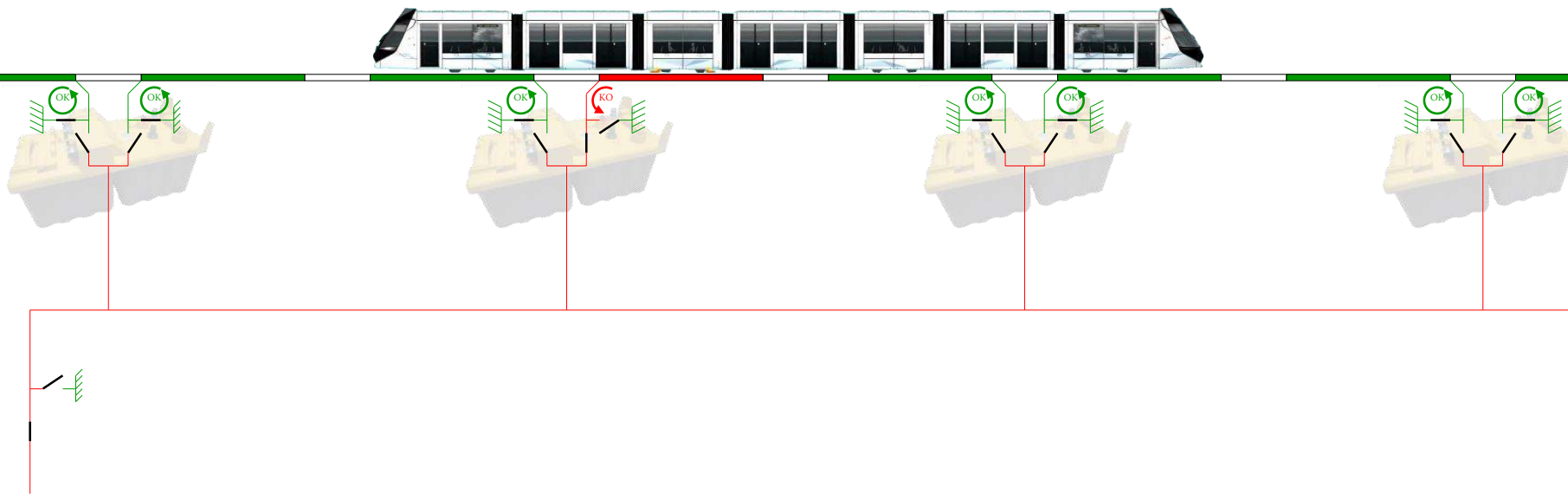
Return current via the running rail

Presence detection loop detects presence both detection signals



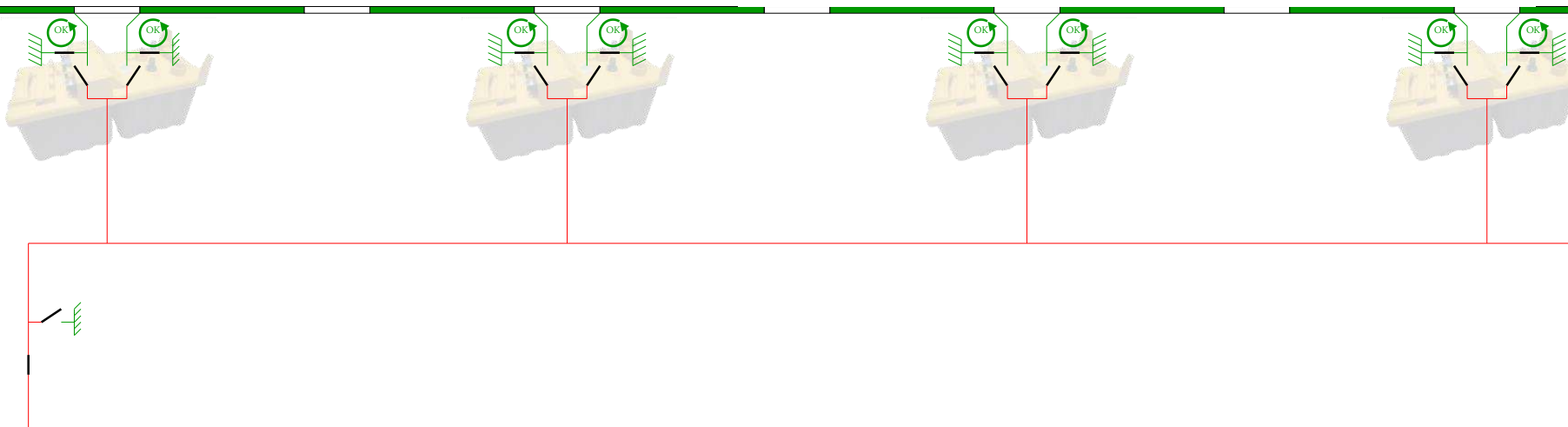
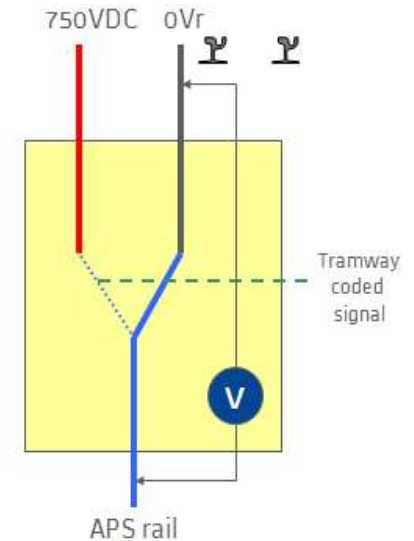
APS embedded safety

- ✓ APS system has been designed to:
 - ensure a full safety when an unwanted event occurs.
 - maintain the operation in most of the cases.



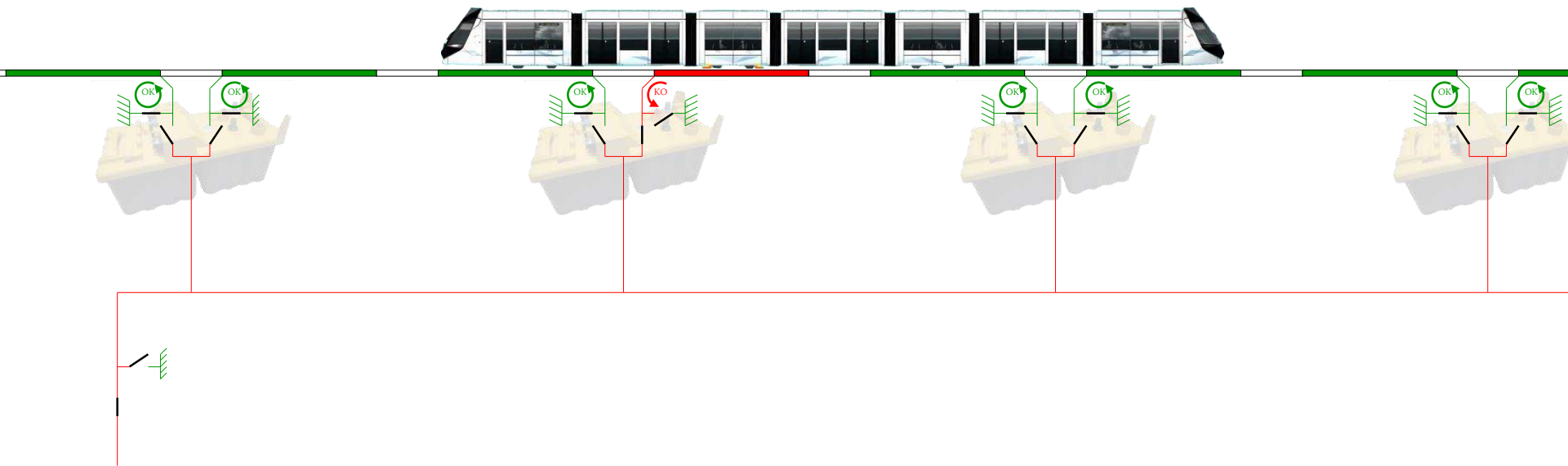
APS embedded safety : Nominal mode

- ✓ Each Power Box continuously and safely checks its connection to the running rail potential (OVr).
- ✓ Use of static relays (no risk of spontaneous closure)



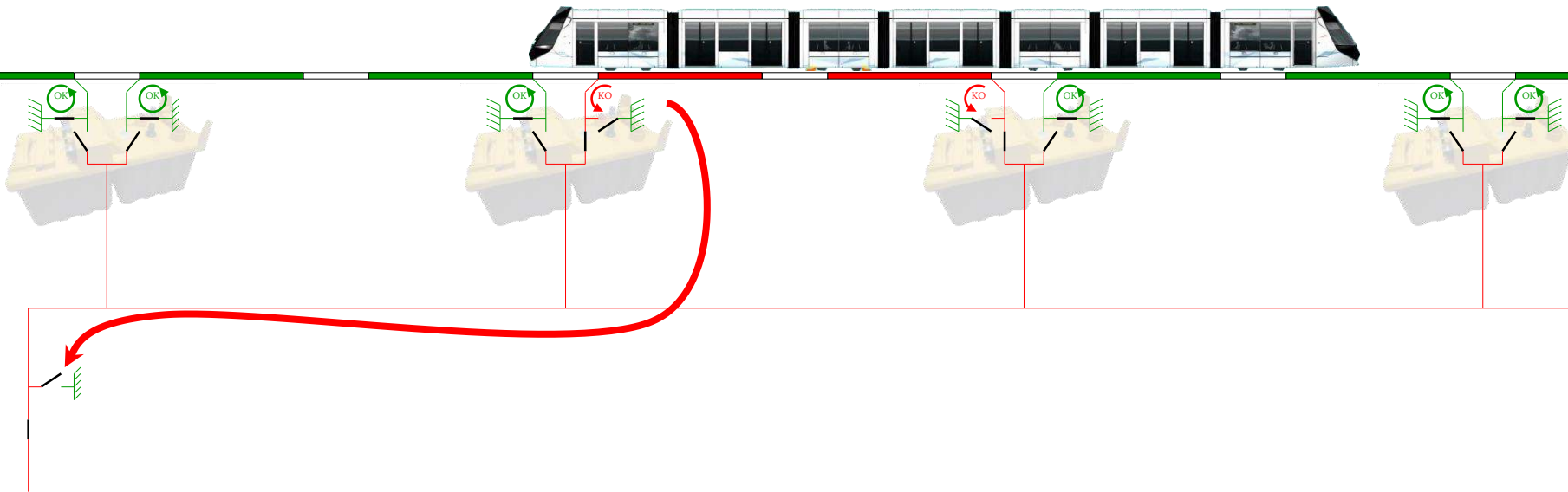
APS embedded safety : Nominal mode

- ✓ A Power Box not connected to the running rail potential (Ovr) when the tramway is detected (safety detection) is a nominal mode.



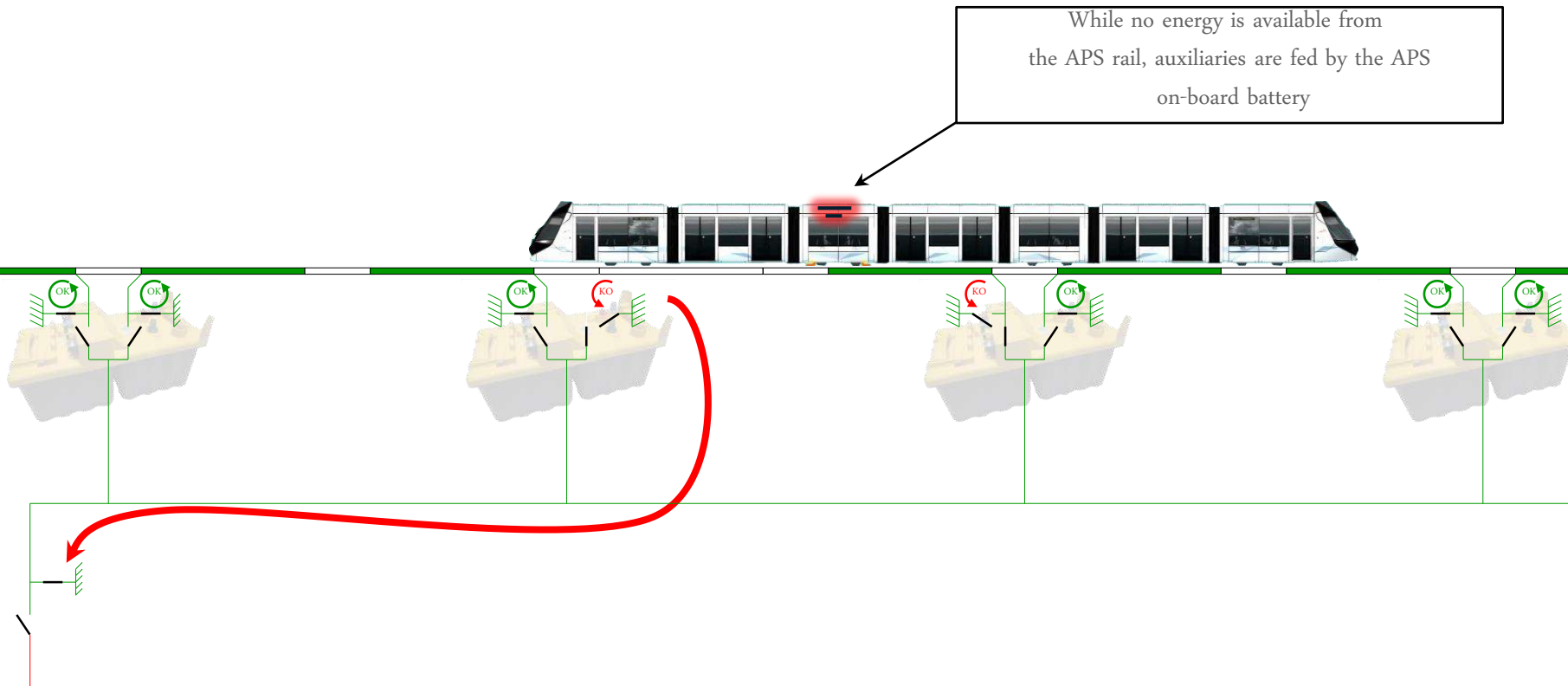
APS embedded safety: Unwanted event management

- ✓ A Power Box not connected to the running rail potential when the tramway is not anymore detected is an unwanted event.
- ✓ The unwanted event is immediately reported upstream to the APS cabinet in the substation.



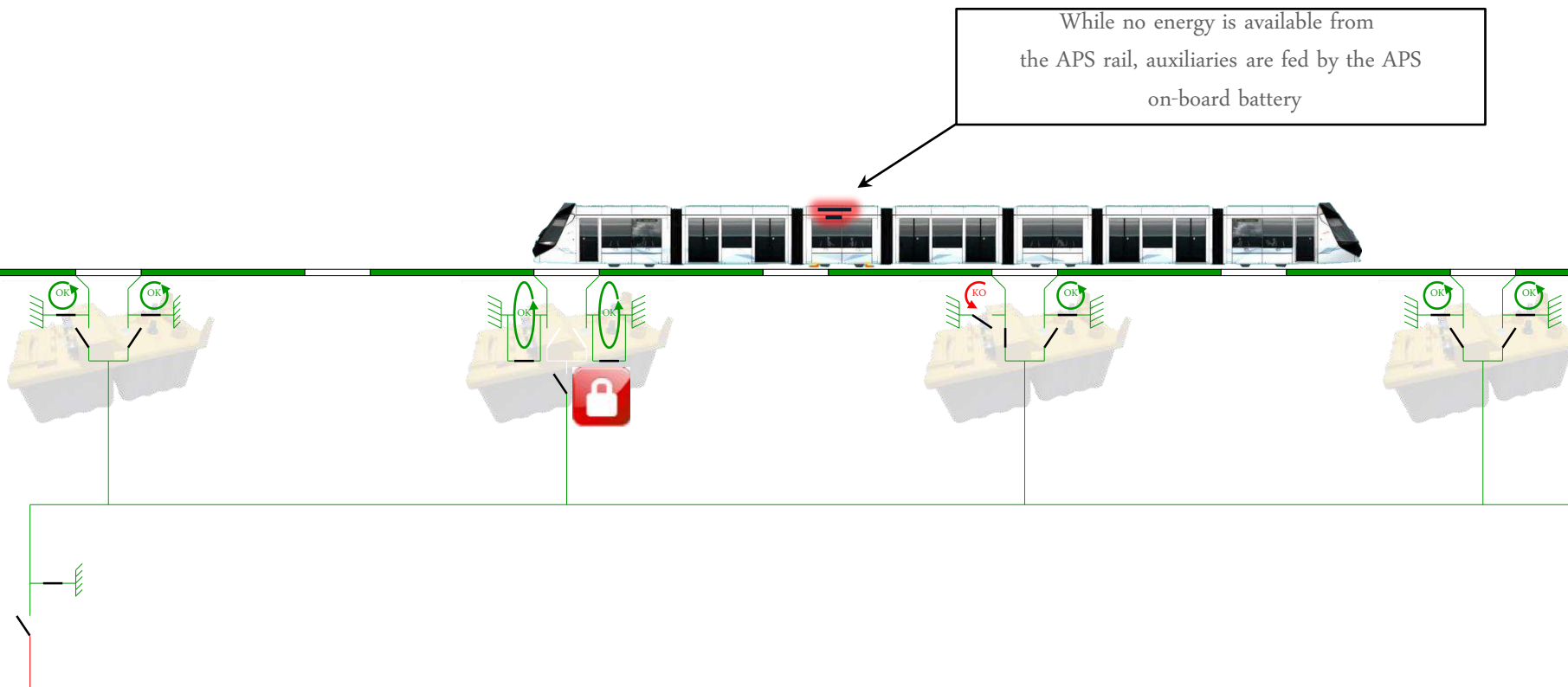
APS embedded safety: Unwanted event management

- ✓ The total section is unpowered and set in a safe status.



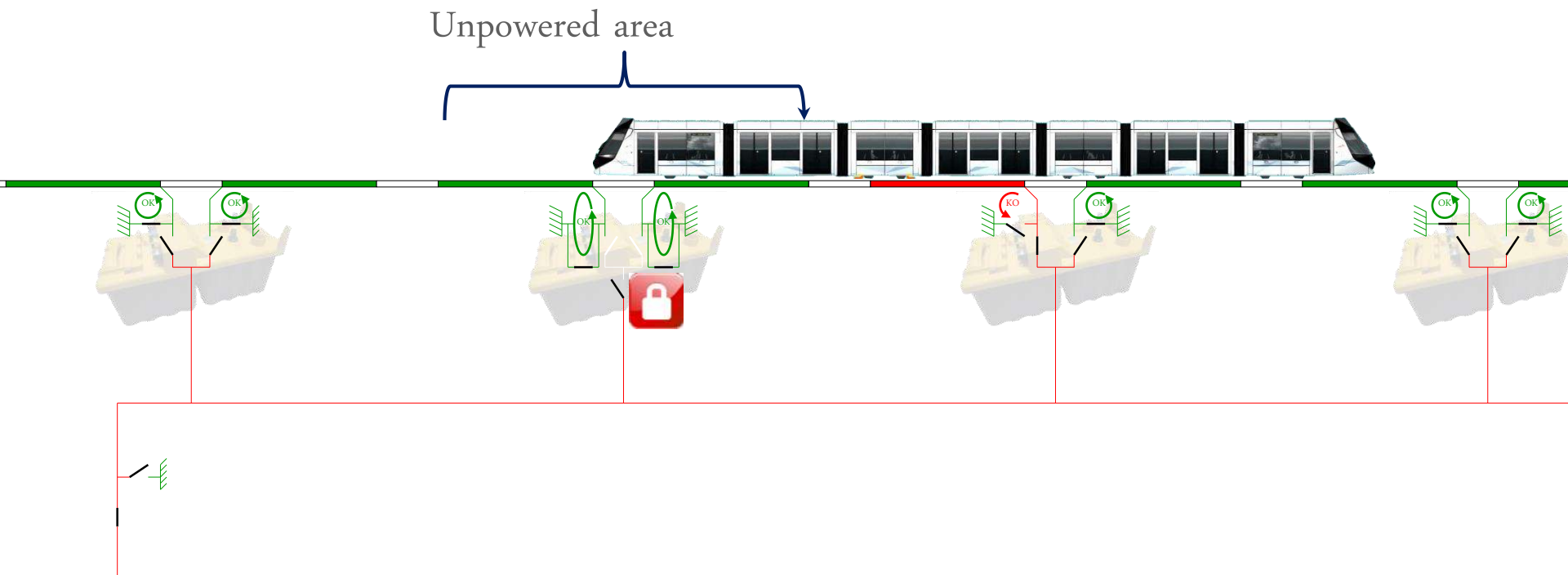
APS embedded safety: Unwanted event management

- ✓ Automatically, the static relay inside the Power Box switches to the running rail potential and is locked in this position. This status is called “Power Box isolated”.



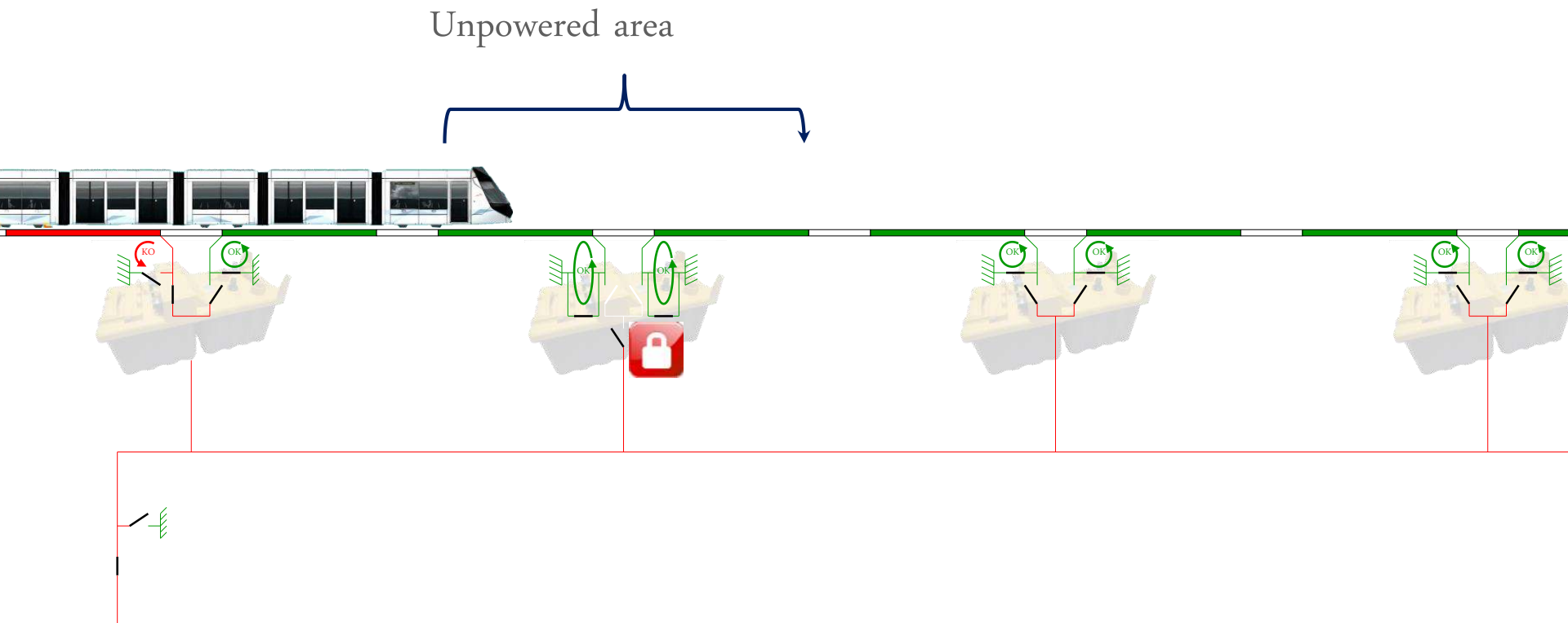
APS embedded safety: Unwanted event management

- ✓ The electrical section is then re-energised to the 750V.
- ✓ The operation resumes with an isolated power box.



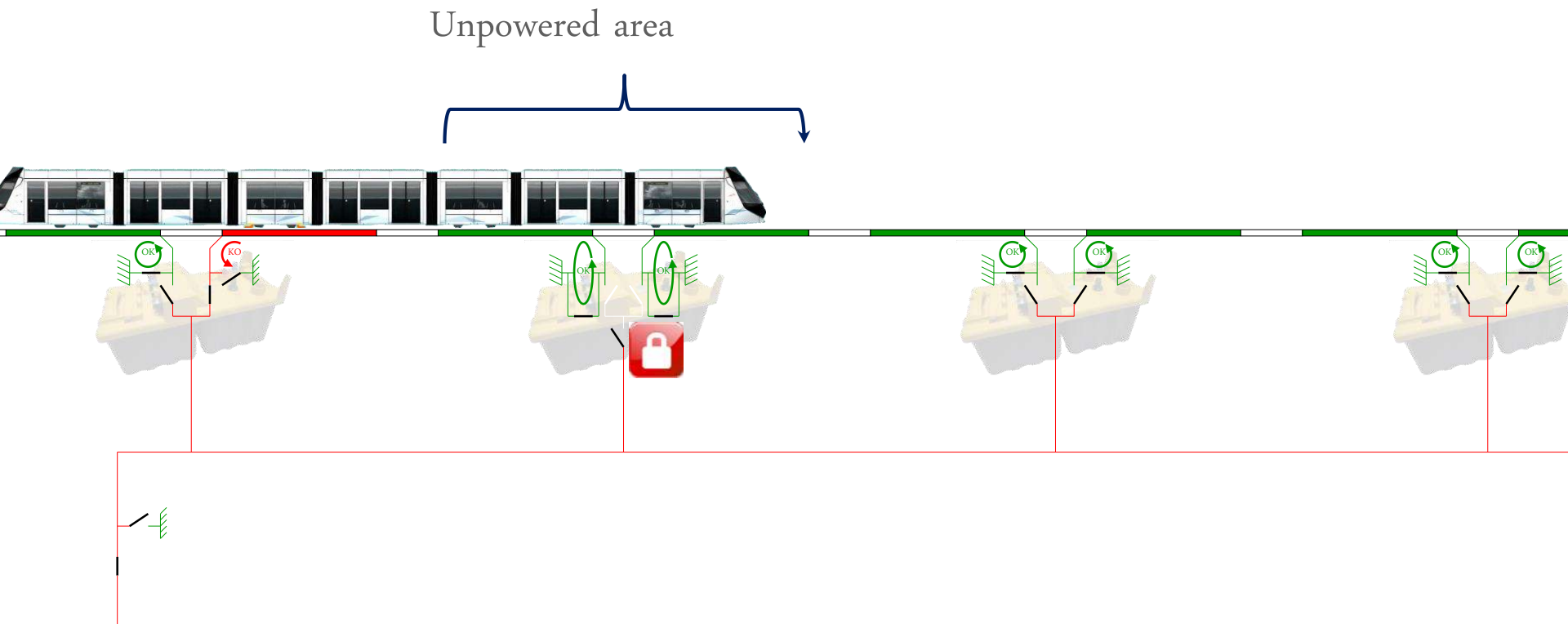
APS embedded safety: Unwanted event management

- ✓ Next trams will proceed on momentum with auxiliaries supplied by **battery** on this isolated Power Box until its replacement.



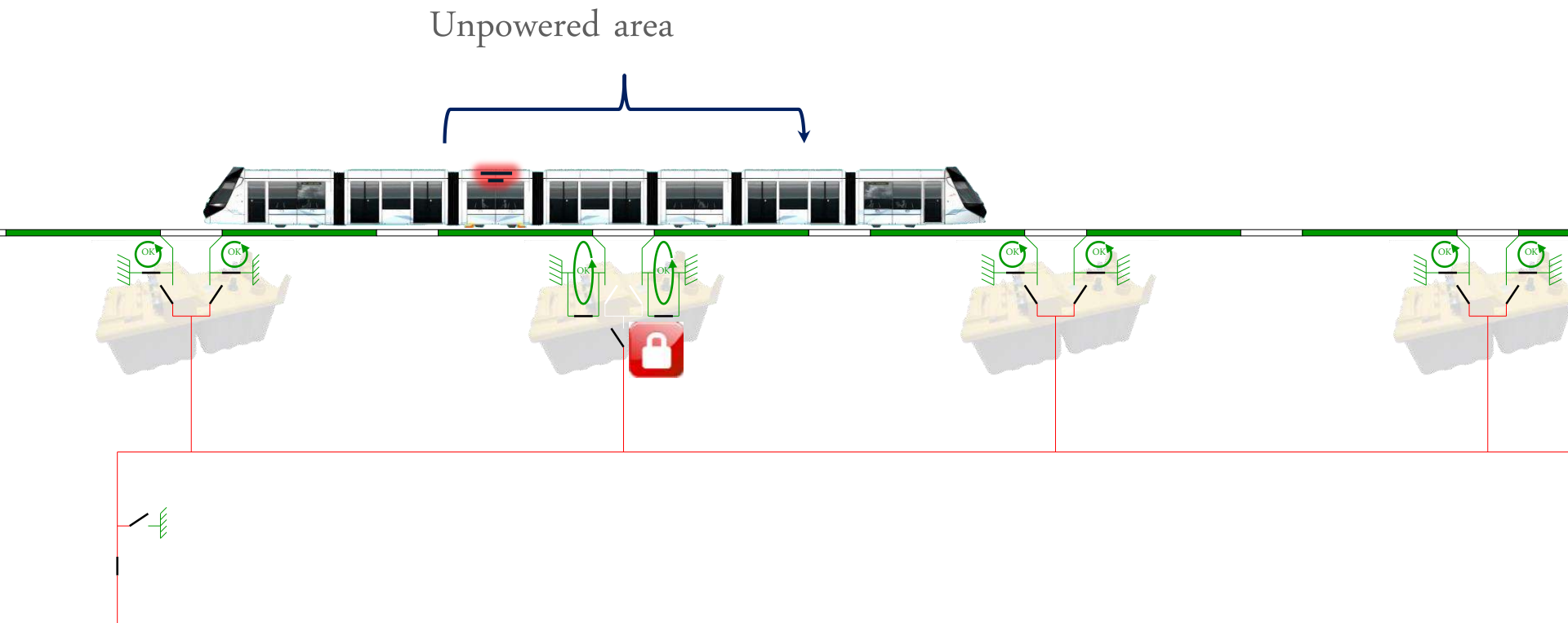
APS embedded safety: Unwanted event management

- ✓ Next trams will proceed on momentum with auxiliaries supplied by **battery** on this isolated Power Box until its replacement.



APS embedded safety: Unwanted event management

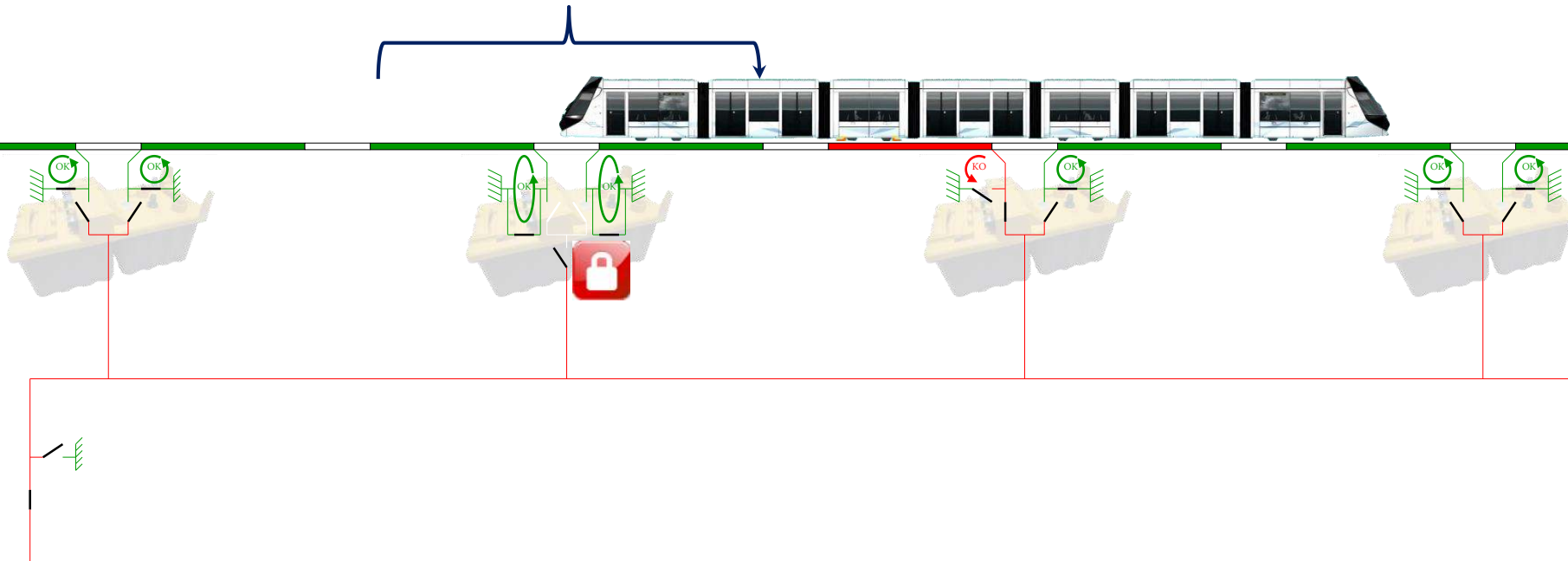
- ✓ Next trams will proceed on momentum with auxiliaries supplied by **battery** on this isolated Power Box until its replacement.



APS embedded safety: Unwanted event management

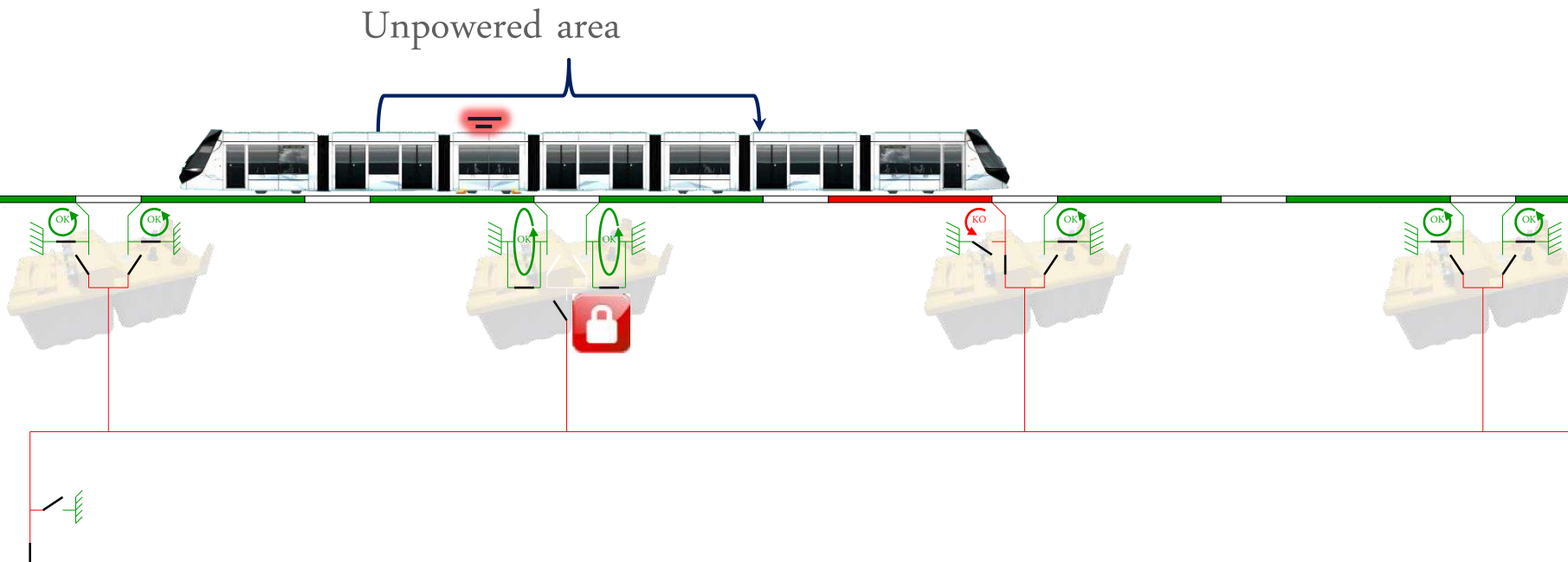
- ✓ Next trams will proceed on momentum with auxiliaries supplied by **battery** on this isolated Power Box until its replacement.
- ✓ As soon as the train is back on an powered segment, it switches automatically back to APS mode.

Unpowered area



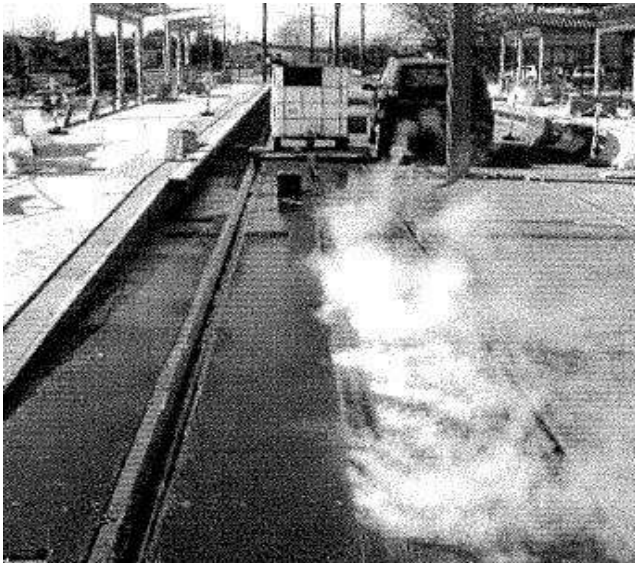
APS embedded safety: Unwanted event management

- ✓ If a train is stopped in a de-energised area, the driver can use the battery for traction to exit the critical area (degraded mode)



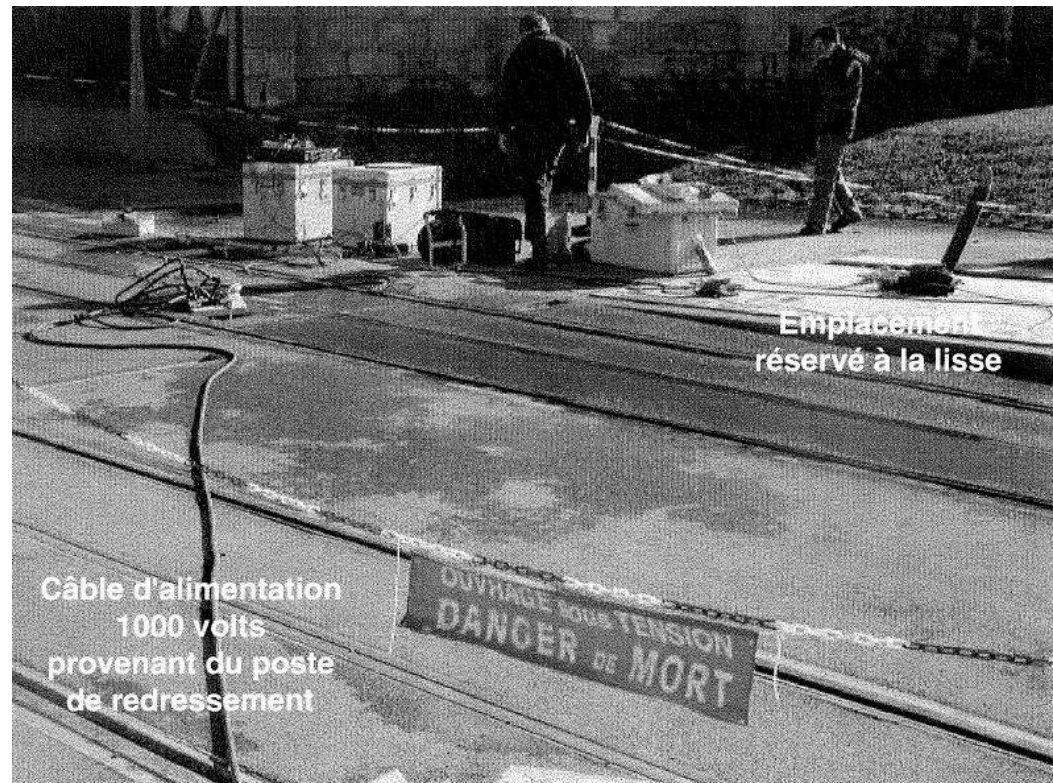
APS remains safe with waterlogged platform

- Measurement performed on different type of :
 - Dry asphalt
 - Wet asphalt
 - Wet Grass
 - Etc...



Fogging near the APS rail

- Test Area Set-up



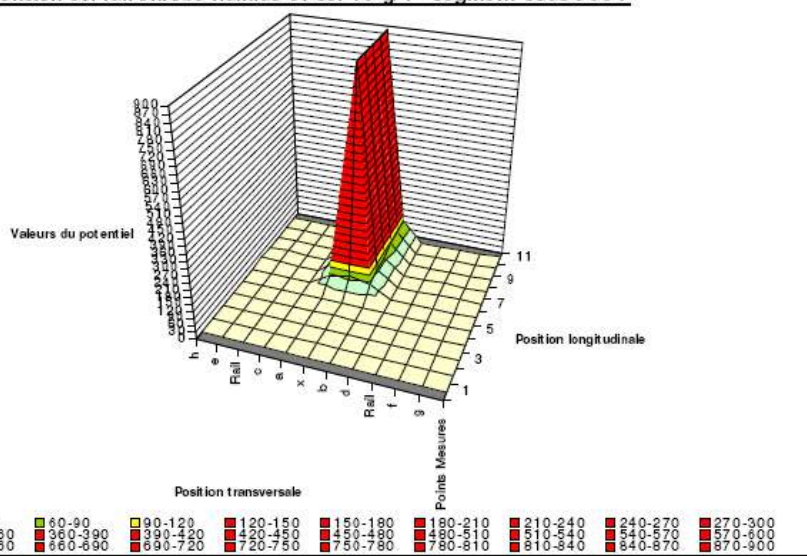
APS remains safe with waterlogged platform

Result on wet asphalt and 40g/l salt (equivalent sea water)

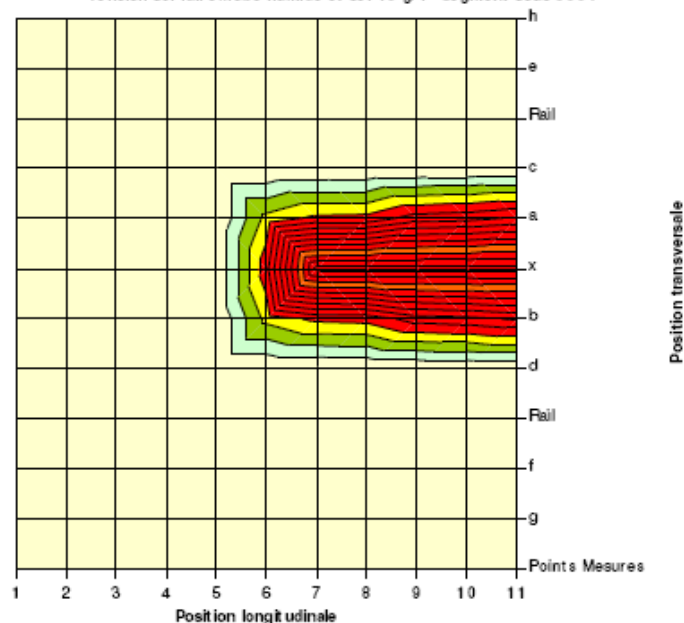
Tension à Vide Uo - conditions d'essais : Enrobé humide et sel à 40 g/l Alimentation: 900 volts											
Points Mes	0	1	2	3	4	5	6	7	8	9	10
g							8,35	1,34	1,38	1,53	1,42
f							6,08	7,08	2,08	2,6	2,18
Rail		0	0	0	0	0	0	0	0	0	0
d											
b						50	63,9	65	82	85	92
x		3		5,04		70	900	900	900	900	900
a						50	63,9	65	82	85	92
c											
Rail		0	0	0	0	0	0	0	0	0	0
e							6,08	7,08	2,08	2,6	2,18
h							8,35	1,34	1,38	1,53	1,42

> 120V = Red zone
 90 to 120V = Yellow zone
 60 to 90V = Green zone
 < 60V = Light blue zone

Tension sol-rail enrobé humide et sel 40 g/l - Segment sous 900V

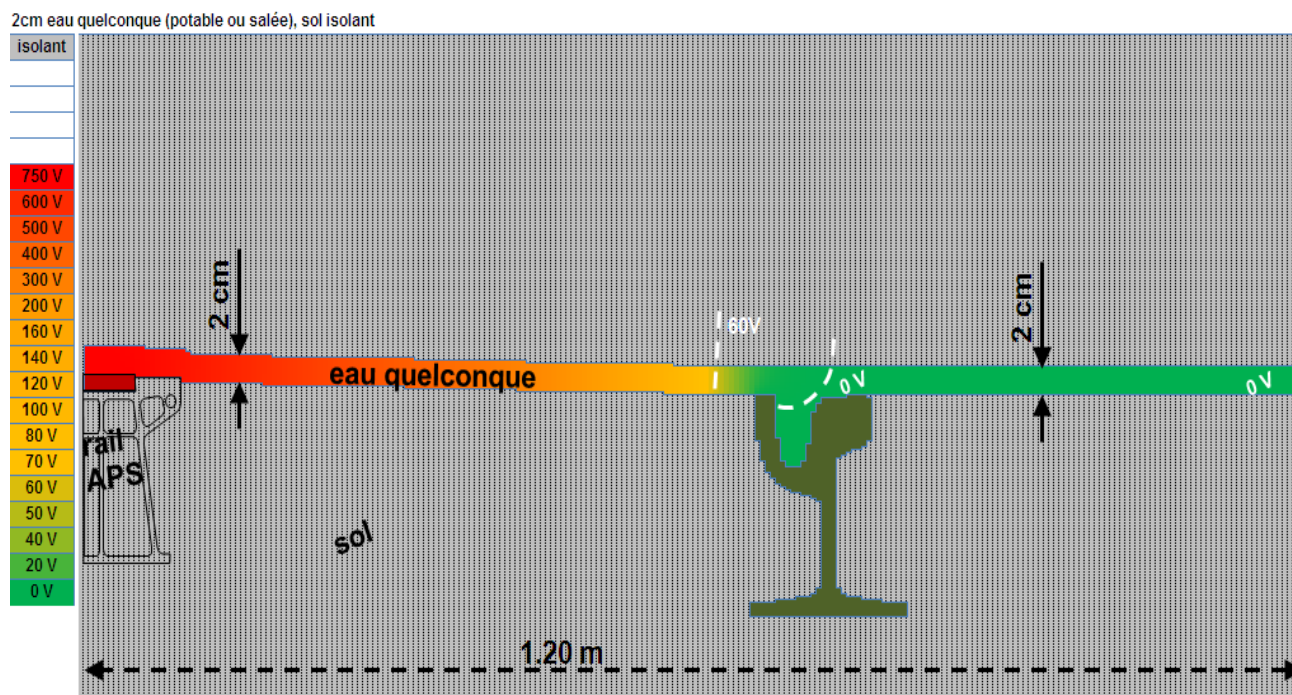


Tension sol-rail enrobé humide et sel 40 g/l - Segment sous 900V



APS remains safe with waterlogged platform

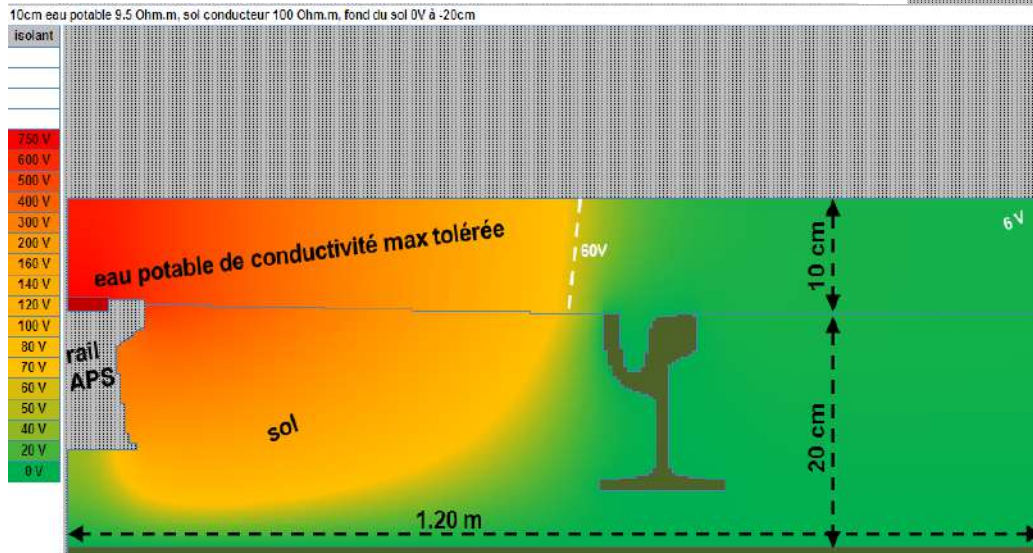
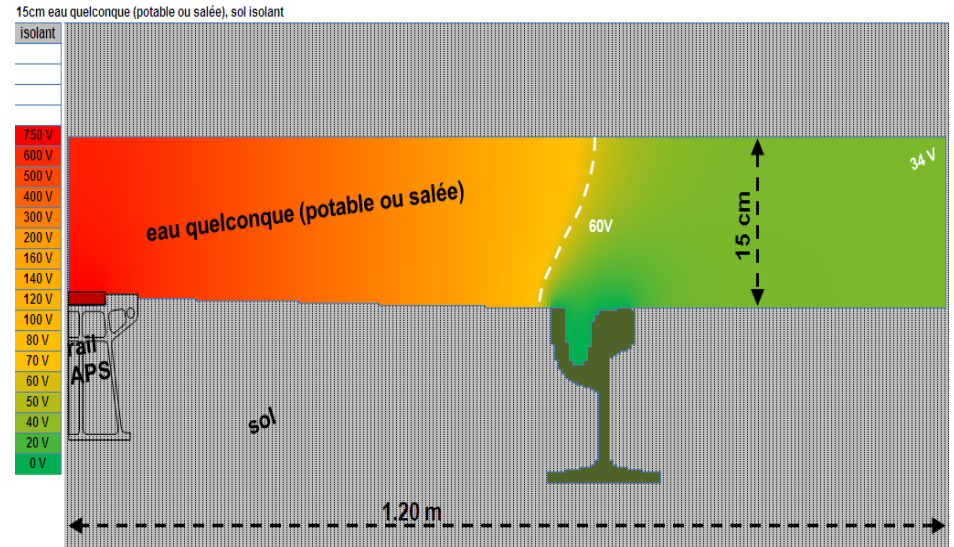
Simulation with 2cm of some water (Drinkable or salty)



APS remains safe with waterlogged platform

Other simulations with :

- 15cm of some water
- Insulated ground
- 10cm of drinkable water $9.5 \Omega \cdot \text{m}$
 - Conductive ground $100 \Omega \cdot \text{m}$
 - Underground $0V$ at -20cm



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A small Video on HESOP



VIDEO_Hesop - Sous-station de traction réversible 543a42efc18d17d8_560_496_64_512_288_25_baseline_1.mp4

What is HESOP?

Definition

- An advanced reversible substation with a single converter both rectifier & inverter
- For DC networks from 600V to 1500V and from 900kW to 4MW (urban & suburban)

Main advantages :

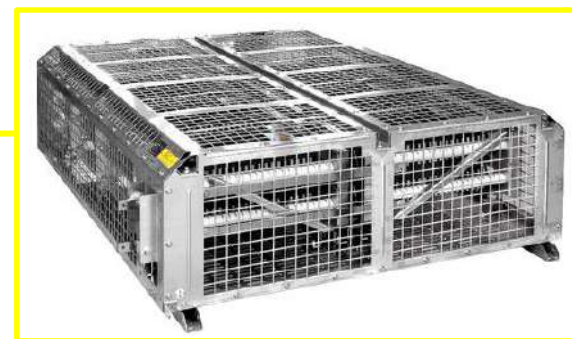
- To **capture recoverable energy** in braking mode
- To provide dynamic voltage regulation **to optimize power use** in traction mode



What is HESOP?

How is Energy lost?

- During braking, electric motors in a train behave like generators, transforming movement into electricity, or 'braking energy'
- Some of this energy is used by the train itself and by trains running nearby, but the rest is lost.



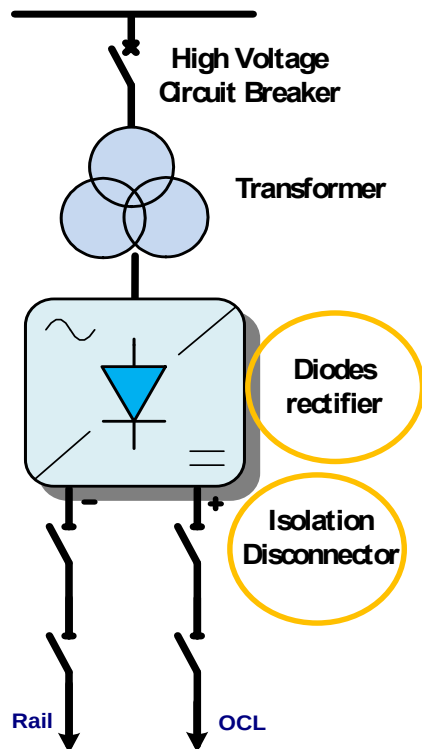
Brake resistors

Braking energy dissipated into the on-board resistors

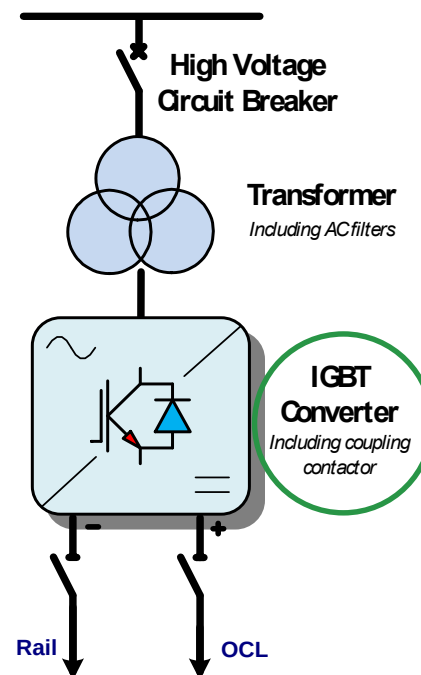
What is HESOP?

Different Architecture

Classic substation



HESOP substation



IGBT : Insulated-Gate Bipolar Transistor

- No energy recovery
- No traction optimization

- **99%** braking energy recovery
- Traction optimization

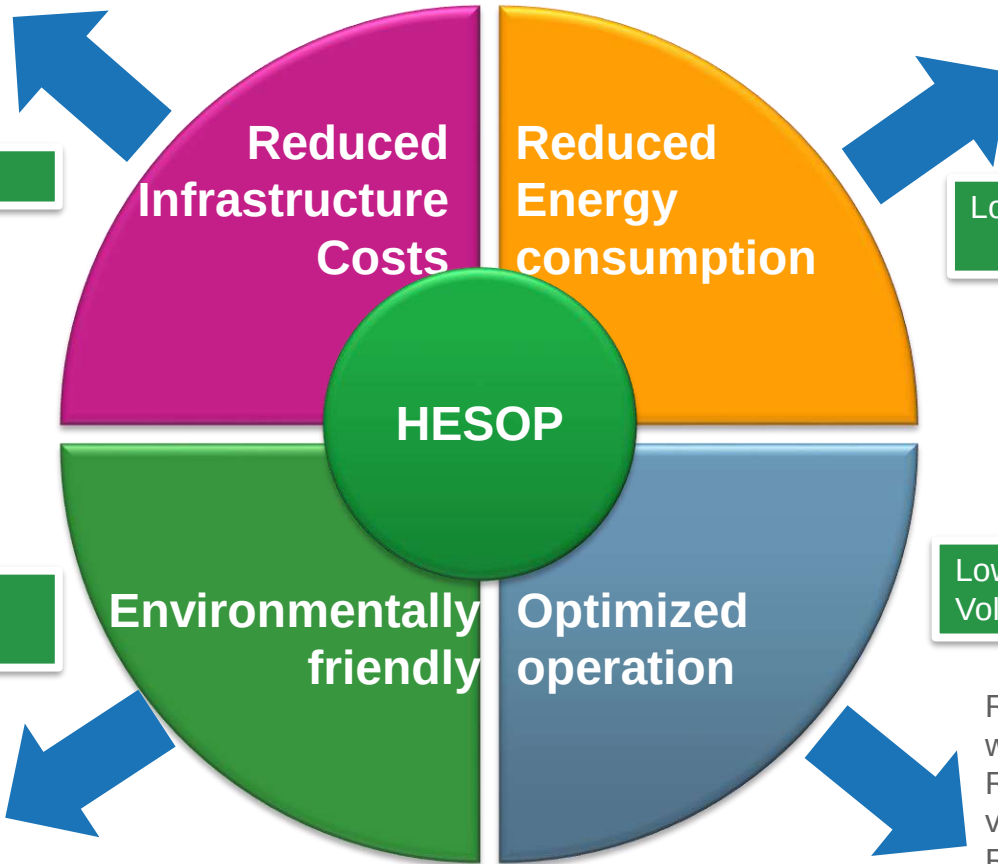
Why HESOP is adapted to Sydney

SLR = High Capacity System
HESOP Optimises the use of
substations

~ 20 Less substations

99 % Braking energy
recoverable

Very High Sustainability
Target
Re-Generation TfNSW
requirement



Very High Sustainability
Target
Good for OPEX

Low Harmoniscs
Voltage Regulation

Reduced Harmonics, in line
with Ausgrid requirements
Reduced susceptibility to AC
voltage fluctuation
Reduced use of Mechanical
brakes

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X05 : A LITTLE VIDEO



X05-FINAL_OK_DF.avi

More than 2200 Citadis sold worldwide with 1700 in service



X05 IN SYDNEY – WHAT IS SPECIFIC?

HVAC : high performance Cabin and
Passenger area units

Carbody :
5 passenger cars, low floor
6 double doors per side

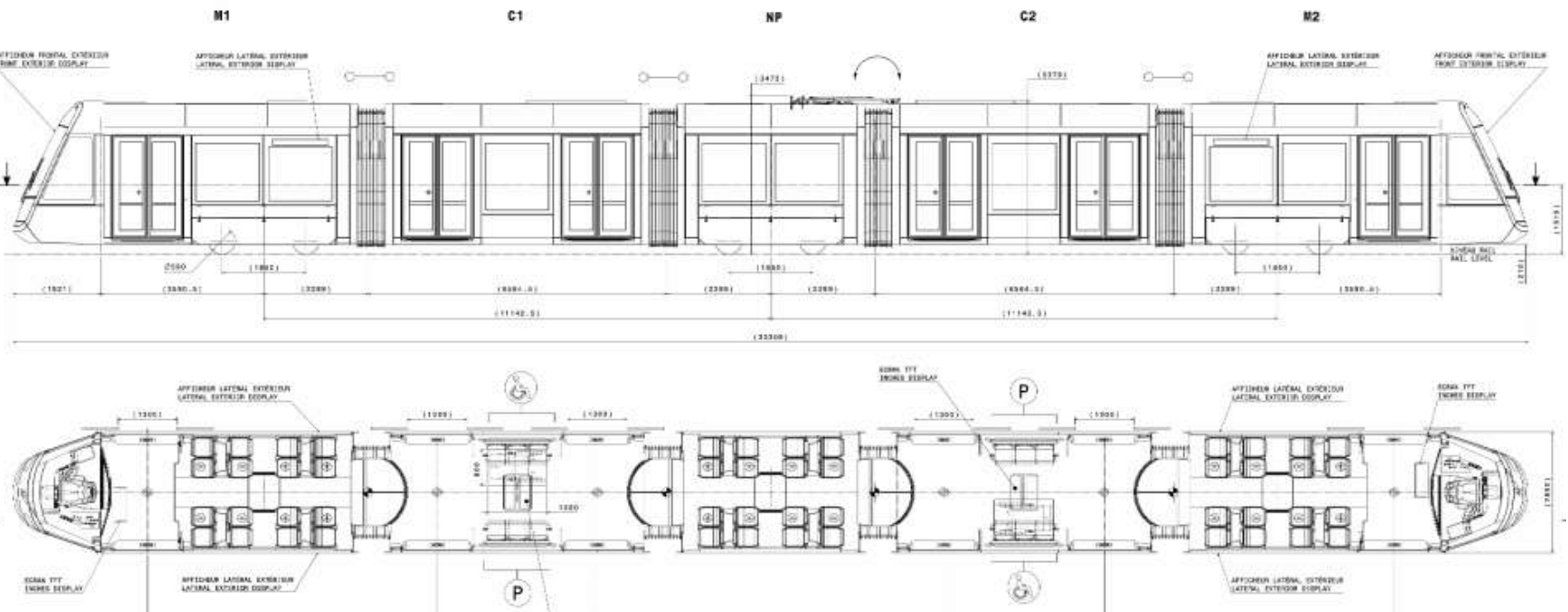
Fireprotection:
Passenger areas with Smoke detection

High Capacity:
Operation in double unit
68 m long
>450 passengers

Accessibility
Inductive loop in suspended modules
Compliance with Disability Standards for
accessible public transport

Traction System :
Compatible for
-OHW / pantograph
-APS / track captation





			AW3 Load (4p/m²)		AW4 Load (6p/m²)	
	Seats	Passenger Surface Area (m²)	Standees	Total	Standees	Total
Tip-up seats Up position	48	46.25	185	233	277	325
Tip-up seats Down position	60	42.79	171	231	256	316

HOW DOES IT LOOK LIKE INSIDE?



Motor Car

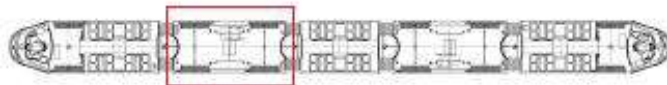


Customer approval

Alstom Approval

HOW DOES IT LOOK LIKE INSIDE?

Suspended Car



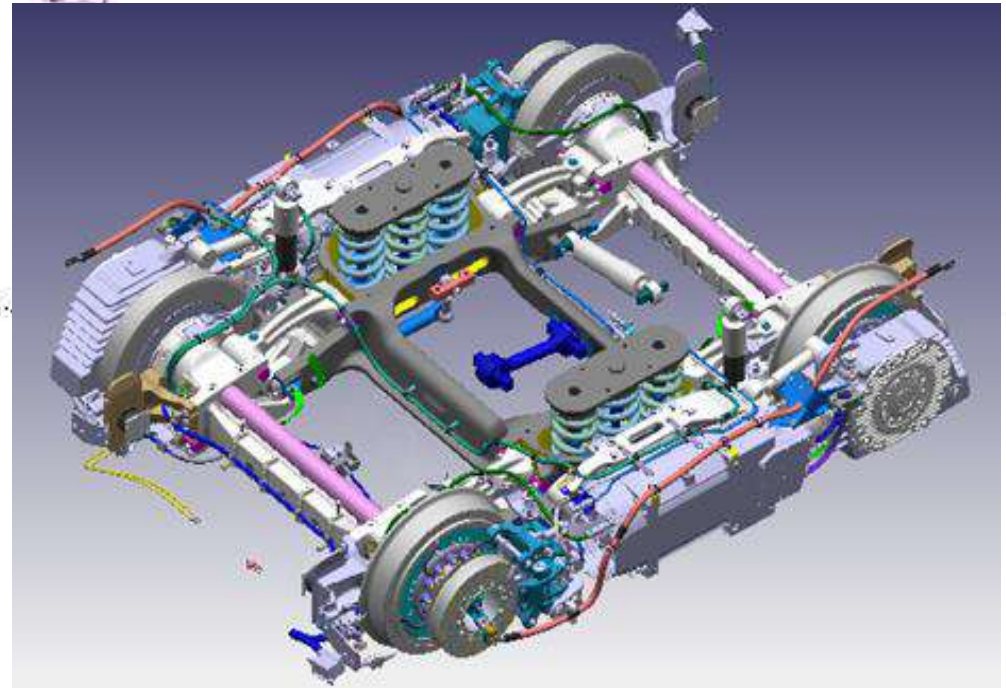
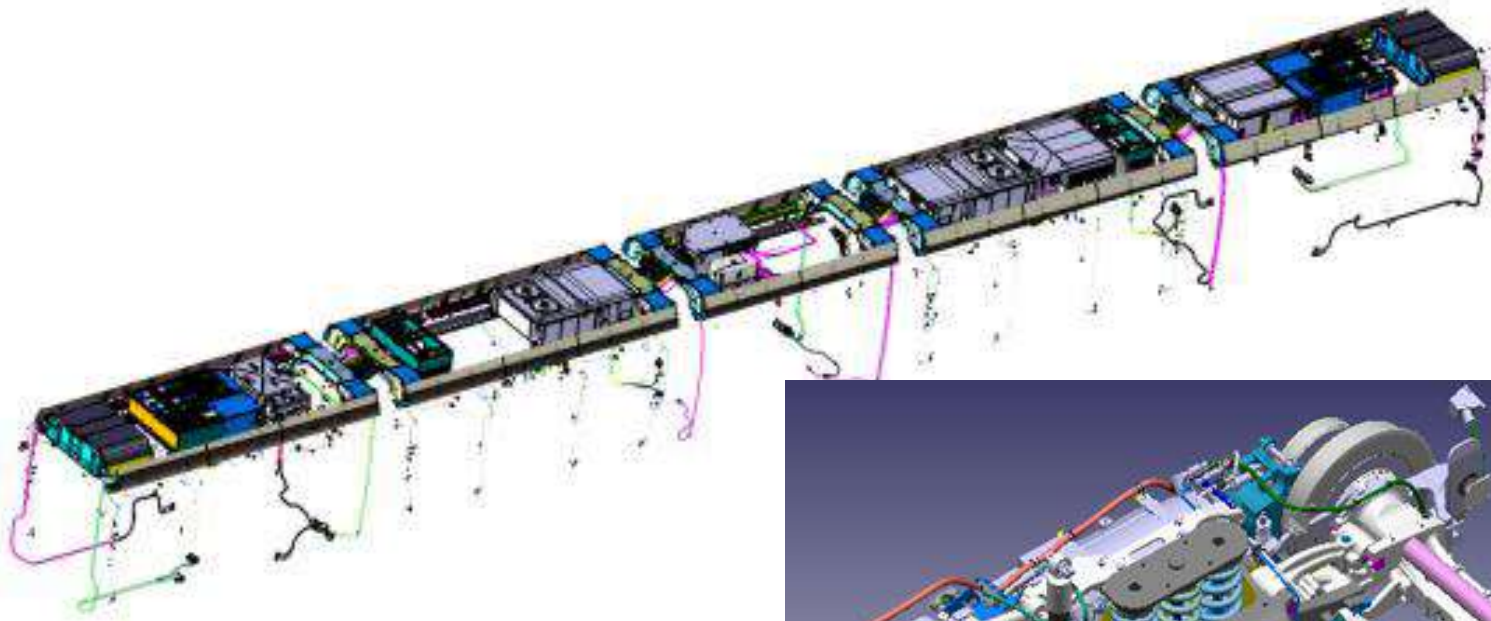
Customer approval

Photo

Alstom Approval

Photo

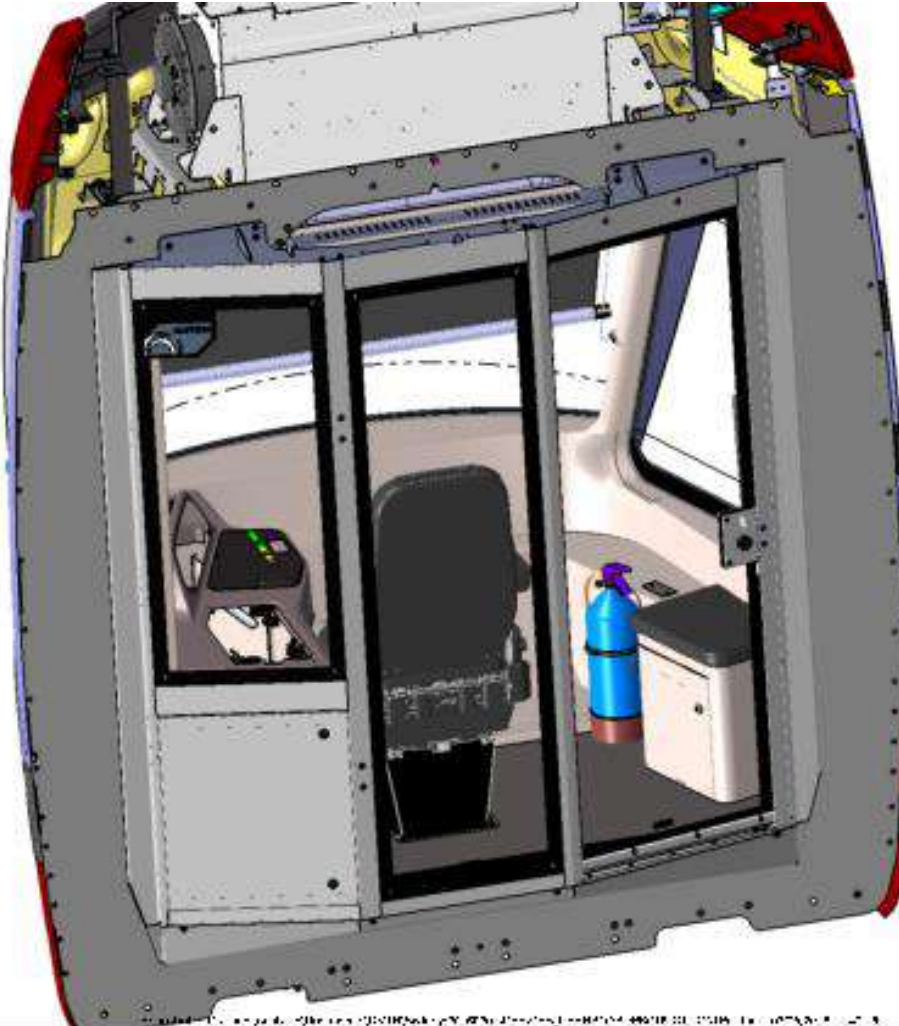
EXTENSIVE 3D MODELLING USE



BUT ALSO FOR THAT

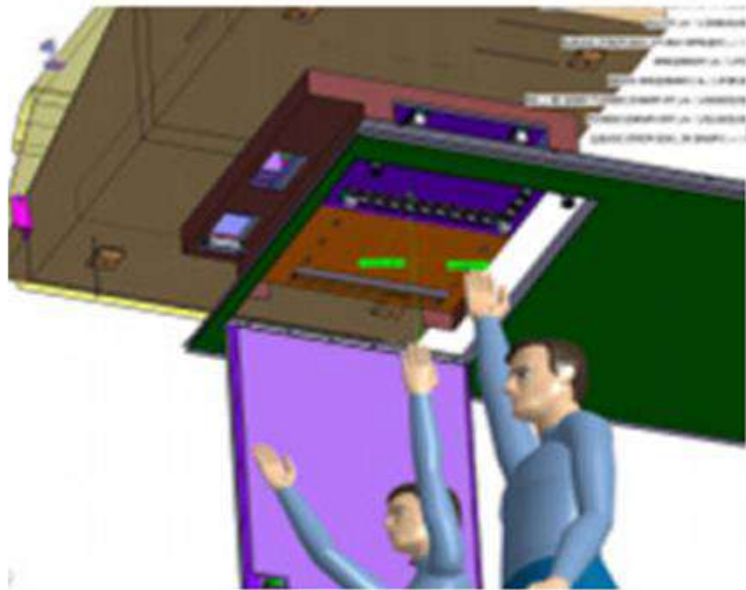


EXTENSIVE 3D MODELLING USE

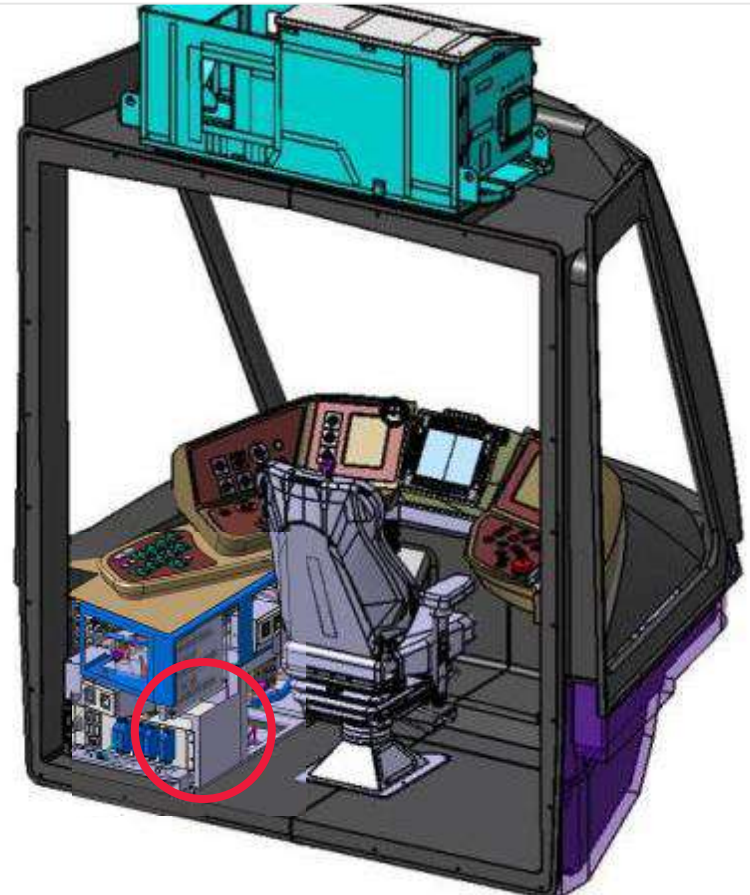


- SPACE PROOFING
- ACCESSIBILITY
- CONSTRUCTION SEQUENCES

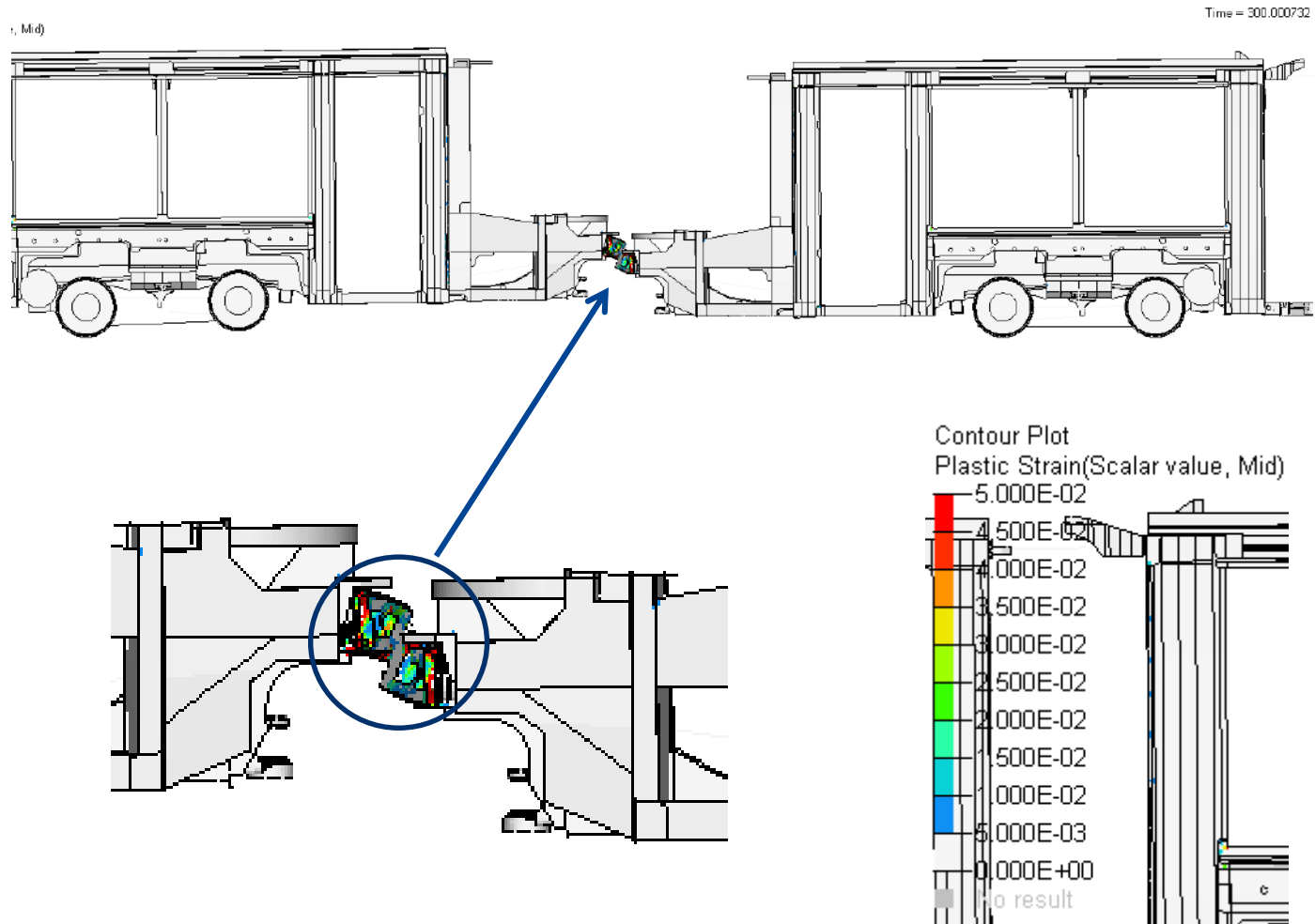
EXTENSIVE 3D MODELLING USE



- MAINTAINABILITY
- ERGONOMICS
- VALIDATION



CRASH DYNAMIC MODELLING IN 3D



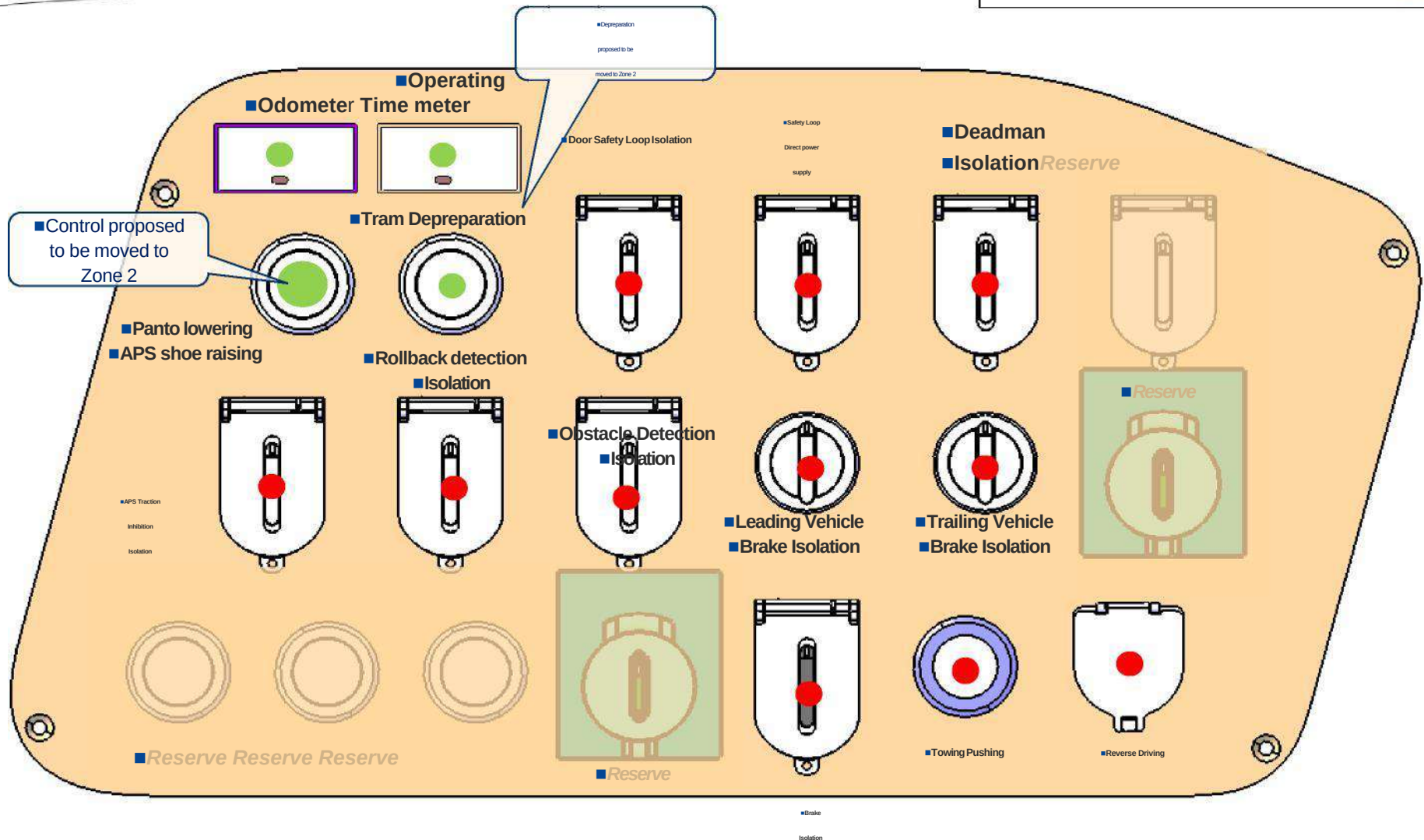
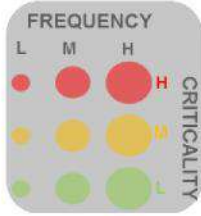
OTHER USE OF NEW TECHNOLOGIES



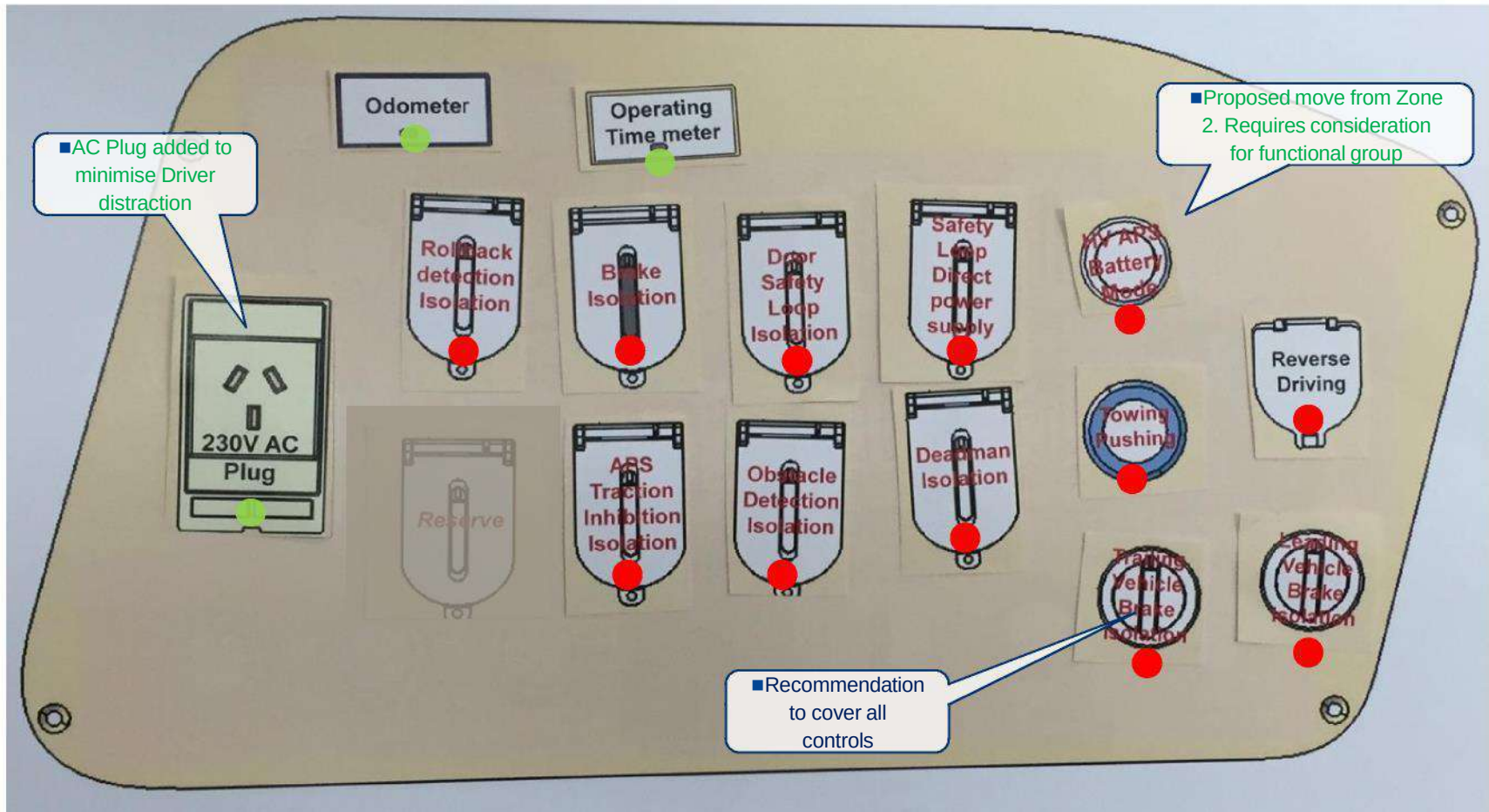
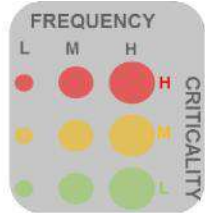
HIGH-TECH 3D MODEL? NOT EVERYTHING



HUMAN FACTORS INTEGRATION



HUMAN FACTORS INTEGRATION



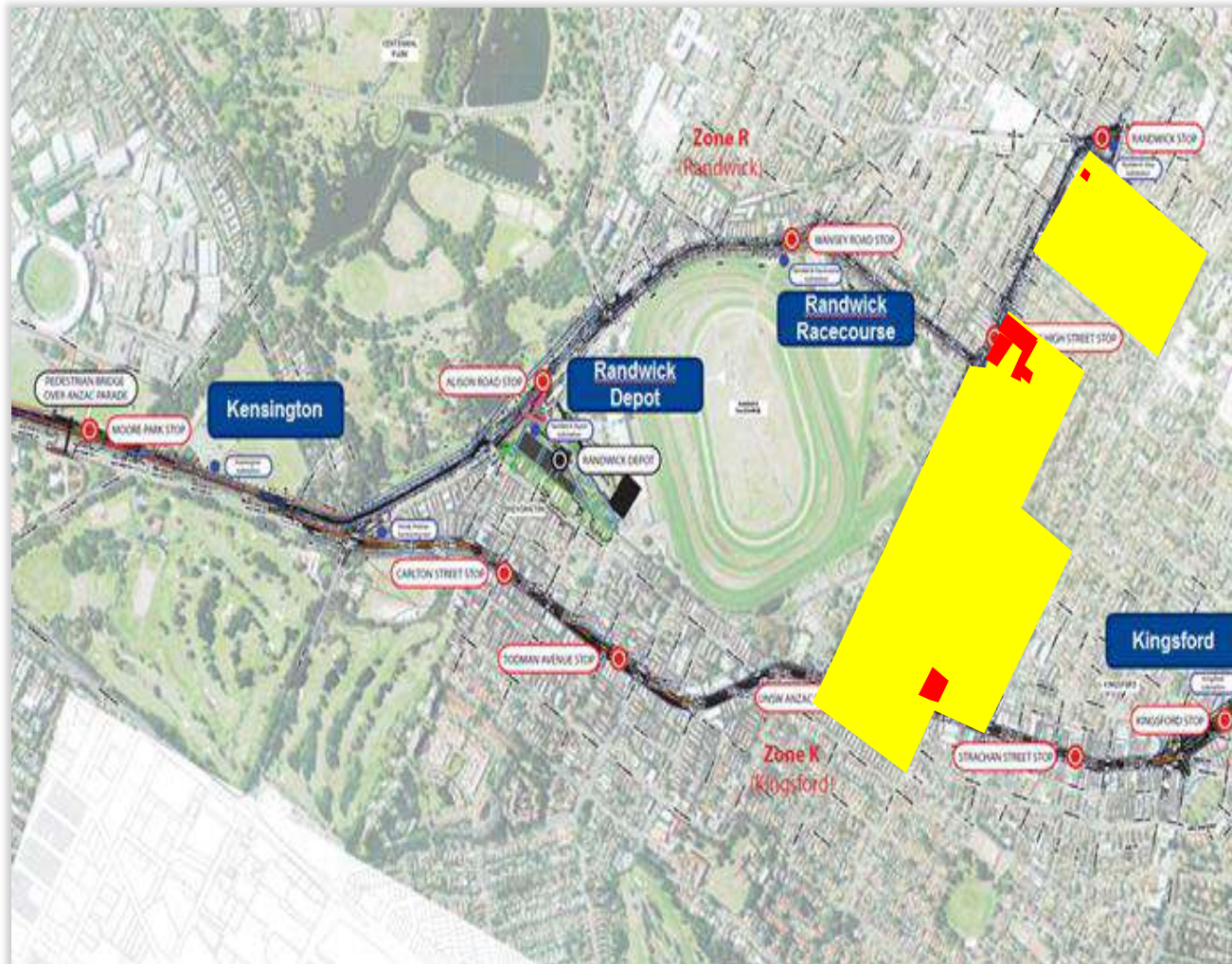
THE DRIVER'S DECK



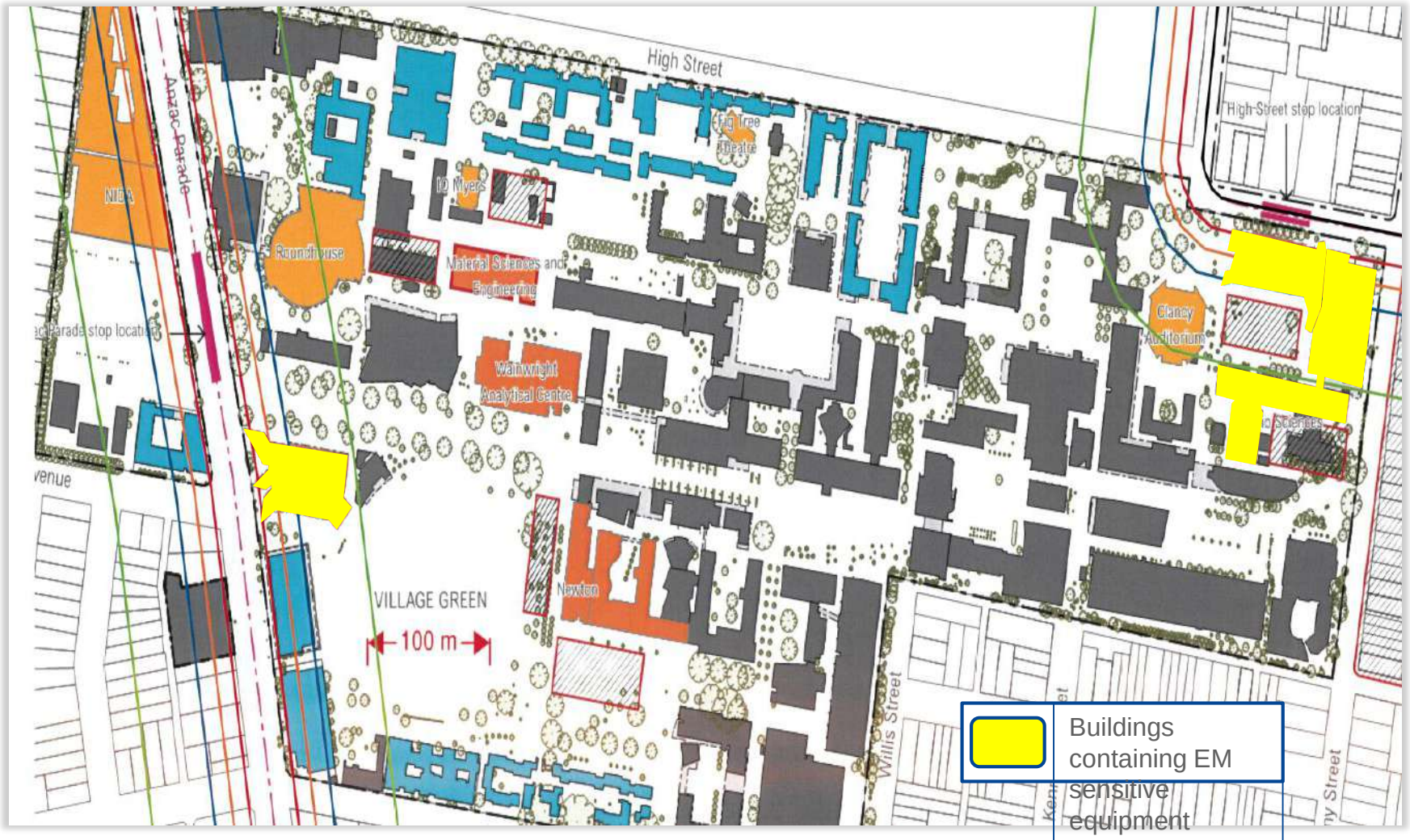
Agenda

1. Introduction
2. Project Overview and Organisation
3. Focus on System Engineering
4. Focus on APS
5. Focus on HESOP
6. Focus on Citadis X05
7. **Focus on EMC Studies**
8. Focus on Sustainability
9. Other Engineering Challenges

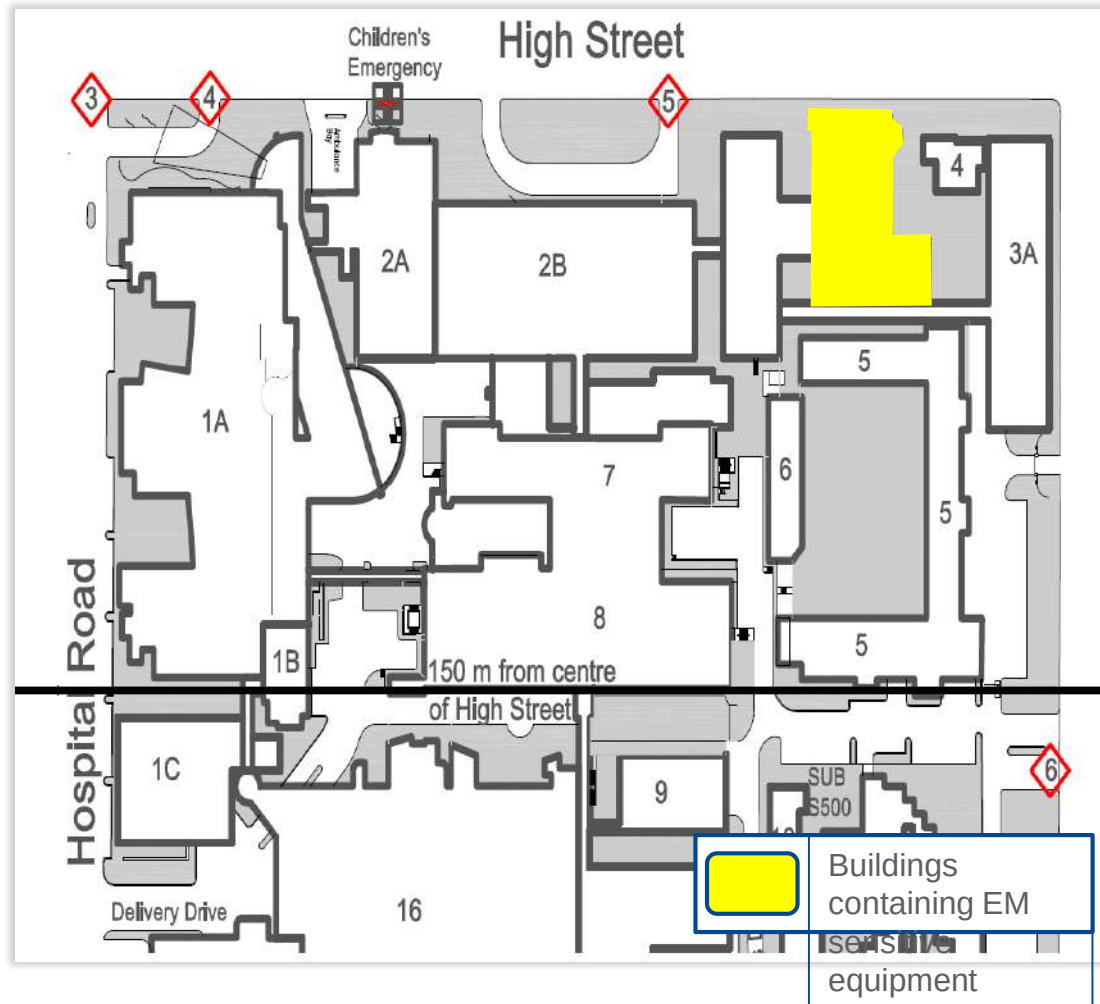
ENGINEERING CHALLENGE – PROXIMITY OF UNSW AND PRINCE OF WALES HOSPITAL



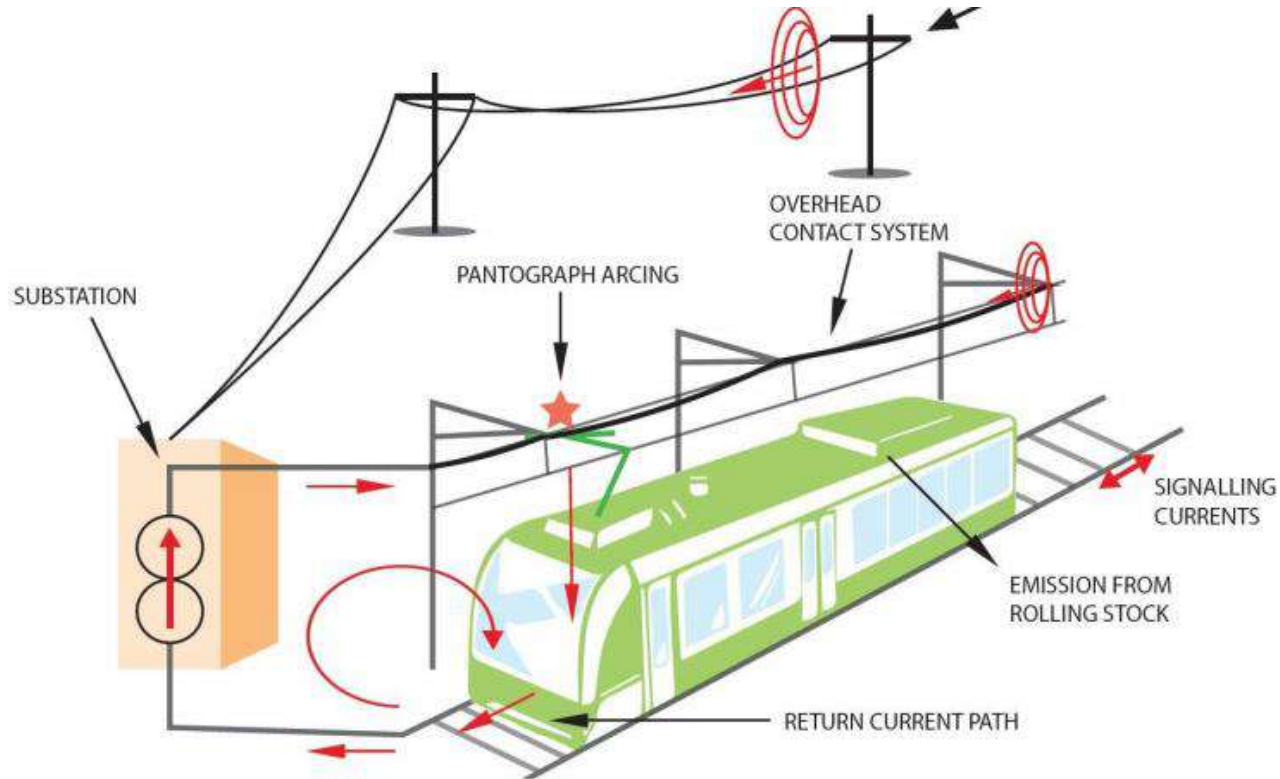
CONTEXT: UNSW EM SENSITIVE BUILDINGS



CONTEXT: PRINCE OF WALES HOSPITAL EM SENSITIVE BUILDING



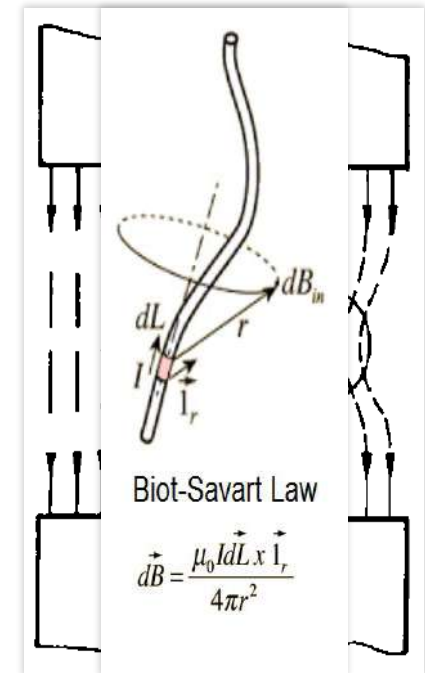
FOREWORD ON THE MAGNETIC PERTURBATION



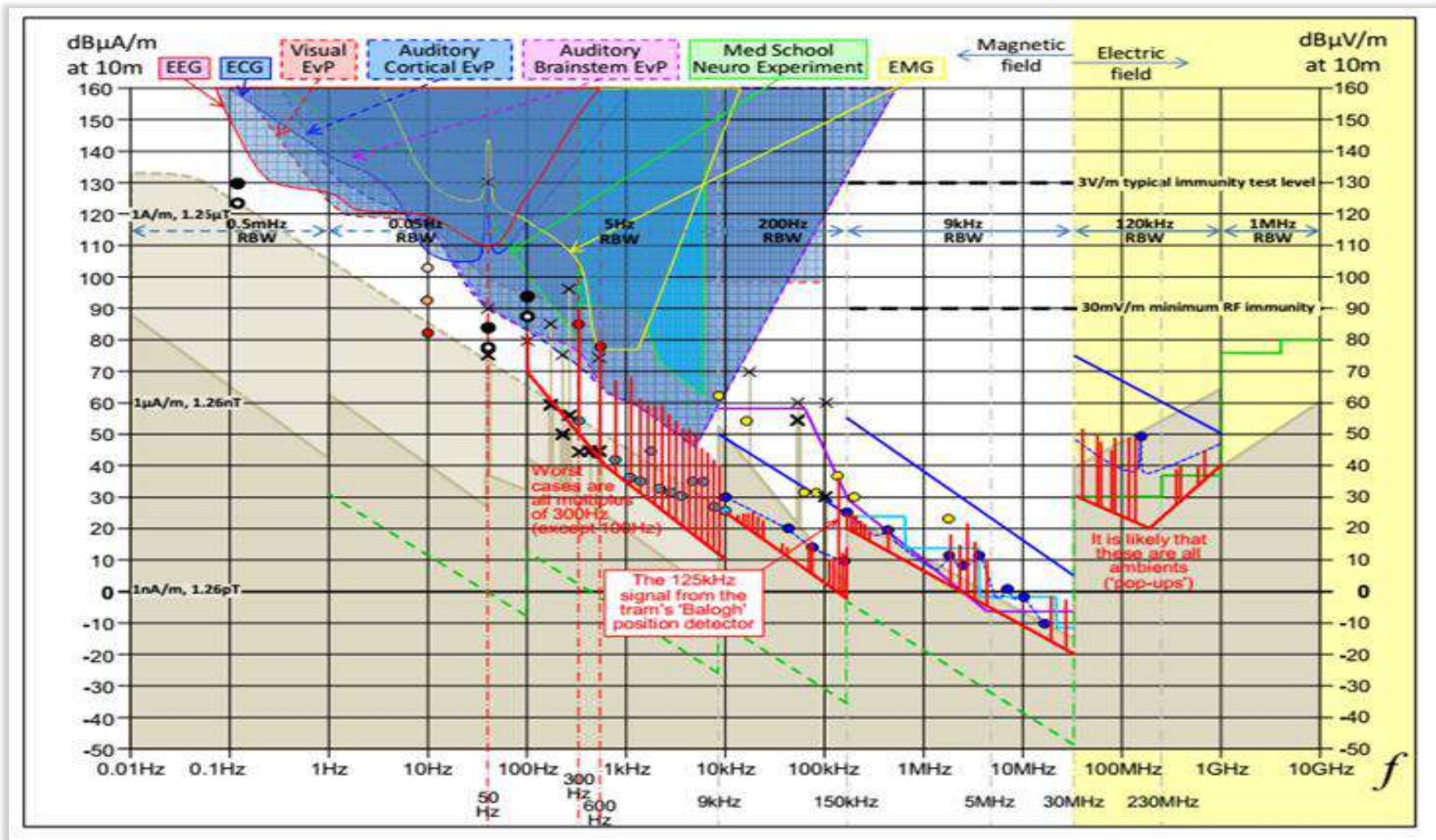
Radiofrequency (RF) and extremely low frequency (ELF) are the two main forms of EM Fields

FOREWORD ON THE MAGNETIC PERTURBATION

- The Magnetic perturbation generated by the tram is caused by:
 - The local distortion of a magnetic field (earth magnetic field) by a ferromagnetic object (Steel parts of the LRV)
 - The generation of a magnetic field by the electric equipment (current through feeder cables, injection cables, OCS, LRV, rails)



PRINCIPLES OF EMC COMPATIBILITY VERIFICATION



Example of a sensitivity graph

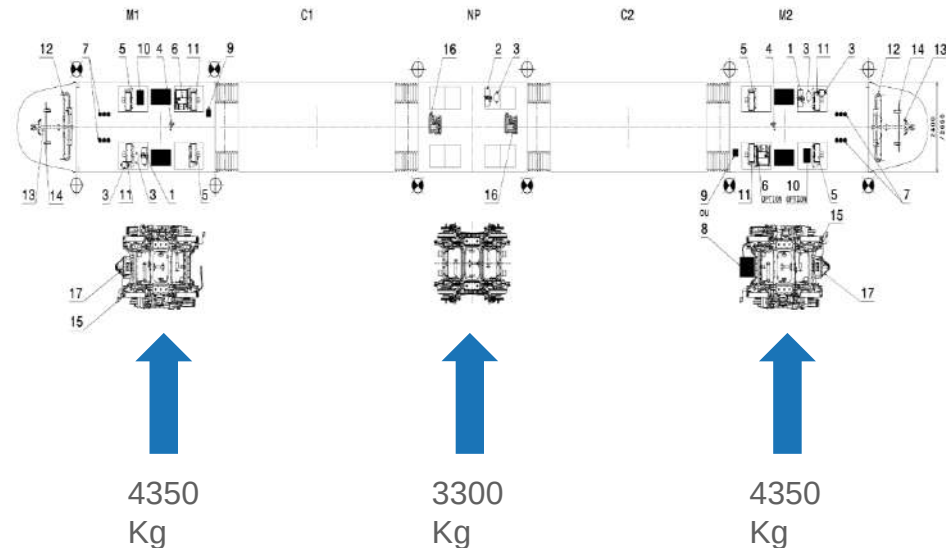
DEALING WITH EARTH FIELD DISTURBANCE

- A moving metallic object is locally disturbing the earth magnetic field
=> metallic parts of a LRV should be reduced to a minimum

In SLR Project, the steel mass of a LRV is about 20t spread along 33,4m.

Most of the frame is made of Aluminium.

Bogies constitute local mass concentration.



More than half of the tram mass is not ferromagnetic

DEALING WITH EARTH FIELD DISTURBANCE

- The low steel density LRV (compare to road vehicle) significantly reduces the geomagnetic perturbation.

=> confirmed by measurements
(November 2015)

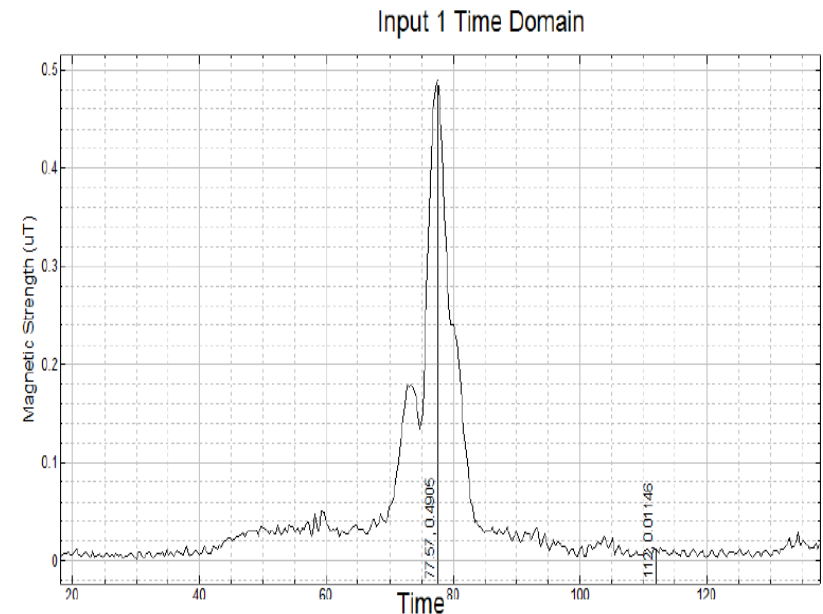


DEALING WITH EARTH FIELD DISTURBANCE

- @7m from the track, the perturbation is similar to that of a bus at 10m.

* Measurements performed in Reims at night between the 30/11/2015 & 01/12/2015 on an equivalent LRV.
Convoy moved at 15km/h

Total (offset to zero)

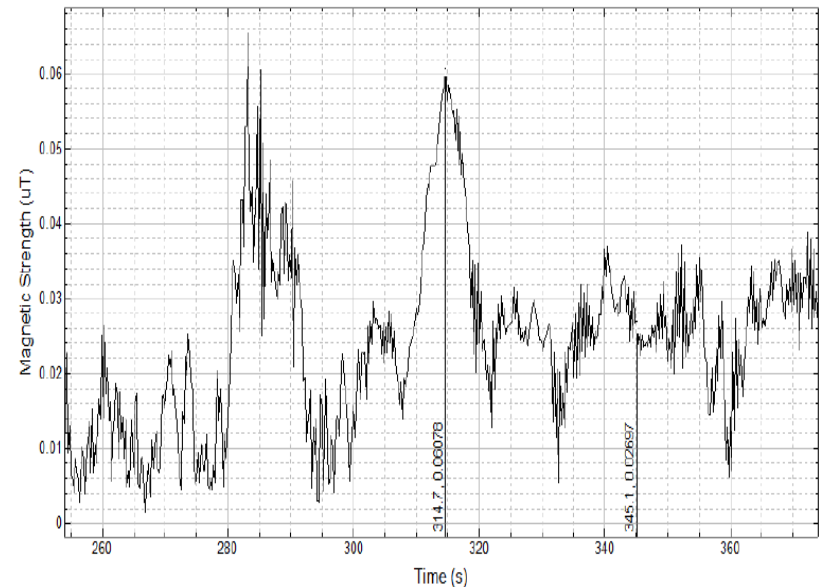


Total Magnetic perturbation at 7m from the track centreline due to the moving mass effect of 1 tram towed by a truck

DEALING WITH EARTH FIELD DISTURBANCE

- @21m from the track, the perturbation is negligible*

Total (offset to zero)



Total Magnetic perturbation at 21m from the track centreline due to the moving mass effect of 1 tram towed by a truck

* Measurements performed in Reims at night between the 30/11/2015 & 01/12/2015 on an equivalent LRV.
Convoy moved at 15km/h

REDUCING THE DC MAGNETIC FIELD

MAIN PRINCIPLES/IDEAS

- **REDUCTION OF THE OVERALL IMPEDANCE OF THE TRACTION NETWORK:**
 - LESS IMPEDANCE = LESS LOSSES = LESS CURRENT FOR SAME POWER
- **REDUCTION OF THE SIZE OF THE FIELD EMITTING LOOP**
 - GREATER DECAY RATE OF THE FIELD.

REDUCING DC MAGNETIC FIELD

- Normal design : 1 injection every 300m

Summary of the EM Perturbation @10m

EM perturbation on normal section :
100

REDUCING DC MAGNETIC FIELD

- Enhanced design : 1 injection every 30m
 - Feeder Pole every 30m
 - Feeder Box every 30m
 - Injection Cables every 30m
 - Additional Traction fault equipment
 - Additional Surge Arrestor

Summary of the EM Perturbation @10m

- 28%  EM perturbation on normal section :
100

EM perturbation with injection every 30m :
72

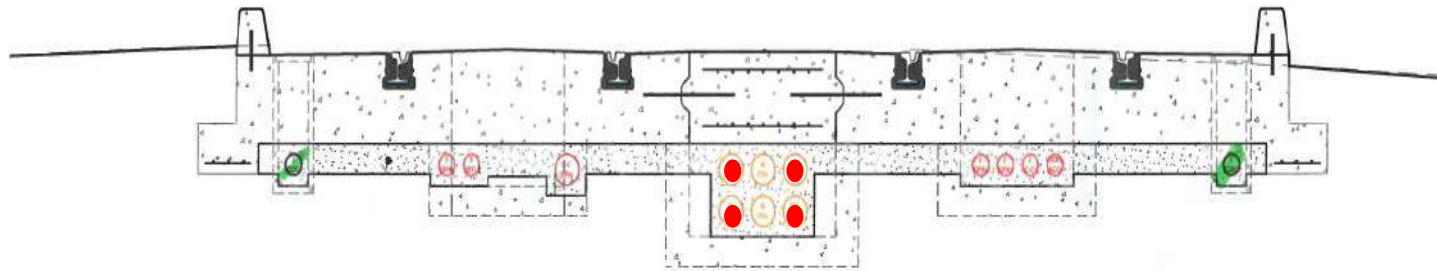


REDUCING DC MAGNETIC FIELD

- Enhanced design : More feeder cables
 - 2 additional 400mm² Cu feeder cables
 - => reduction of the resistance

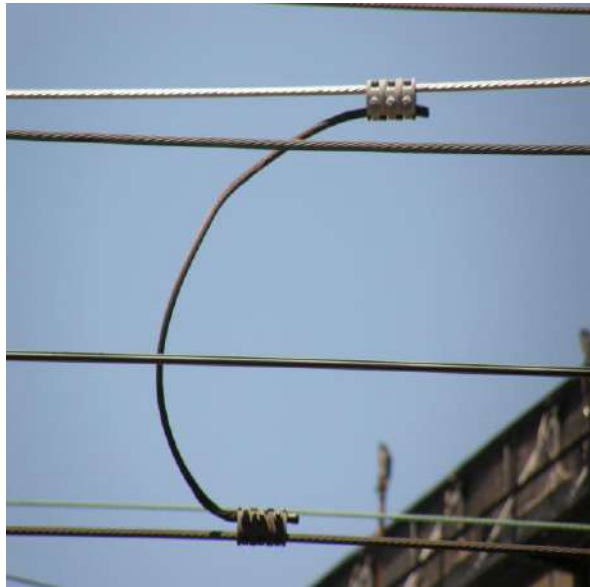
Summary of the EM Perturbation @10m

- 39%	EM perturbation on normal section :
	100
	EM perturbation with injection every 30m :
	72
	EM perturbation with added feeder cables :
	61



REDUCING DC MAGNETIC FIELD

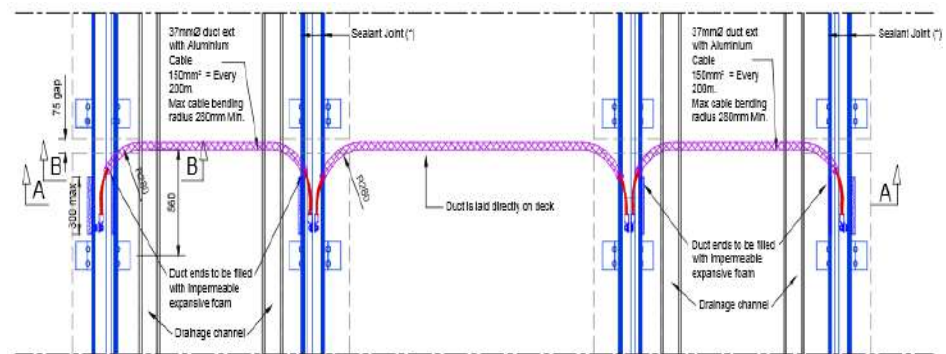
- Enhanced design : Crossbonds every 30m
 - Track crossbond every 30m
 - OCS crossbond every 30m
- => Total equipotentiality of the rails & OCS



Summary of the EM Perturbation @10m

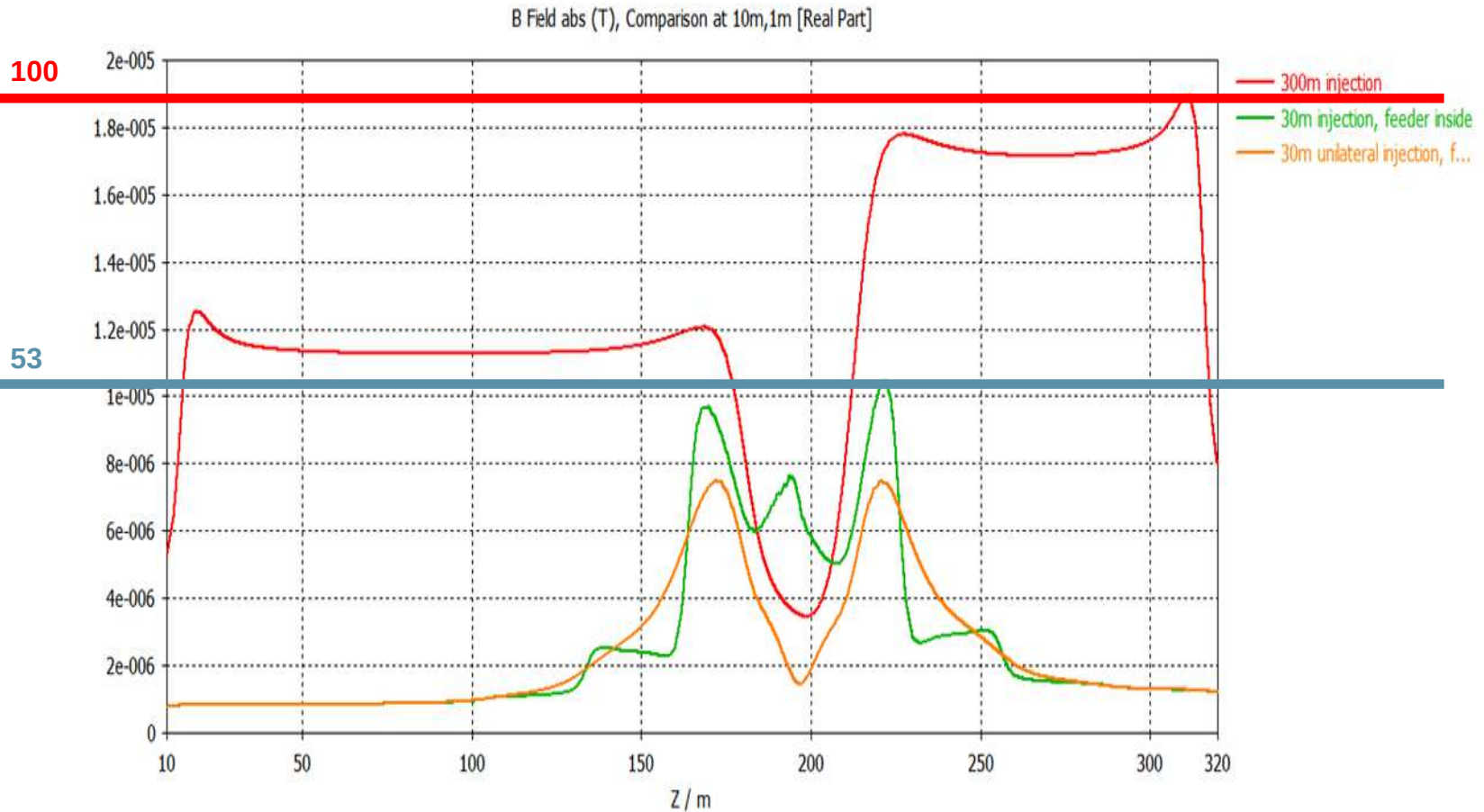
EM perturbation on normal section :	100
EM perturbation with injection every 30m :	72
EM perturbation with added feeder cables :	61
EM Perturbation with crossbonds every 30m :	53

- 47%



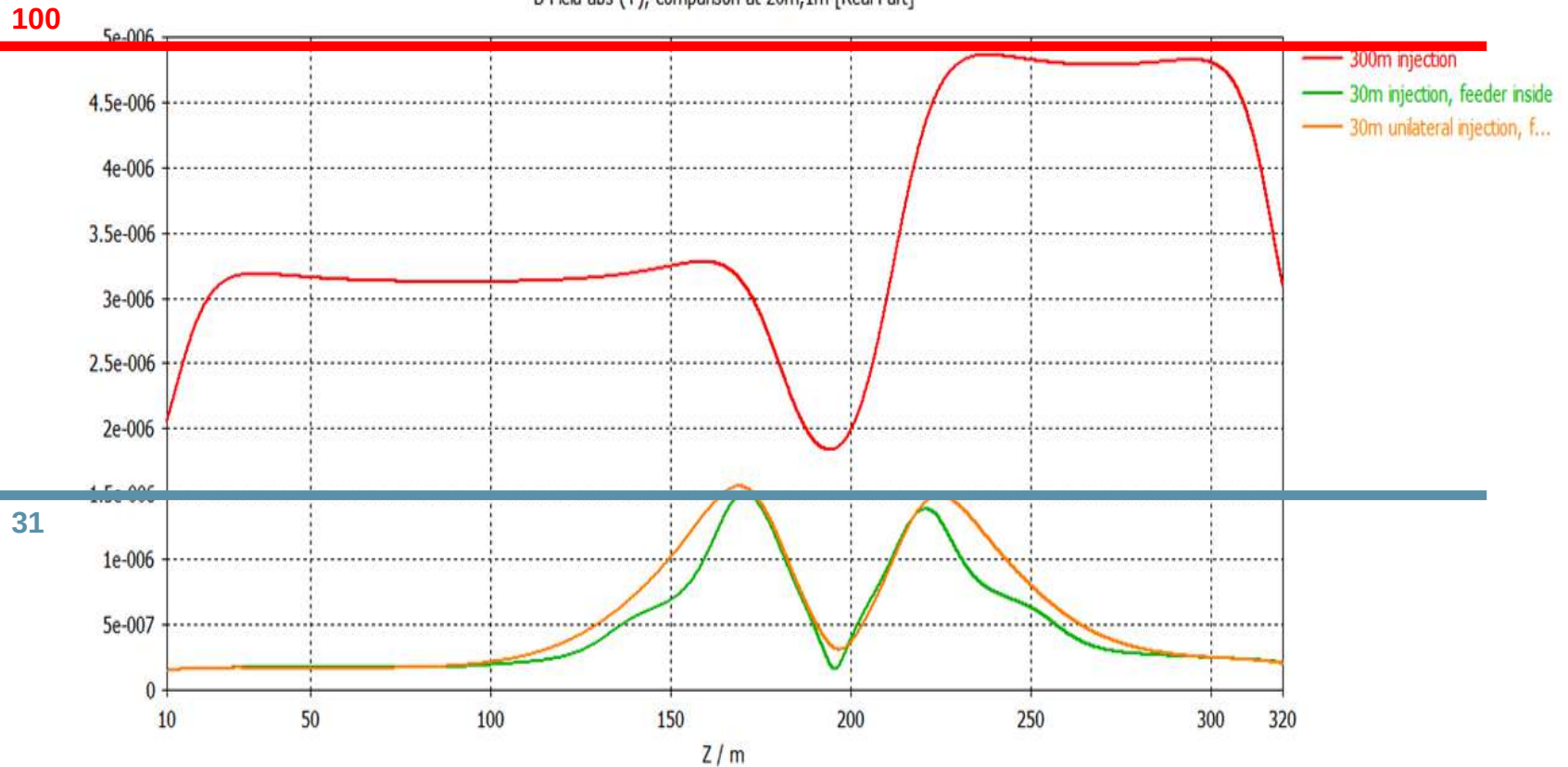
REDUCING DC MAGNETIC FIELD

RESULTS AT 10 M



REDUCING DC MAGNETIC FIELD

RESULTS AT 20 M



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SLR - Sustainability requirements



Sydney Light Rail

Public Private Partnership

Project Deed

Schedule E1 Scope and Performance Requirements

Appendix 7 - Sustainability

- 17 pages document
- Requirements to comply with other standards:
 - ISO 14040, 14064
 - AS 5334-2013
 - BS 8903
 - ISCA
 - SDG



- 52 credits
- 3 levels for each credit
- Objective: Excellent - 65/100

Management Systems	Man
Procurement and Purchasing	Pro
Climate Change Adaptation	Cli
Energy and Carbon	Ene
Water	Wat
Materials	Mat
Discharges to Air, Land and Water	Dis
Land	Lan
Waste	Was
Ecology	Eco
Community, Health, Wellbeing and Safety	Hea
Heritage	Her
Stakeholder Participation	Sta
Urban and Landscape Design	Urb
Innovation	Inn



NSW Sustainable Design Guidelines Version 3.0

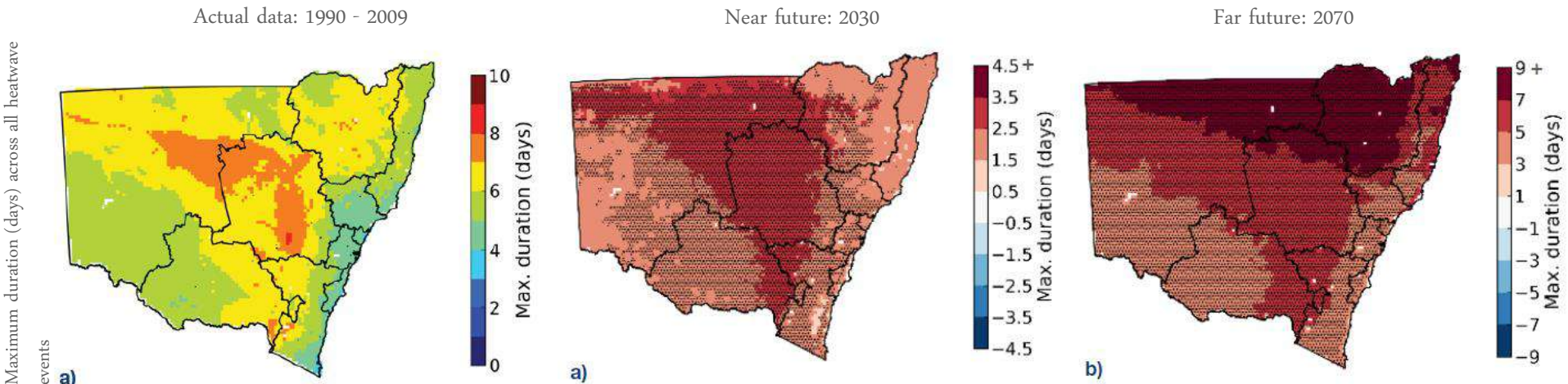
- 23 Compulsory initiatives
- 208 Discretionary initiatives
- Objective: Gold – 80/100



Climate change

- 1st project requesting analysis to demonstrate resilience to climate change of proposed equipment and infrastructure

Heatwave events across NSW actual and projections



=> Tram system designed to withstand outside $T^{\circ} > 40^{\circ}\text{C}$ (infrastructure and equipment resistance , HVAC dimensioning)
and even $>50^{\circ}\text{C}$ in degraded mode

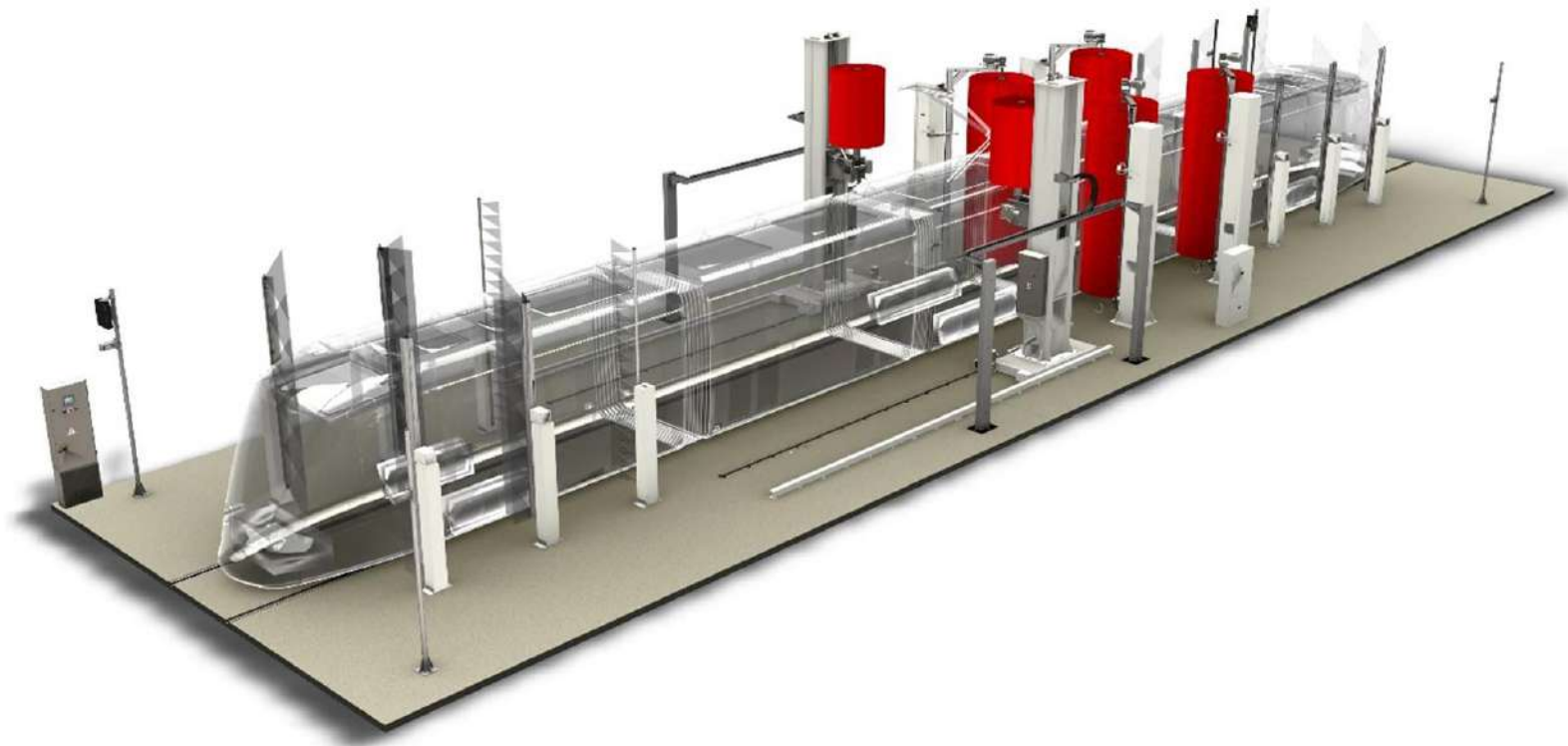
Reducing project energy & carbon footprint

- Monitoring, reduction and use of renewable energy
- SLR target: energy requirements reduced by 15-25% vs. business as usual (level 2 of 3 in ISCA dedicated category)
- Achievable for Systems thanks to:
 - Citadis X05 generation
 - Permanent magnet motor
 - HESOP system
- Civil work footprint reduction:
 - Use of recycled materials:
 - Aggregate
 - Concrete
 - Substitution of 30% of cement
- Other:
 - 150 kW solar panels on depot roof



Limiting water use

- Monitoring, reduction and use of non potable water

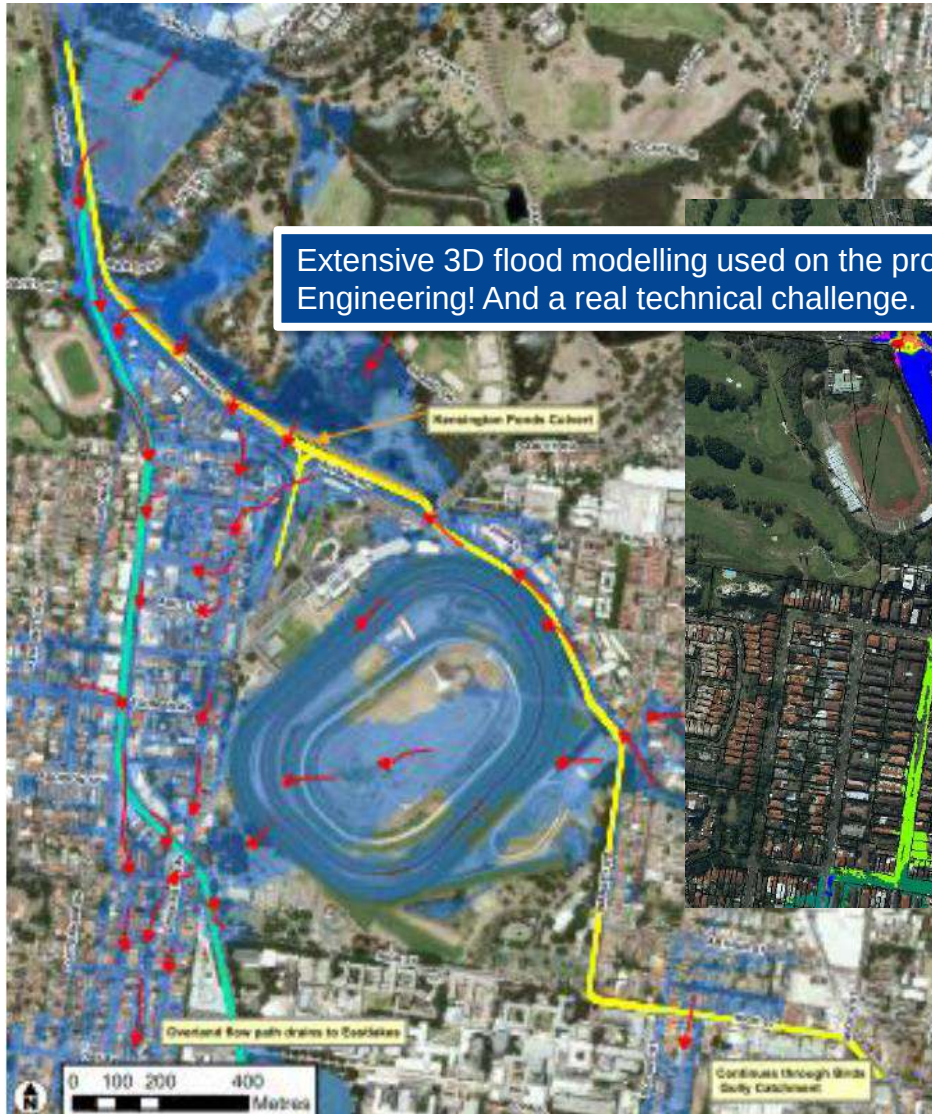


- Target: 80% of water for the wash machine to be collected, recycled and reused
- Water will be mostly harvested rainwater

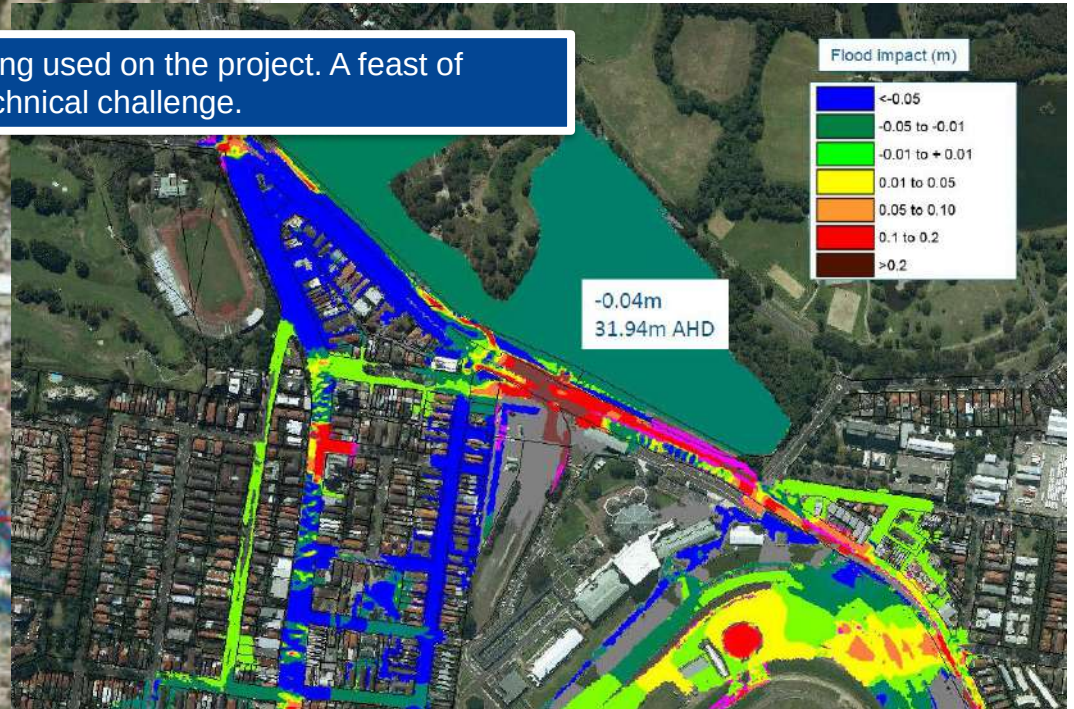
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Flooding issues



Extensive 3D flood modelling used on the project. A feast of Engineering! And a real technical challenge.



Flood Impact (m)



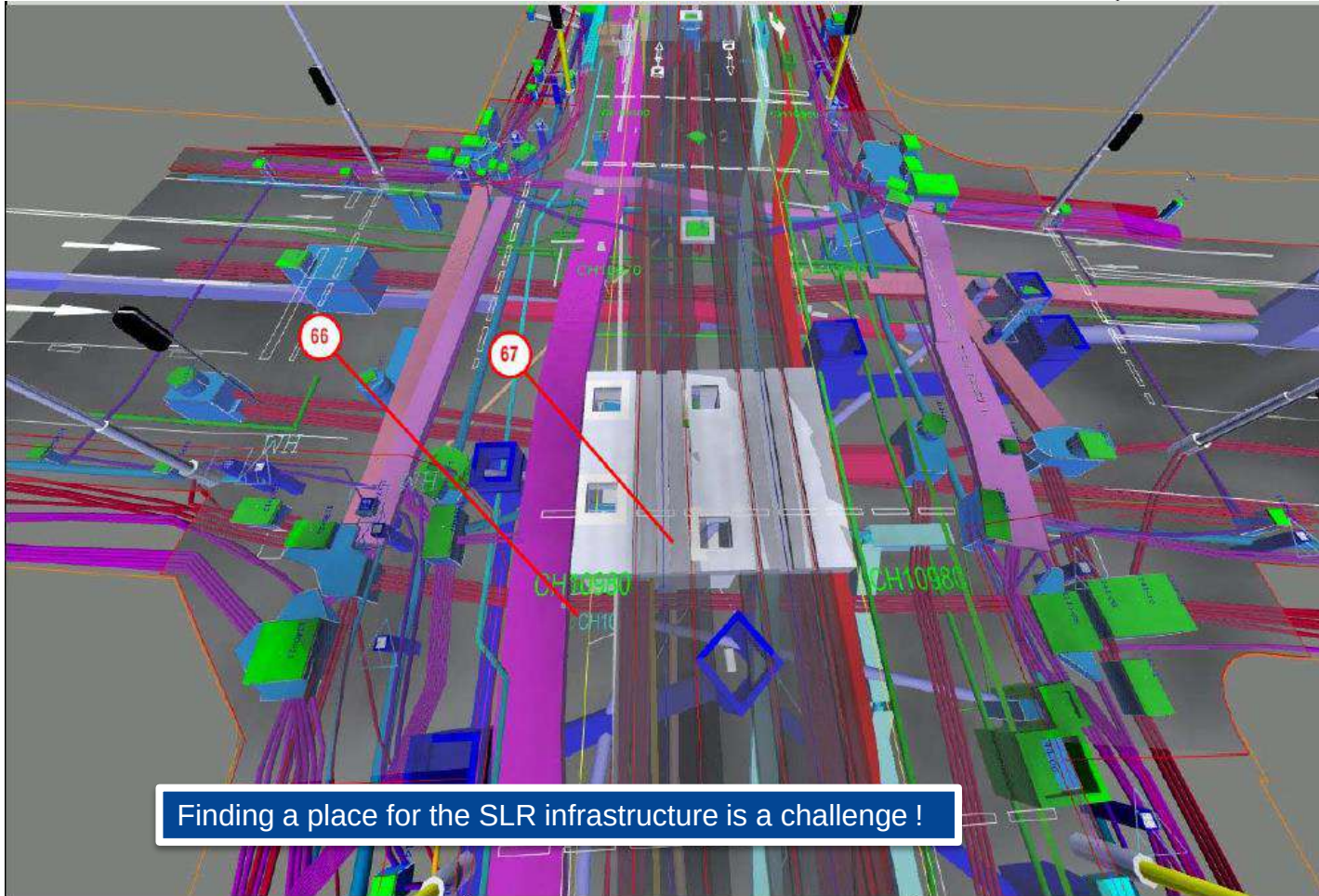
SLR DJV

JACOBS



Courtesy of

ALSTOM



Finding a place for the SLR infrastructure is a challenge !

Courtesy of



- SLR project is an Engineering Feast with Innovation at all levels
 - APS system in CBD
 - HESOP traction power system
 - Latest development of Citadis
 - Extensive use of 3D modelling
 - Sustainability engineering to a state-of-the art level
- New disciplines of engineering emerge in our activity (Dynamic modelling, 3D, Virtual reality, etc)
- There is a fantastic opportunity for all sorts of people with different background to bring something in the world of Transport engineering



Thank you for your attention
Any Question?