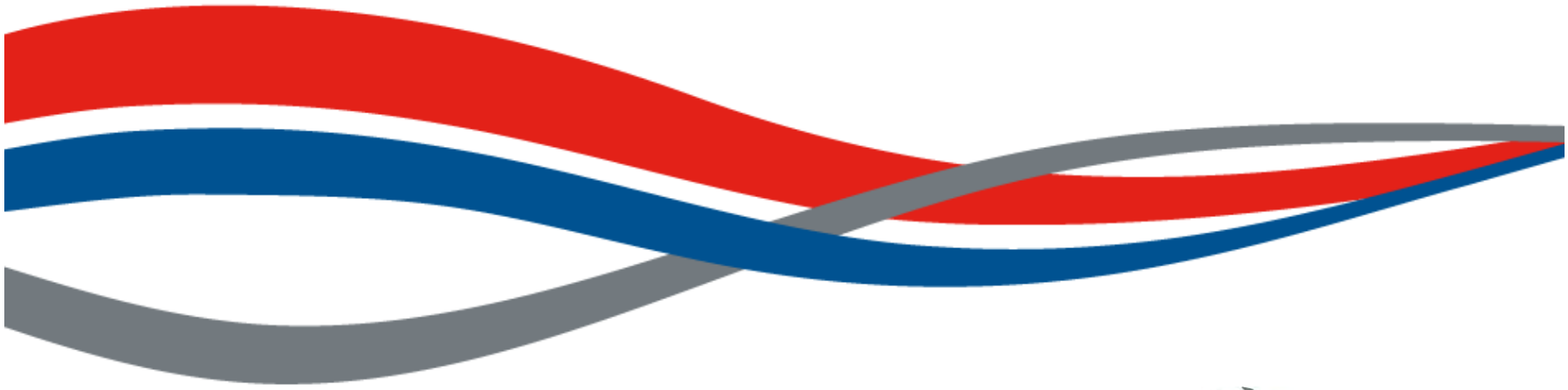
TramWave

Catenaryless power supply system

Robert Vitali
Mass Transit Product Manager
Ansaldo STS



AnsaldoSTS

TramWave solution

TramWave is the key technology to :

- design the future of cities in a “low carbon” scenario.
- maintain and preserve natural or cultural heritage, artistic beauty landmarks and monuments
- make life more pleasant for the residents
- respect the urban legacy and the old buildings near the line
- integrate multi-modal urban transit solutions

Introduction to TramWave
Characteristics of the application

- **TramWave is an innovative power supply solution designed to minimize :**
  - Visual impact removing the overhead catenary
  - Displacement of utilities (water pipes, gas connectors, electrical grid etc.)
  - Constraints to urban vehicular and pedestrian circulation.
  - Effect of stray currents
  - Pollution
- **TramWave is as solution apt to maximize :**
  - Eco-friendliness
  - Safety (only gravity and electro-magnetic principles), reviewed and validated by TŰV Rhineland
  - Absence of electronics to guarantee safety in all conditions
  - Limited width of the powered section
  - Diagnostic level in all perturbed conditions

AnsaldoSTS

Introduction to TramWave
Characteristics of the application

- **TramWave is a solution designed to be applicable to:**
  - Tram lines
  - Bus lines
  - Special purpose vehicles (utility vehicles, urban maintenance vehicles, etc.)
  - A mix of any of the previous
  - New concept of private vehicle + urban development
- **TramWave is a flexible and modular system designed to be adaptable to a widespread array of configuration and demands of administration and planners**

Introduction to TramWave
Characteristics of the application

- **Tram application:**
  - Continuous power supply
  - Same level of performance as per traditional catenary (VAC, acceleration, speed etc.)
  - No need of auxiliary systems onboard for autonomous movement
  - TramWave, can virtually be installed on any rolling stock provider
  - Mixed mode power supply. TramWave and traditional catenary (i.e. TramWave in historic or architectural centers, traditional in the suburbs)

AnsaldoSTS

Introduction to TramWave
Characteristics of the application

- **Bus application:**
  - Same level of performance as per traditional buses (VAC, acceleration, speed etc.)
  - Auxiliary systems onboard for autonomous movement off the TramWave sections to overcome obstacles on the line
  - Auxiliary systems onboard for autonomous movement off the TramWave sections even for considerable length, up to 5-6 km
  - Short recharge time on the tramwave line while running (5 minutes per km off TramWave line)
  - Passive self-centering system of the pickup shoe over the TramWave line

Introduction to TramWave
Characteristics of the application

- TramWave is covered by several worldwide patents owned solely by Ansaldo STS
- TramWave has been implemented in all electric bus version in TRIESTE (Italy)
- TramWave has been revised and assessed by TüV Rhineland
- TramWave has been homologated by the Italian Ministry of Transportation in March 2002

All Electric Bus TramWave application

AnsaldoSTS

TramWave tram application

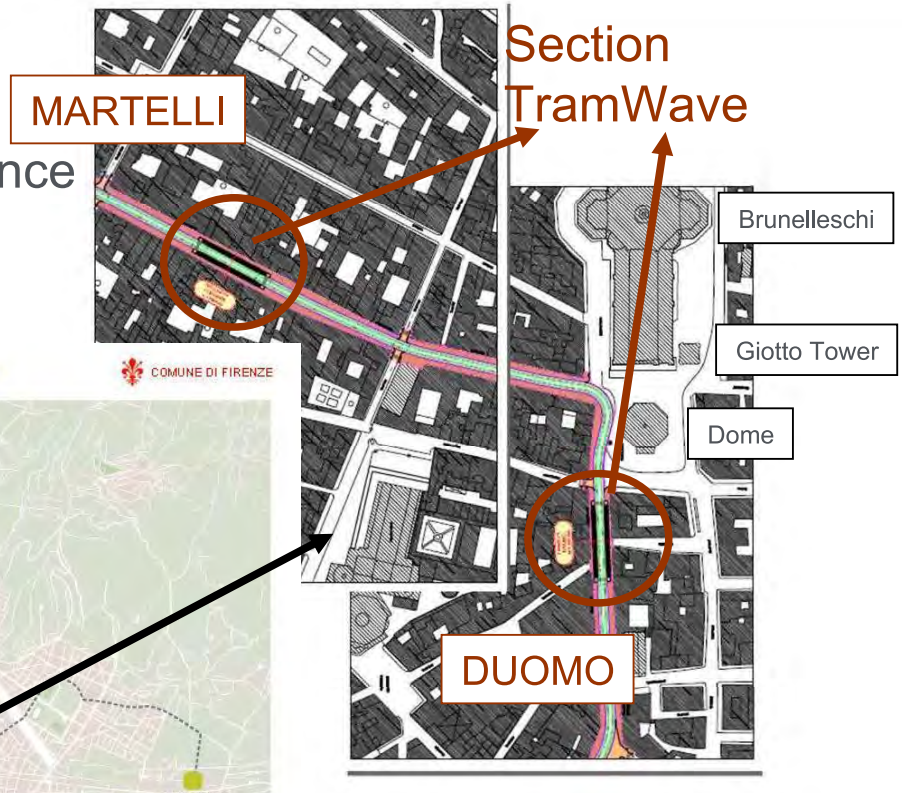
TramWave installed on the test track in Naples.
Stress tests for extreme and unusual conditions

AnsaldoSTS

Tram application in the test site in Naples

TramWave for Florence

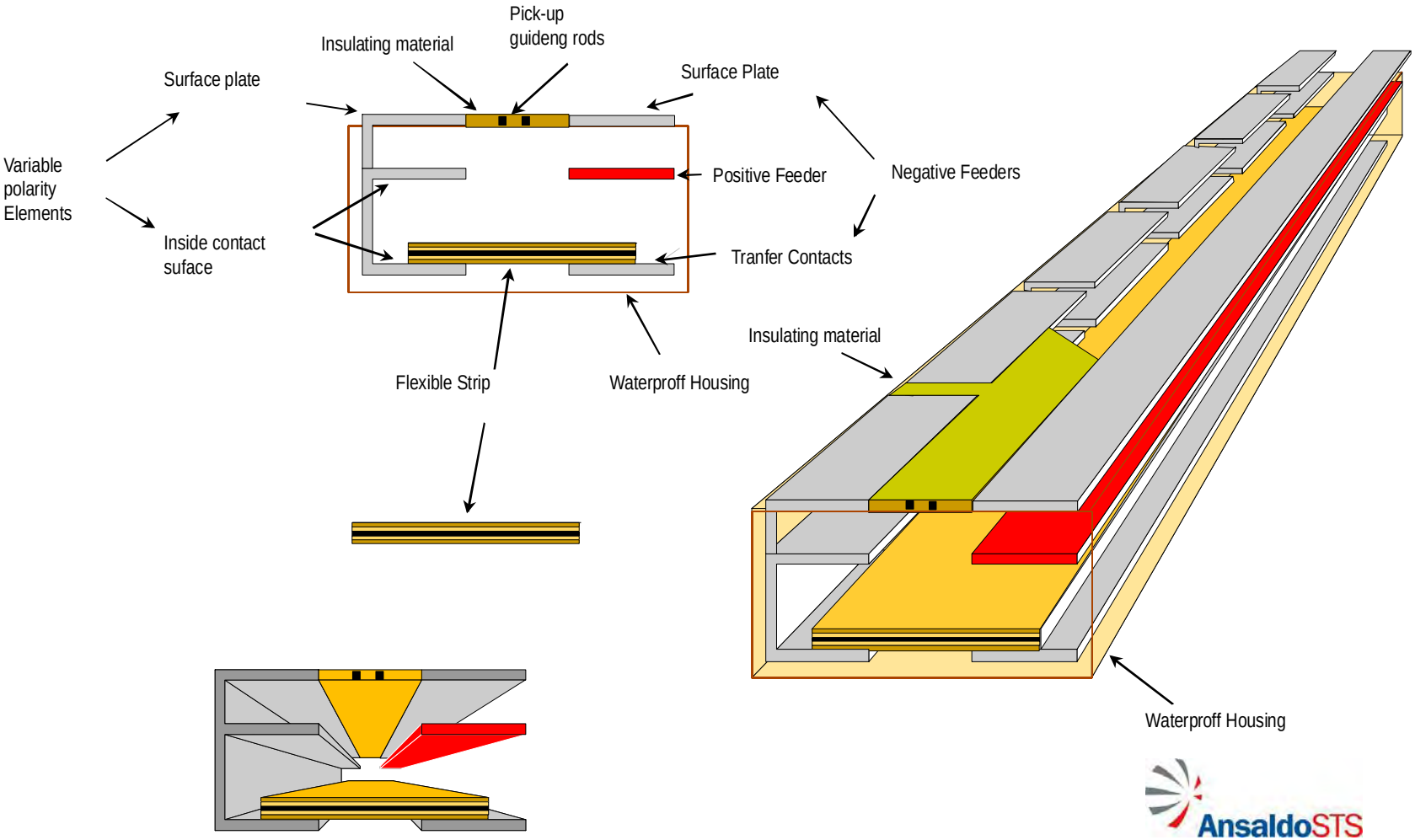
Ansaldo STS is the leader for the Construction of 3 tramlines in Florence



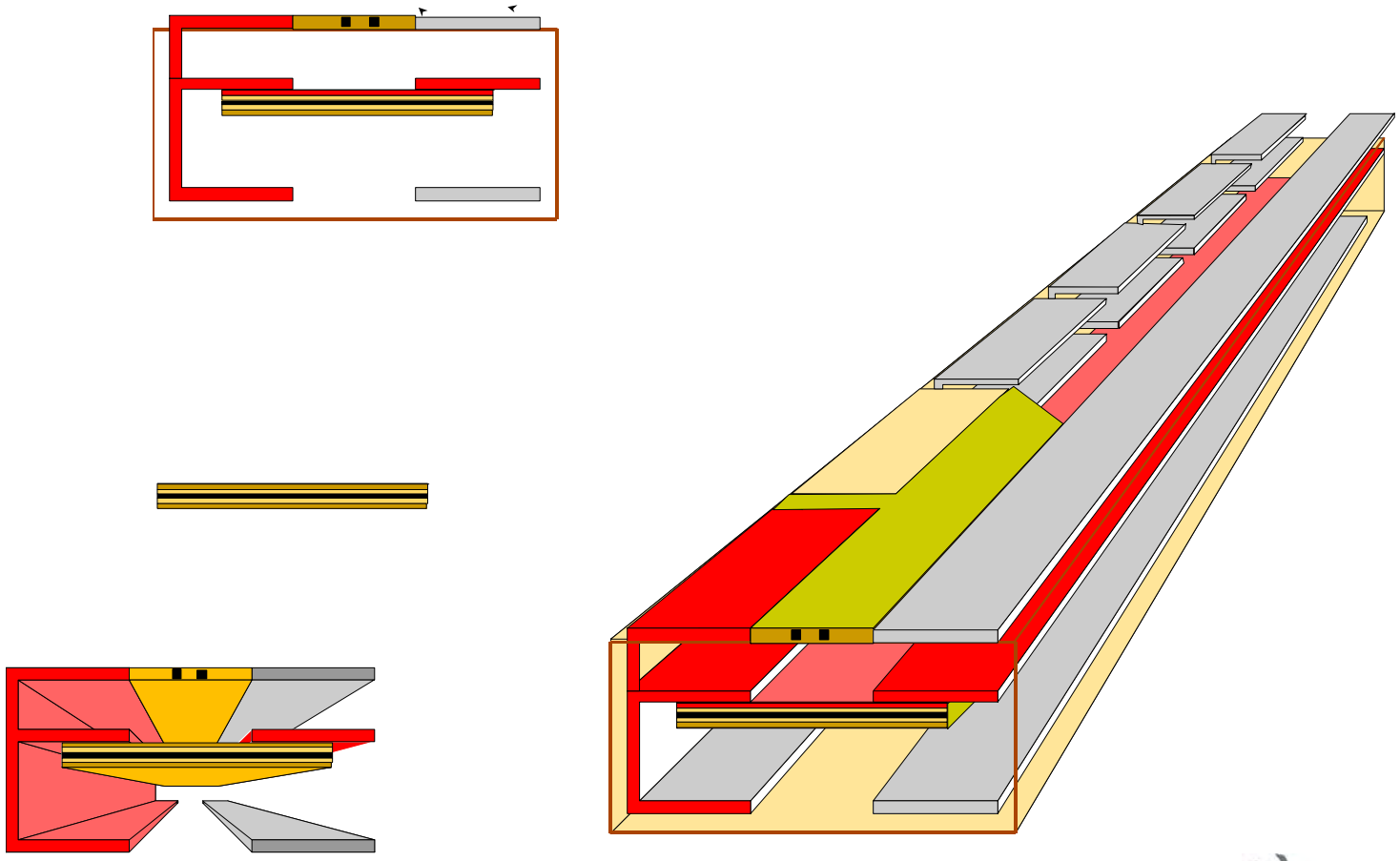
AnsaldoSTS

TramWave Concept

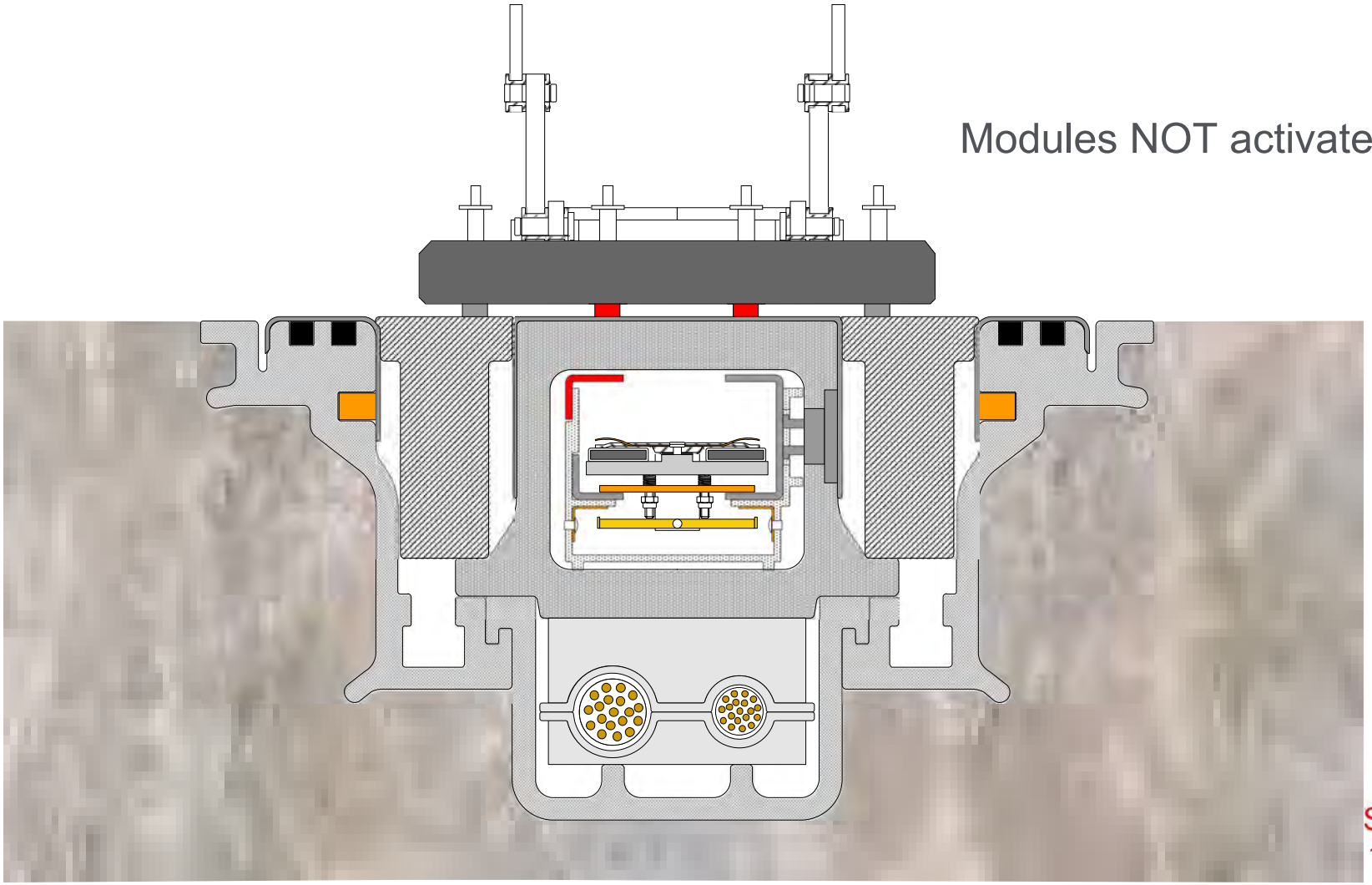
Basic functioning concept of TramWave

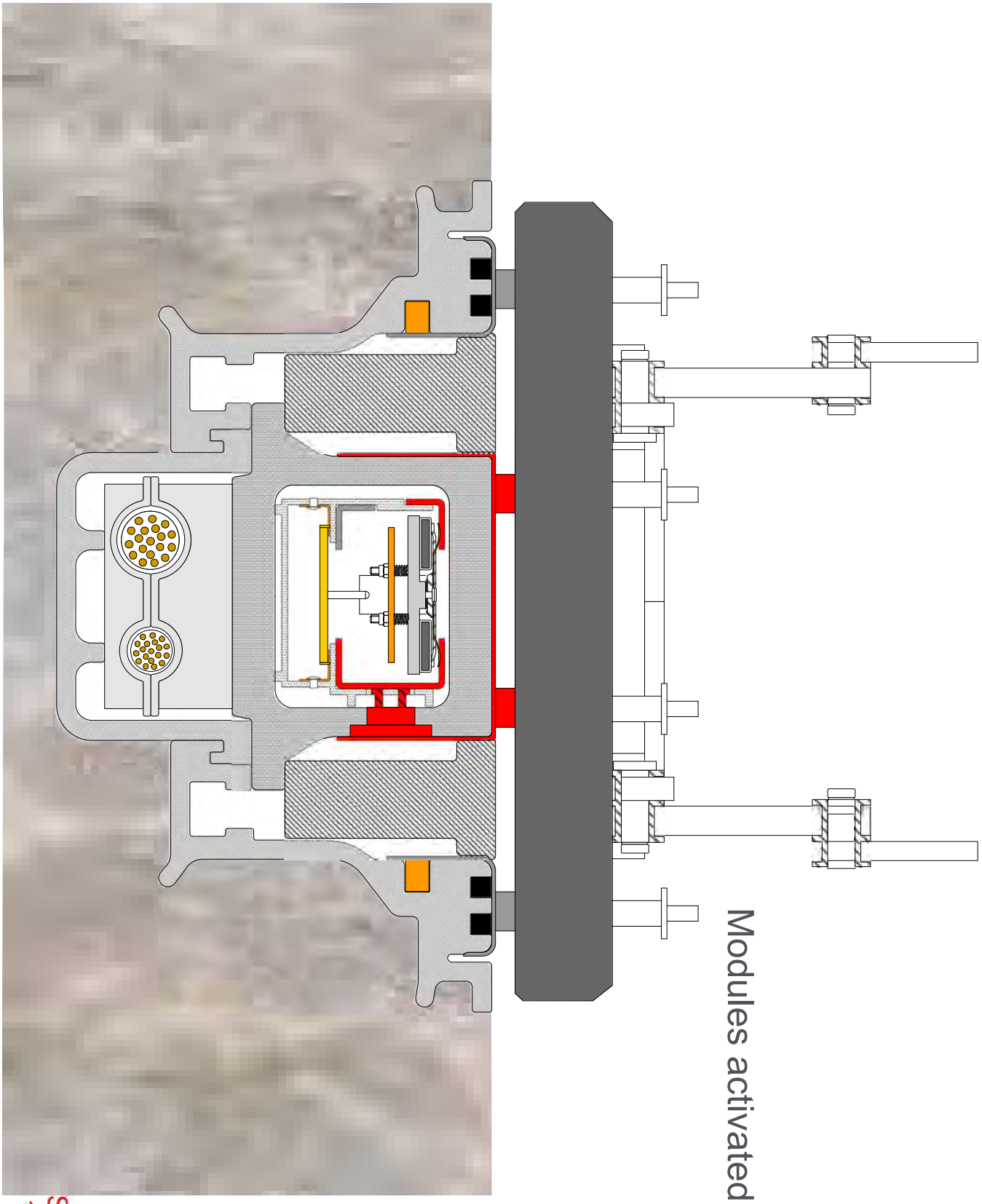


Basic functioning concept of TramWave

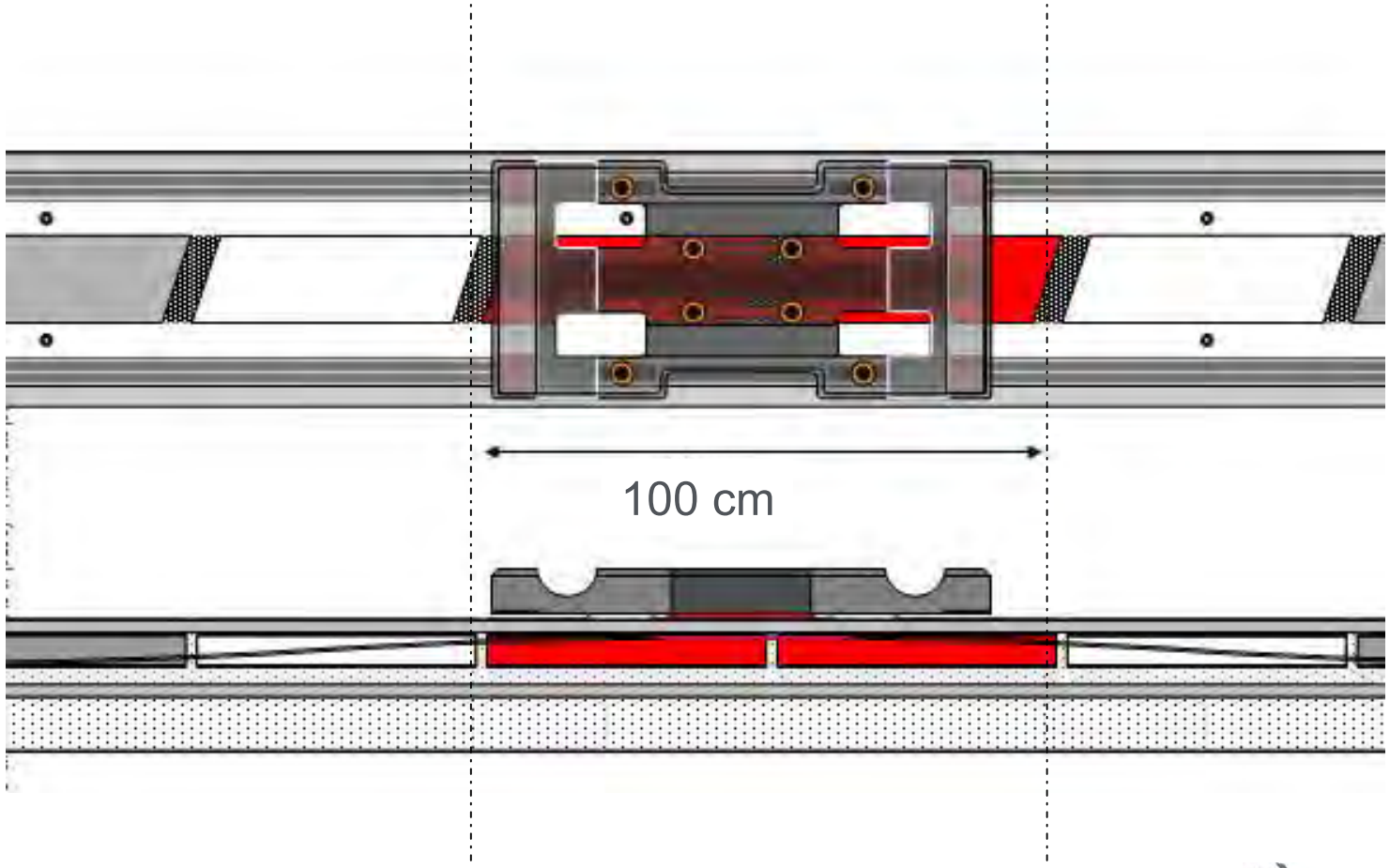


Modules NOT activated

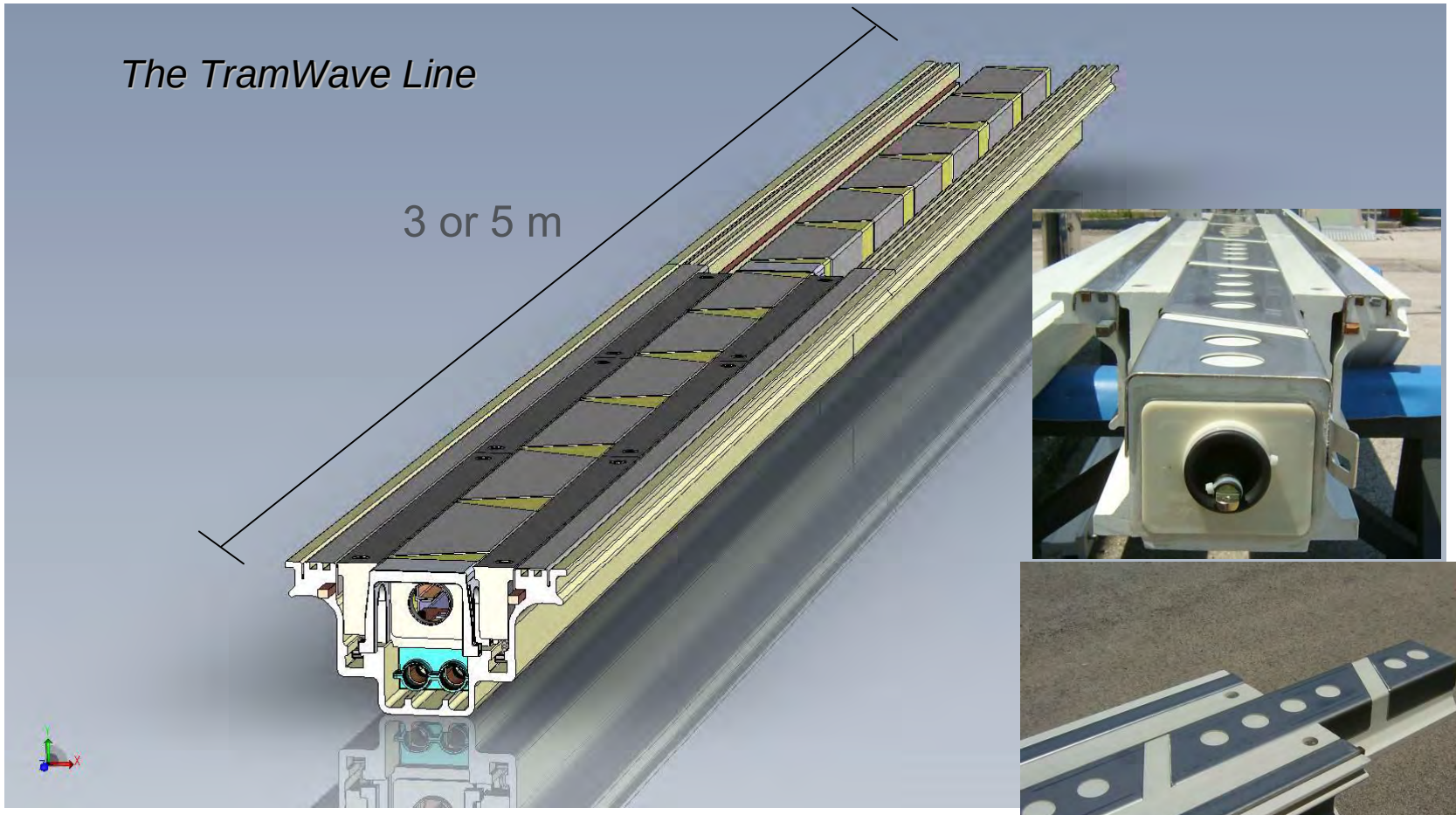


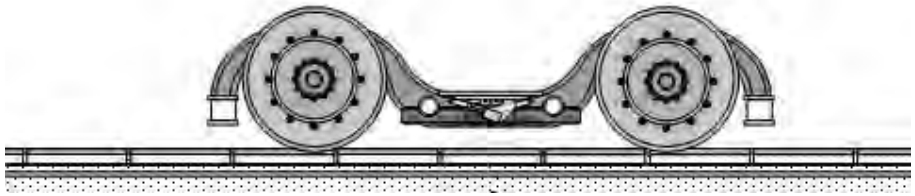


Power collector and activated modules



Module layout





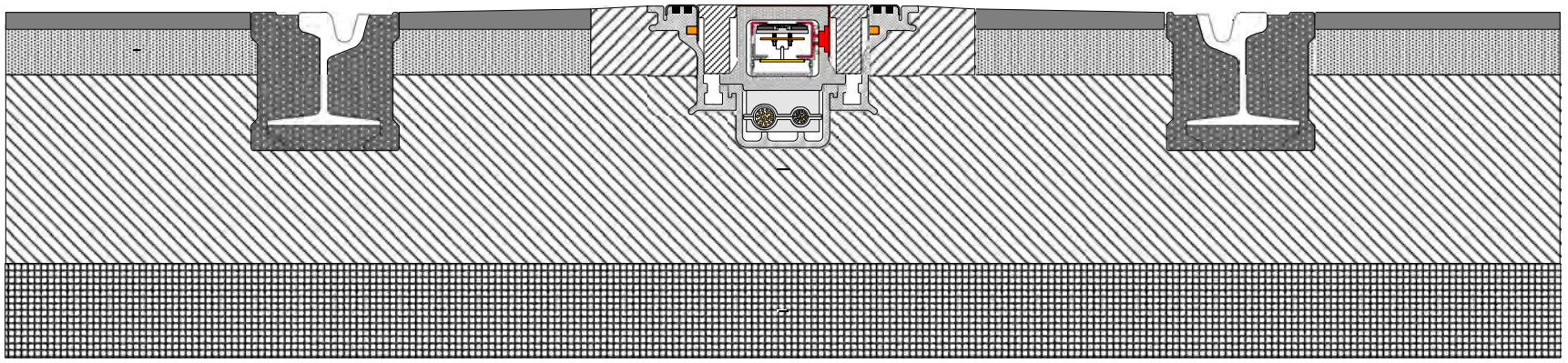
Power collector rest position

- 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.

Power collector active

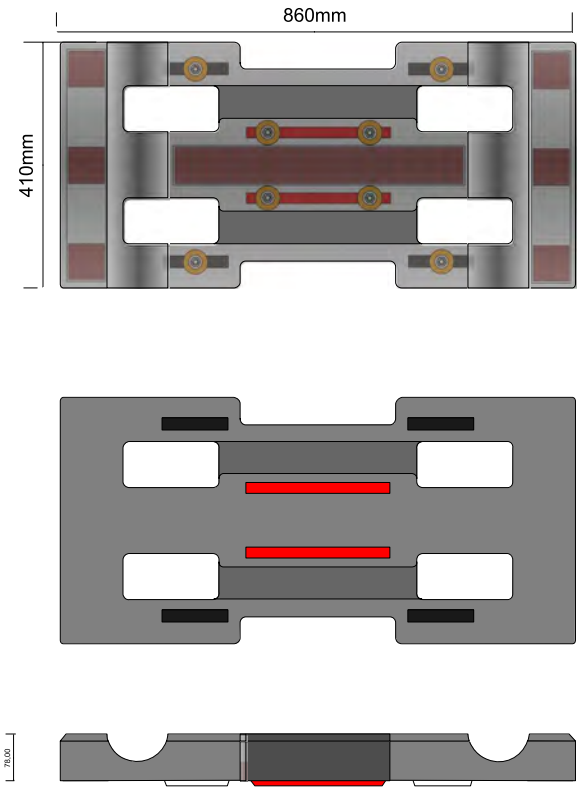
- the power collector is in contact with the line segments
- the flexible belt reaches its working position and activates the underlying segment (s)

Street level section with the line fully equipped, circulation ready for tram as well as all electric buses



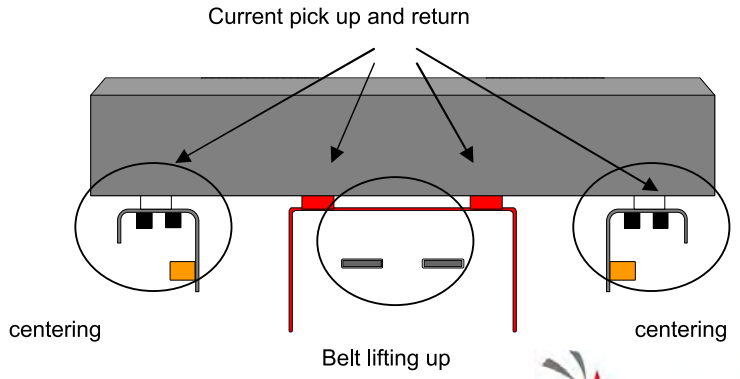
AnsaldoSTS

The vehicle magnetic power collector or pickup shoe



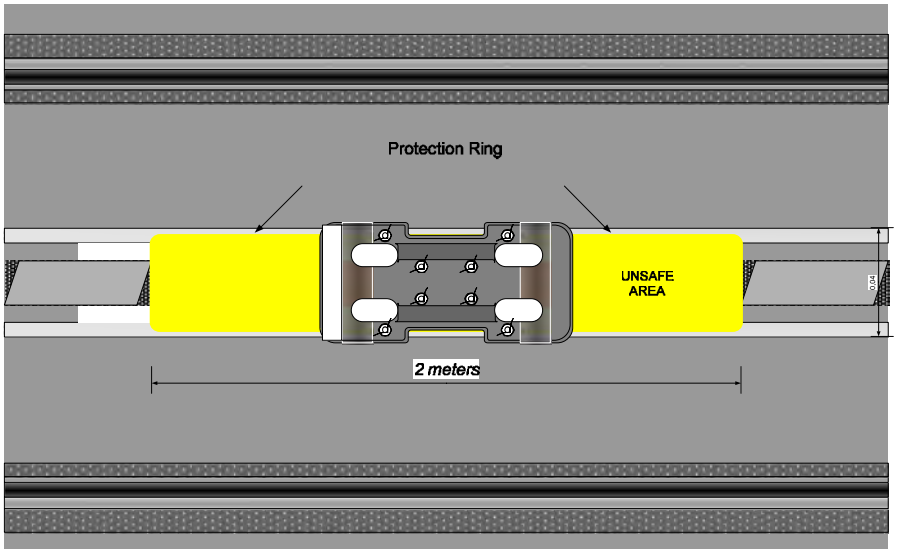
Three main functions

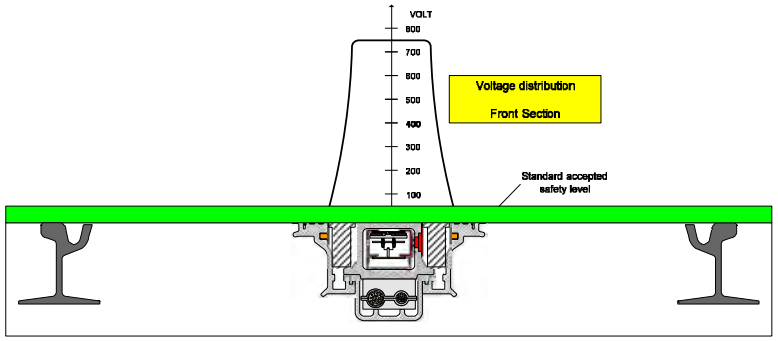
- Activation of line segments
- Current pick up and current return
- Guide the power collector over the line

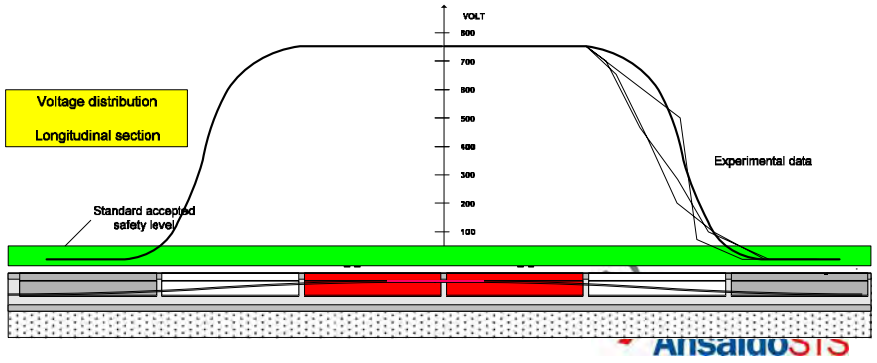


AnsaldoSTS

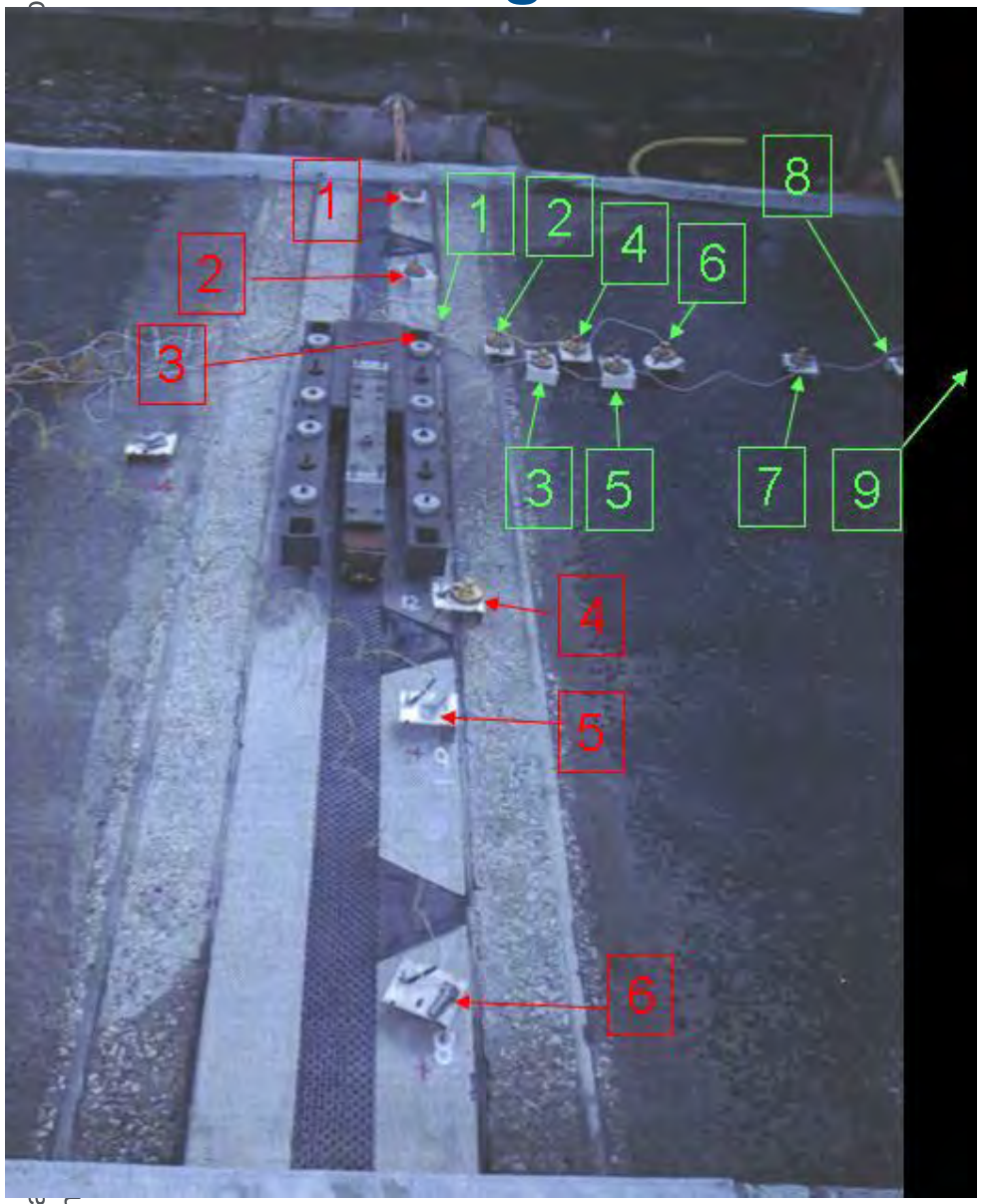
- **The activated part of the line is always enclosed by elements connected to the negative.**
  - These element act as a “Virtual Protection ring”
  - The protection ring follows the power collector .
  - Safety is always assured even in case of water puddles .
  - The running rails act as a second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

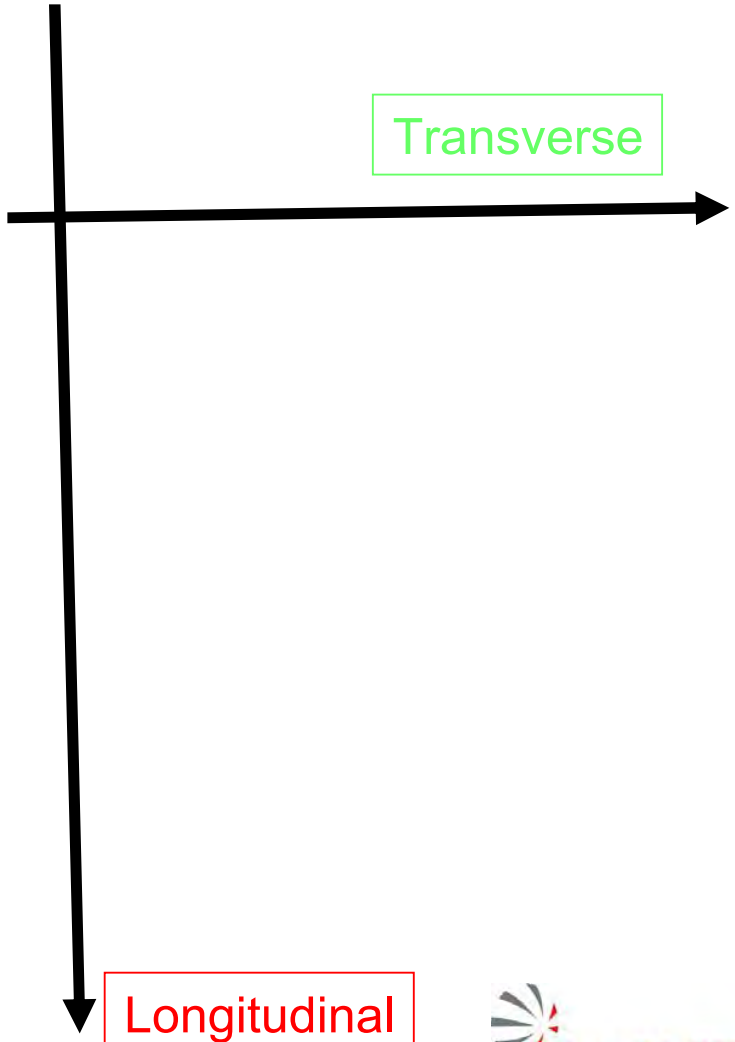






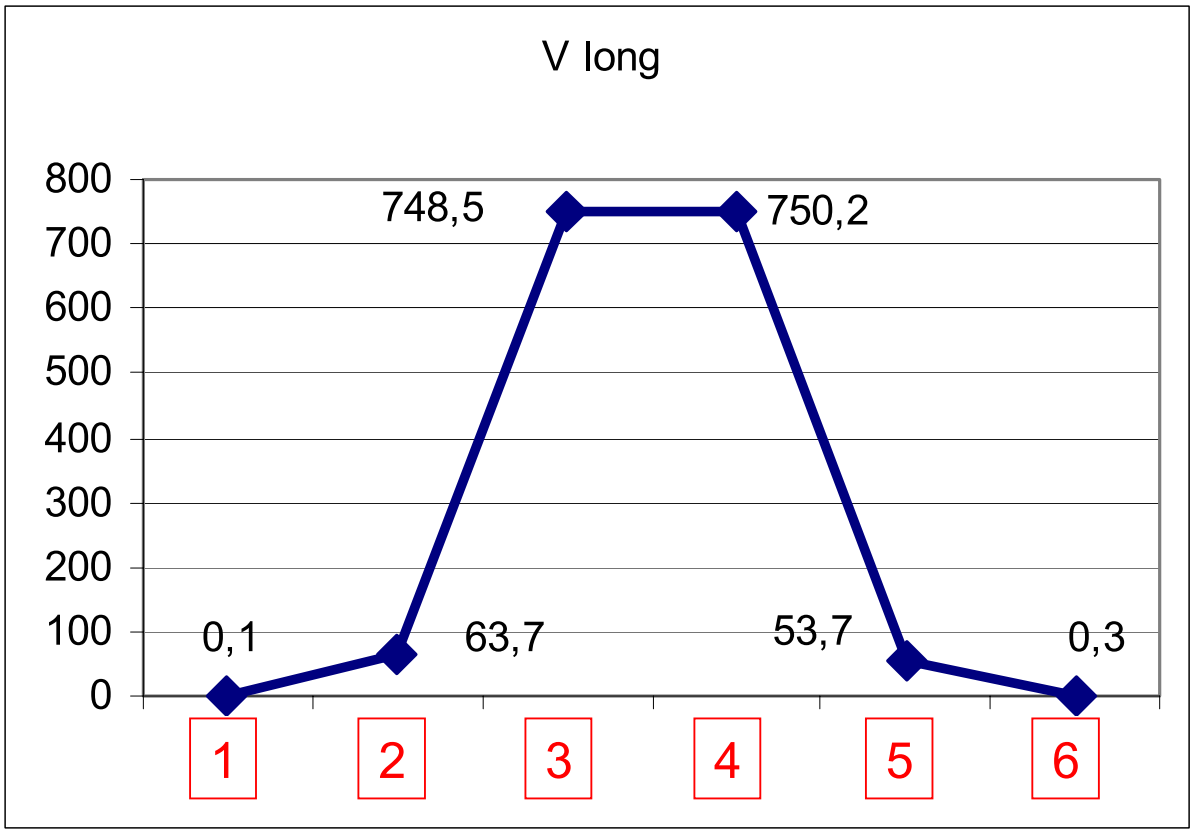
Voltage disribution along the line



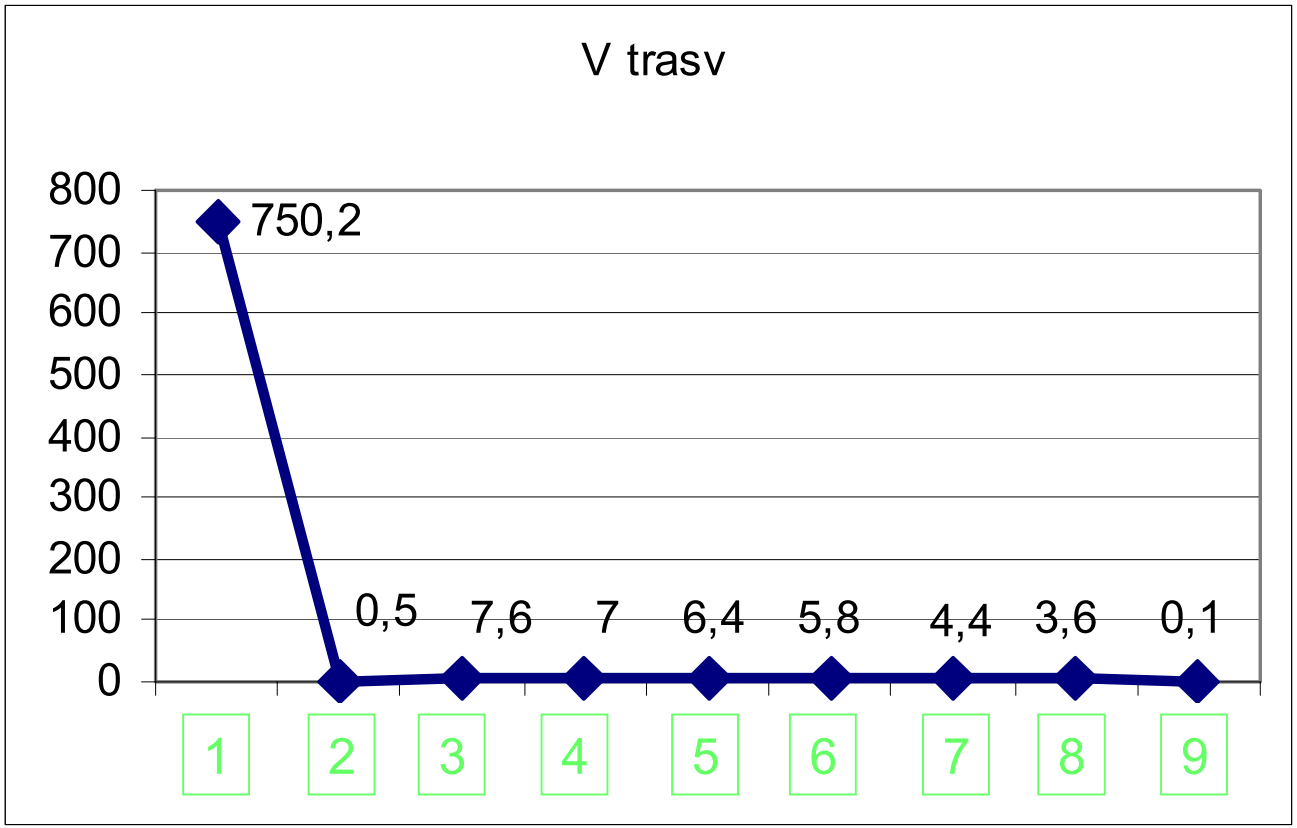


AnsaldoSTS

Voltage distribution along the direction of motion

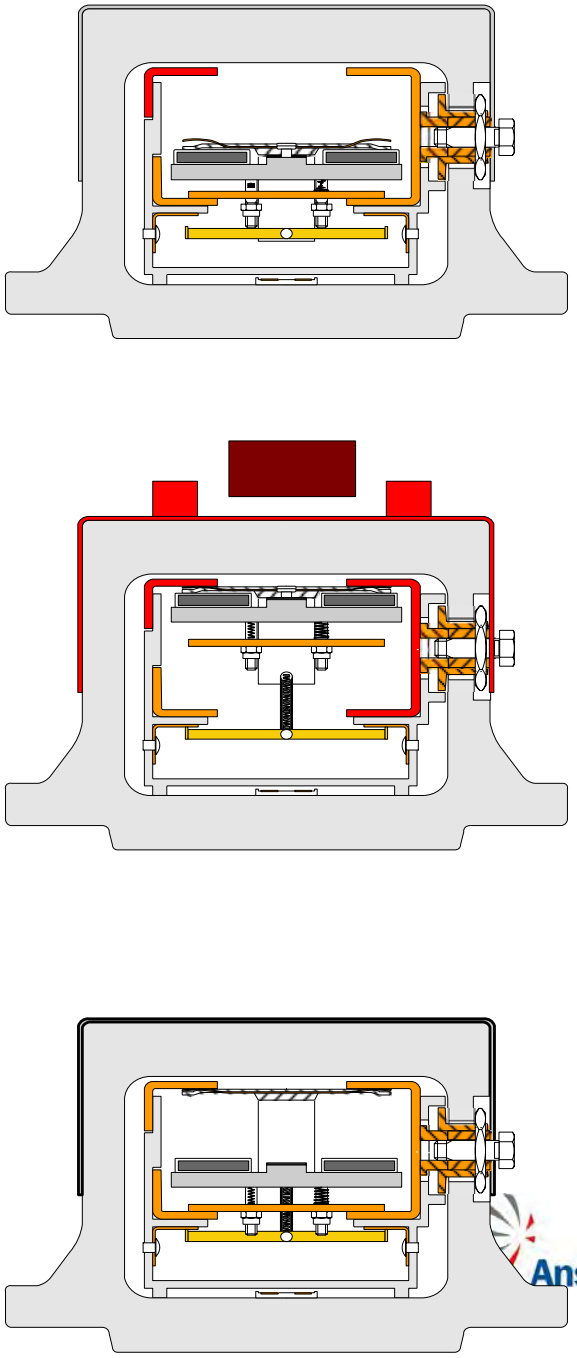


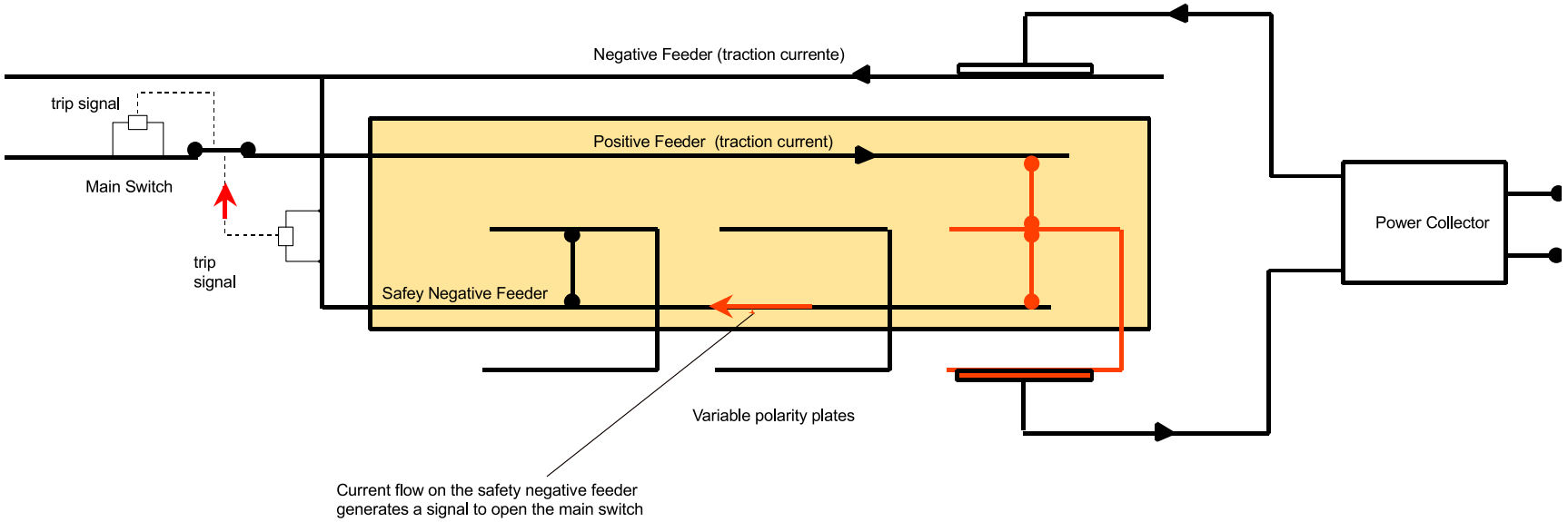
Voltage distribution along an orthogonal direction to the motion



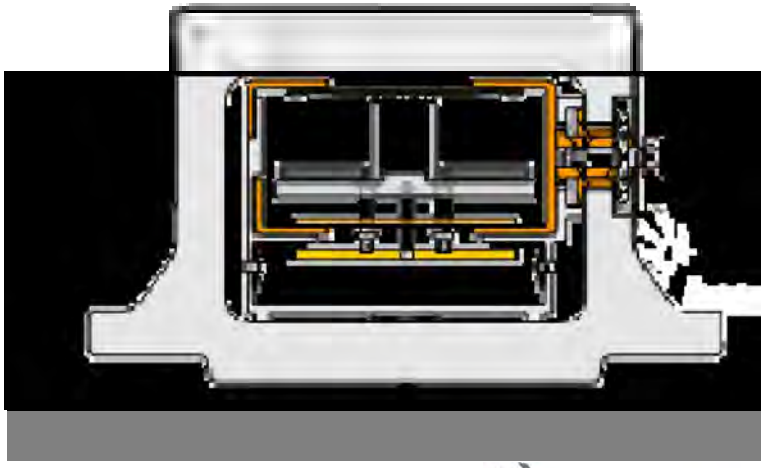
TramWave intrinsic safety concept

- **The design of TramWave assure the safety of the system even in the most severe conceivable accident events:**
  - the “stick” of a positive contact
- **The diagnostic system allows a fast detection of the faulted module.**





TramWave intrinsic safety concept



AnsaldoSTS

TramWave visual impact example

TramWave

ground-level power supply system (no overhead lines)

AnsaldoSTS

A Finmeccanica Company

TramWave

TramWave is a ground-level power supply system for light rail vehicles and trams where the contact line is embedded in the permanent way, so that there are no obstacles to pedestrians and vehicles crossing the rails.
Power is provided via a contact line that only energises a small section of the line as the tram passes over it. the live section of the line is therefore always underneath the tram.
The working range of the tramwave system is up to 750

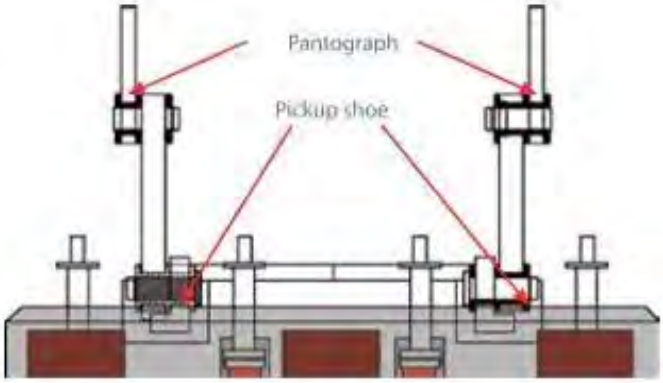
Contact line

The basic building block of the tramwave system is a modular box that is embedded in the permanent way. The box is usually 3 or 5 meters long and it contains all the elements needed for the correct functioning of the ground-level power supply system.
A series of steel contact plates (~50cm) are located at intervals on the top of the box (see figure). the modular boxes are joined together to form the power supply of the light rail line. The modules are placed in a "continuous conduit" that contains the positive feeder and a negative cable to protect the line.

Vehicle pickup shoe

The pickup shoe is the interface between the contact line and the vehicle.
It is placed in the vehicle bogie and its functions are to:
- "energise" one or two of the steel contact plates on the external surface of the power supply "module" located under the vehicle
- transfer energy to on-board equipment

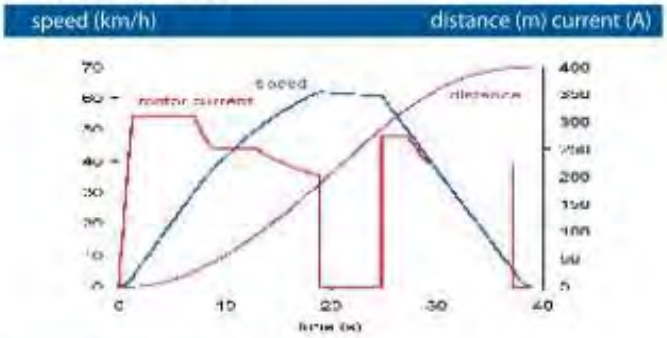
the pickup shoe includes copper and graphite contact shoes and permanent hybrid magnets with high residual induction.



Sirio Tram

City	Nr. of vehicles
Naples	22
Milan II	68
Sassari	4
Gotheborg	40
Bergamo	14
Florence	46
Athens	35
Kayseri	22
Milan I	48

Typical running diagram



General Technical Data

Car-body width 2,40-2,60 m
Maximum speed 70-80 km/h
Rail gauge narrow-standard
Bogie power 210 kw
Bogie wheel base 1700 mm
Floor heigh from t.o.r. 350 mm
Consist (3-5-7 casse 2-4 carrelli)
% Motor bogie (50%-75%)
Total capacity 155-285 passengers

Vehicle – Tramwave interface

Vehicles can be retrofitted with a pickup shoe as an alternative or in addition to an overhead pantograph.
The tramwave power collector, which is placed under the vehicle, is interfaced with the vehicle via a hydraulic electrical device and is retractable.
This system allows power to be drawn from the "ground module" continuously at full performance. this is a fully-equivalent alternative to overhead power lines.
An on-board diagnostic system controls operating conditions:
- power collector up
- power collector down

in the case of a mixed traction power supply (overhead and tramwave line), where there is no tramwave contact line the power collector down command is not available.

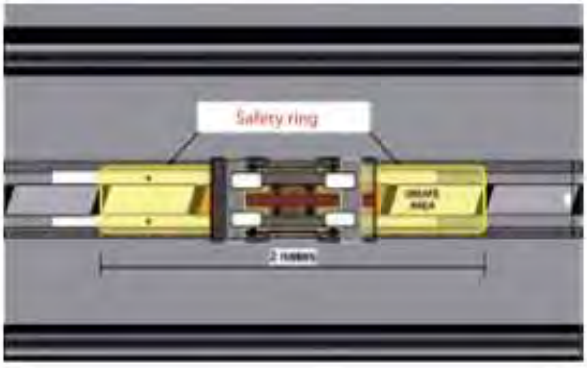
An on-board energy management system can be used to optimise kers (kinetic energy recovery system)performance.

System safety

The safety of pedestrians and the public in general is guaranteed at all times during normal functioning and in any situations where functioning is compromised.

Presence of water on the active module

An earthed "safety ring" is always present around the energised contact plates when the vehicle is moving. this ring comprises the two negative return cables included in the modular boxes and the contact plates above and below the energised plates.



Internal failure

In the unlikely event that a contact plate remains energised after the vehicle has passed, the TramWave system immediately activates a hscb cutting off the power supply.

TramWave Performance

With the TramWave system the return current can be transferred via the contact plates and the tracks do not need to be used for this purpose. This is an important feature since the tramwave system eliminates the effects of stray currents, which can offer significant savings on construction costs.

TramWave is also designed for future multimodal applications:
• availability of a positive and negative traction feeder
• capability of the pickup shoe to remain centred and connected to the contact line
these features mean that the power supply system can also be used by electrical vehicles which have rubber tyres.
Consequently a tramway line equipped with the TramWave system can become the backbone power line for different vehicle fleets and/or a global network that uses it as a mobile charging station for battery-powered vehicles.

TramWave applications

In Naples Ansaldo factory, a Tramwave line section of about 400 meters has been implemented on the elevated test track.
On this stretch, the TramWave system is being tested under extreme operating conditions.

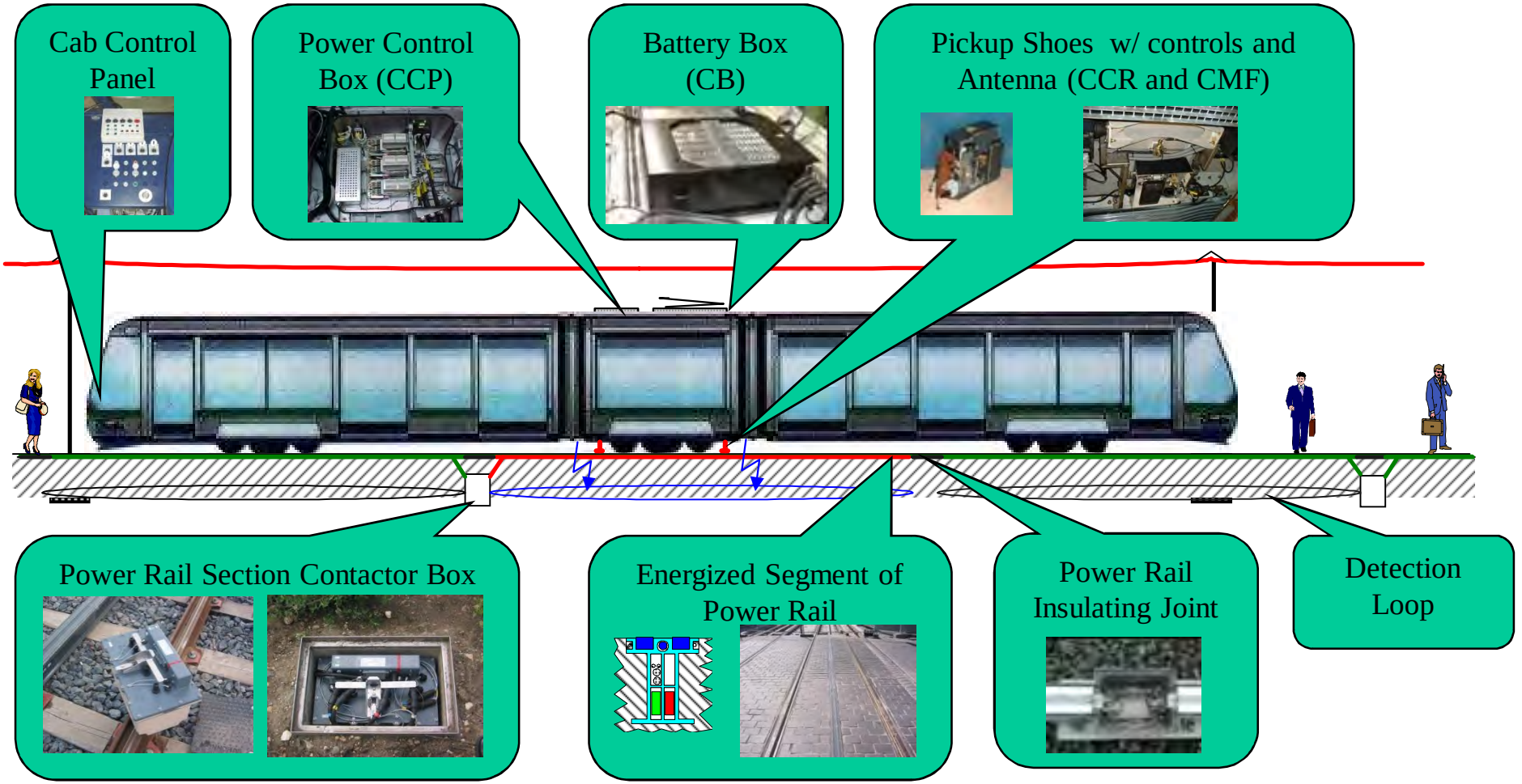
On Naples tram line Poggioreale - via Stadera a trial version of the TramWave system is being implemented on a single track section of about 600 meters.

Ansaldo STS SpA
Via Paolo Mantovani 3 - 5
16151 Genoa - Italy
www.ansaldo-sts.com

A Finmeccanica Company

INNORAIL

INNORAIL System Components




Valley Metro
RAIL
Valley Metro
RAIL

Central Phoenix/East Valley Light Rail Project

INNORAIL Embedded Power System Update

March 03, 2003

- Following the issue of a CDROM covering recent INNORAIL developments to key Valley Metro staff in November 2002, a technical visit was made by PB personnel to Bordeaux, France from the 17th through the 20th of February 2003 to further evaluate the system on behalf of Orange County Transit Authority (OCTA) with a view to implementing this system in whole or in part in their new LRT system design.
- Given the high level of local interest always shown in having a power supply without overhead wires for the CP/EV LRT system, this system may also be a possibility for this project.

INNORAIL Product Development

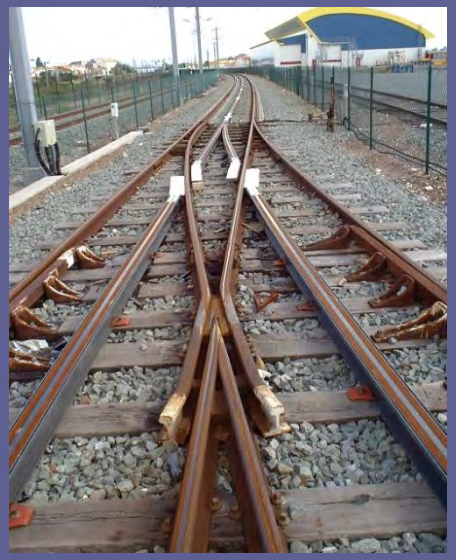
- **Prototype Development – Marseille Line 68 – 1999 – 2001 – with older vehicles at 600 Vdc to prove basic concept**

INNORAIL Product Development

- **Endurance Testing – Ollainville - successful 30 year accelerated test of all embedded components**

INNORAIL Product Development

- **Continued development – La Rochelle (Alstom works) - - 2001 to present – test track with modern low floor LRV at 750) Vdc. Over 2000 miles endurance testing plus battery operation and crossing of special trackwork.**



The New Bordeaux LRT System

- **Phase 1 – 23.5 km [14.1 mi] long system (Lines A & B) – opens before end of 2003**
- **In 1999, requirement was for 3 km [1.8 mi] without OCS**
- **In 2002, decision changed to require 11 km [6.6 mi] using INNORAIL, nearly half the system**
- **70 X 100% low floor, air conditioned vehicles running at 4 minute intervals (2 minutes at peak)**
- **Only single car trains**
- **Phase 2 – adds another 20.5 km [12.3 mi] (Line C). Percentage with INNORAIL not yet decided.**

The New Bordeaux LRT System

The New Bordeaux LRT System

The Vehicles

- 6 X 33m long (Citadis 302) and 38 X 44m long (Citadis 402) 100% low floor vehicles in Phase 1
- 12 X 33m long (Citadis 302) and 14 X 44m long (Citadis 402) 100% low floor vehicles in Phase 2

The New Bordeaux LRT System

Additional Vehicle Equipment for INNORAIL Operation

- One roof mounted **Emergency Battery Set** to allow vehicle to transition any dead power segments
- Two sets of center truck mounted **Retractable Power Pickup Shoes** for current collection
- One **Pickup Shoe Control Box** to activate pickup shoes and interlock with pantograph controls
- One roof mounted **Power Control Box** with additional contactors and controls for switching power from pickup shoes and emergency battery set

The New Bordeaux LRT System

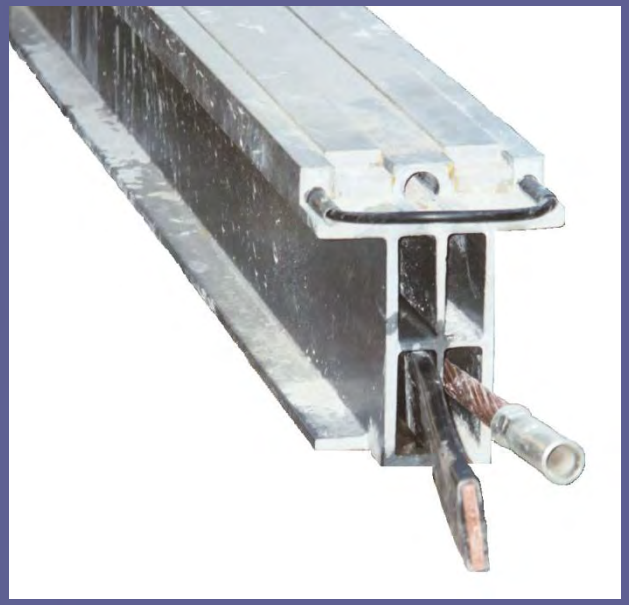
Additional Vehicle Equipment for INNORAIL Operation, cont'd.

- Additional **Cab Controls and Monitoring** to monitor and control INNORAIIL related equipment
- Additional **Safety Earthing** under low floor section of vehicle

The New Bordeaux LRT System

Ground Level Equipment for INNORAIL Operation

- **Low profile, sectional Power Rails - 11m [36 ft] long sections with 8m [26.25 ft] of conductor rail and 3 m [9.84 ft] of insulating rail with integral duct bank and detection loop**



The New Bordeaux LRT System

Ground Level Equipment for INNORAIL Operation

- Modular, quick replacement **Power Rail Control Contactor** - one every 22m [72.2 ft], controls two segment of power rail

The New Bordeaux LRT System

Ground Level Equipment for INNORAIL Operation

- **Insulating Joint Box** one every 22m [72.2 ft]

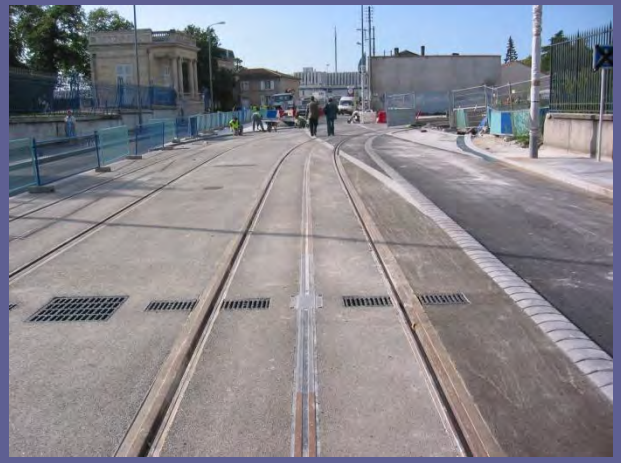
The New Bordeaux LRT System

Ground Level Equipment for INNORAIL Operation

- **Substation Earthing Contactor and System Monitoring Cabinet – one per substation**

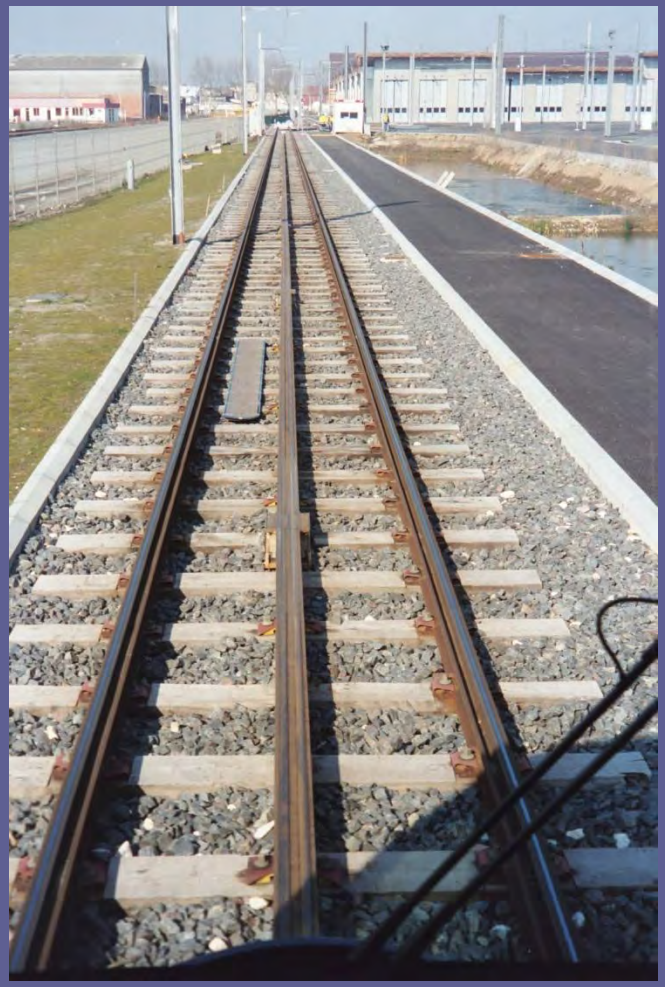
The New Bordeaux LRT System

Ground Level Equipment for INNORAIL Operation



The New Bordeaux LRT System

Depot Test Track



The New Bordeaux LRT System

Coming Soon

The New Bordeaux LRT System

Safety and Certification

- **Being independently assessed to EN 50126 –** *Railway Applications – The Specification and Demonstration of Availability, Maintainability and Safety (RAMS*) **and ENV50129 –** *Safety Related Electronic Systems for Signaling*
- **Preliminary Safety Case approved January 2000**
- **System Safety Case 85% complete and awaiting energizing of complete system in summer of 2003**

Adapting the INNORAIL System to US Requirements

- The INNORAIL system concept is well designed with no “Fatal Flaws” and adequately mitigates identifiable safety hazards, thus Safety Certification in the US should be achievable.
- Such certification will require considerable preparation and documentation to be presented to the local certifying authorities, but can build on the experience of the Bordeaux certification process.
- Adapting for multi-car operation – this is readily achieved by increasing the size of the main power bus

Adapting the INNORAIL System to US Requirements

- Adapting for higher speeds – the current system is designed for a speed of 20m/sec [44.7 mph] . Relatively minor changes in the relative lengths of the conducting and insulating rails will easily allow for higher speeds where required
- Product Availability – INNORAIL currently being sold to Alstom. Willingness of Alstom to provide this system for the US market or license same not yet known.
- Sole sourcing – the technology is proprietary, thus sole sourcing would be required. This is allowable under FTA C4220.1D.

Adapting the INNORAIL System to US Requirements

- Buy America – many of the system components can be manufactured under license in the US
- Adapting for gradients – given the relatively steep gradients on the CP/EV LRT system at the Washington Street underpass and coming out of the Maintenance Facility, a larger set of batteries will be required for the Emergency Battery Set, adding to the vehicle cost and weight
- Adapting for US LRVs – universal nature of additional vehicle equipment will allow fitting to any modern low floor LRV

Adapting the INNORAIL System to US Requirements

- **Cost – based on current Bordeaux prices, it is estimated that the cost will be $1.6 to $2.0 million per double track mile for the embedded power rail, plus $40,000 per substation for the earthing contactor and monitoring equipment , plus $129,000 to $161,000 per LRV for the additional INNORAIL related vehicle mounted equipment.**
- **Other US systems – none as yet, but Orange County (OCTA) seriously considering system and Honolulu has also expressed interest. Once availability of system known, demand will increase dramatically.**


Valley Metro
RAIL
Valley Metro
RAIL

Making your world a quieter place

CDM 60th Anniversary

CDM-QTRACK-JIG 3rd Rail Installation Catenaryless Power Supply System Napoli 2010

BOTYM 2011 - Brussels

Vincent Brasseur

Phase I – MOCKUP Installation

ASTS challenges CDM

Making your world a quieter place

- Ansaldo Signalling and Transportation Solution:
  - Headquartered in Genoa, Italy
  - Employs over 4,300 people in 28 different countries
  - 2009 revenues € 1.176 M
    - Gross operating margin of € 125 M
    - Net profits of € 88 M

Phase I – MOCKUP Installation

ASTS challenges CDM

Making your world a quieter place

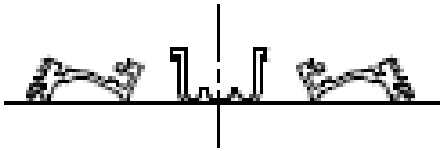
- ASTS:
  - Leading technology company:
    - Listed on the Milan stock exchange
    - Operating in the global Railway & Mass Transit Transportation Systems business
    - Provision of:
      - Track Project Management
      - Catenaryless Power Supply & Signalling Systems and Services
      - Traffic Management
      - Planning
      - Train Control
    - Acts as lead contractor and turnkey provider on major projects worldwide (Europe, Middle-East, Asia, …)

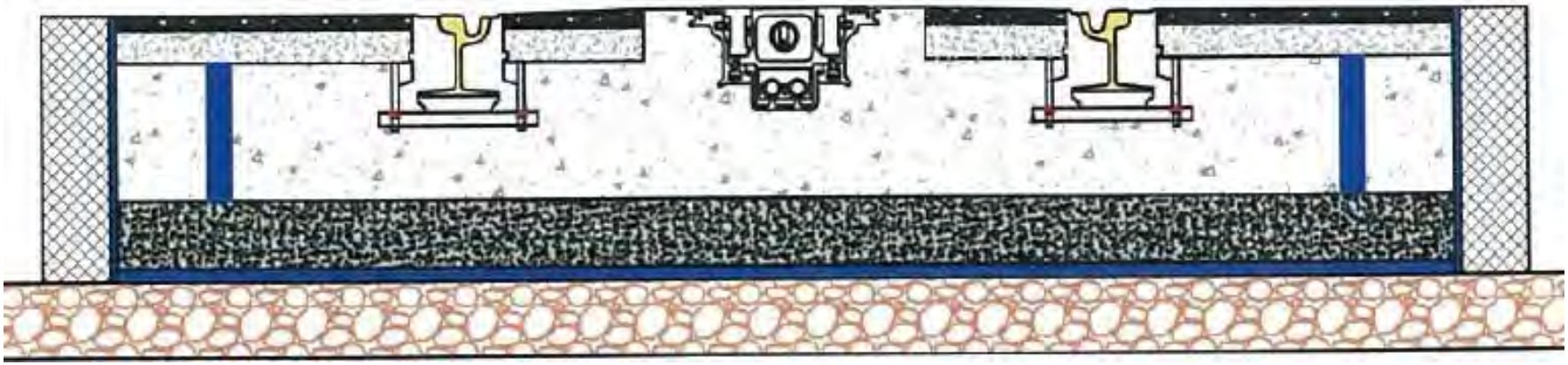
Phase I – MOCKUP Installation

ASTS challenges CDM

Making your world a quieter place

- ASTS challenges CDM to prove:
  - We can efficiently install a 36 lmst MOCKUP included:
    - CDM-QTRACK-JIG-60R2-HP-R system into CDM-FSM-L10 floating slab track:
    - ASTS Ground Power Supply System Packing – called “**Trogolo”**:3 pieces





Phase I – MOCKUP Installation

ASTS challenges CDM

Making your world a quieter place

- ASTS Catenaryless Power Supply System = Tramwave: 2 elements:
  - Ground Power Supply System packed in the « Trogolo »
  - Tramway Vehicle Magnetic Power Collector = 3 main functions:
    - Activation of +- 2m line segments
    - Current pick up & Current return
    - Guide the Vehicle Magnetic Power Collector over the line

Phase I – MOCKUP Installation

CDM: “Yes we can”!

Making your world a quieter place

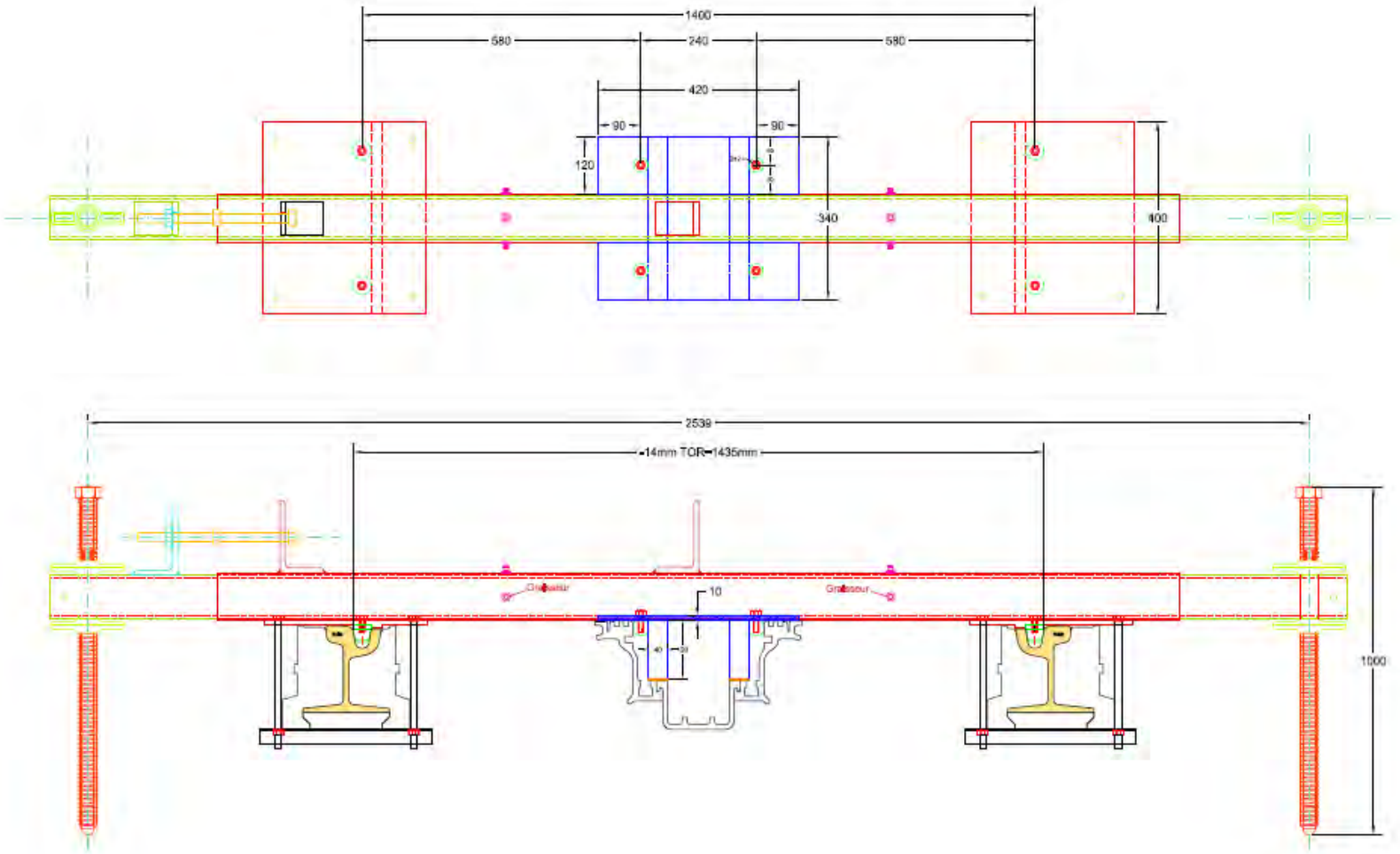
- CDM’s reply: « Yes we can »!
  - CDM supplies asap:
    - **36 lmst** CDM-QTRACK-JIG-60R2-HP-R profiles
    - **# 6** CDM-JIG-TRAMWAVE
    - **100 m²** CDM-FSM-L10 horizontal mats floating slab track
    - **50 m²** CDM-FSM-L10 vertical mats floating slab track

Phase I – MOCKUP Installation

CDM: “Yes we can”!

Making your world a quieter place

- New CDM-JIG design for Mockup:

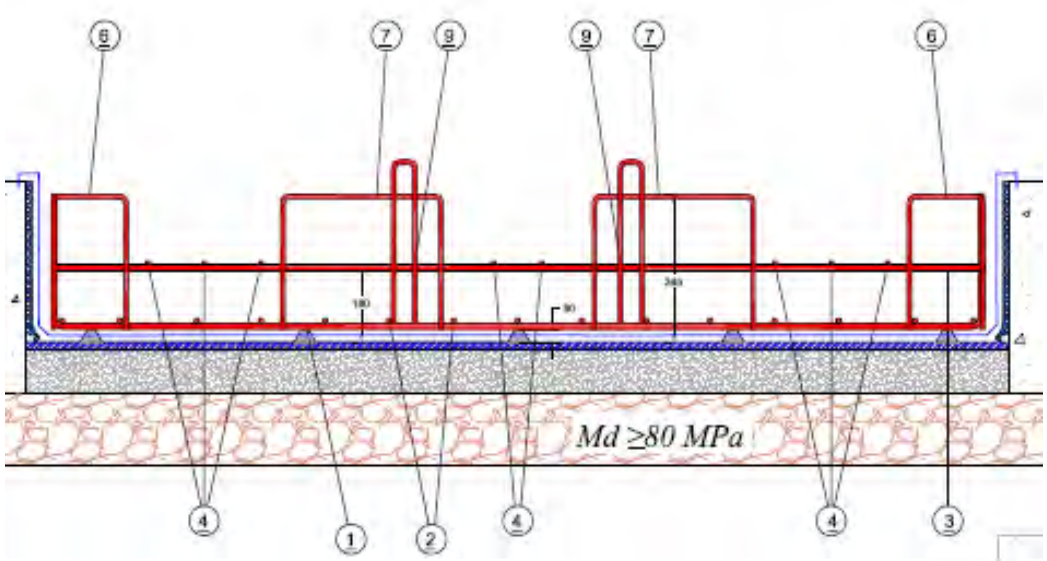


Phase I – MOCKUP Installation

CDM: “Yes we can”!

Making your world a quieter place

Mechanical Calculation Note:



BORDEREAU DES ACIERS - Site partagé (Section A)

N°	Ø	e(cm)	Nbre	L.U.(m)	L.Tot.(m)	Poids (kg)	schéma	Observation
1	12	15	6,67	2,82	18,8	16,7	31 220 31	inf trans
2	10	15	15	1,00	15,0	9,2	100*	inf long
3	12	15	6,67	2,20	14,7	13,0	220	trans s/rail
4	10	-	8	1,00	8,0	4,9	100*	long s/rail
5	10	-	10	1,00	10,0	6,2	100*	sup long
6	10	-	13,3	0,80	10,7	6,6	31 18 31	sup trans A
7	10	-	13,3	1,00	13,3	8,2	31 38 31	sup trans B
8	10	-	2	1,00	2,0	1,2	100*	joues en béton
9	10	15	6,67	0,84	5,6	3,5	39 6 39	joues en béton
					TOTAL	69,5	kg/mlvs	

Phase I – MOCKUP Installation

ASTS'site Mockup Installation

Making your world a quieter place

Phase I – MOCKUP Installation

ASTS'site Mockup Installation

Making your world a quieter place

Phase I – MOCKUP Installation

ASTS'site Mockup Installation

Making your world a quieter place

Phase I – MOCKUP Installation

ASTS'site Mockup Installation

Making your world a quieter place

Phase I – MOCKUP Installation

Phase I - Conclusion

Making your world a quieter place

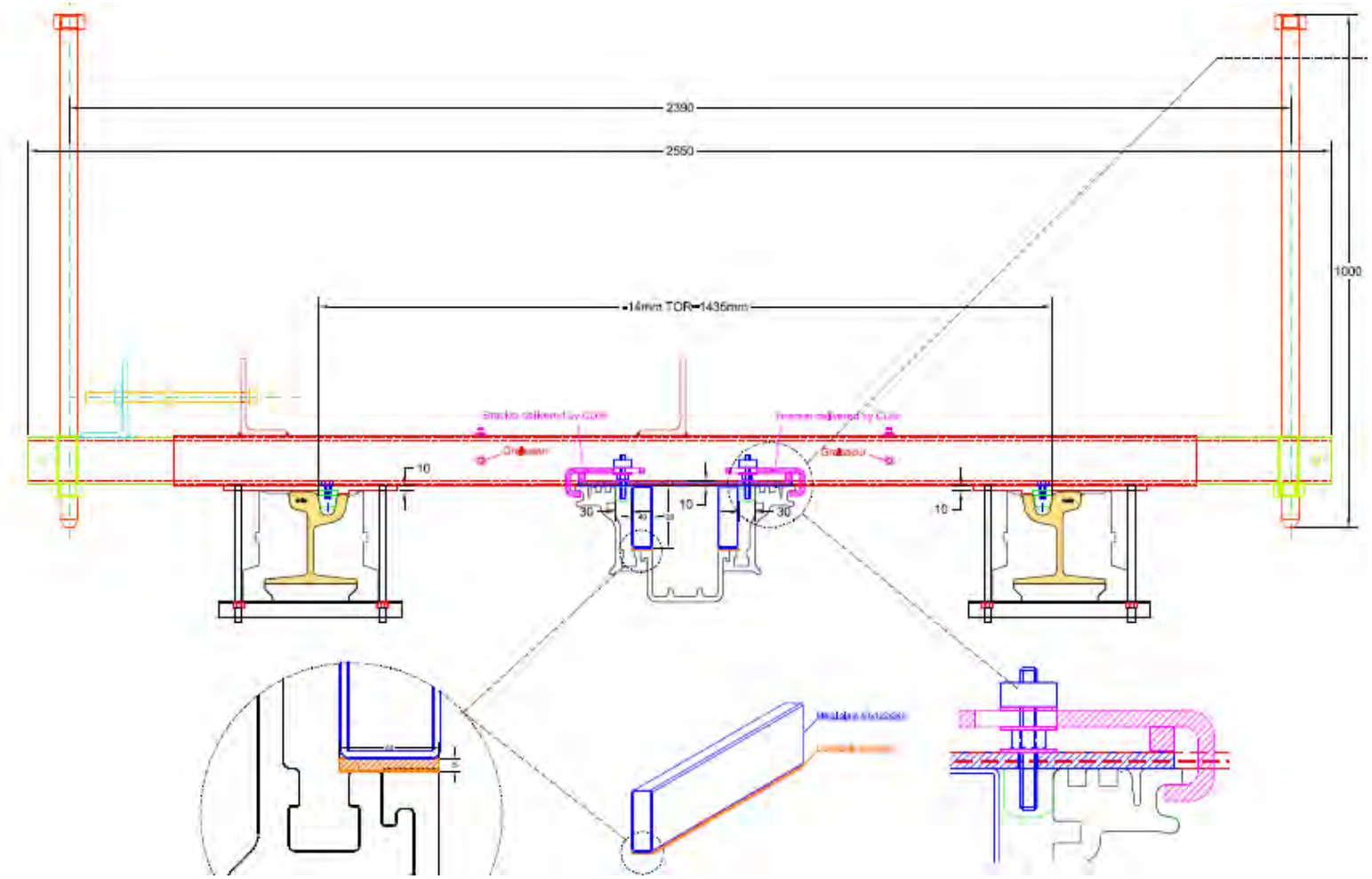
- ASTS: « OK we trust you, just do it on site in Napoli now»
- « But please first improve the plastic straps system you used to fix the trogolo because we need better results in final positionning »

Phase I – MOCKUP Installation

Phase I - Conclusion

Making your world a quieter place

CDM-JIG's design improvement: 4 Brackets:

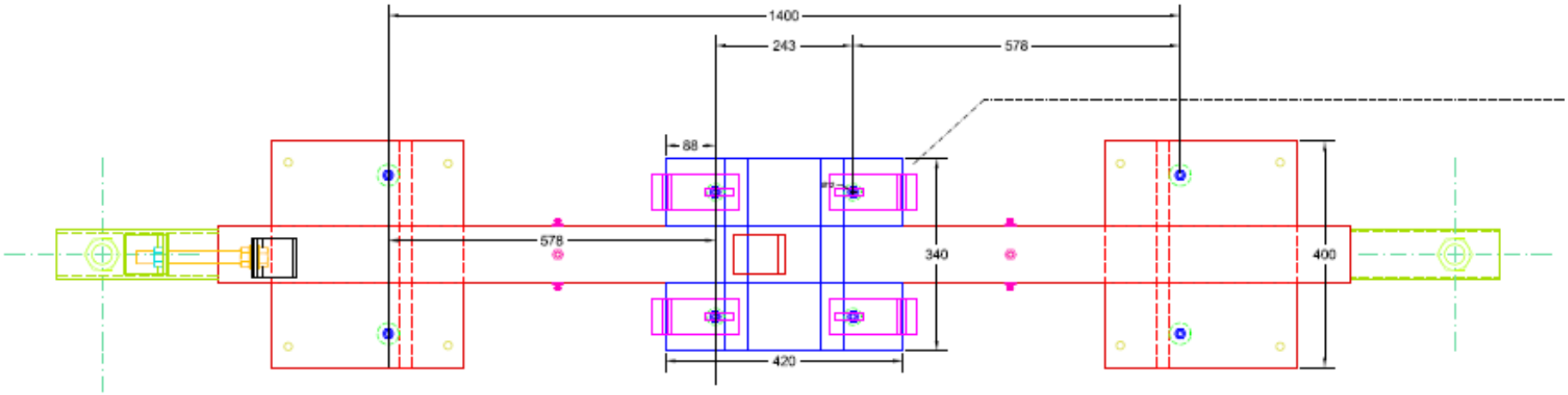


Phase I – MOCKUP Installation

Phase I - Conclusion

Making your world a quieter place

- CDM-JIG's design improvement: 4 Brackets:



Phase I – MOCKUP Installation

Phase I - Conclusion

Making your world a quieter place

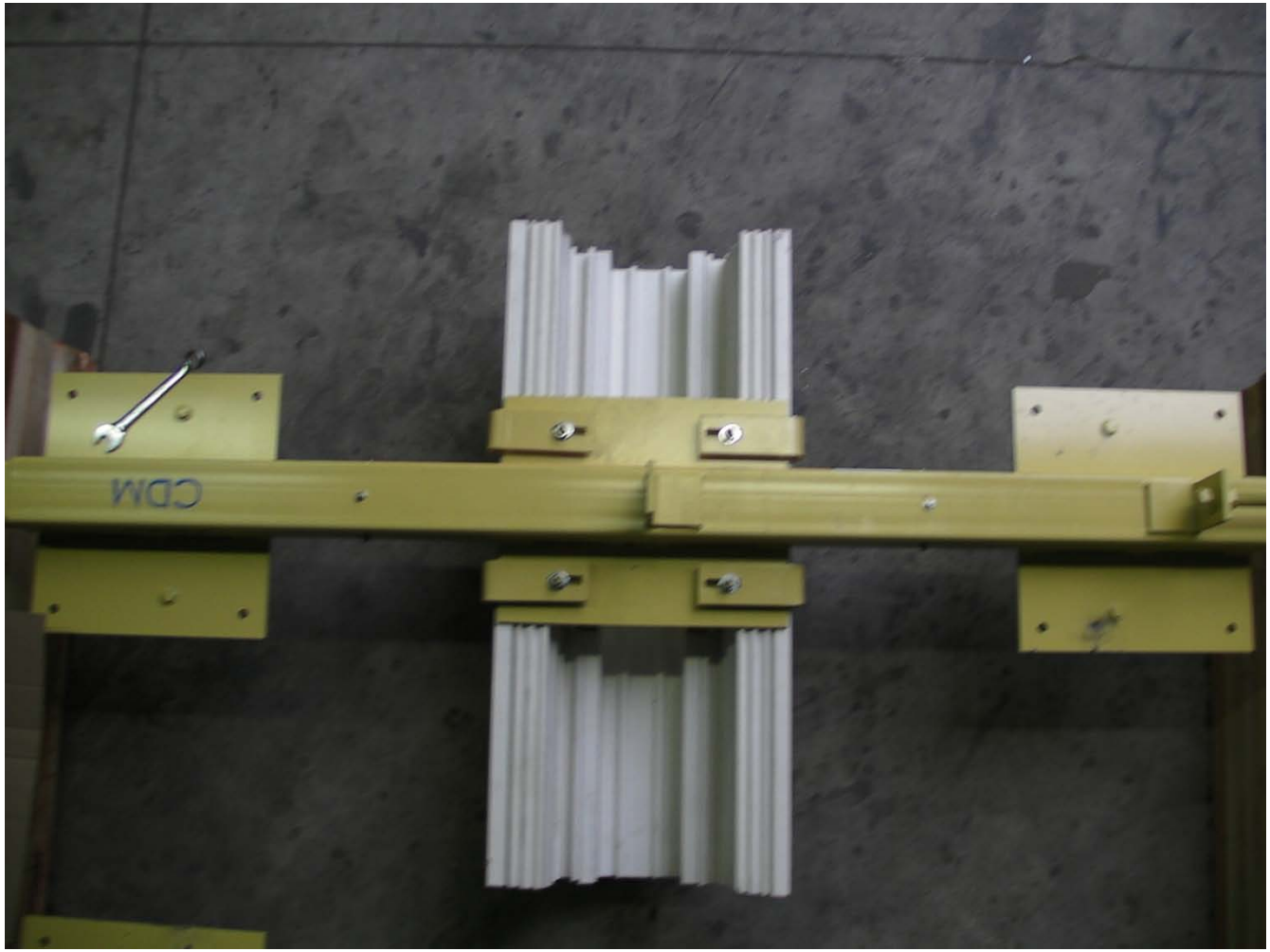
- CDM-JIG's improvement: 4 Brackets: test in factory:

Phase I – MOCKUP Installation

Phase I - Conclusion

Making your world a quieter place

- CDM-JIG's improvement: 4 Brackets: test in factory:



Phase I – MOCKUP Installation

Phase I - Conclusion

Making your world a quieter place

- CDM-JIG's improvement: 4 Brackets: test in factory:

Phase I – MOCKUP Installation

Phase I - Conclusion

Making your world a quieter place

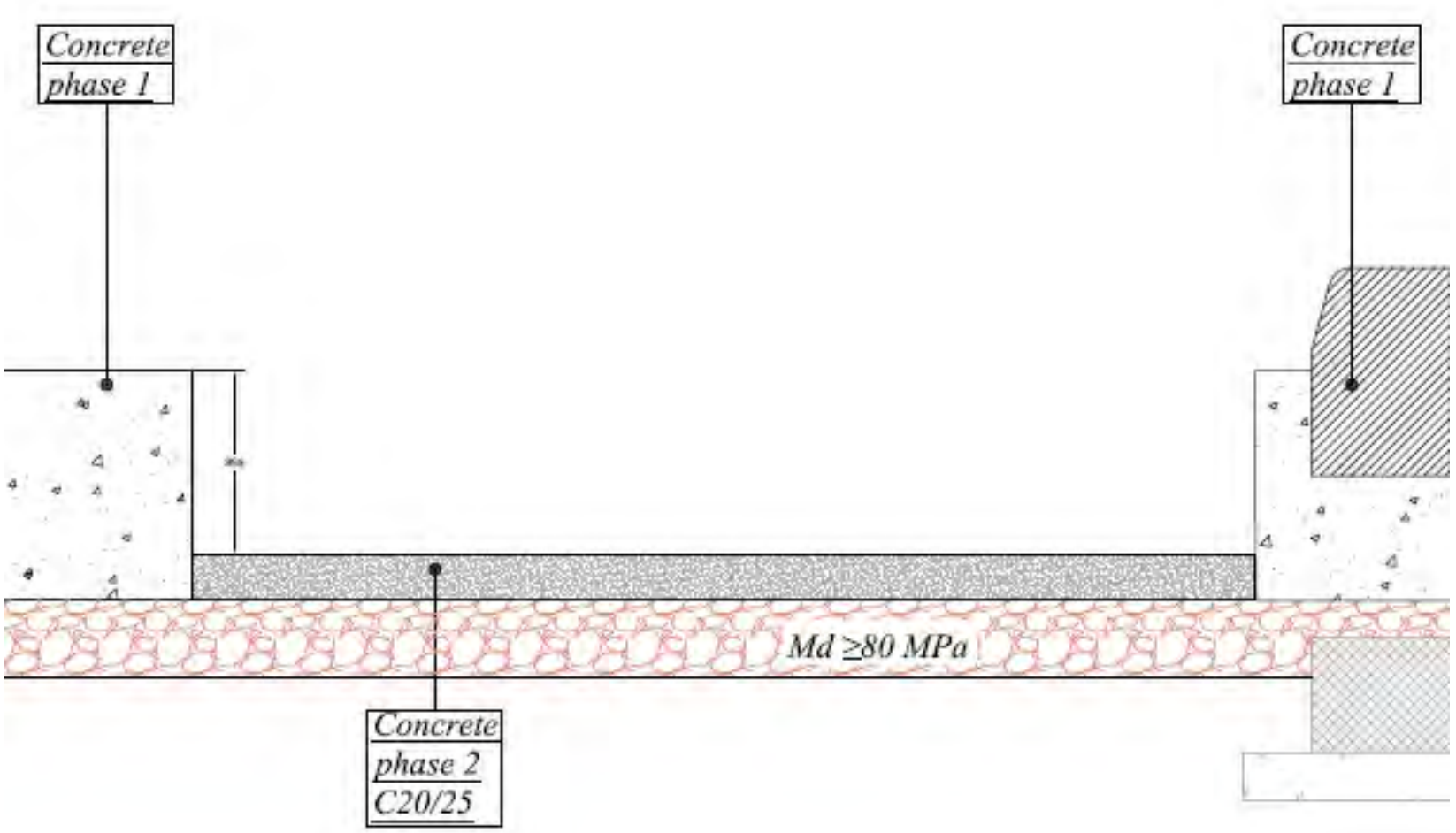
- ASTS: « OK you did it, we order for a first installation in Via Stadera, Napoli:
  - **600 lmst** CDM-QTRACK-JIG-60R2-HP-R profiles
  - **# 30** CDM-JIG-TRAMWAVE
  - **1500 m²** CDM-FSM-L10 horizontal mats floating slab track
  - **500 m²** CDM-FSM-L10 vertical mats floating slab track

Phase II – Napoli Via Stadera Installation

Phase II – Installation Sequence - Mixed Traffic Zone

Making your world a quieter place

Excavation and Lean Concrete phase 2:

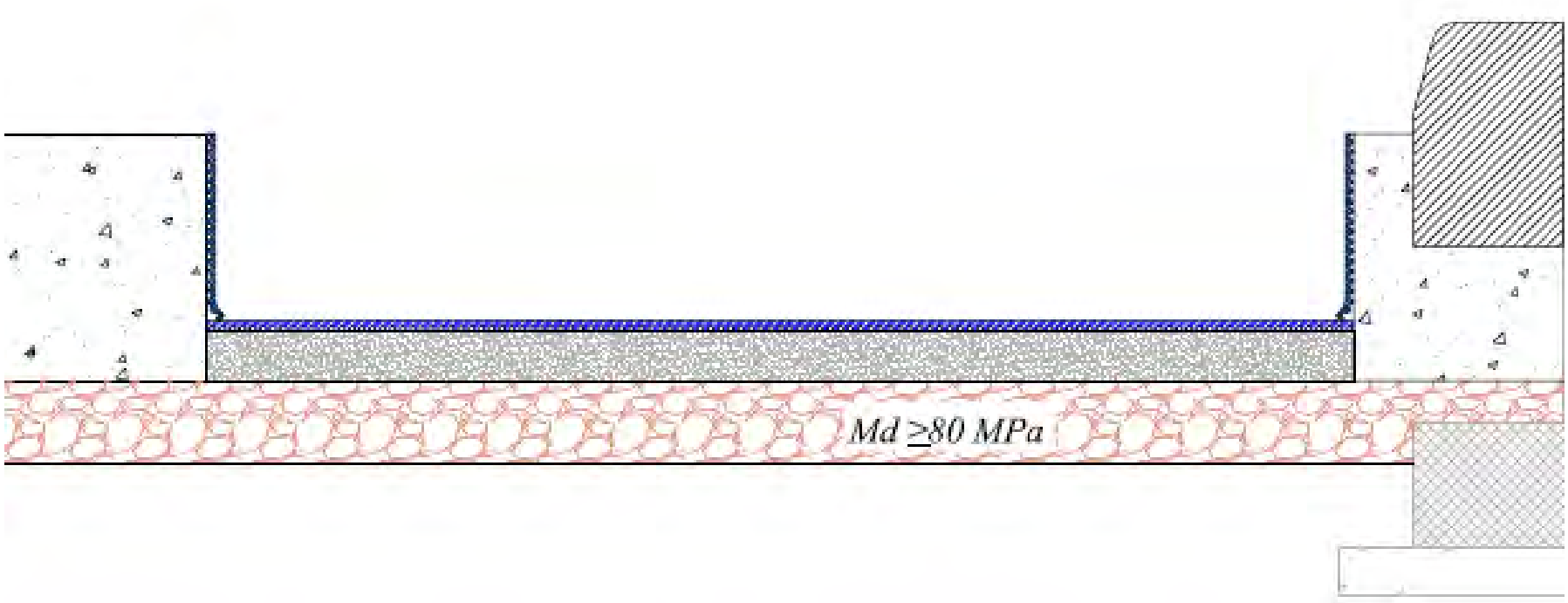


Phase II – Napoli Via Stadera Installation

Phase II – Installation Sequence - Mixed Traffic Zone

Making your world a quieter place

Horizontal & Vertical CDM-FSM Installation:

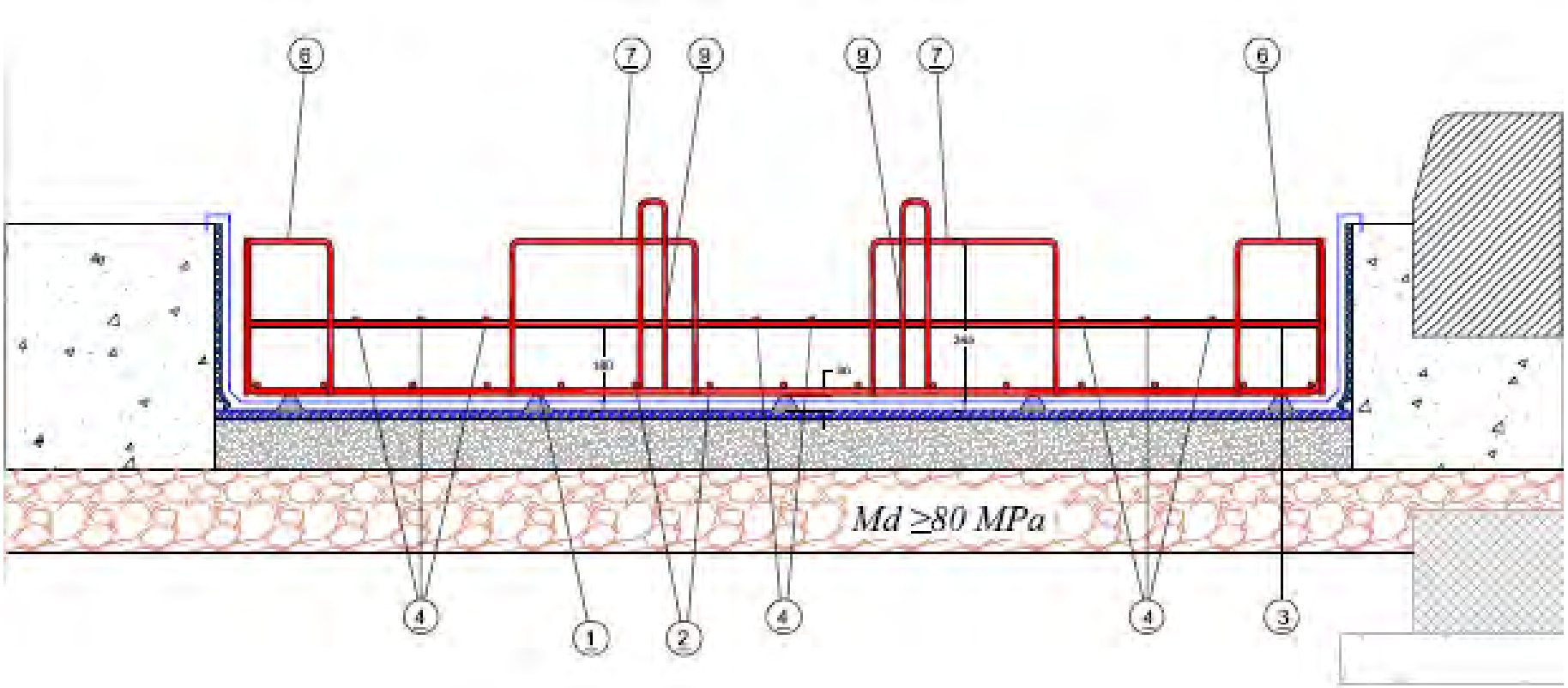


Phase II – Napoli Via Stadera Installation

Phase II – Installation Sequence - Mixed Traffic Zone

Making your world a quieter place

Steel Reinforcements further to Mechanical Calculation Note:

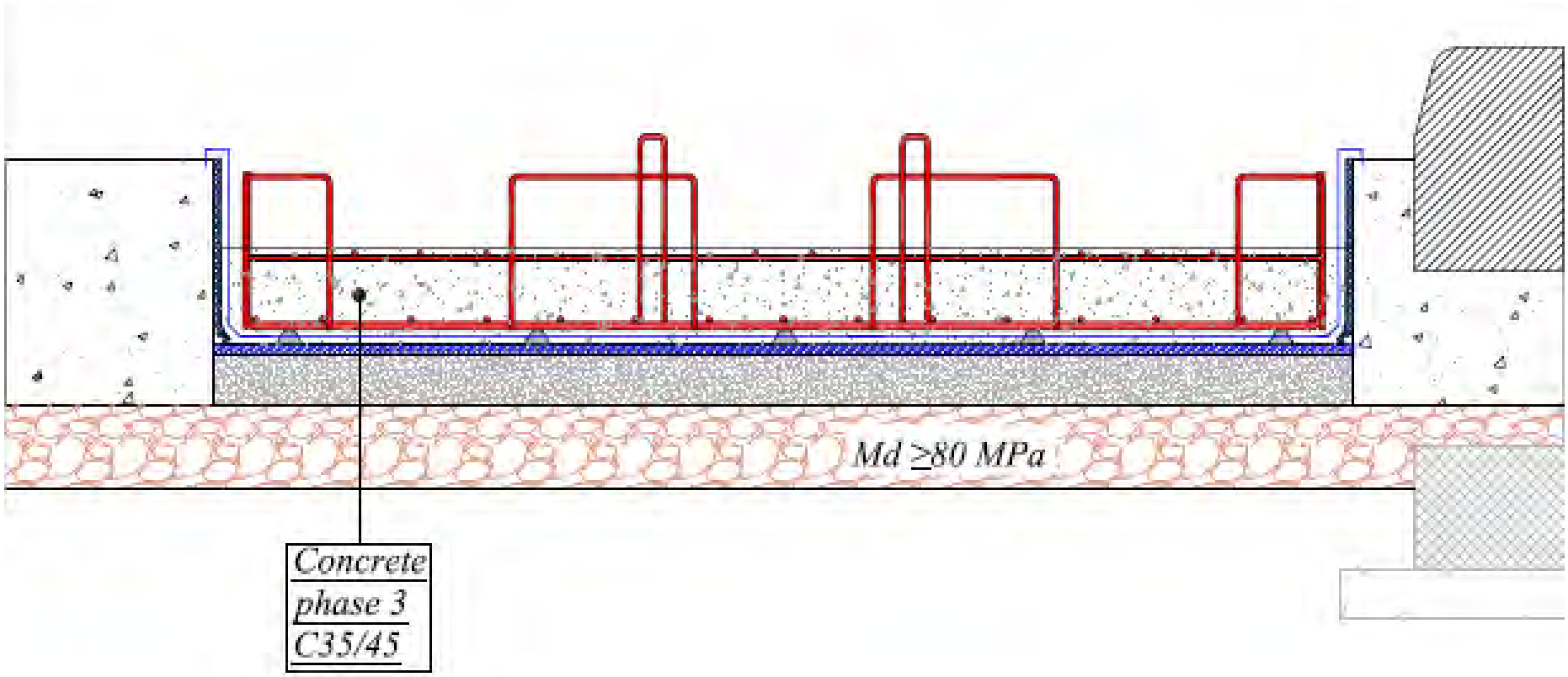


Phase II – Napoli Via Stadera Installation

Phase II – Installation Sequence - Mixed Traffic Zone

Making your world a quieter place

- Concrete phase 3:

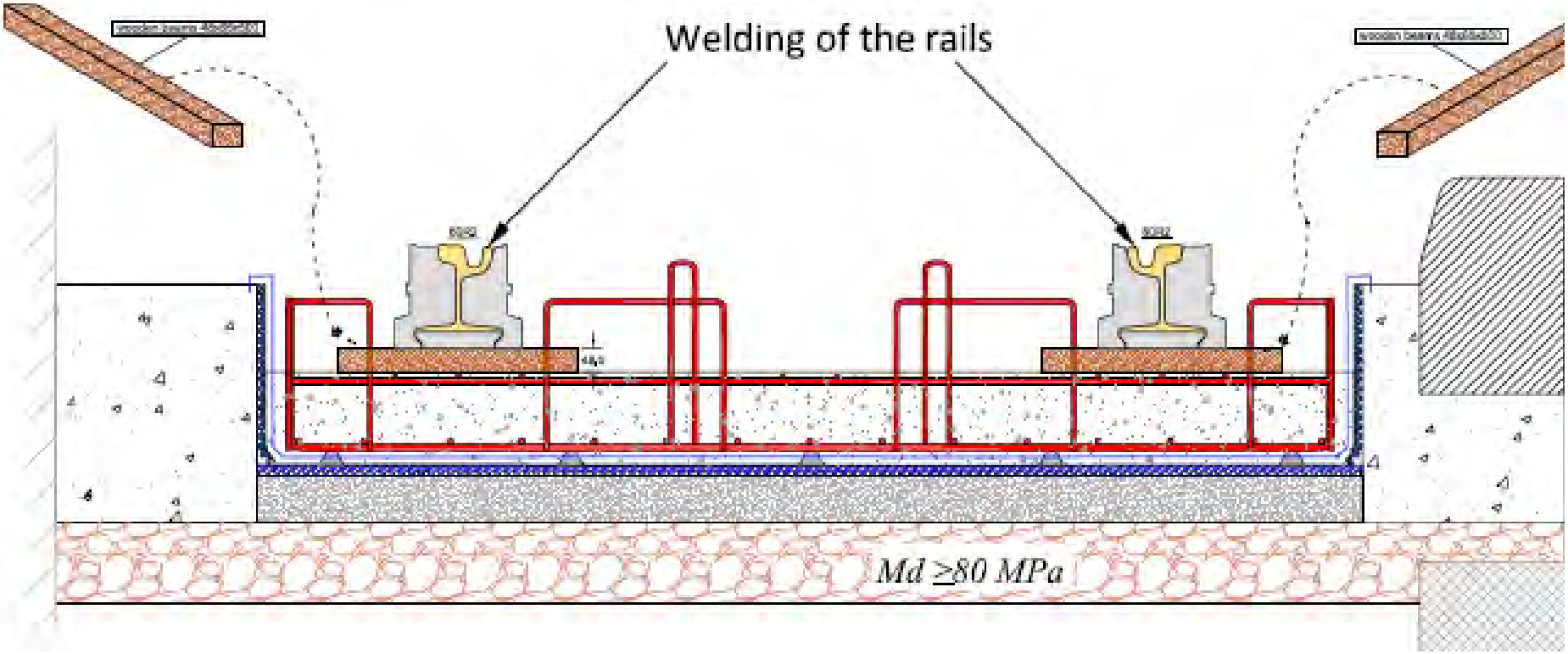


Phase II – Napoli Via Stadera Installation

Phase II – Installation Sequence - Mixed Traffic Zone

Making your world a quieter place

- Encapsulated rails posed on temporary wood sleepers
- Rails welding :

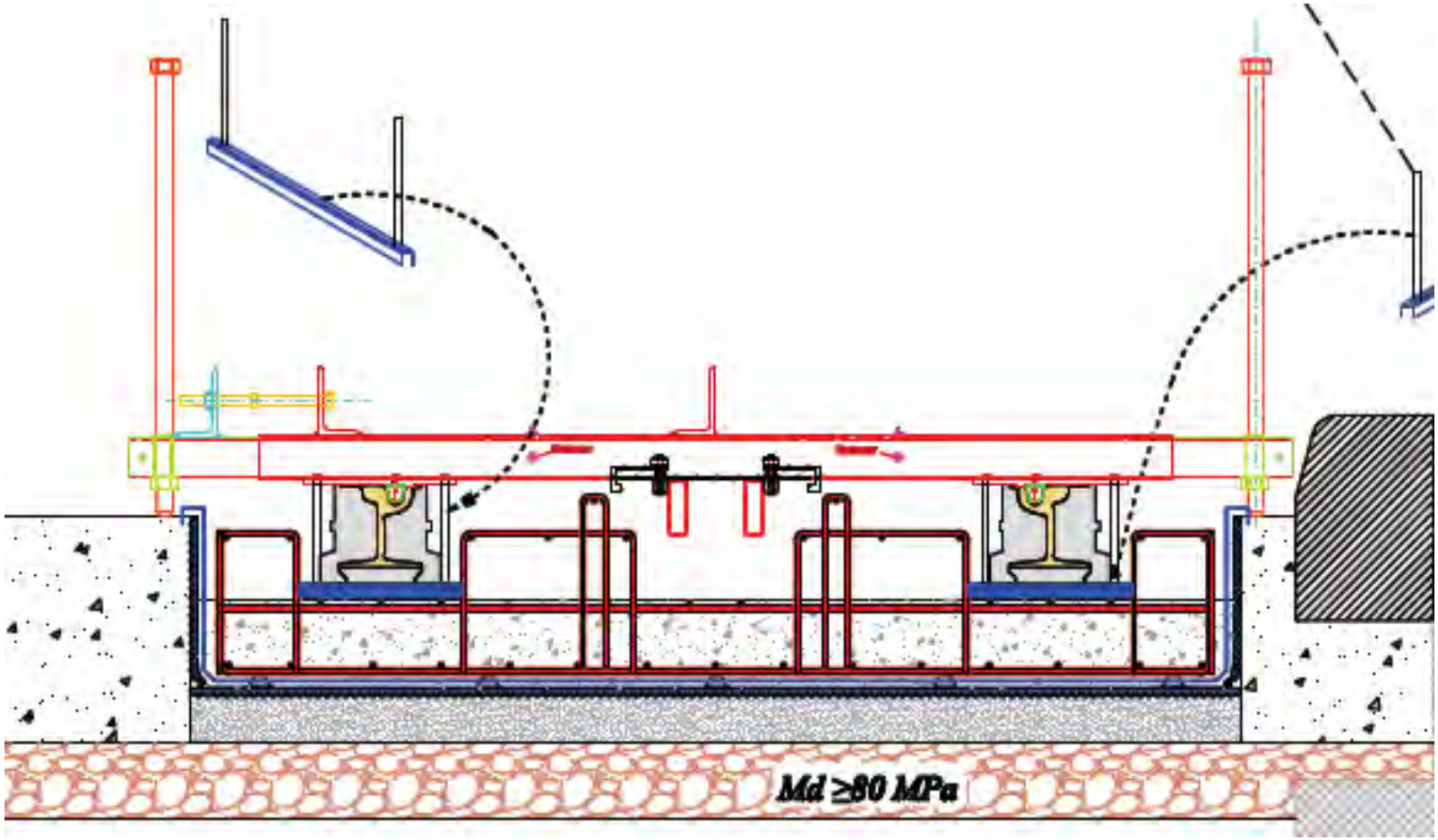


Phase II – Napoli Via Stadera Installation

Phase II – Installation Sequence - Mixed Traffic Zone

Making your world a quieter place

- Track Levelling in X, Y, Z using CDM-JIG's:

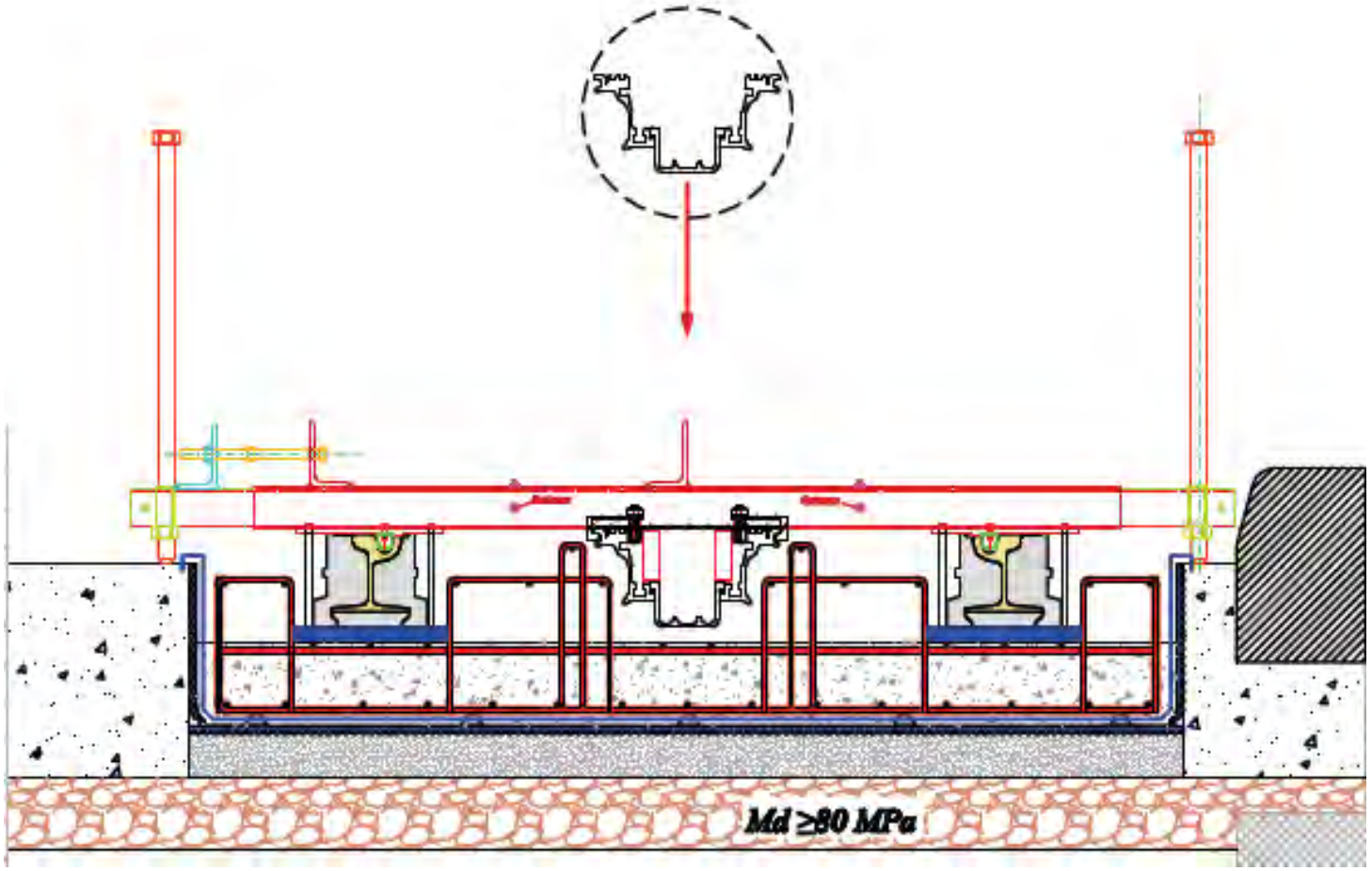


Phase II – Napoli Via Stadera Installation

Phase II – Installation Sequence - Mixed Traffic Zone

Making your world a quieter place

- Trogolo installation using CDM-JIG's + Brackets:

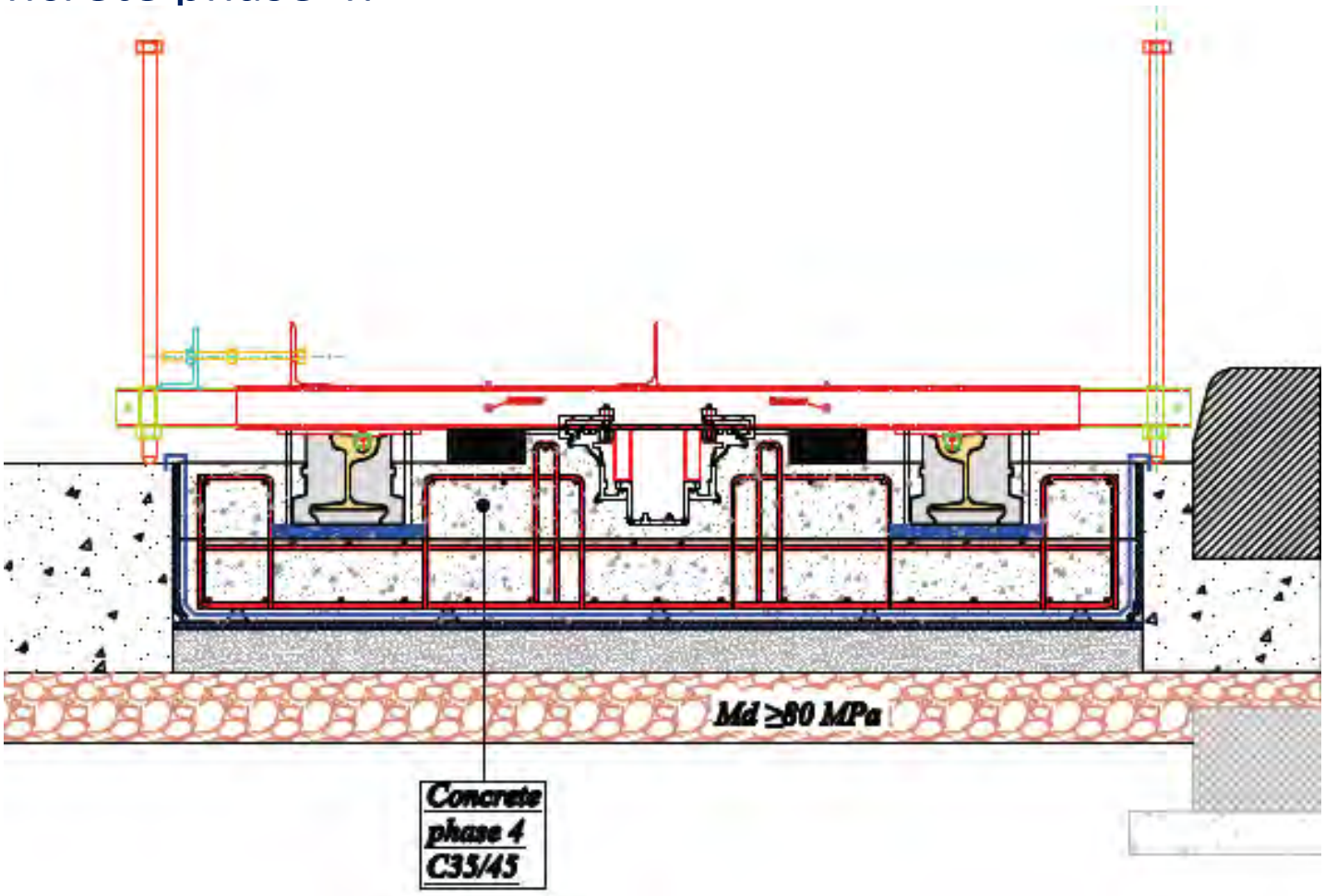


Phase II – Napoli Via Stadera Installation

Phase II – Installation Sequence - Mixed Traffic Zone

Making your world a quieter place

- Concrete phase 4:

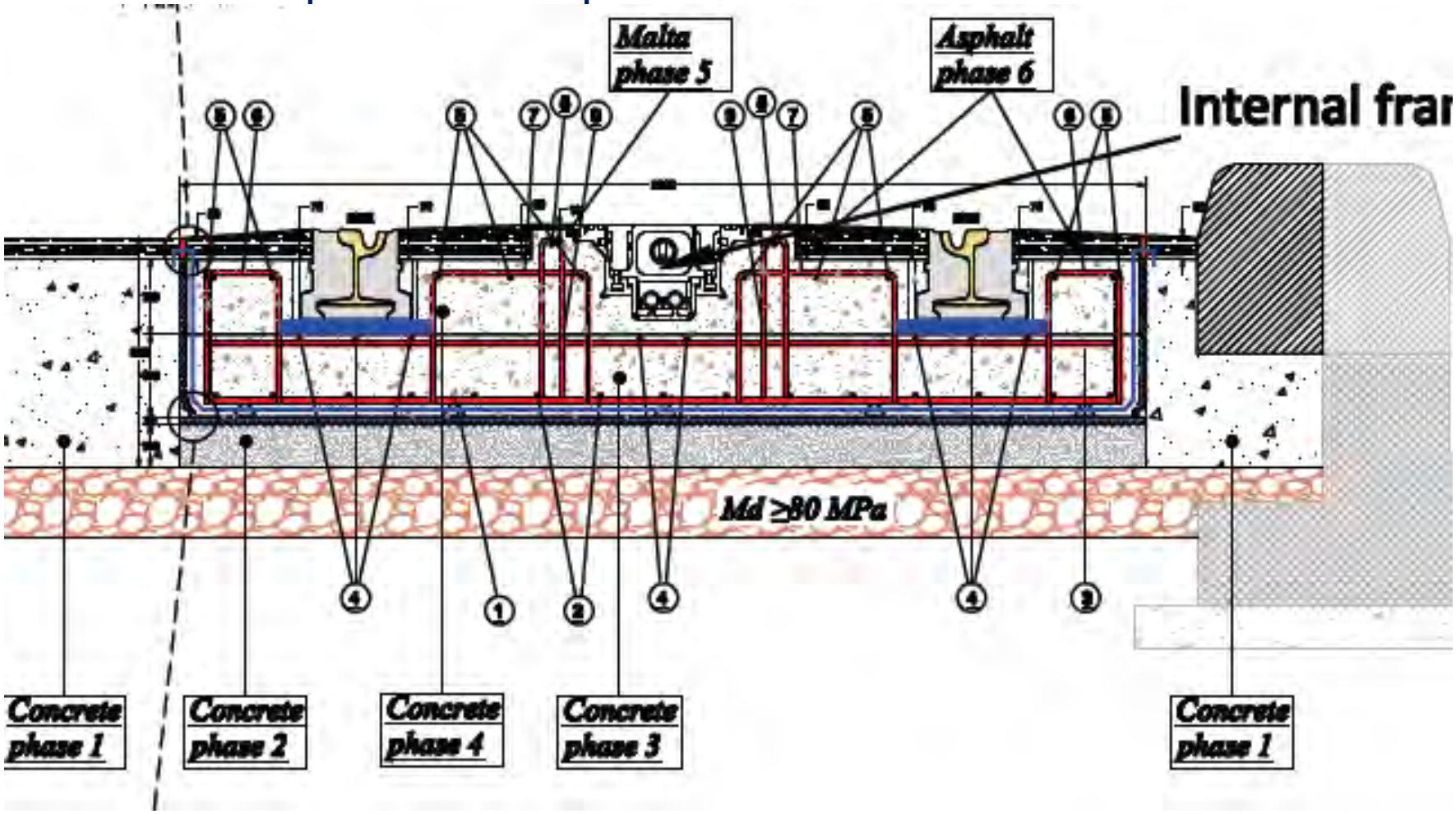


Phase II – Napoli Via Stadera Installation

Phase II – Installation Sequence - Mixed Traffic Zone

Making your world a quieter place

- Concrete phase 4 & Asphalt & Malta:



Phase II – Napoli Via Stadera Installation

Phase II – On Site Installation : CDM-profiles gluing

Making your world a quieter place

Phase II – Napoli Via Stadera Installation

Phase II – On Site Installation: CDM-FSM

Making your world a quieter place

Phase II – Napoli Via Stadera Installation

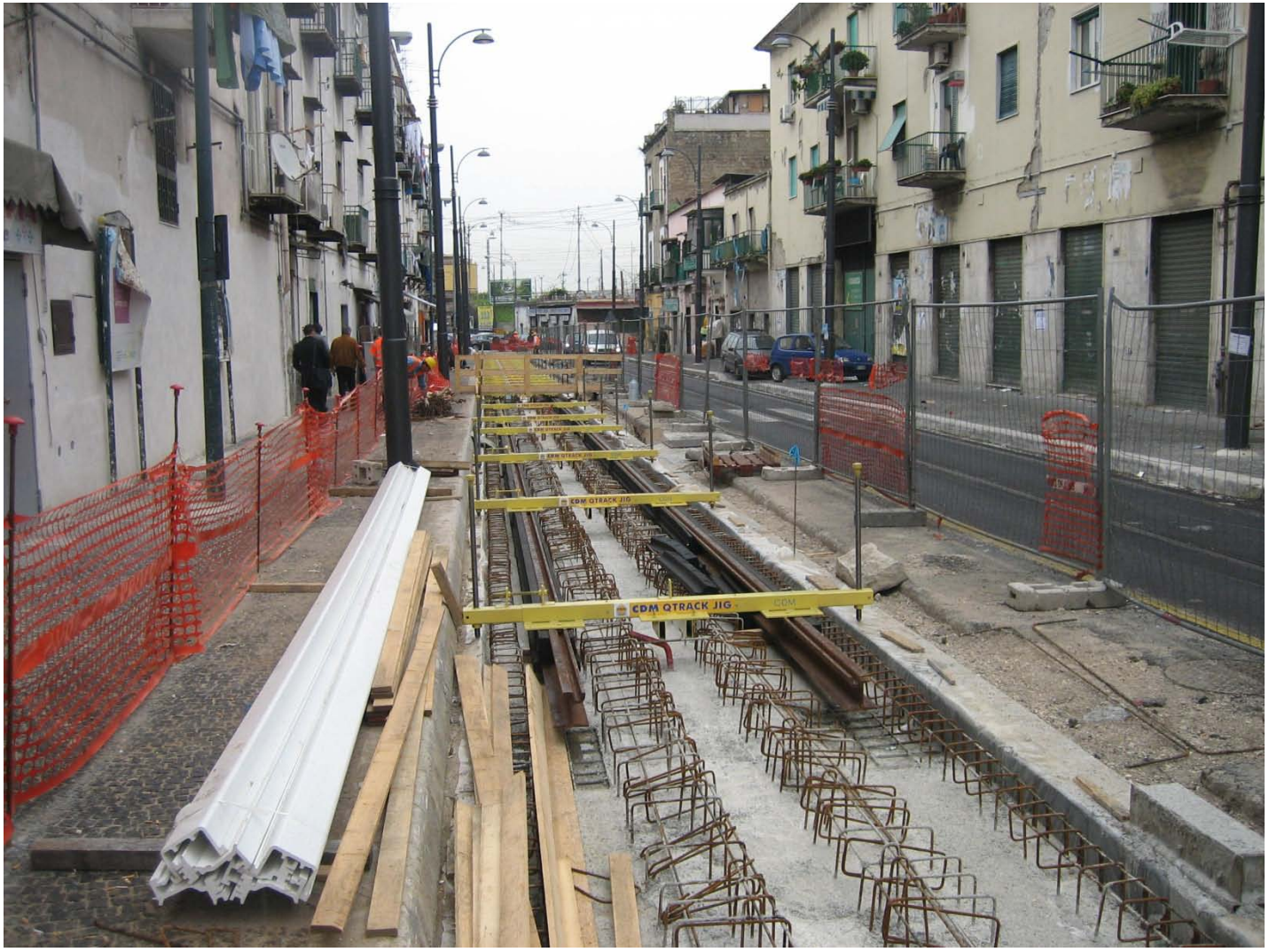
Phase II – On Site Installation: steel reinforcements

Making your world a quieter place

Phase II – Napoli Via Stadera Installation

Phase II – On Site Installation: CDM-JIG's

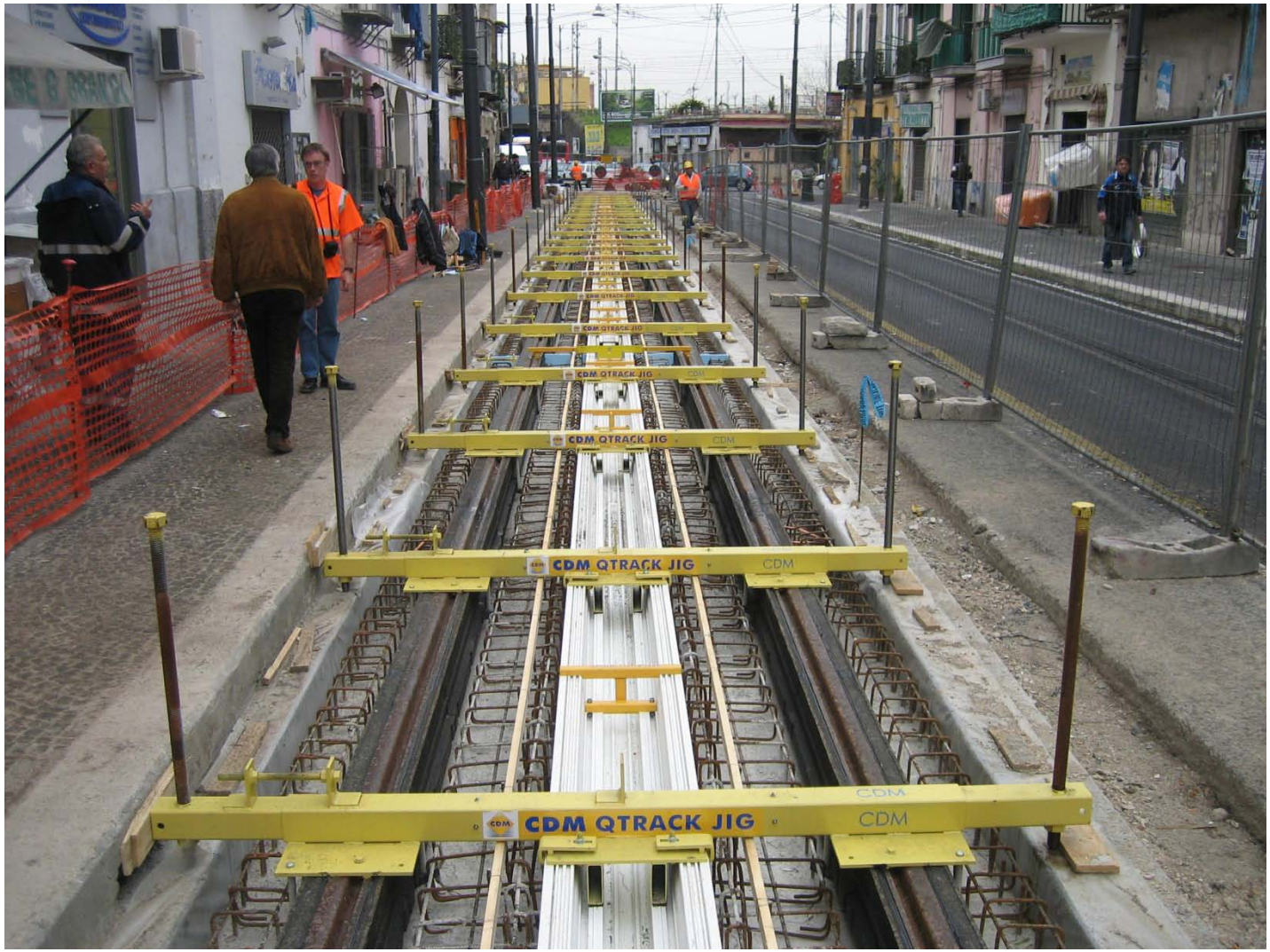
Making your world a quieter place



Phase II – Napoli Via Stadera Installation

Phase II – On Site Installation: Trogolo

Making your world a quieter place



Phase II – Napoli Via Stadera Installation

Phase II – On Site Installation: Trogolo & Brackets

Making your world a quieter place

Phase II – Napoli Via Stadera Installation

Phase II – On Site Installation: CDM-FSM

Making your world a quieter place

Phase II – Napoli Via Stadera Installation

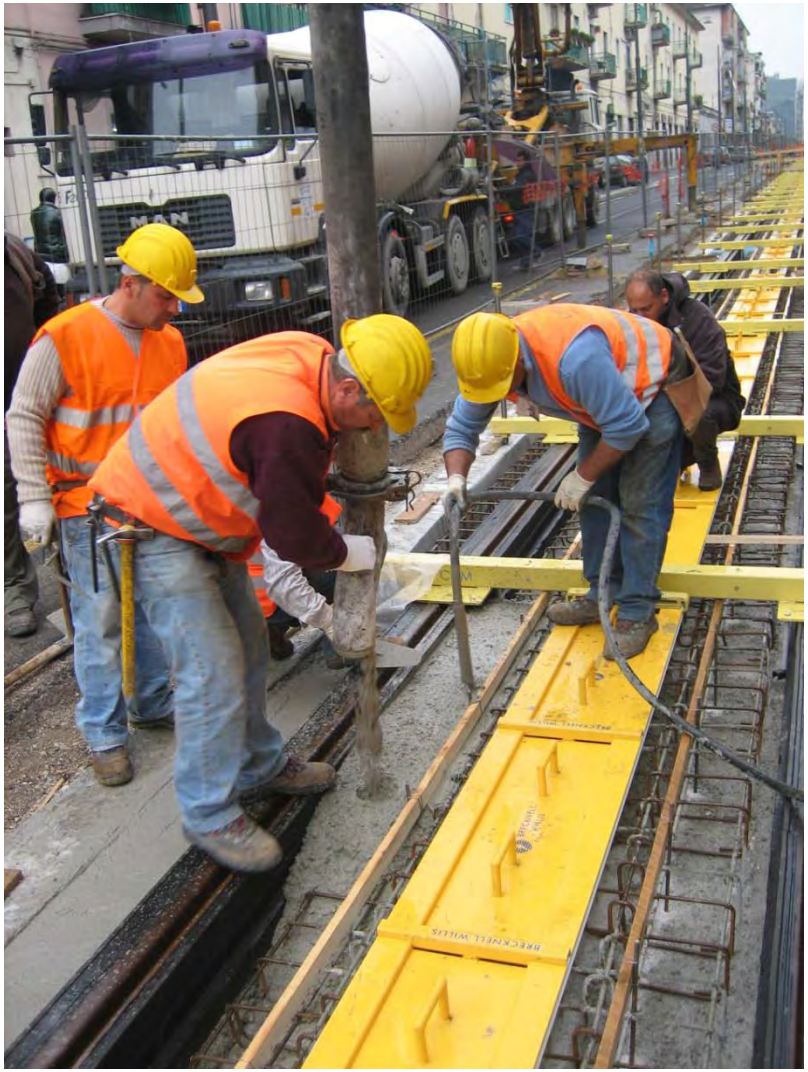
Phase II – On Site Installation: Concrete phase 4 & Asphalt & Malta

Making your world a quieter place

Phase II – Napoli Via Stadera Installation

Phase II – On Site Installation: Concrete phase 4 & Asphalt & Malta

Making your world a quieter place



Phase II – Napoli Via Stadera Installation

Phase II – On Site Installation: Concrete phase 4 & Asphalt & Malta

Making your world a quieter place

Phase II – Napoli Via Stadera Installation

Phase II – On Site Installation: Concrete phase 4 & Asphalt & Malta

Making your world a quieter place

Phase II – Napoli Via Stadera Installation

Phase II – On Site Installation: Concrete phase 4 & Asphalt & Malta

Making your world a quieter place

Phase II – Napoli Via Stadera Installation

Phase II – On Site Installation: Concrete phase 4 & Asphalt & Malta

Making your world a quieter place

Phase II – Napoli Via Stadera Installation

Phase II – On Site Installation: Concrete phase 4 & Asphalt & Malta

Making your world a quieter place

Conclusion

New opportunities for CDM

Making your world a quieter place

- ASTS is now very interested to collaborate furthermore with CDM in different projects with and without the CDM-QT-JIG-TRAMWAVE system:
  - Lusail (Qatar)
  - Copenhagen
  - Italian, European and Worldwide projects …

THANK YOU FOR YOUR ATTENTION

Making your world a quieter place

Making your world a quieter place

CDM 60th Anniversary

Thank you for your attention