TramWave

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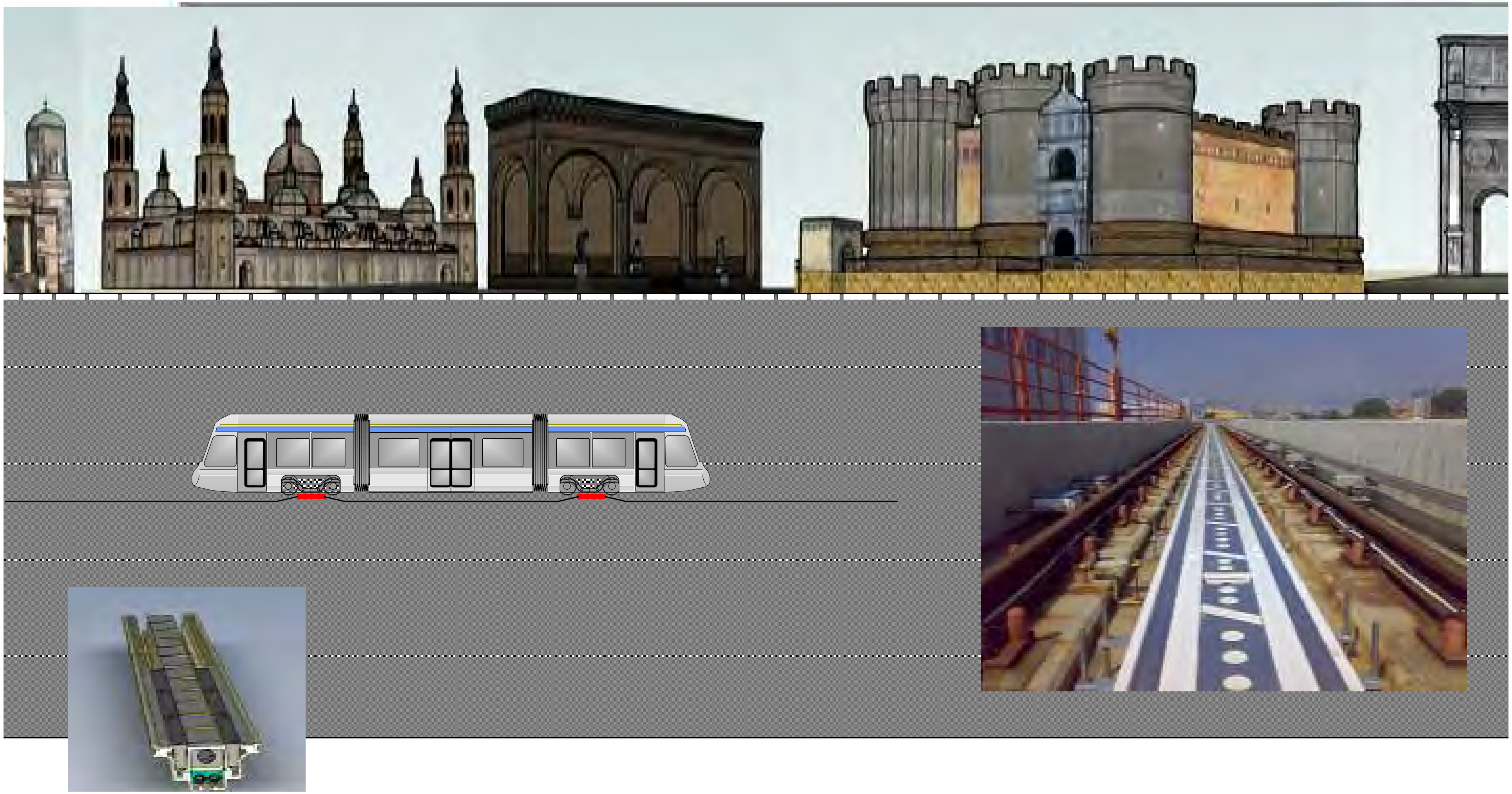

The Ultimate CATENARY FREE TRAMWAY SYSTEM

TramWave

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



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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.*

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- 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.

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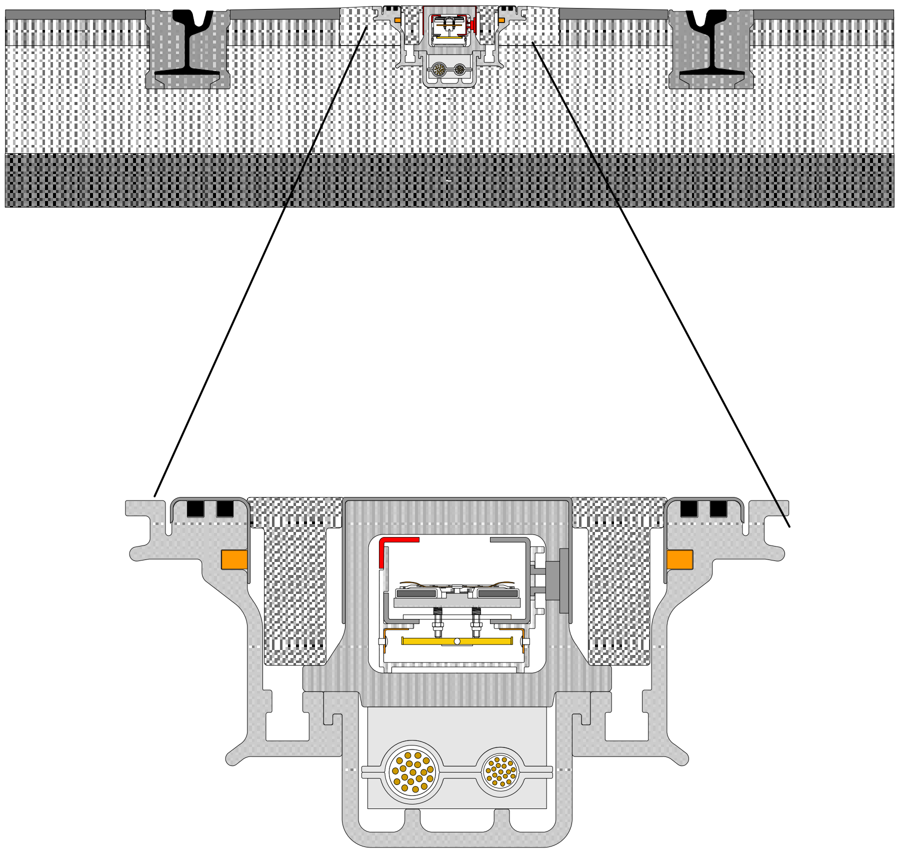
The "Tramwave" power line can be easily installed between the running rails.

- *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.*



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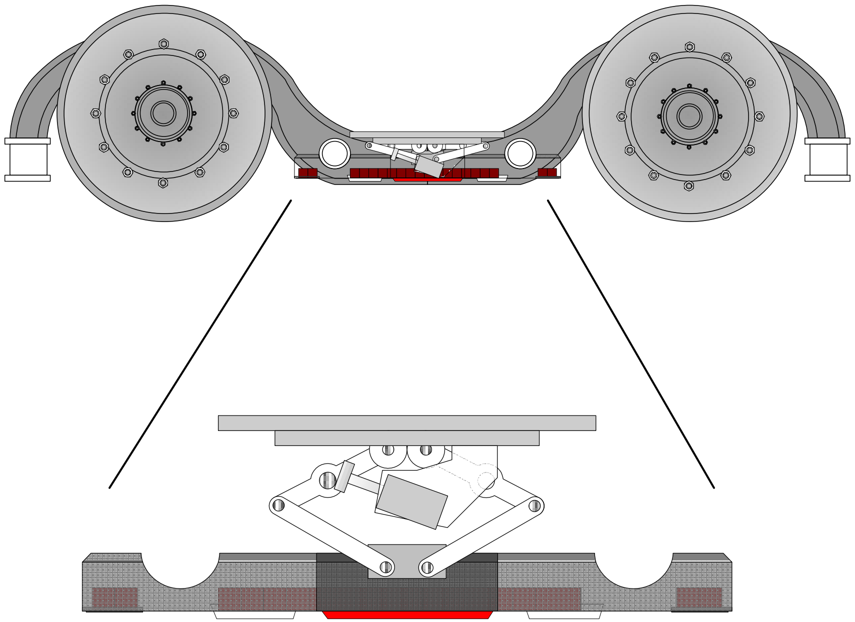
The overall dimensions and functional characteristics of "TramWave" power collector are enough compact to be inserted inside a tram bogie, or, if necessary, under the vehicle body.

- *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.*



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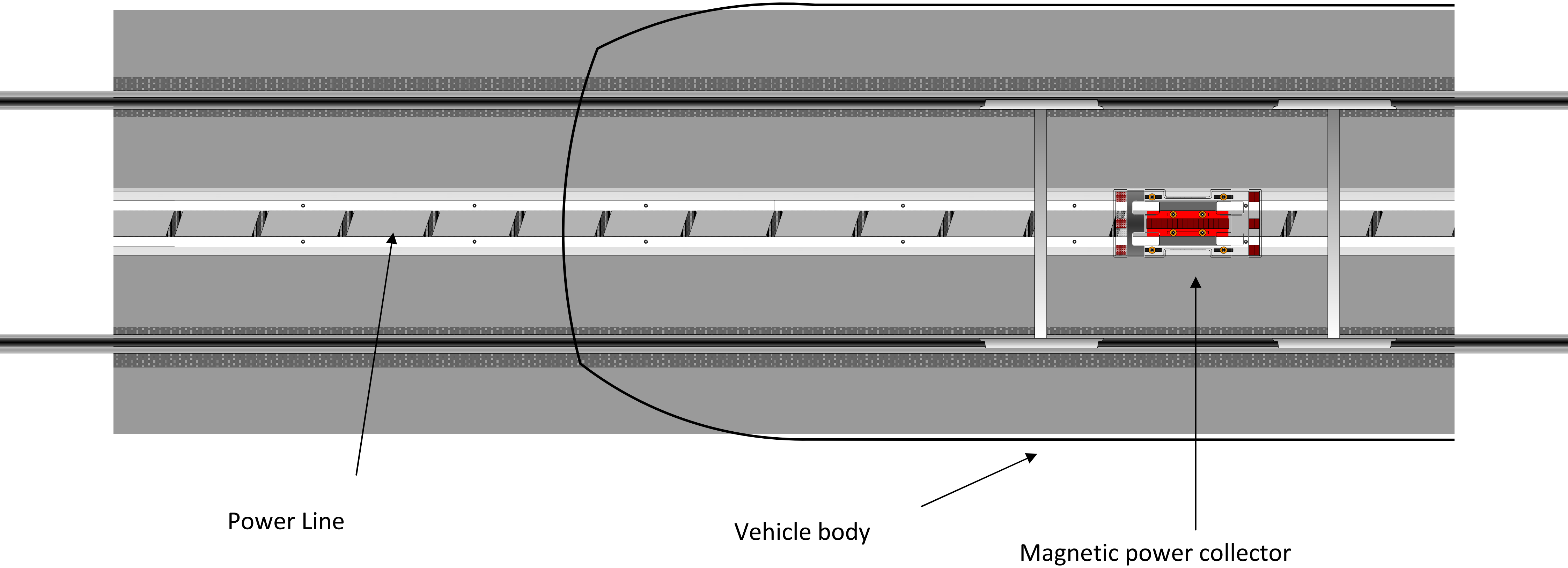
Tramwave components



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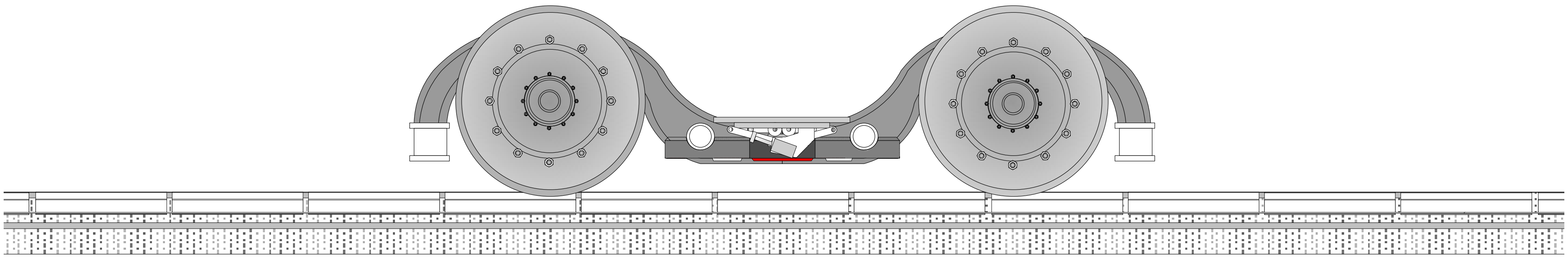

When the pantograph is retracted in rest position:

- *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.*

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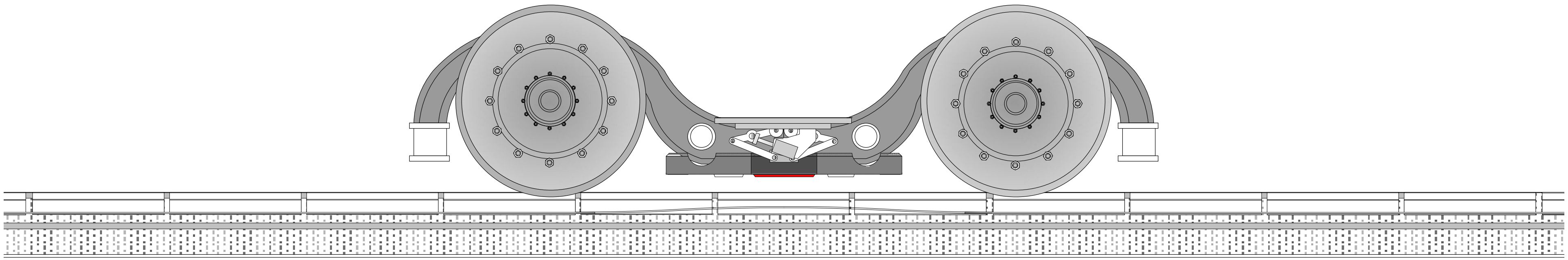

When the pantograph is released:

- *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.*

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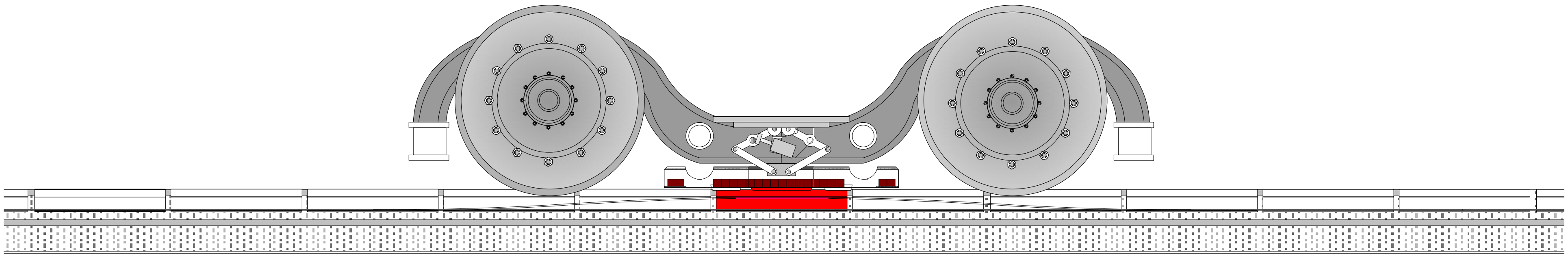

When the pantograph is completely released :

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

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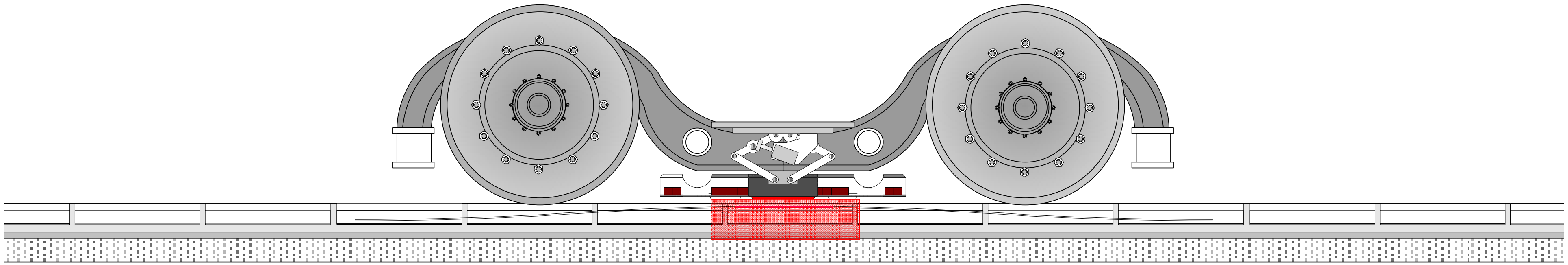

The vehicle is ready to run, powered by the line.

Operating principles

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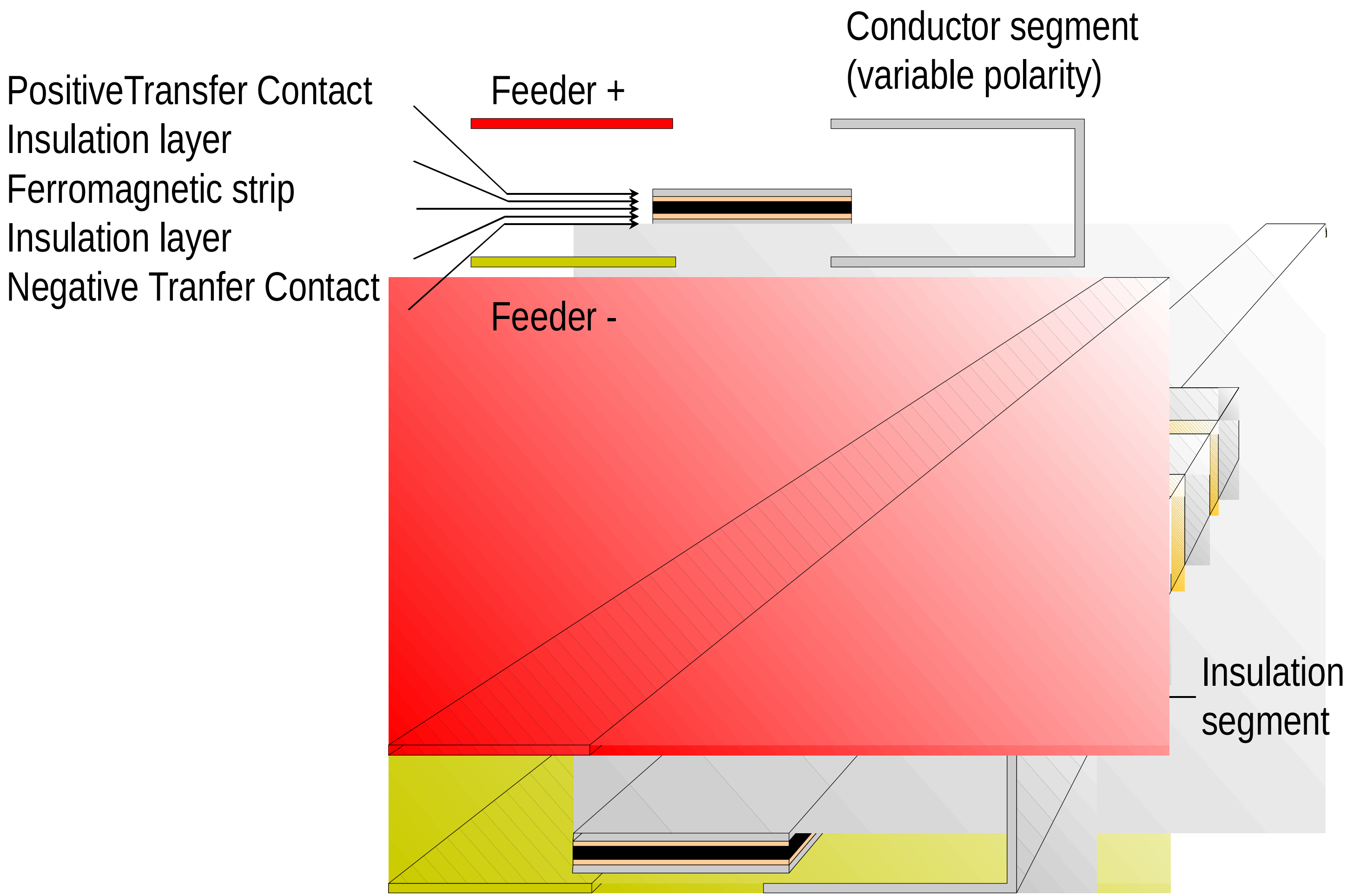

Conductor segment
(variable polarity)
PositiveTransfer Contact
Insulation layer
Ferromagnetic strip
Insulation layer
Negative Tranfer Contact
Feeder +
Feeder -
Insulation
segment

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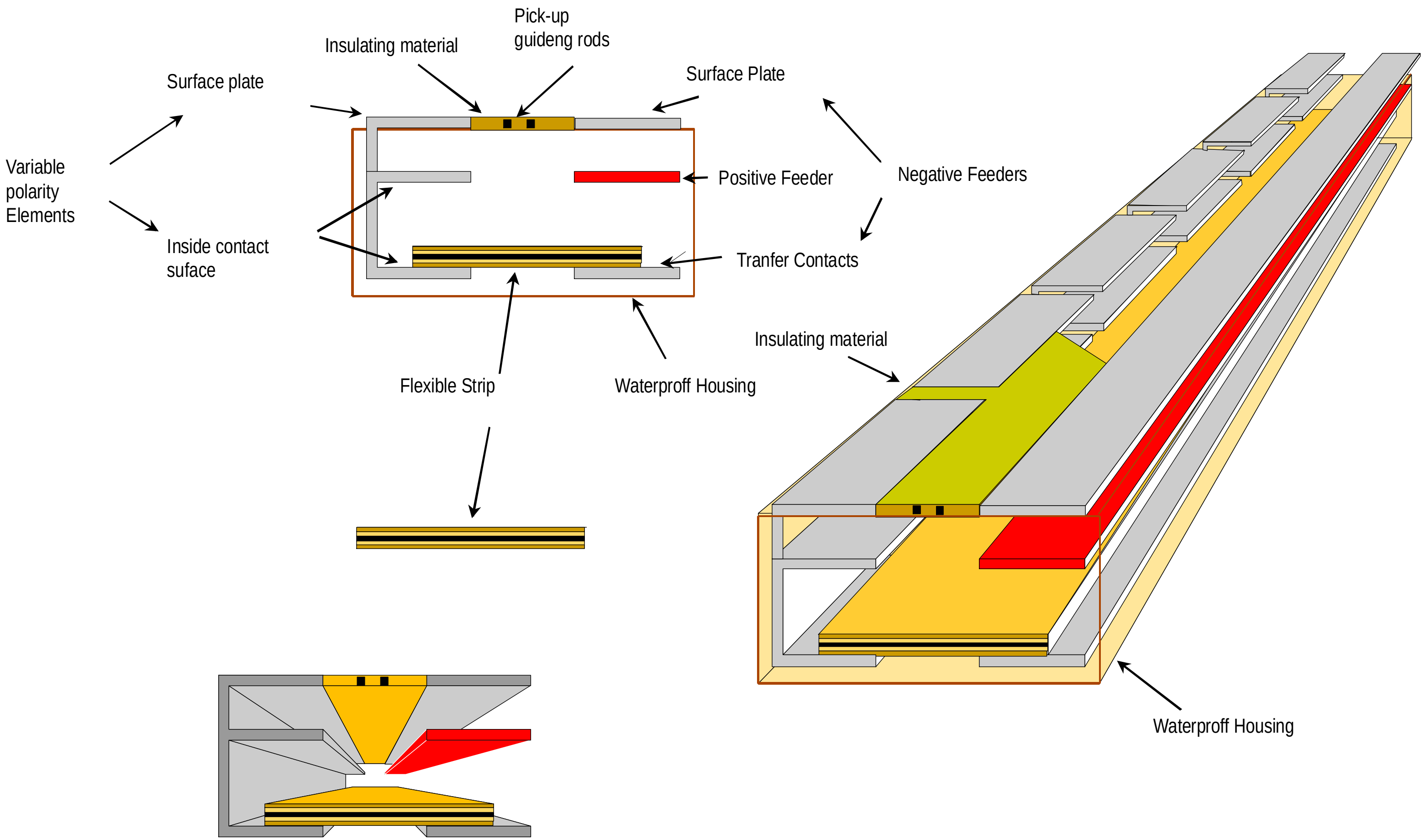
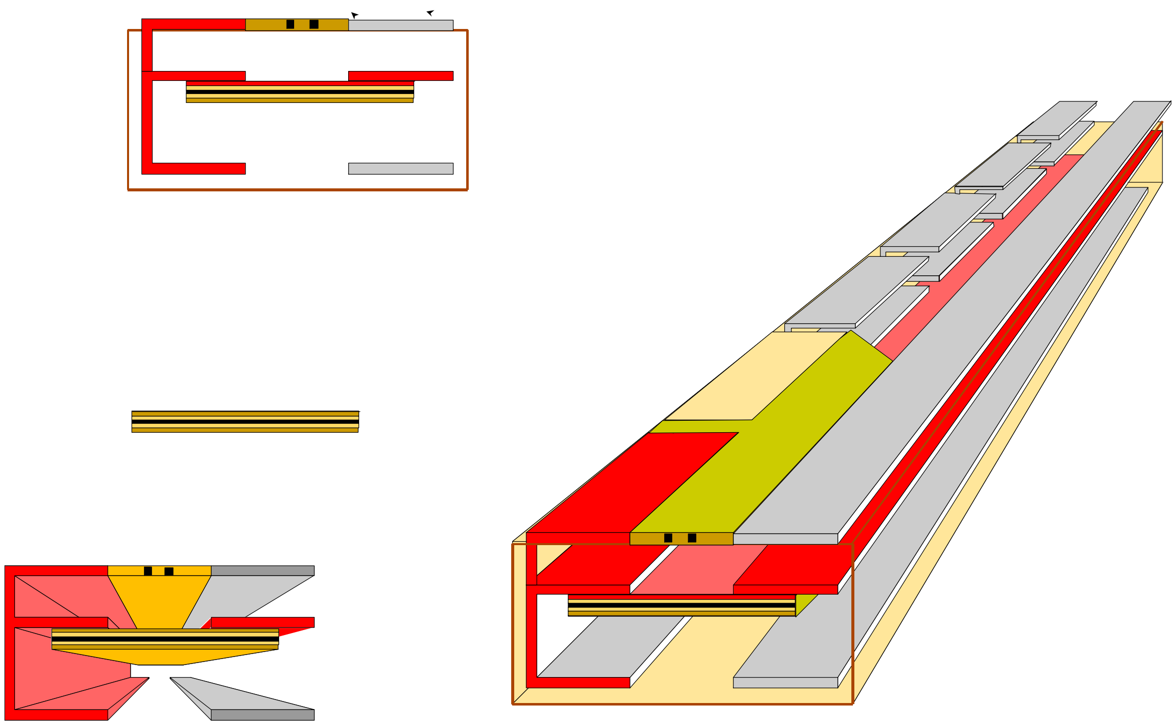
Concept



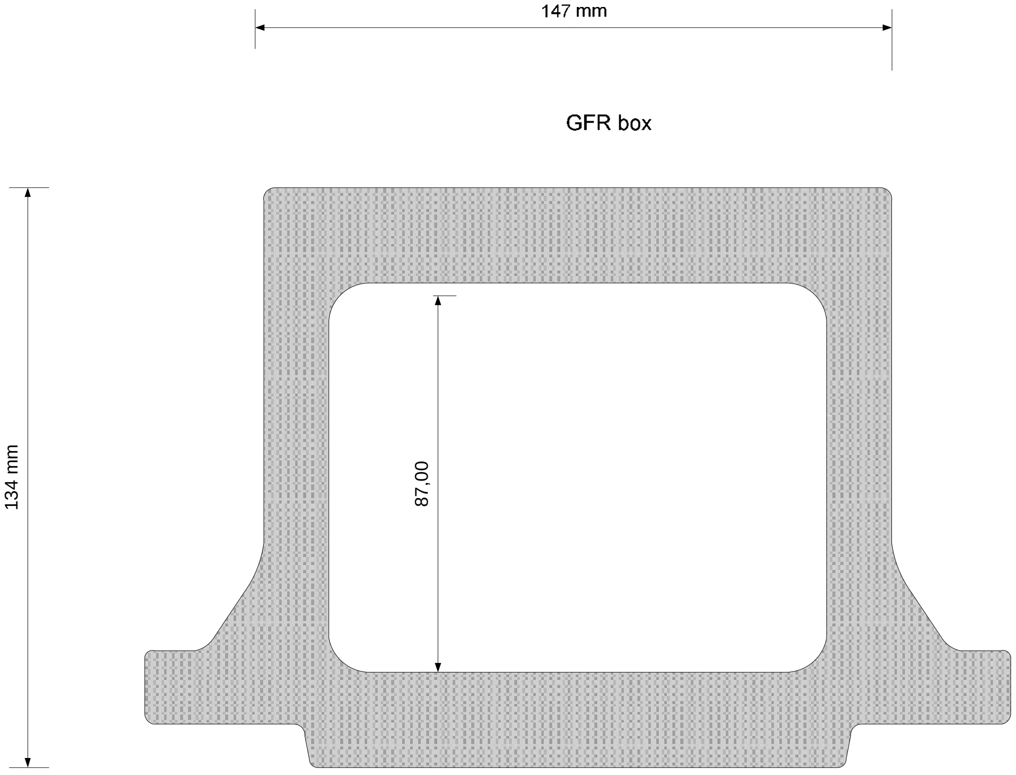
Concept



Main components

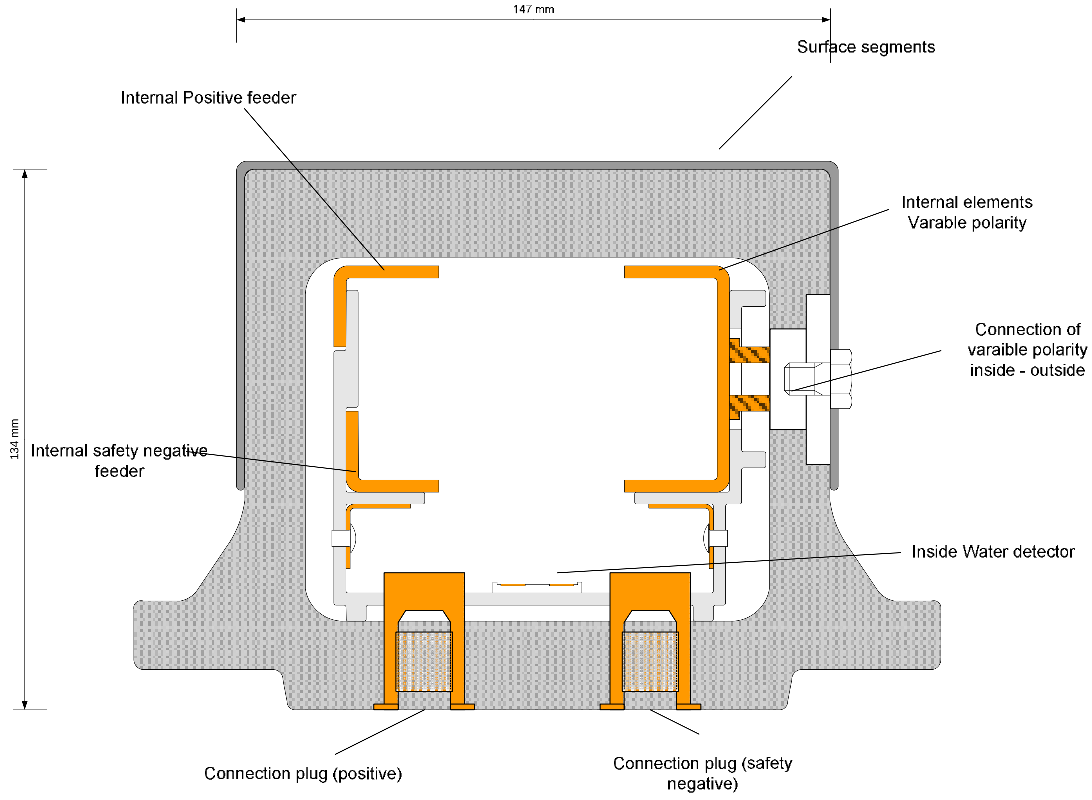
Module section

The Module

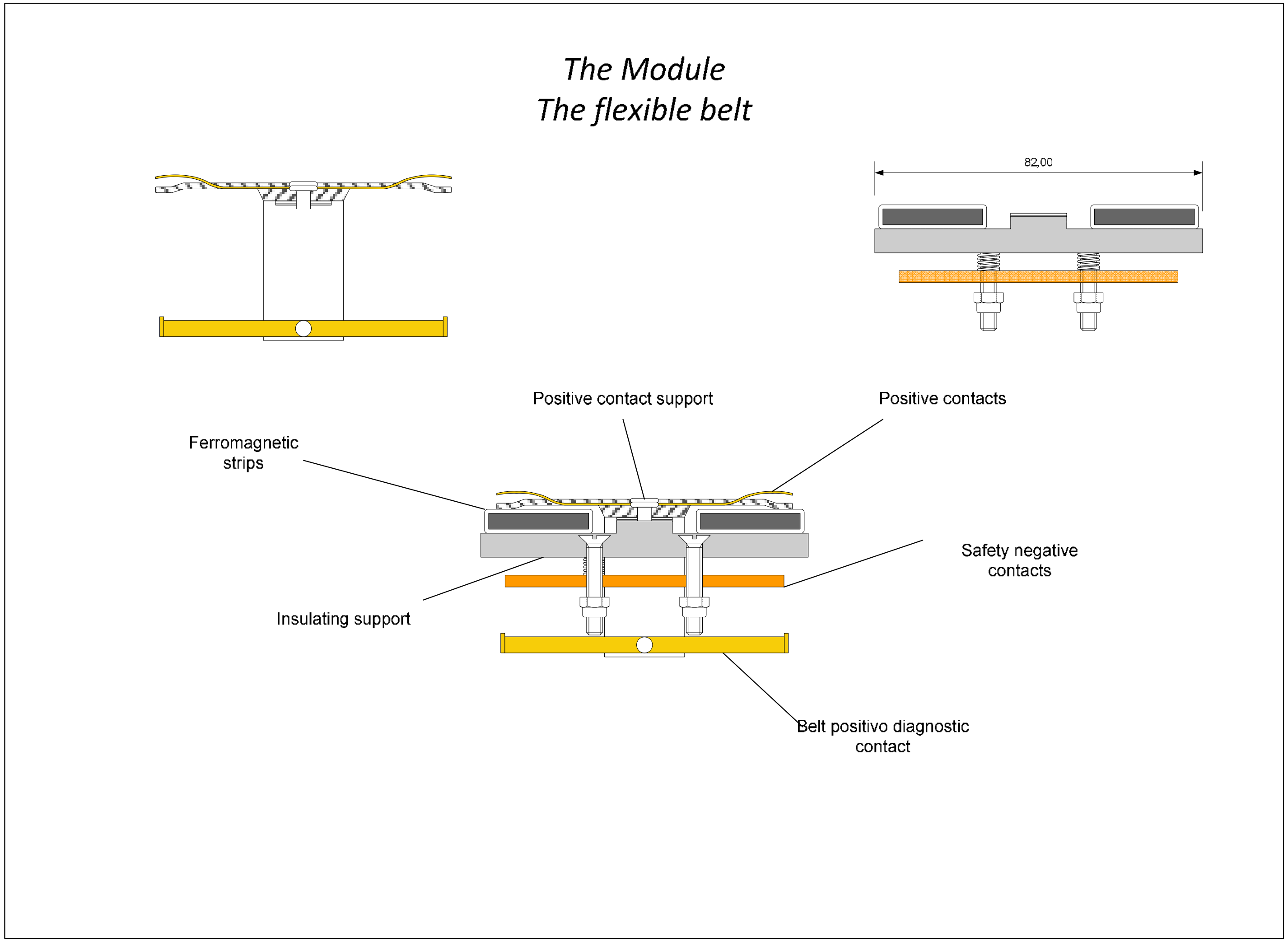


The module: Internals – Fixed elements

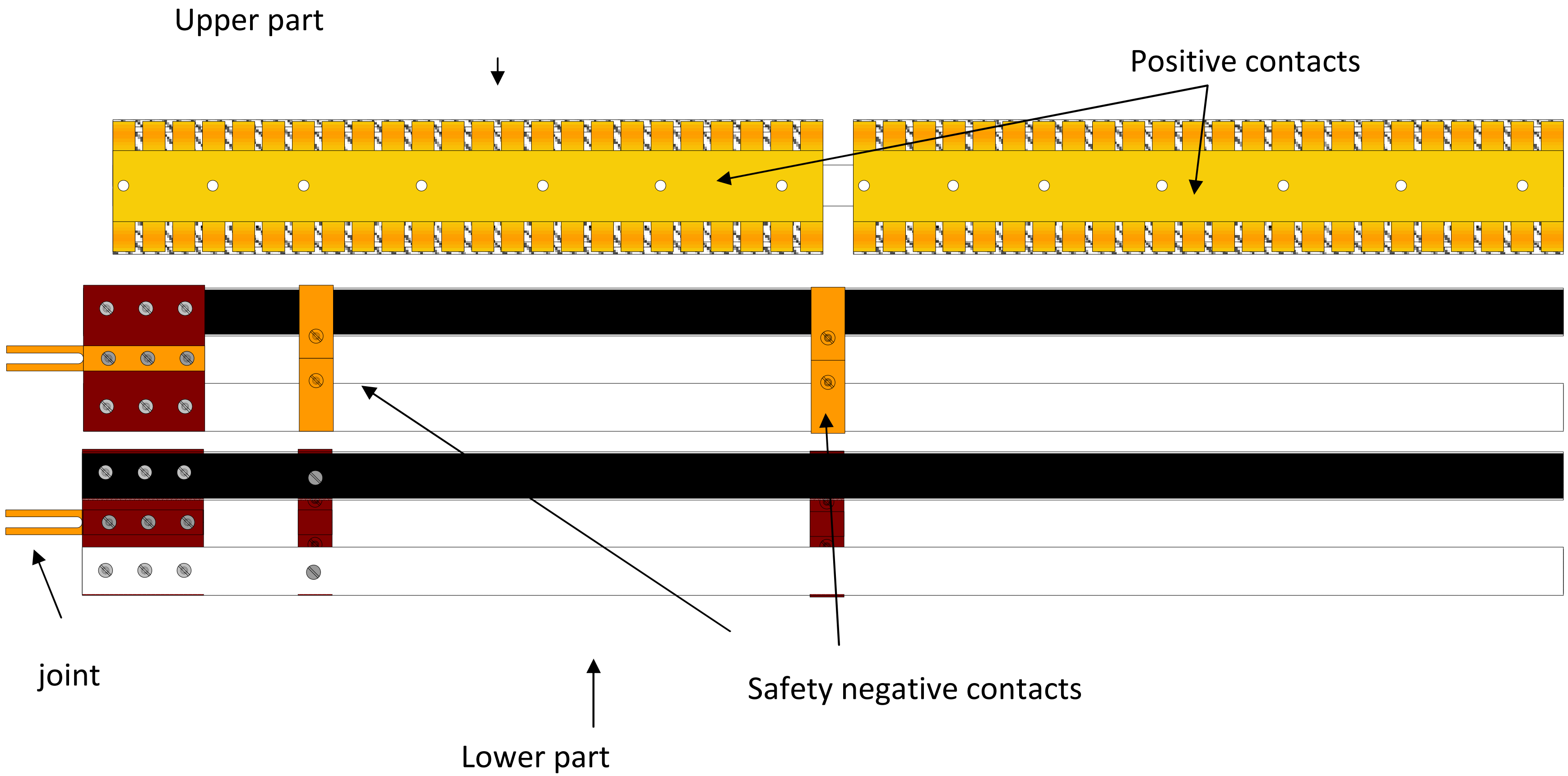
The module fully equipped



The flexible belt and contact carrier



The flexible belt and contact carrier



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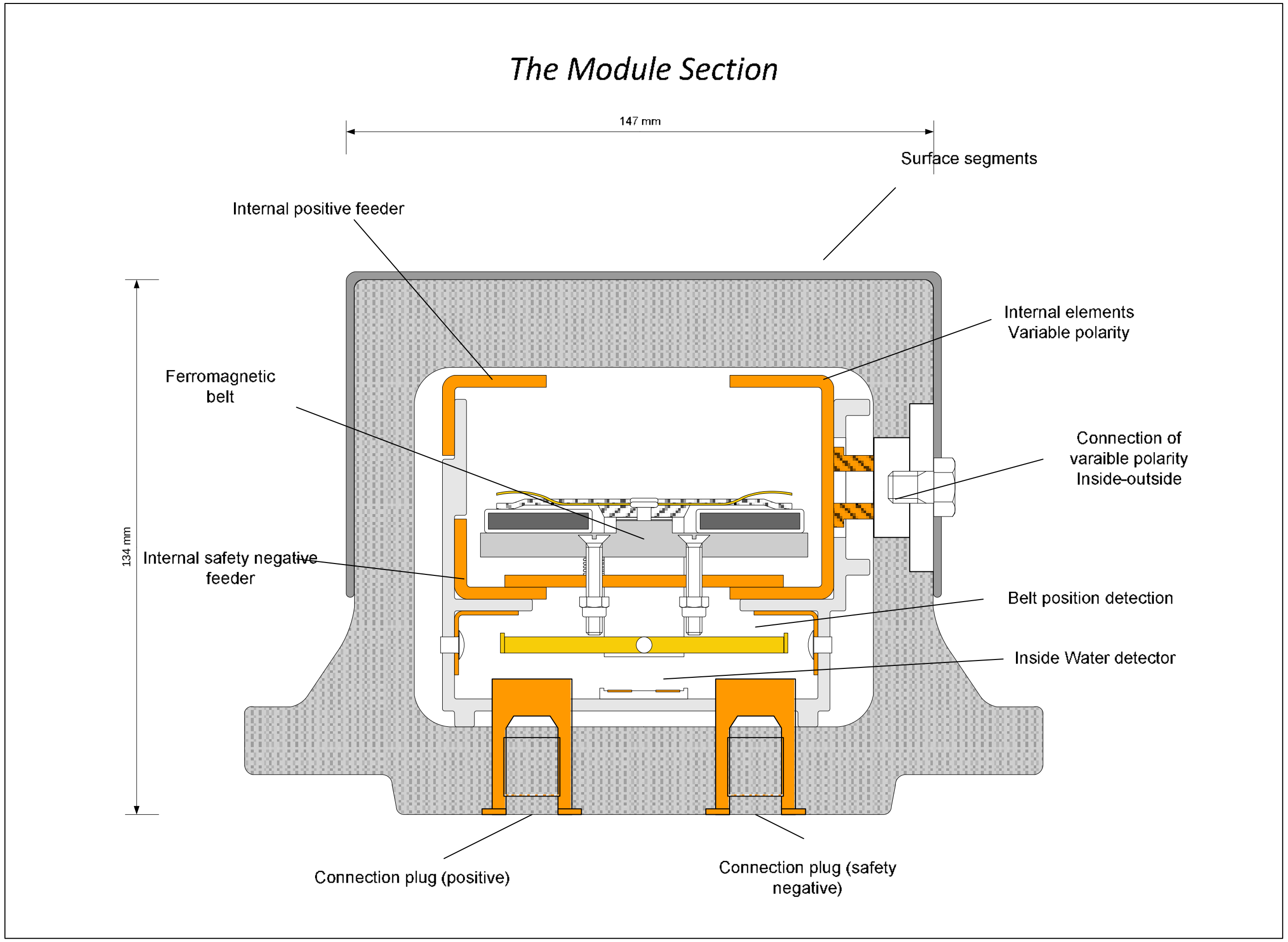
The module: global section



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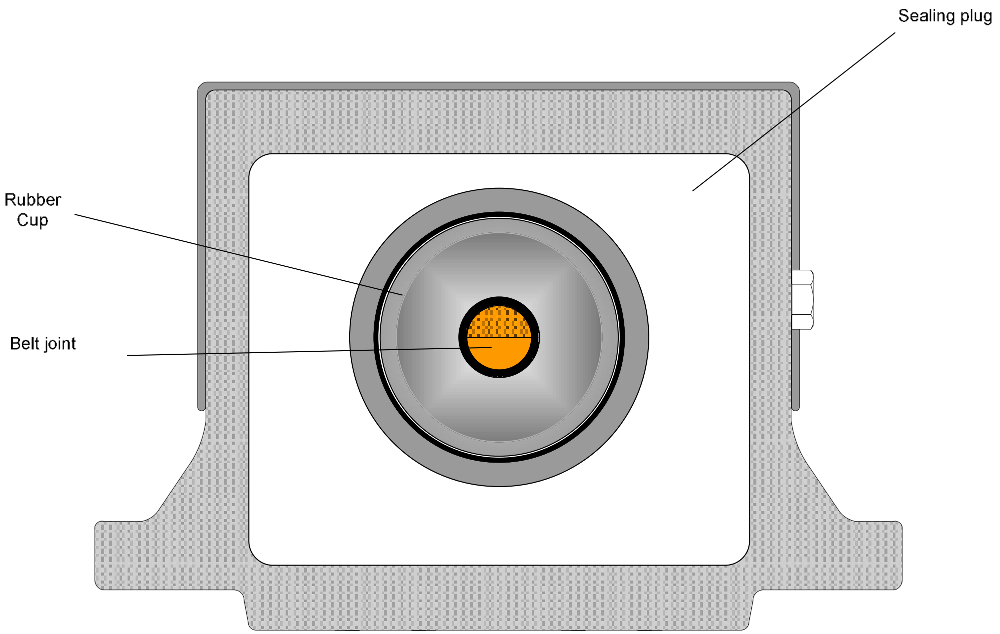
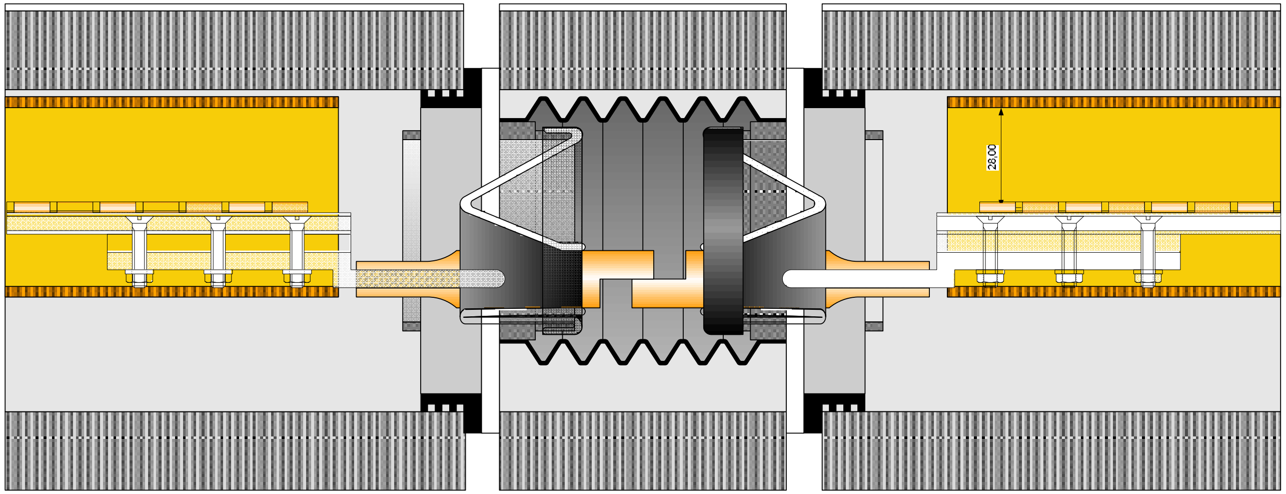
The module
End terminations



Joints between adjacent modules



Rest condition

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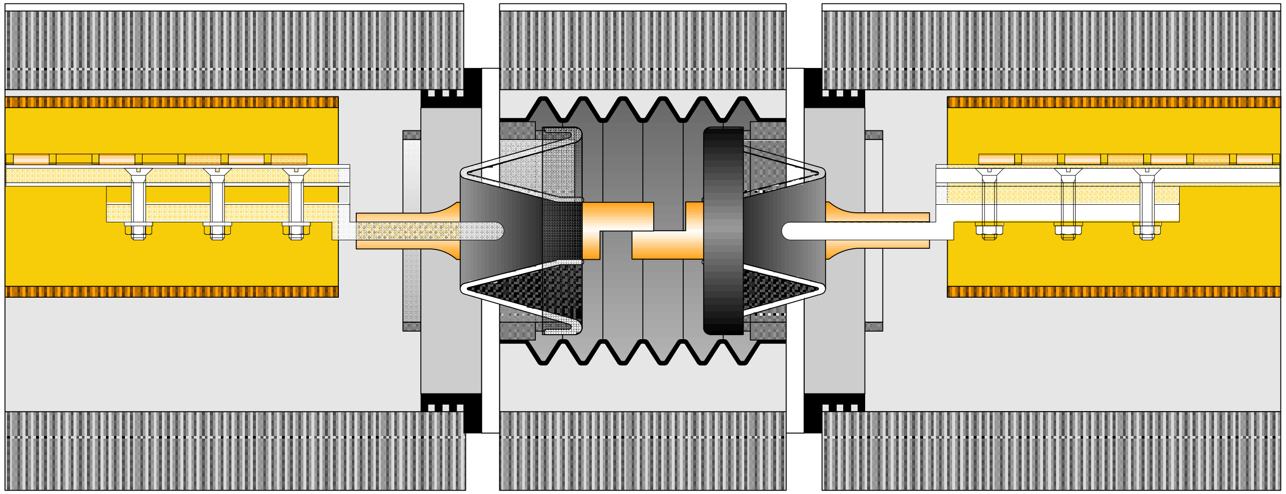

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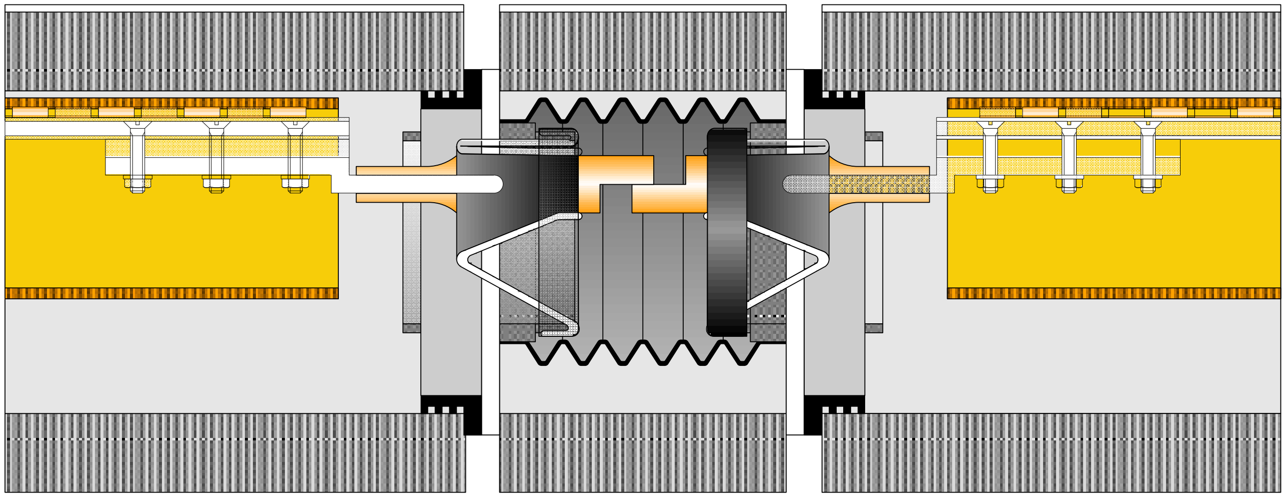

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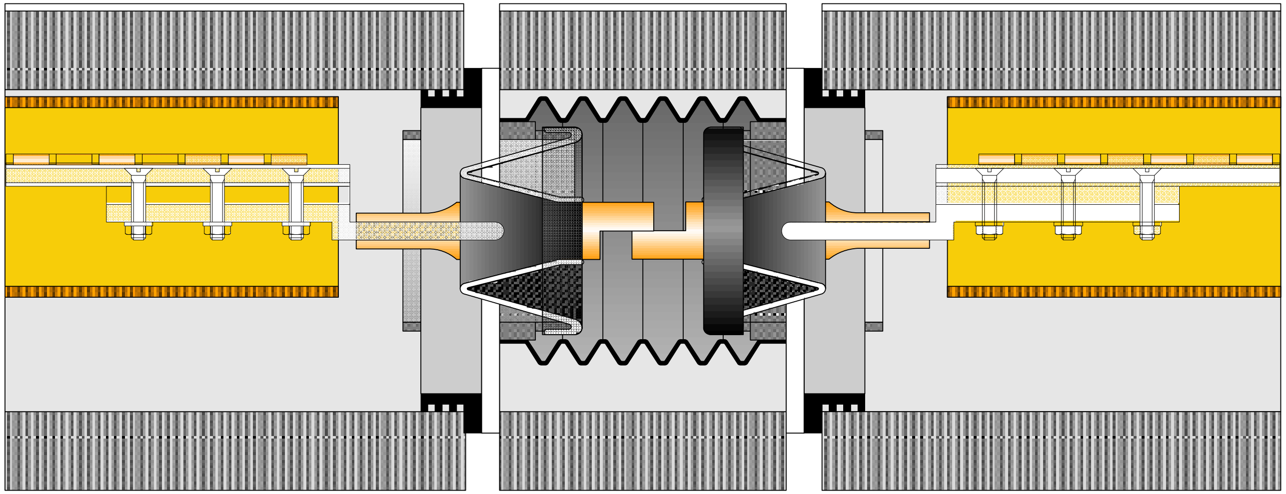

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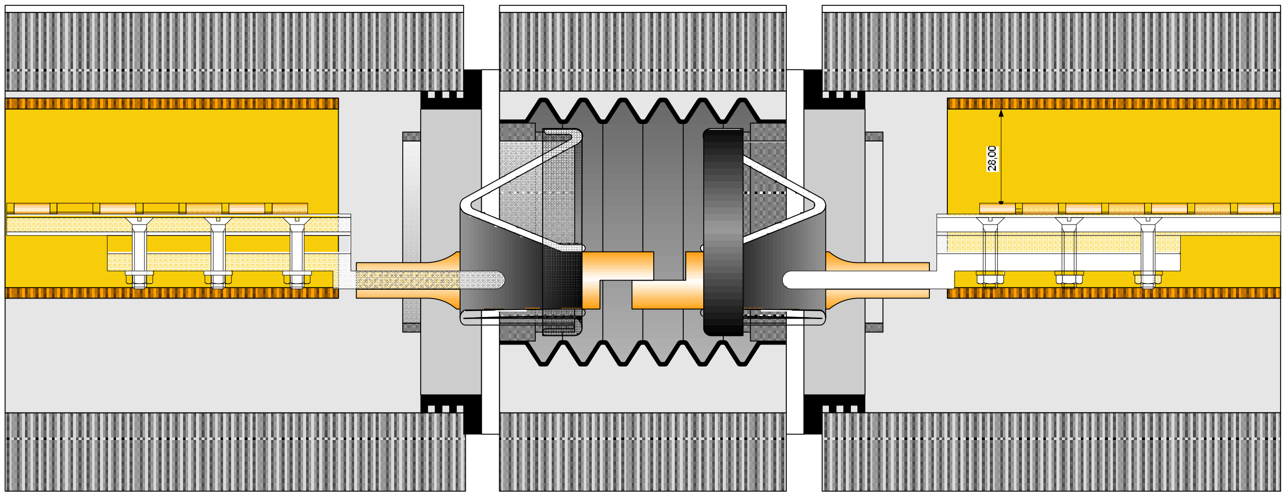
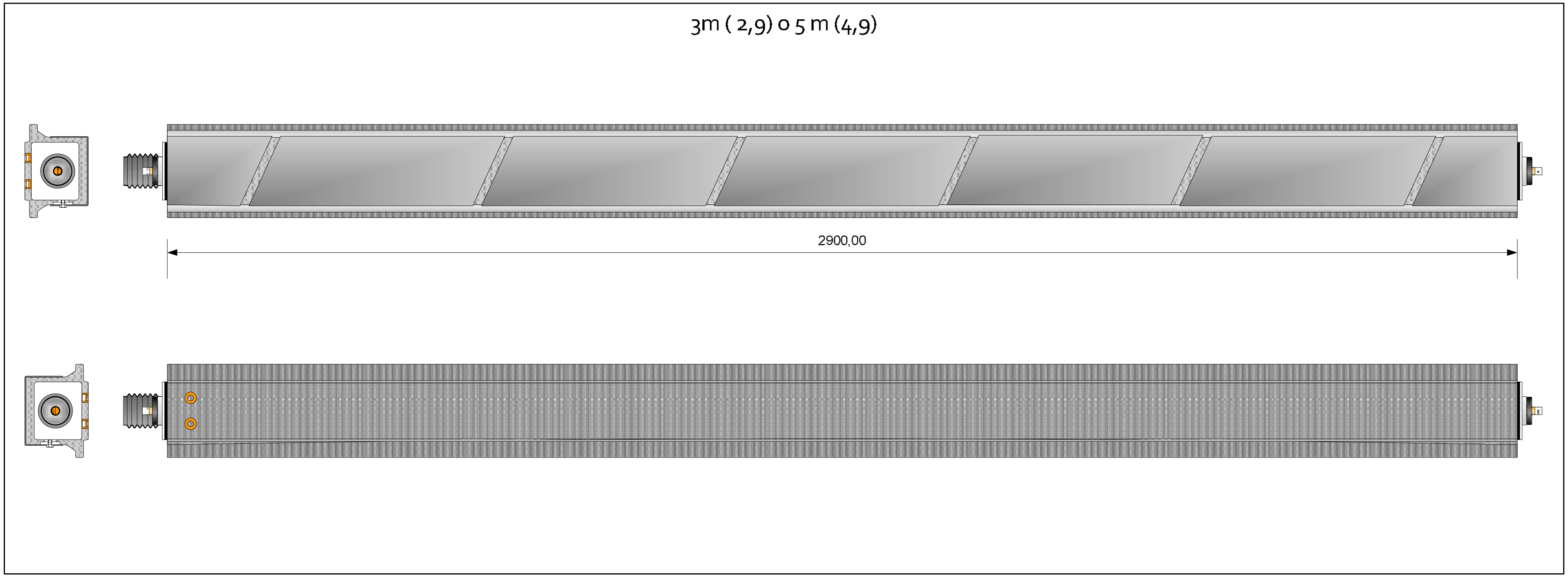
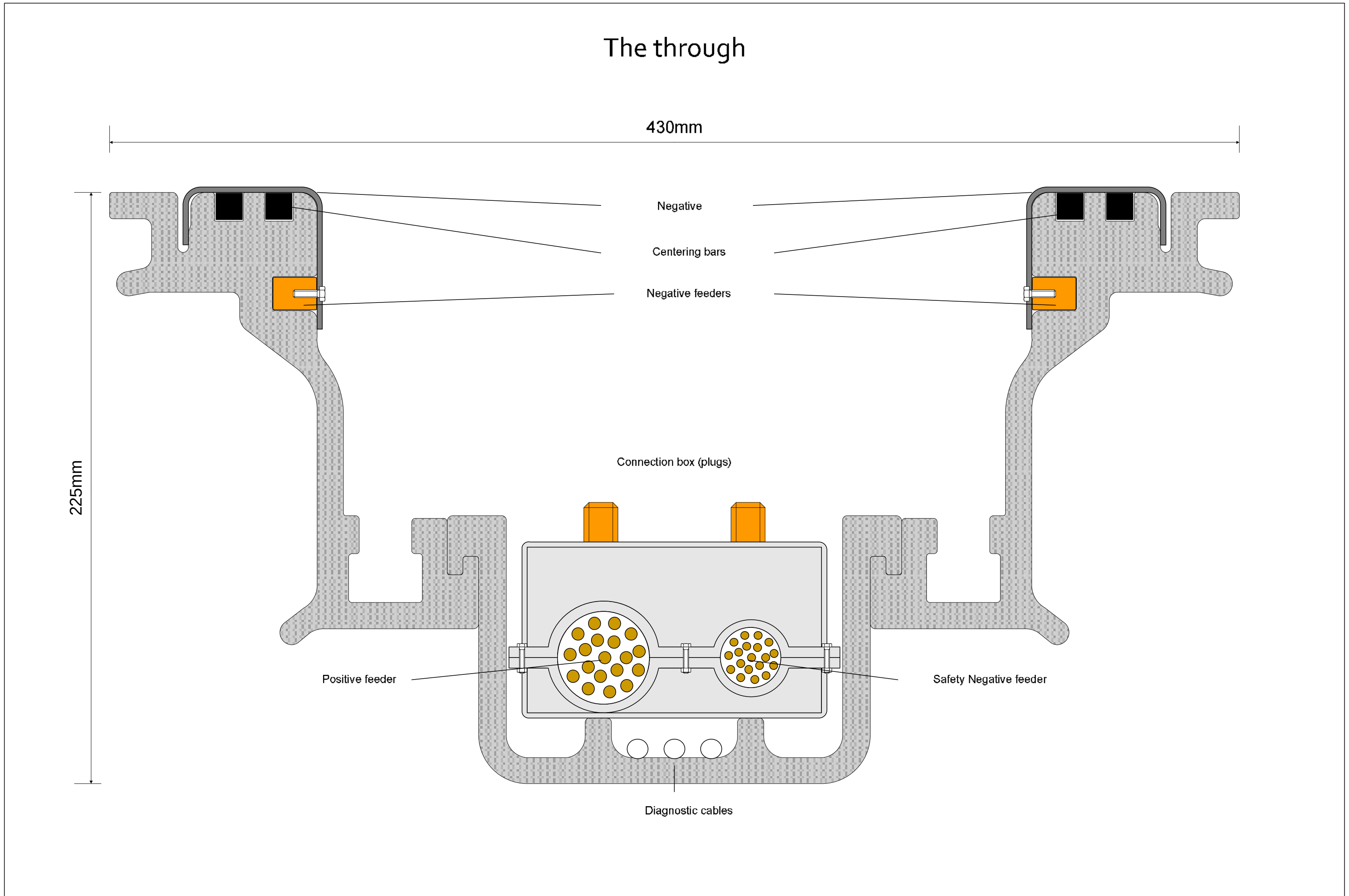


The module fully assembled



The open conduit (the trough) Section



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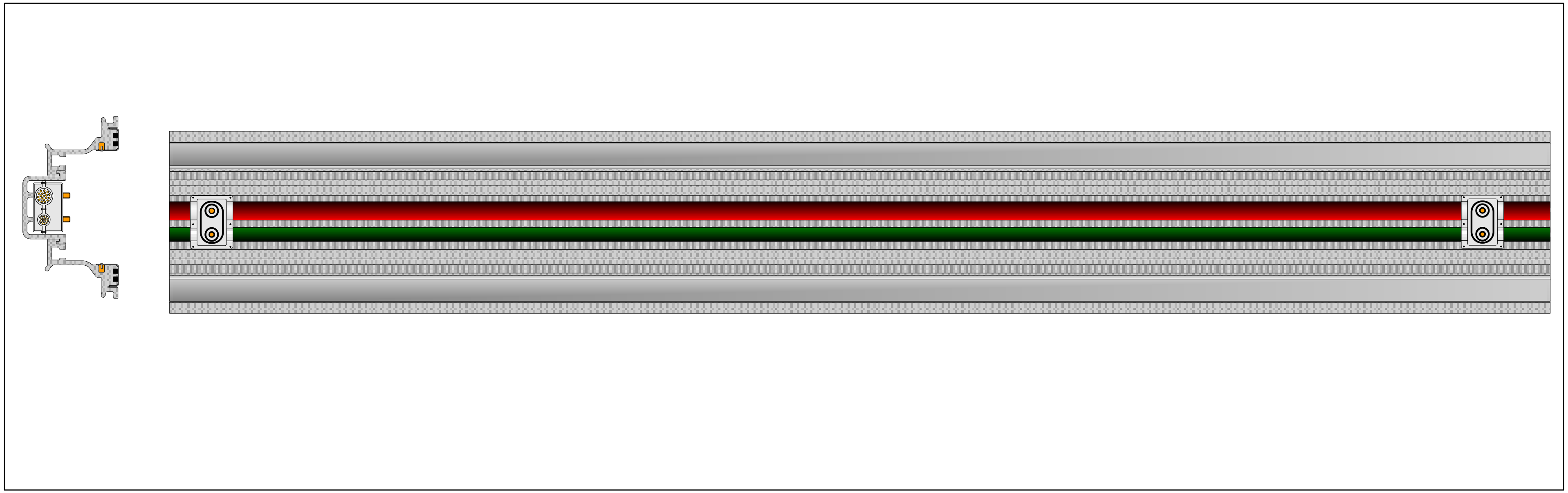
The open conduit (the trough) Top View



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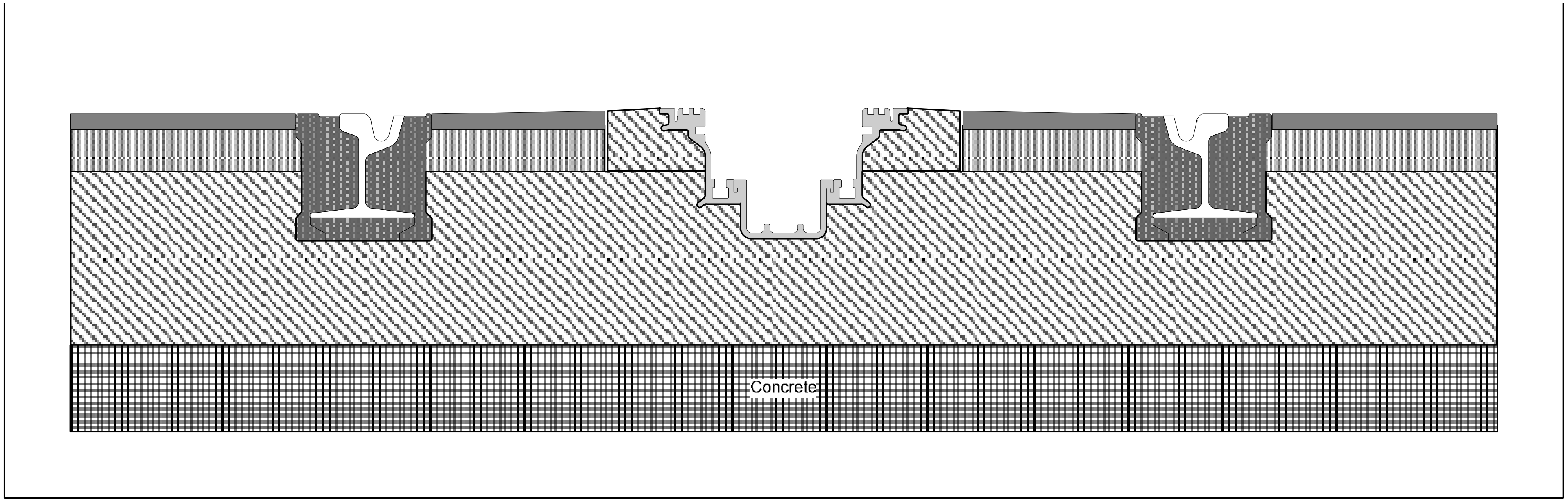
Example of trough insertion in the track



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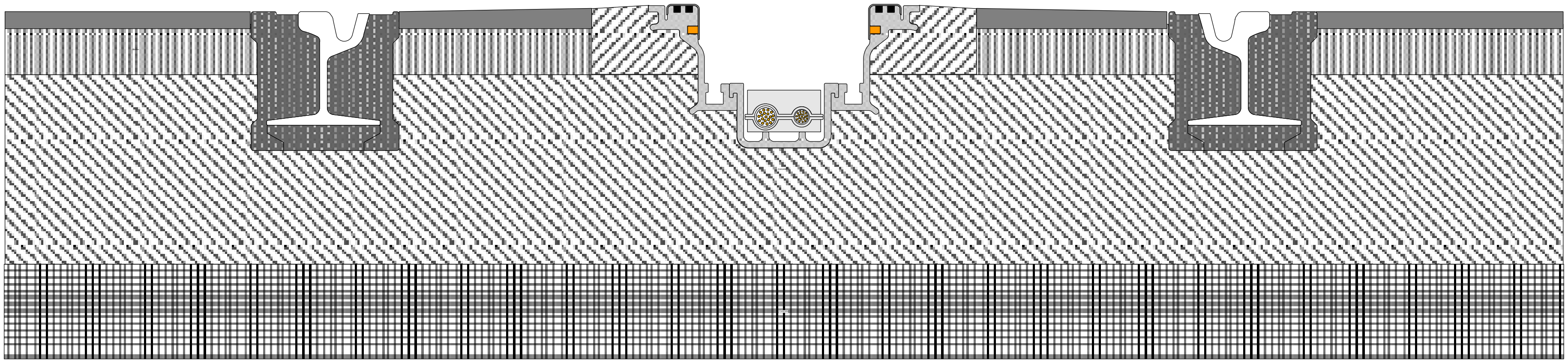
The power line ready fot insertion of the modules



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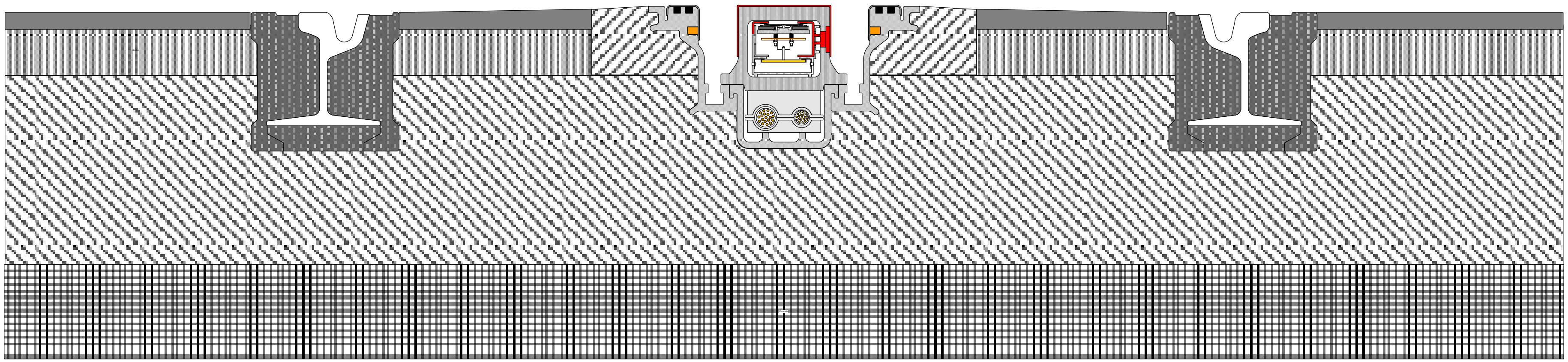
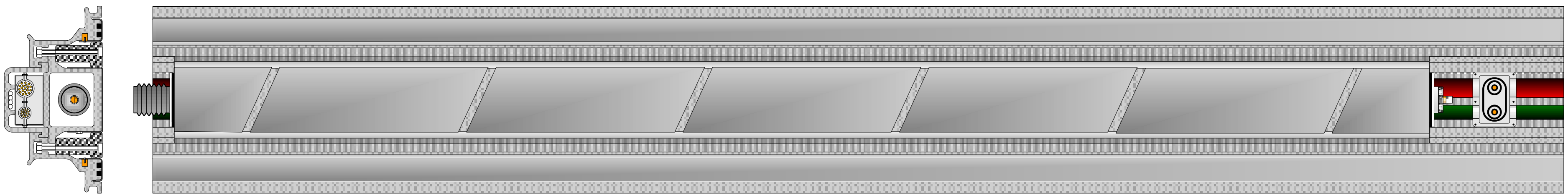
The module in the trough (section)



The module in the trough (top view)



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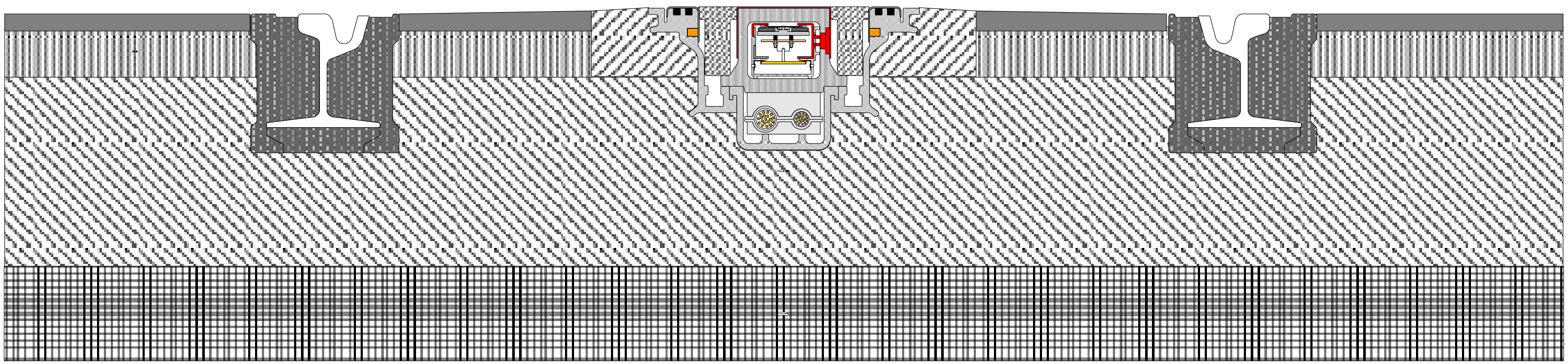
The line fully equipped

(section)



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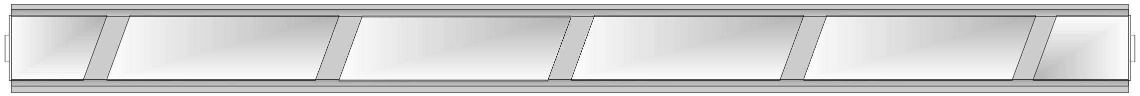
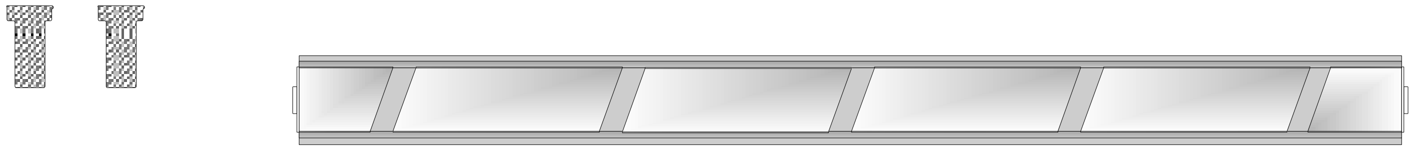
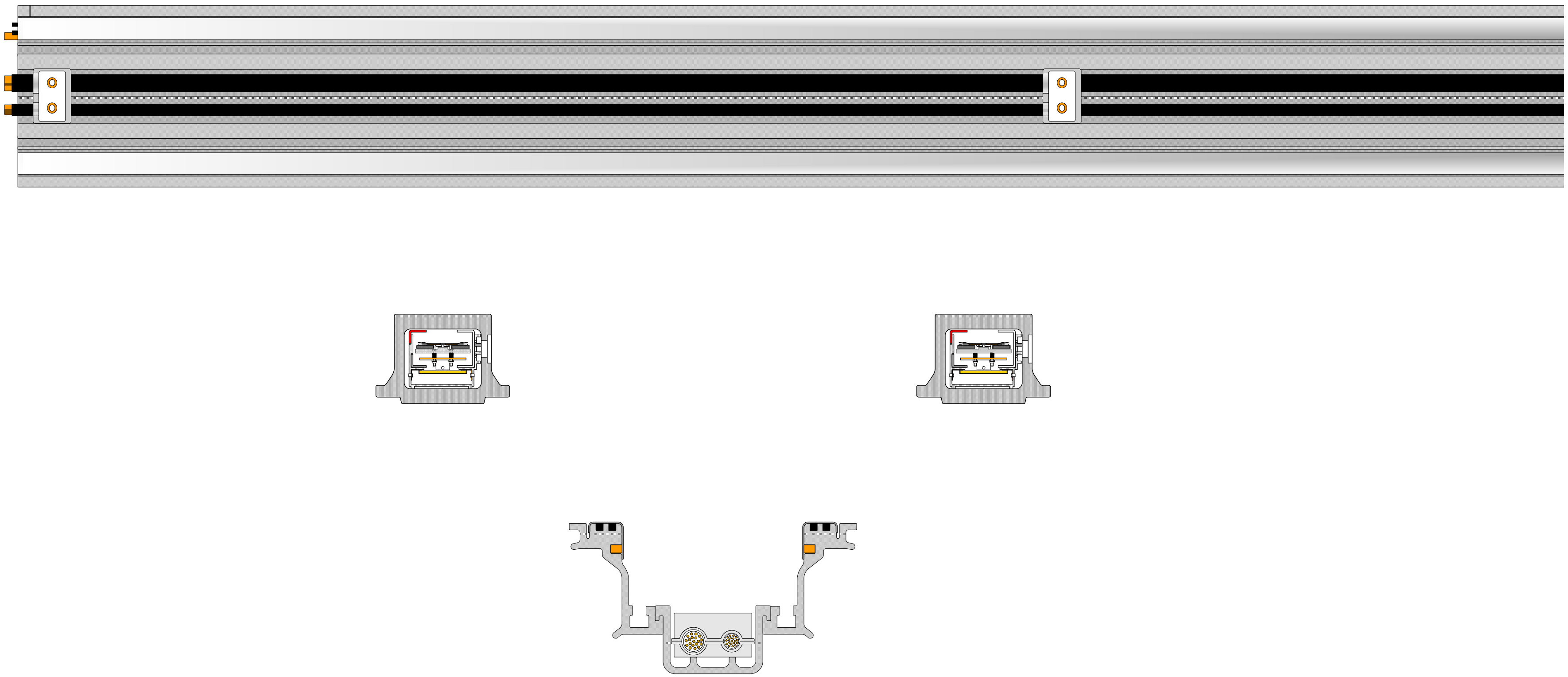
The mounting sequence







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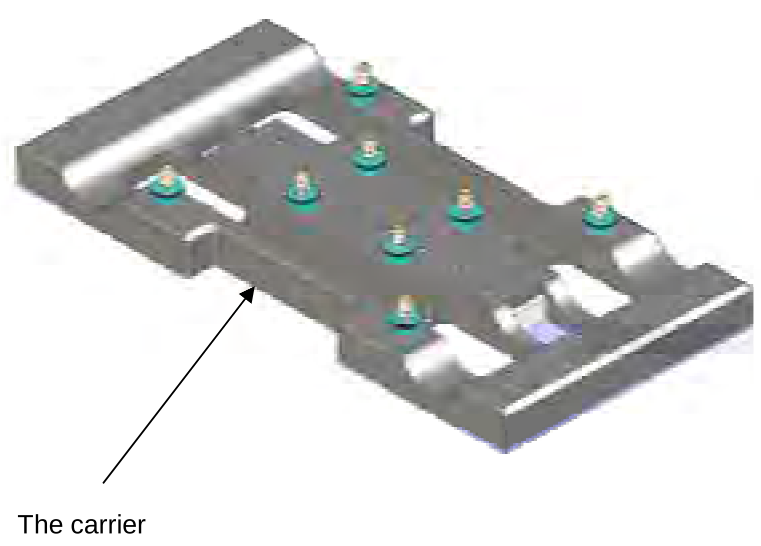
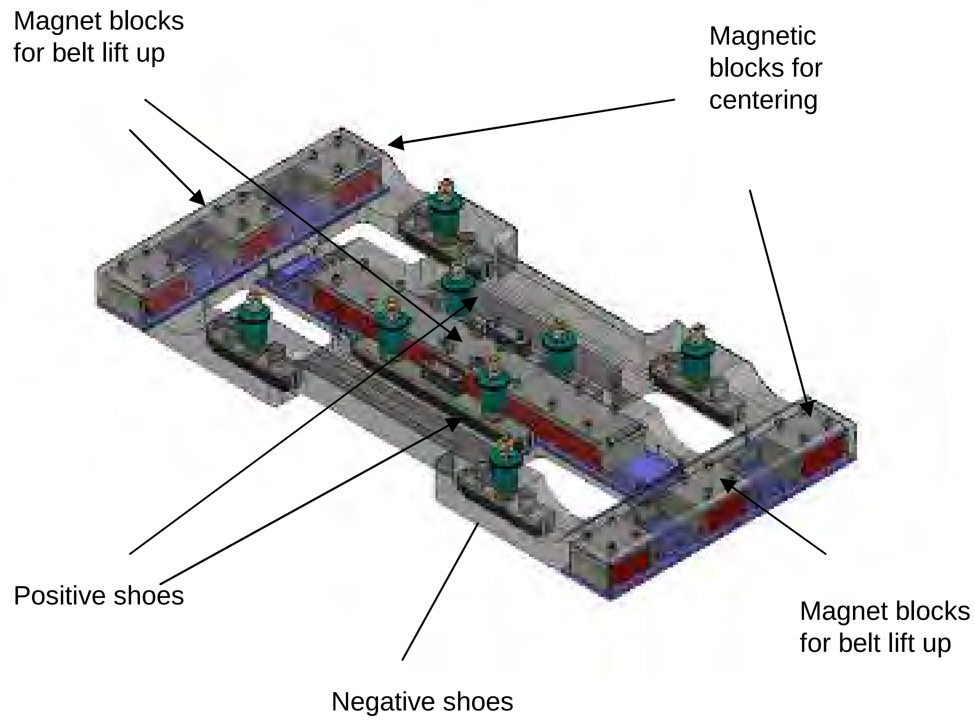
The magnetic power collector





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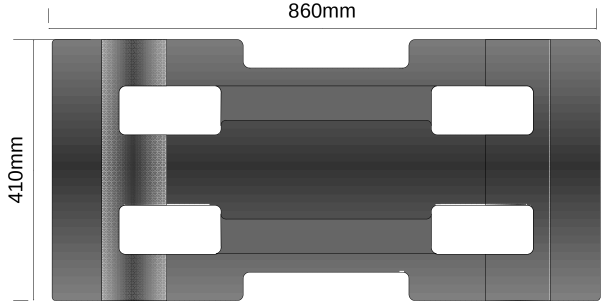
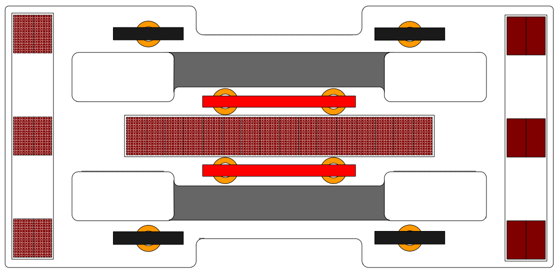
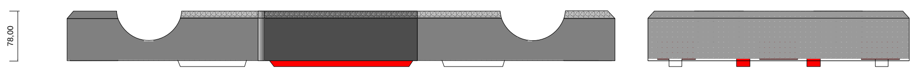
The magnetic power collector

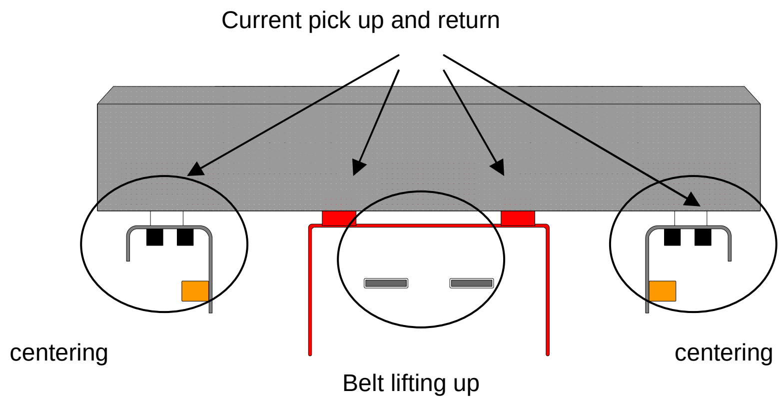


Three main function

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







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- 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

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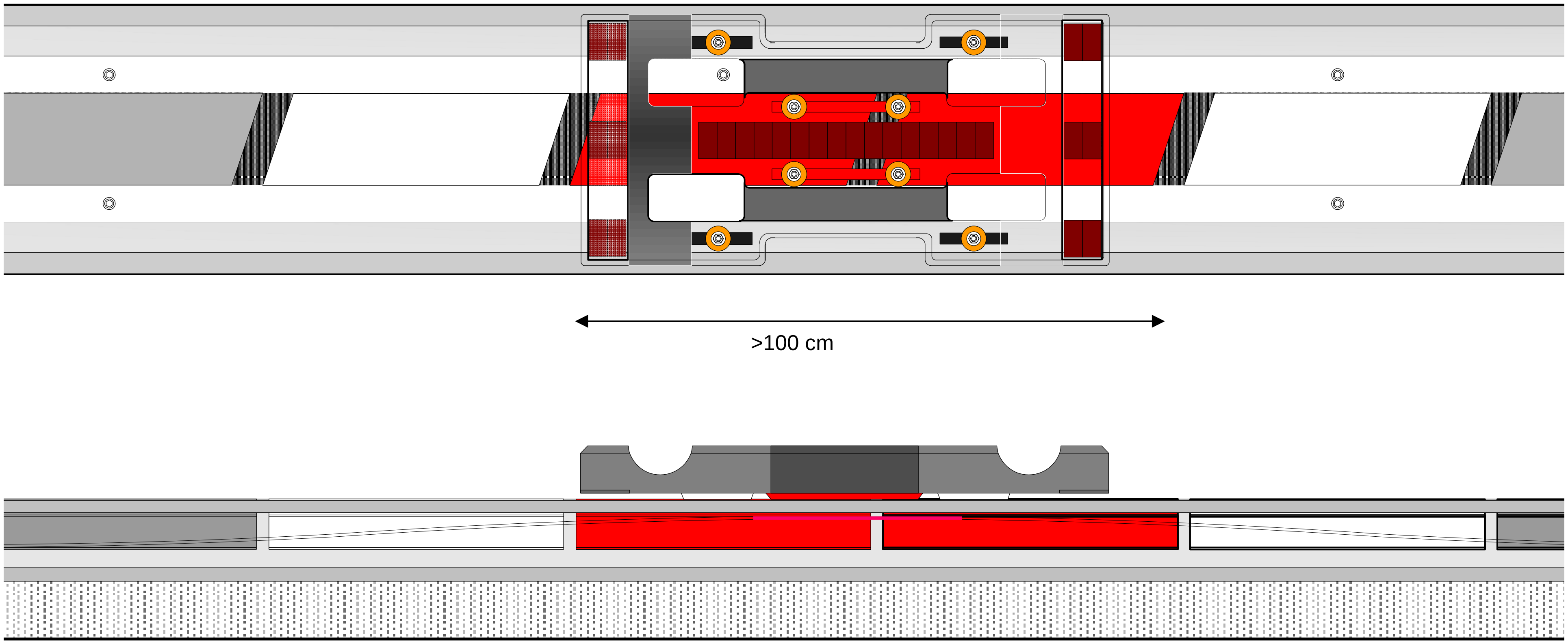

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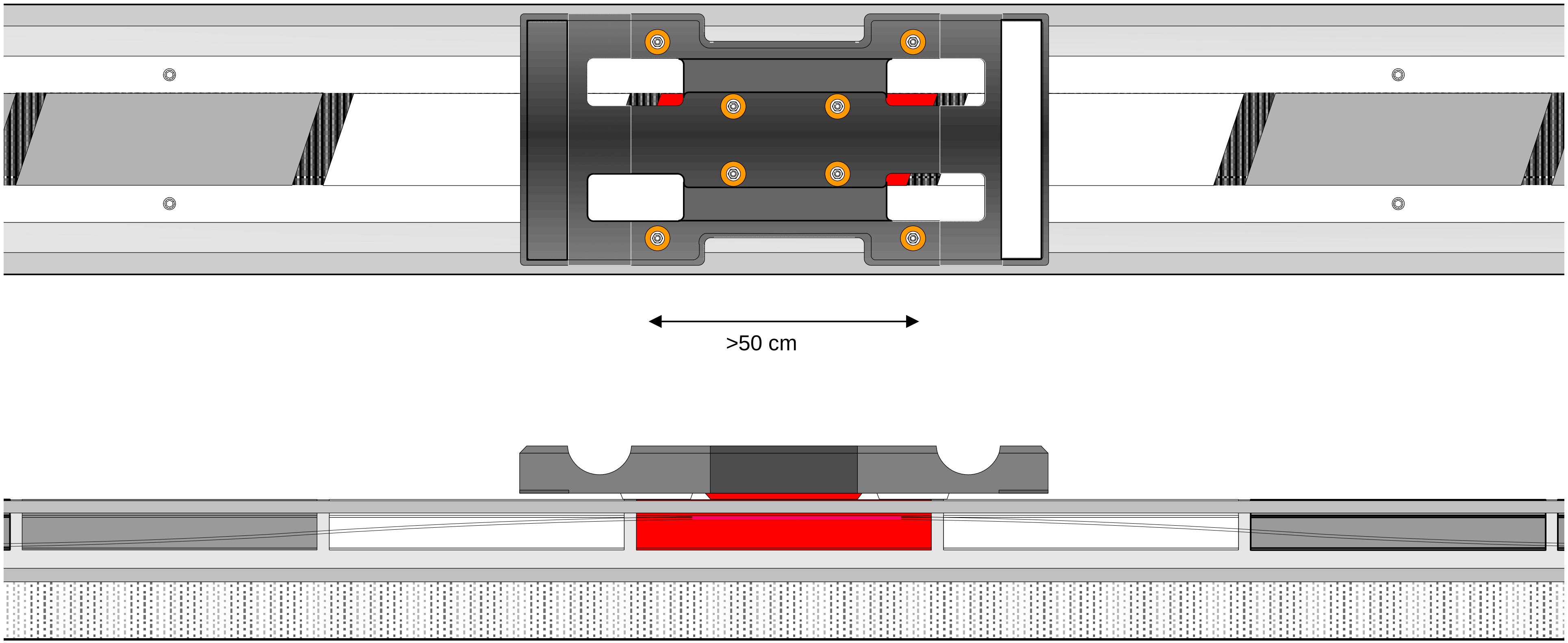

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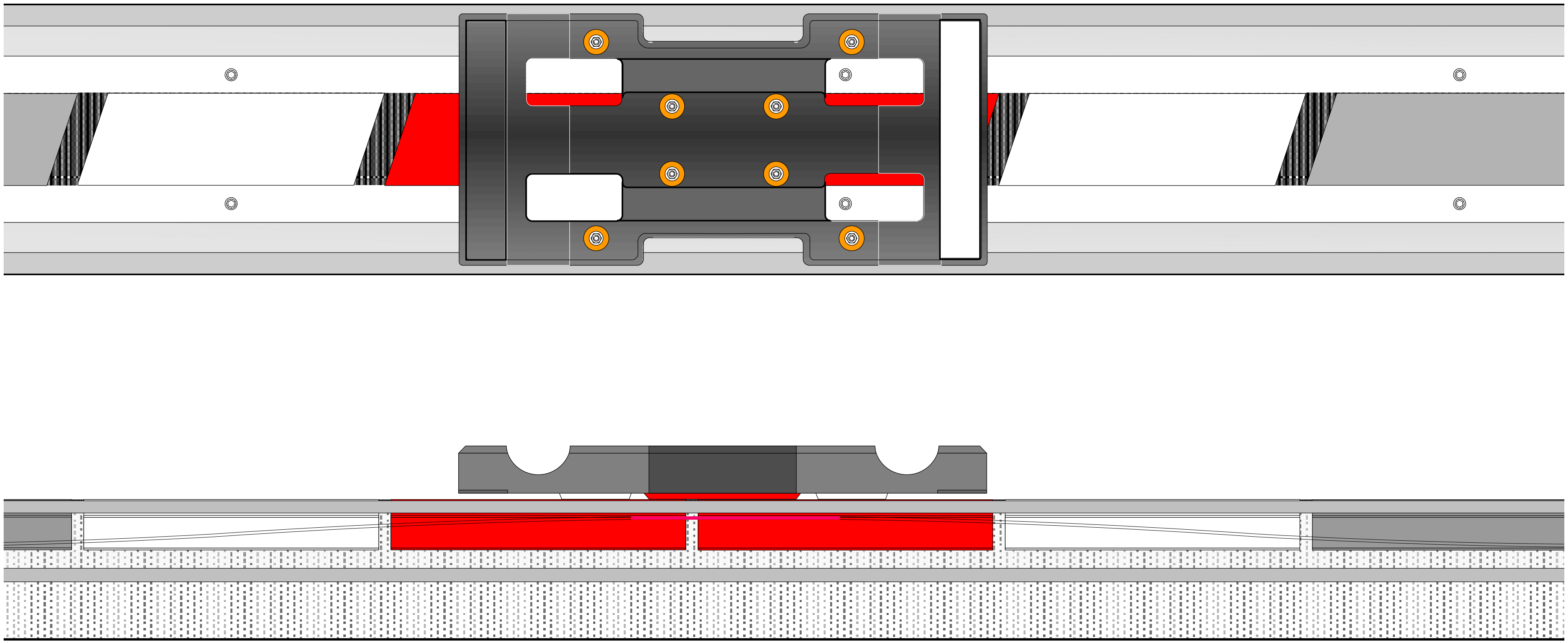

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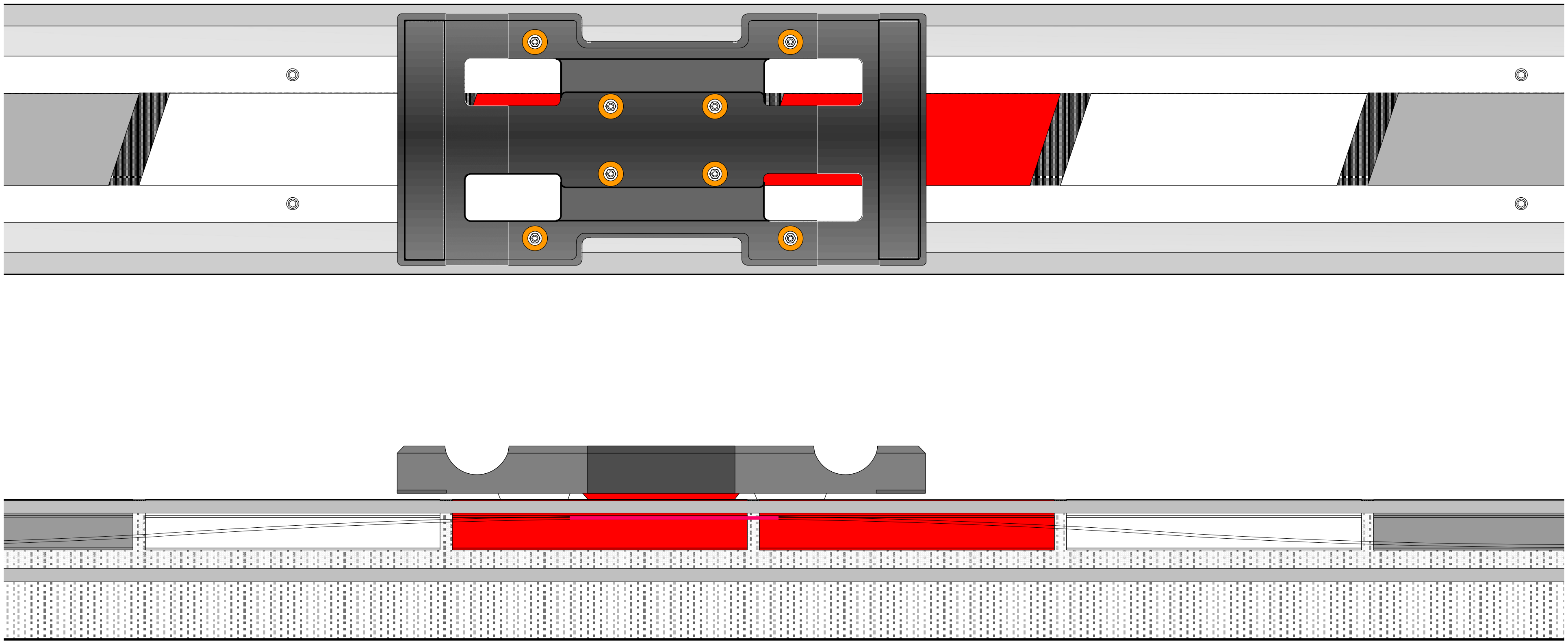

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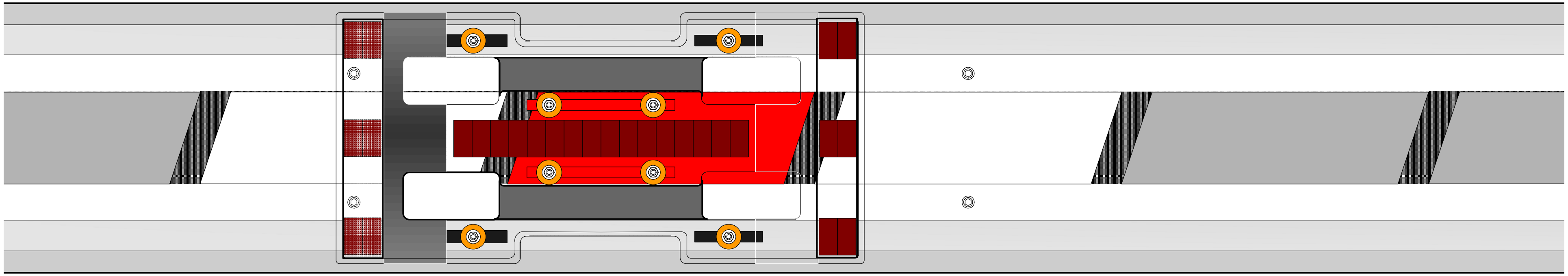

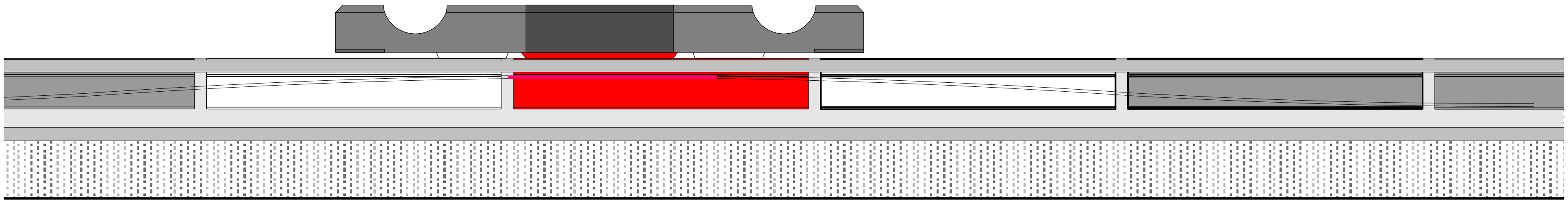

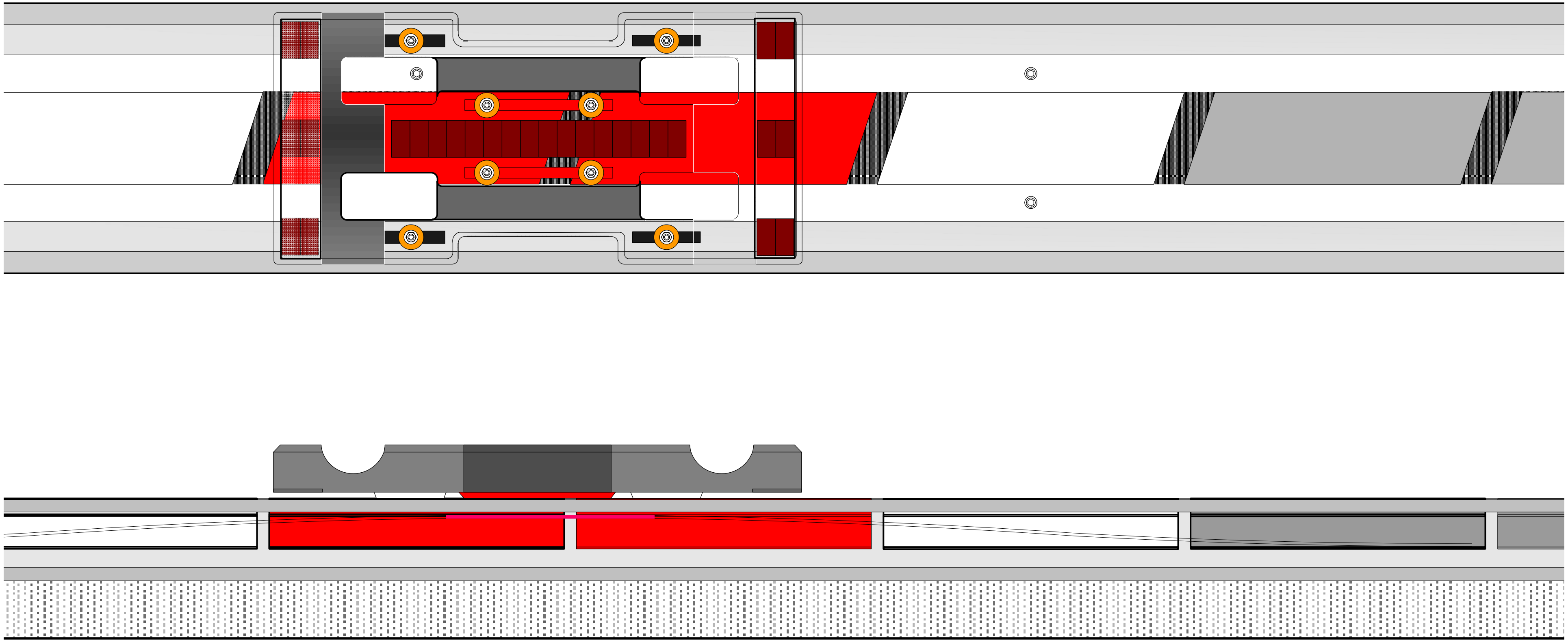

More details of operation

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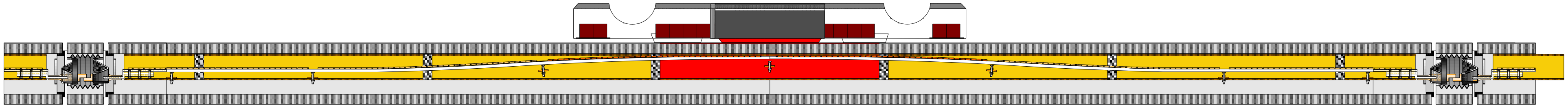

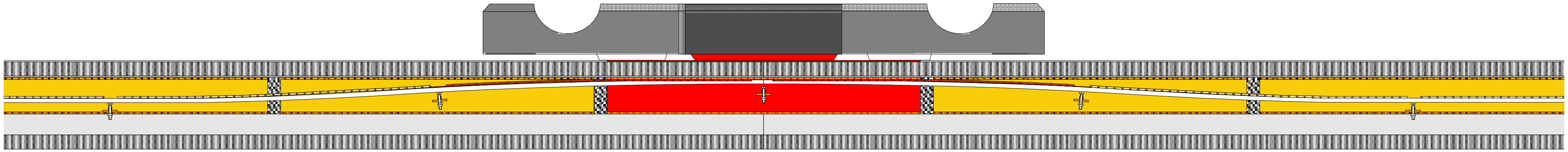

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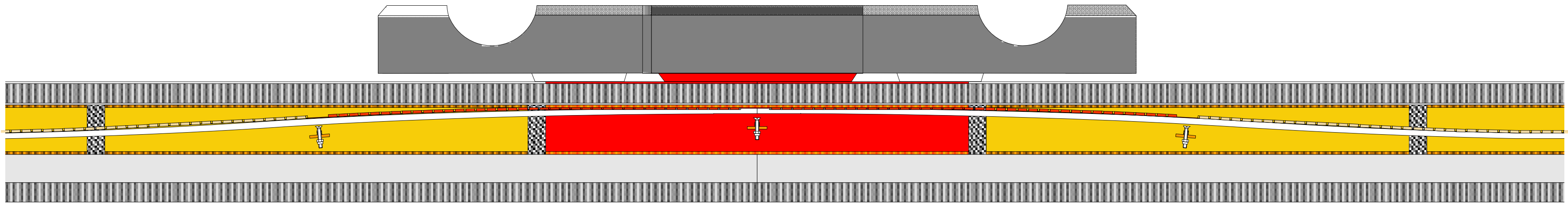

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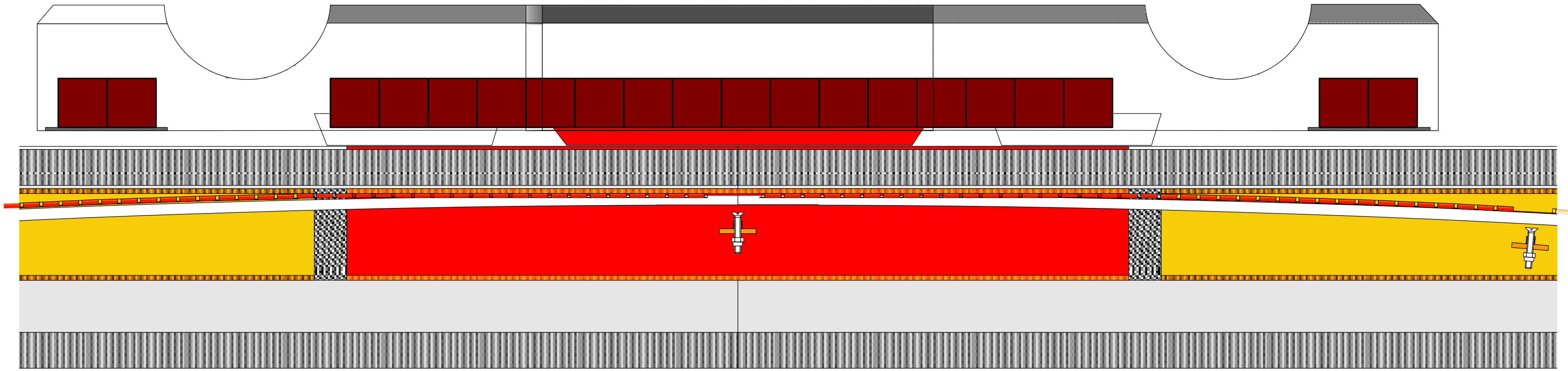

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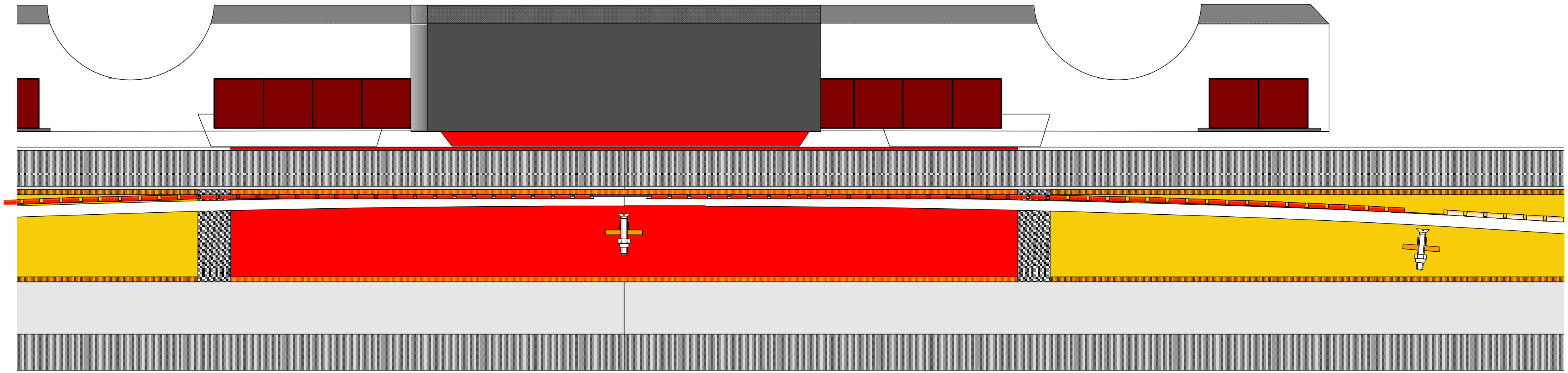

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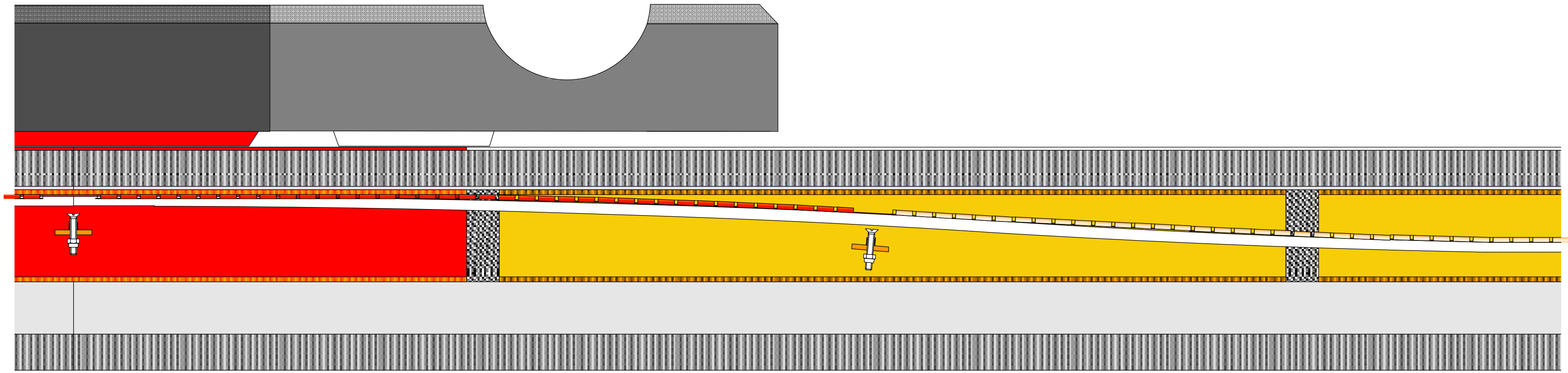

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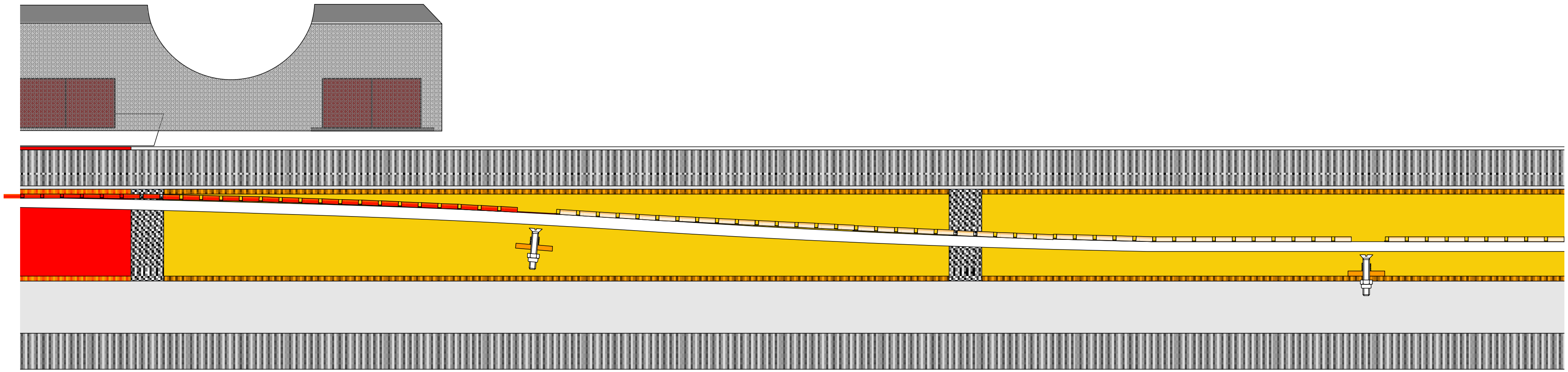

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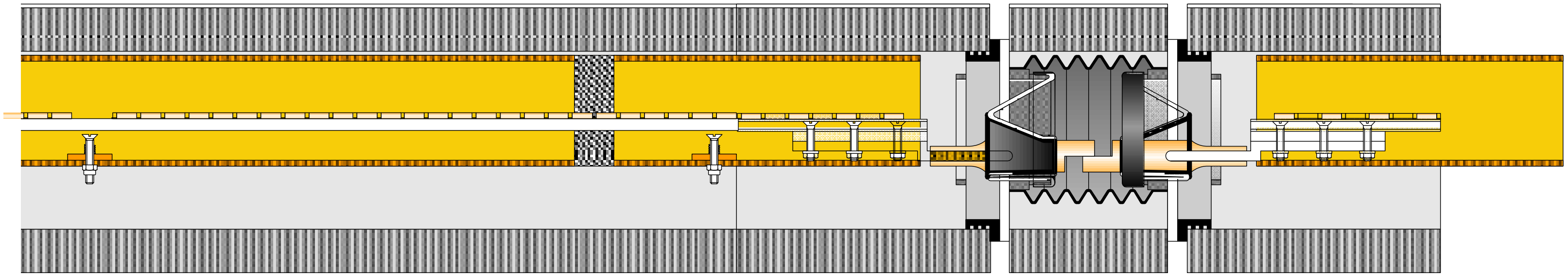

A full line section: view of operation

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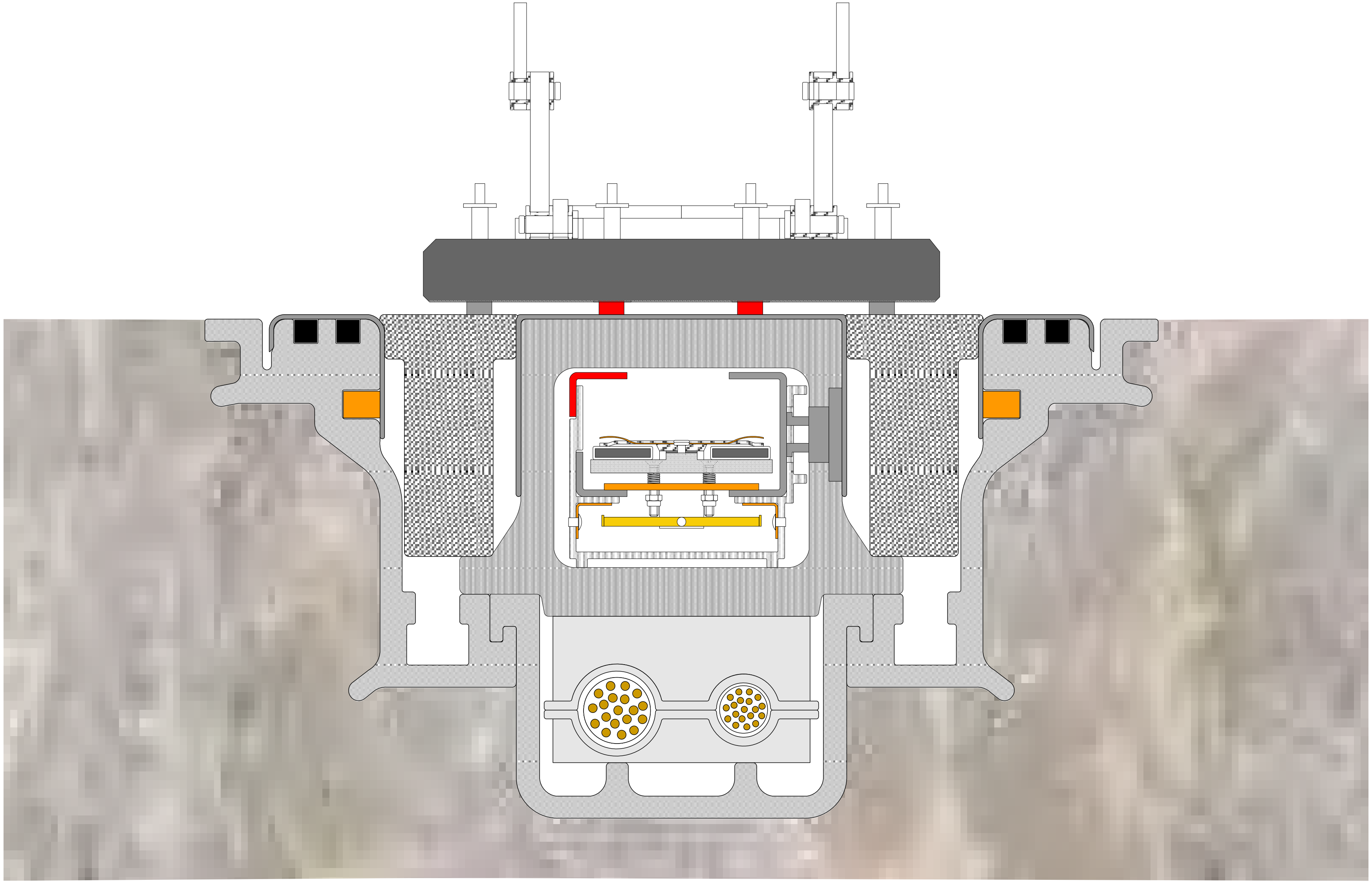

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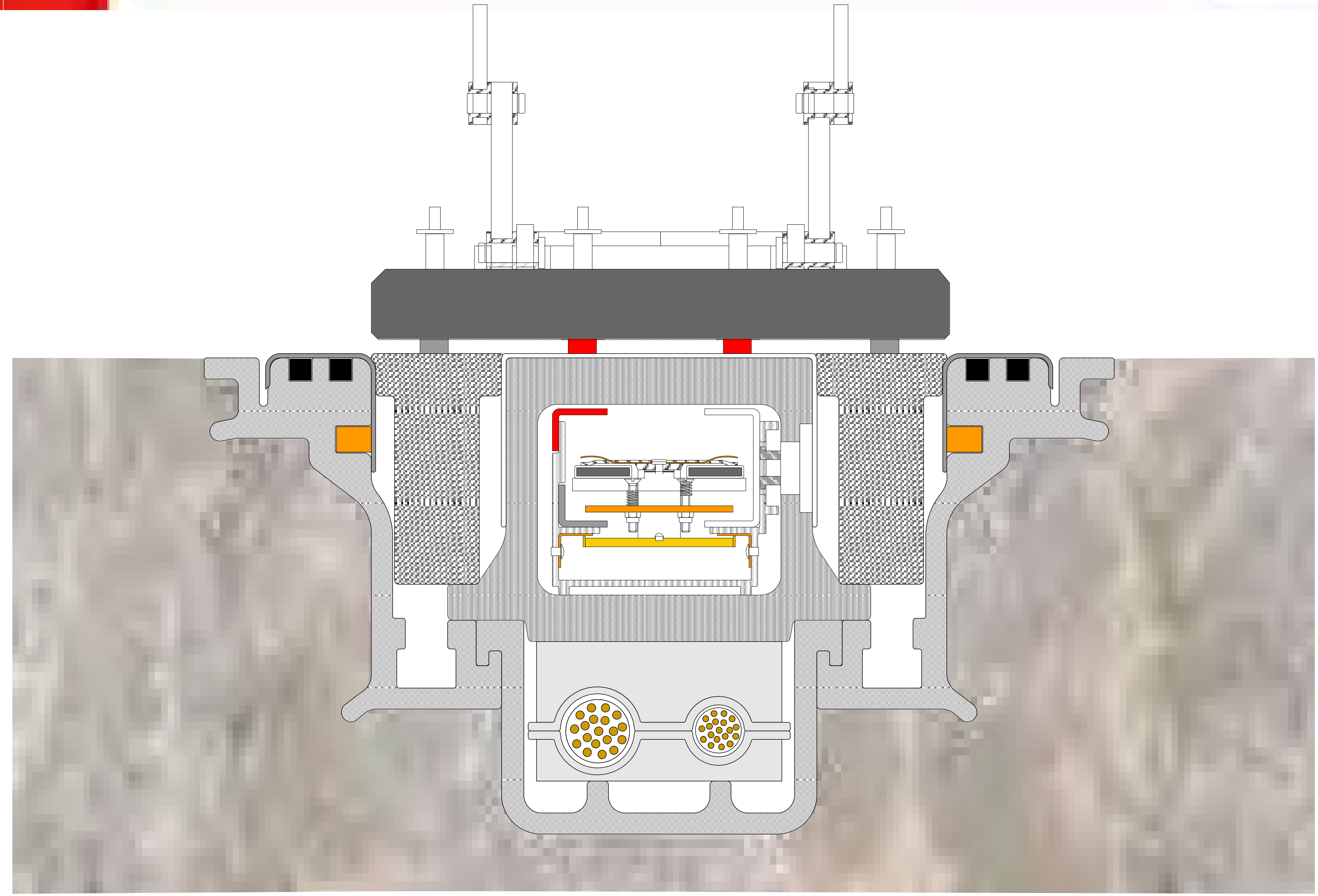

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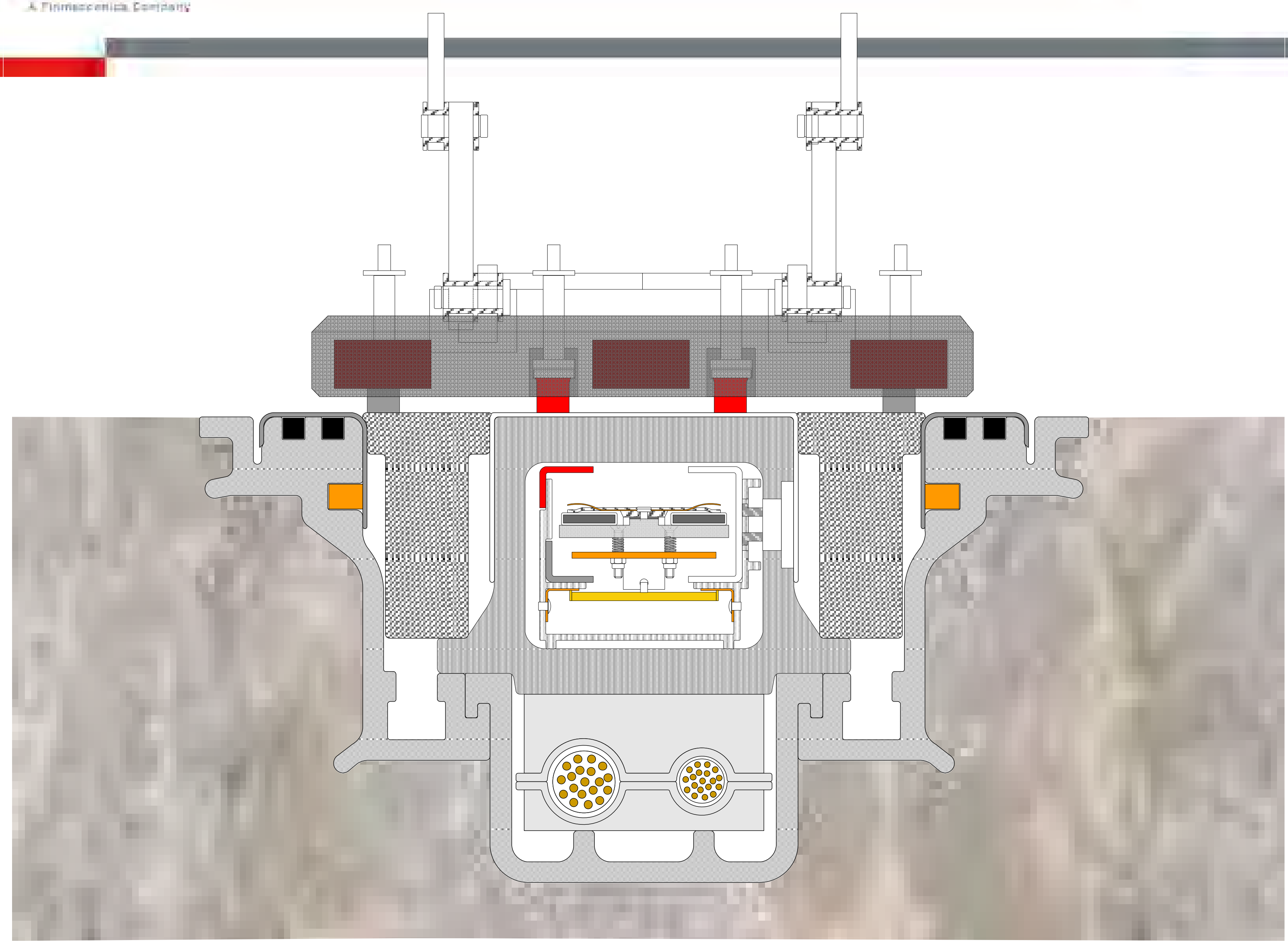

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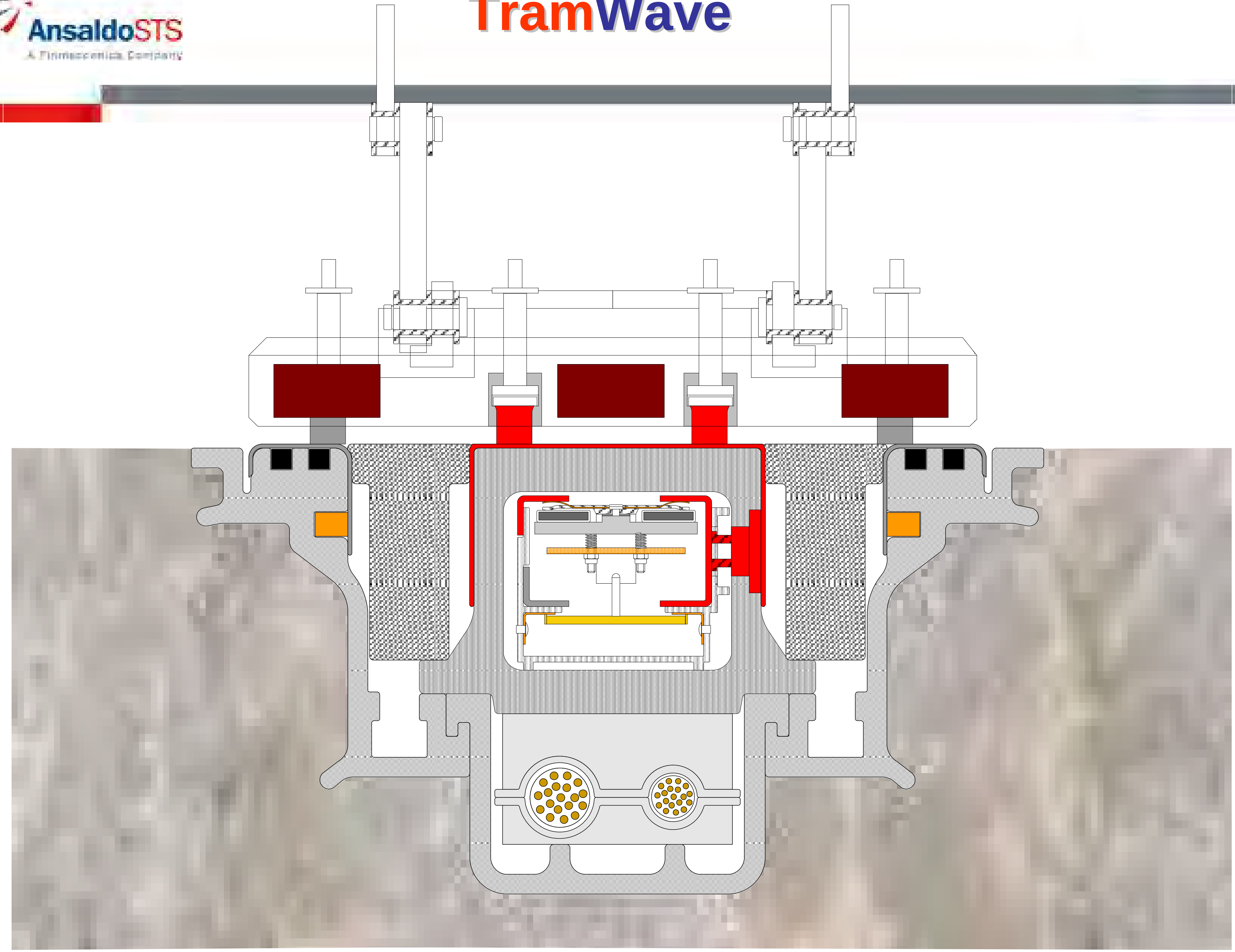

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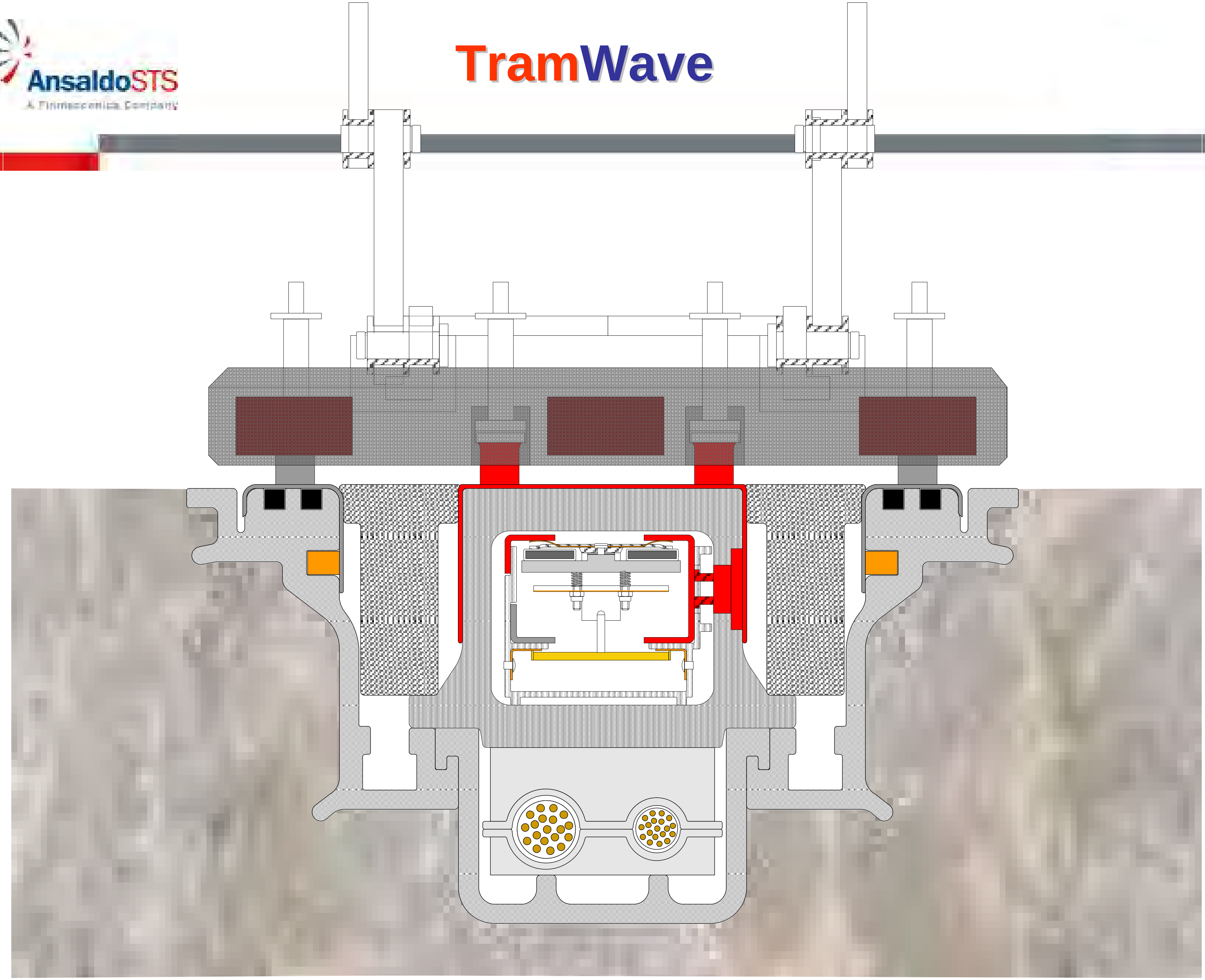

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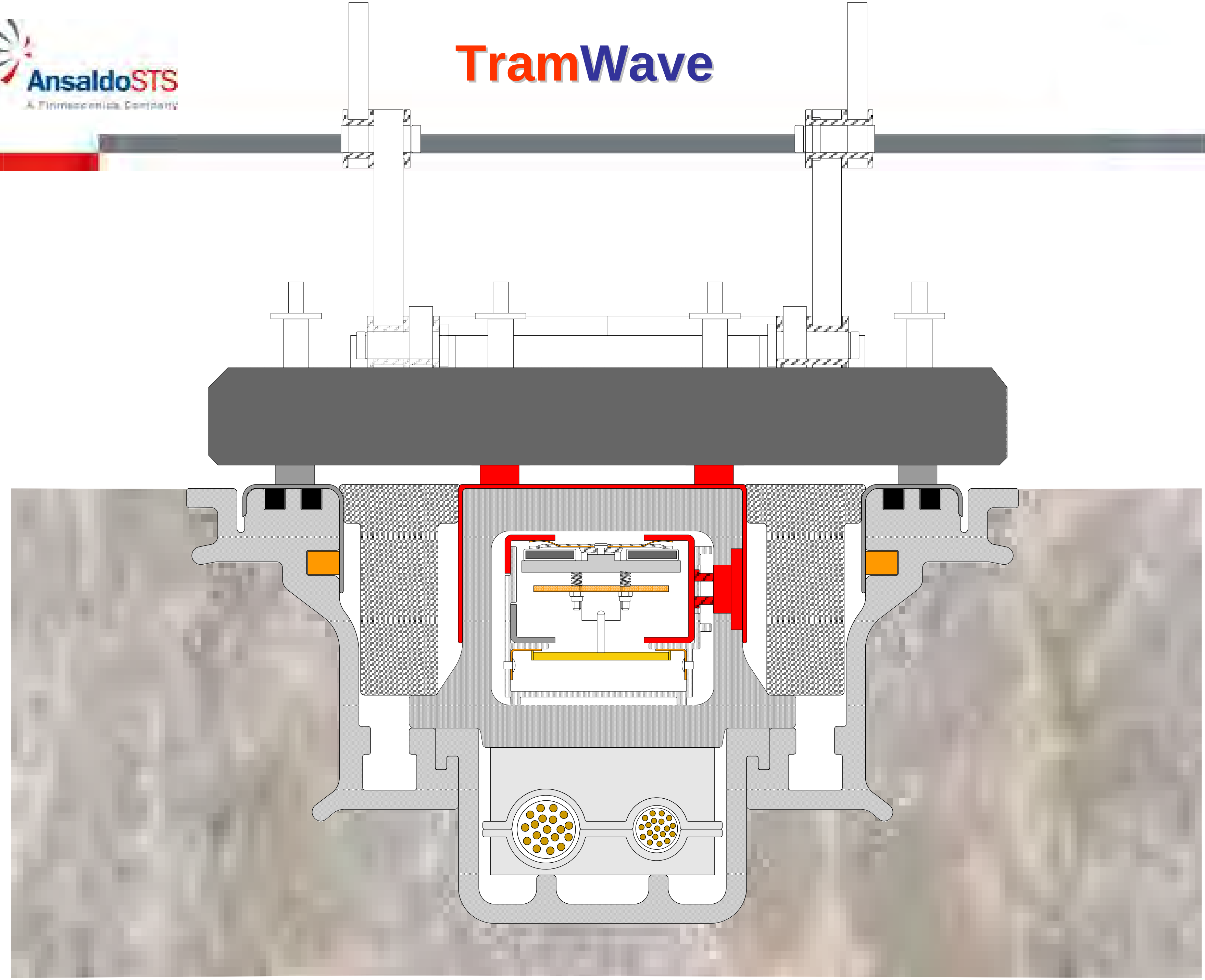

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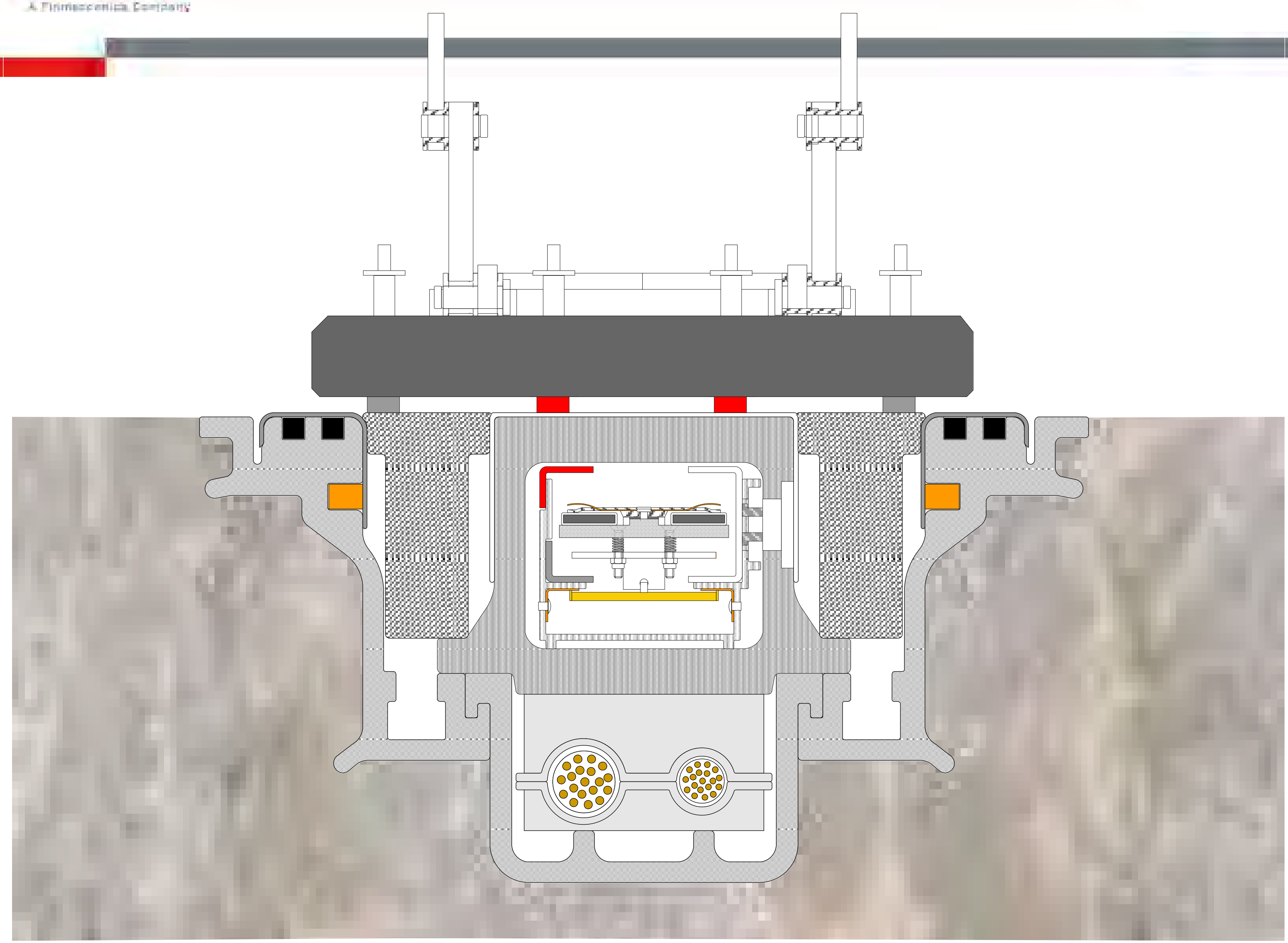

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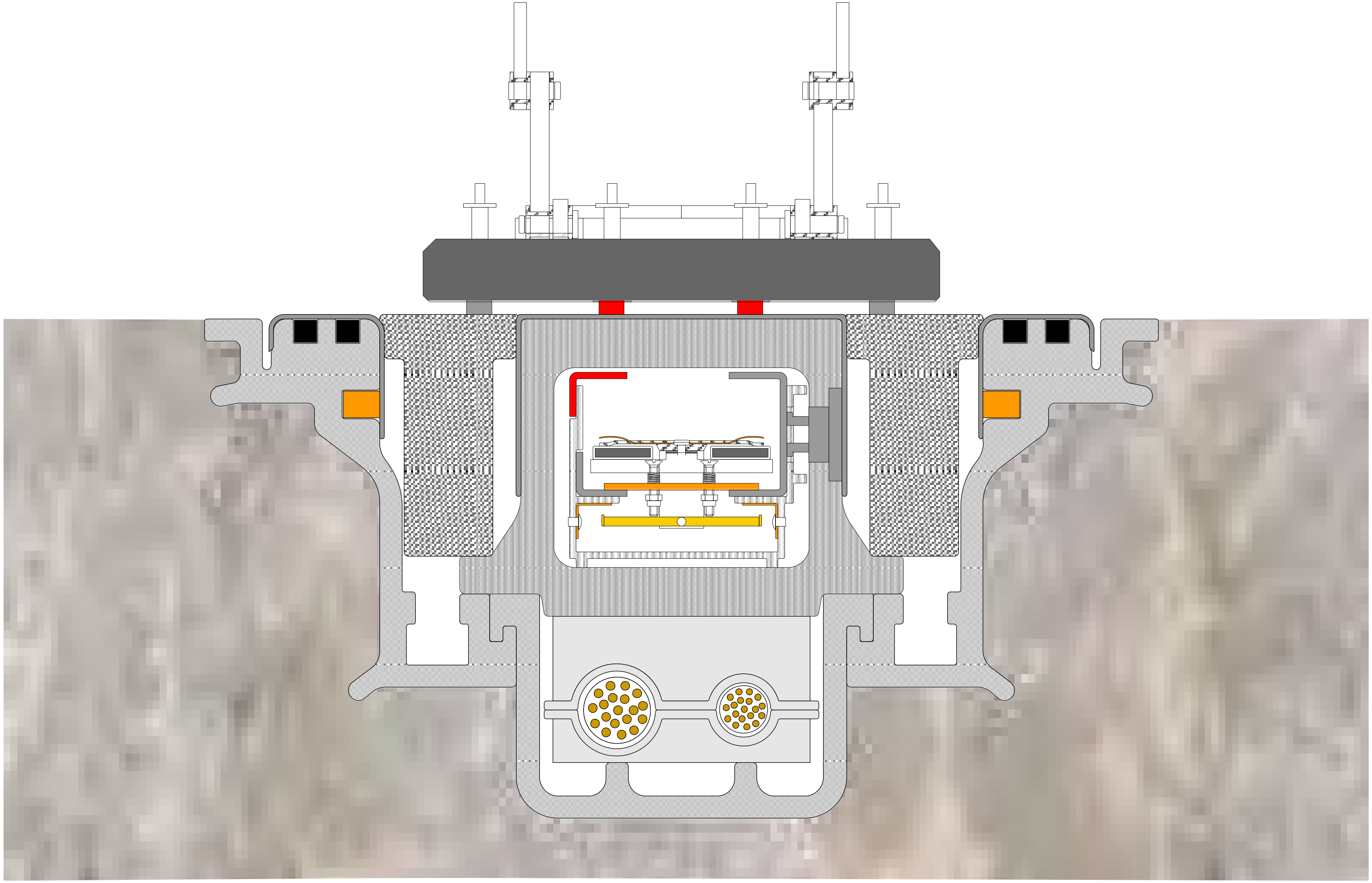
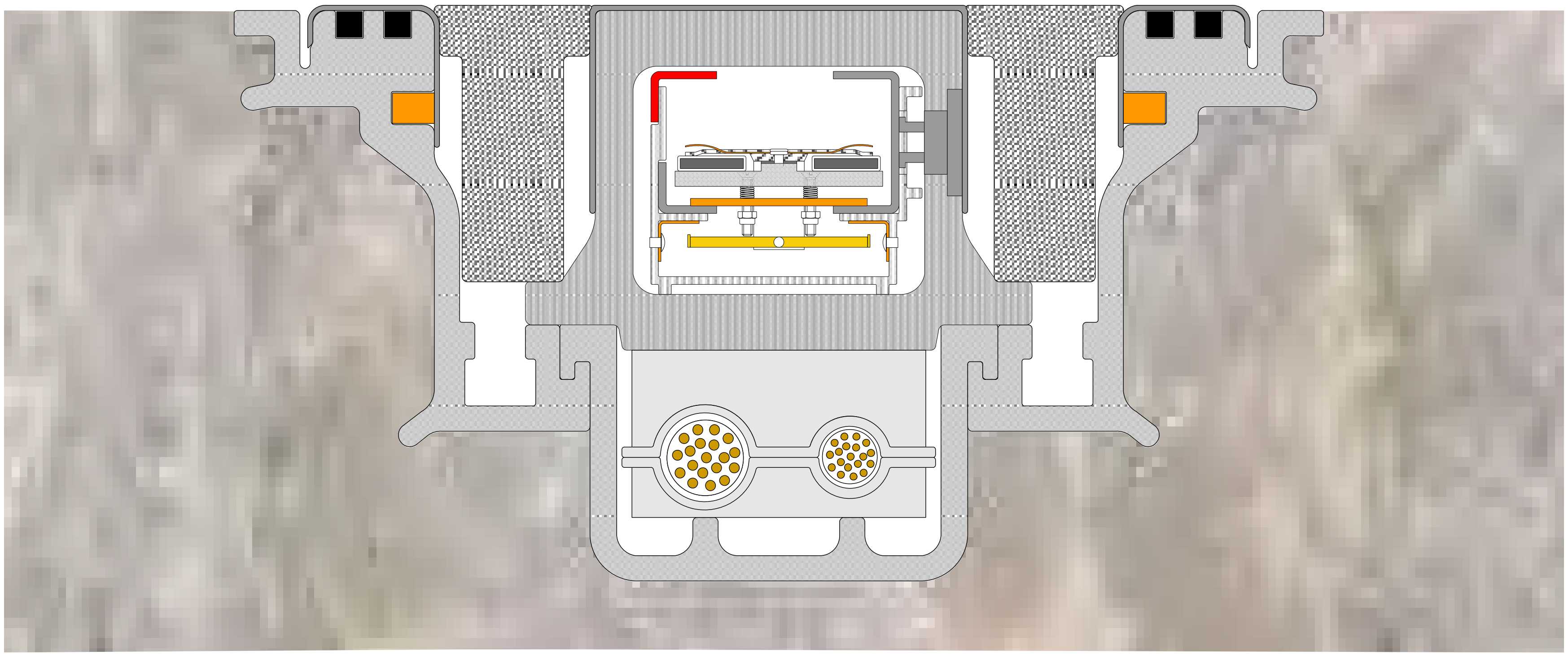


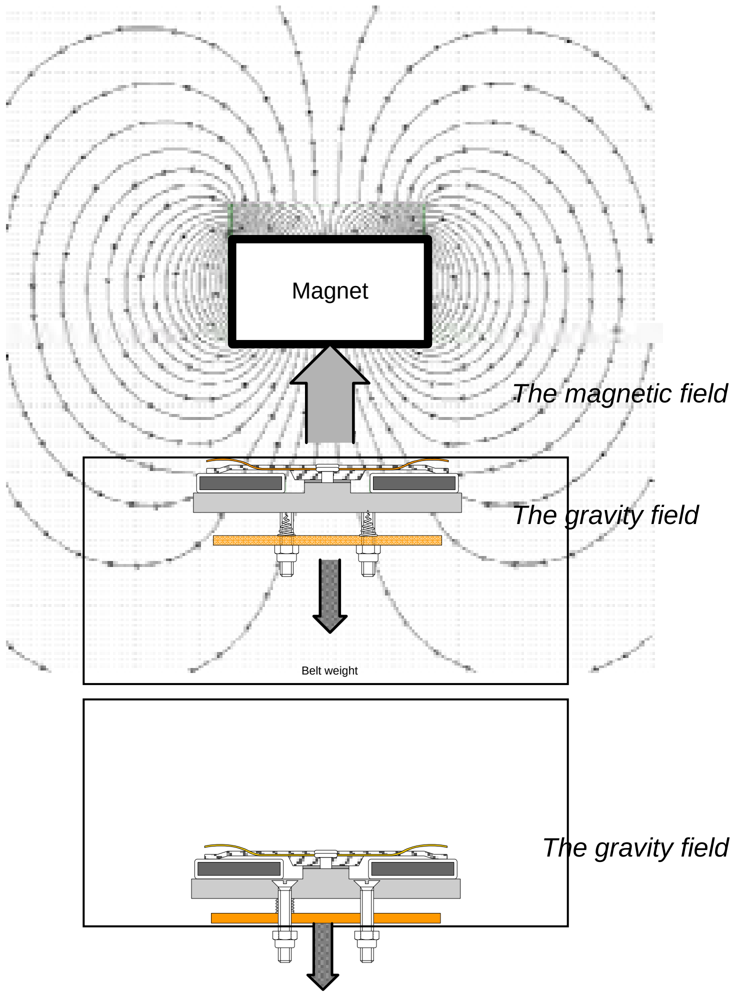
TramWave



Main Safety Issues

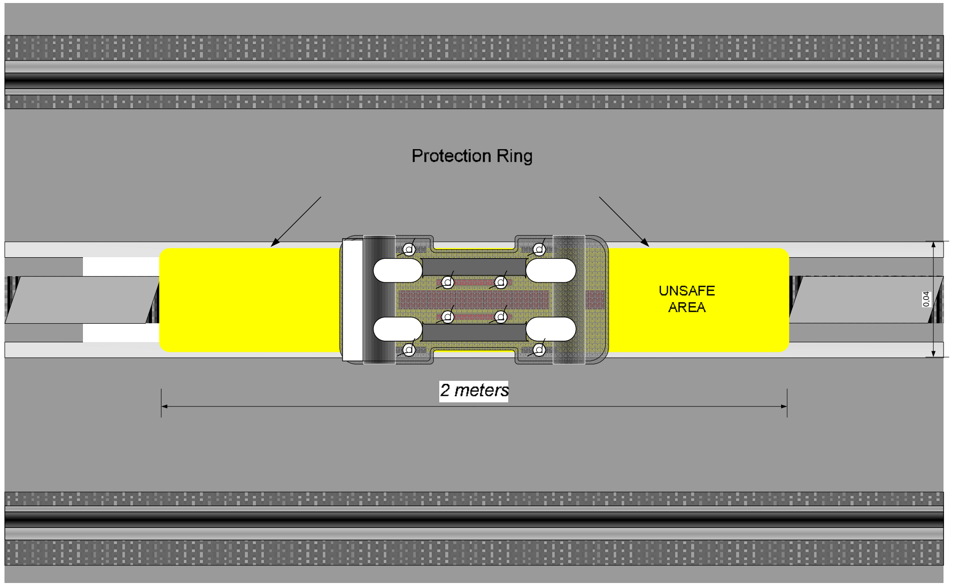
TramWave

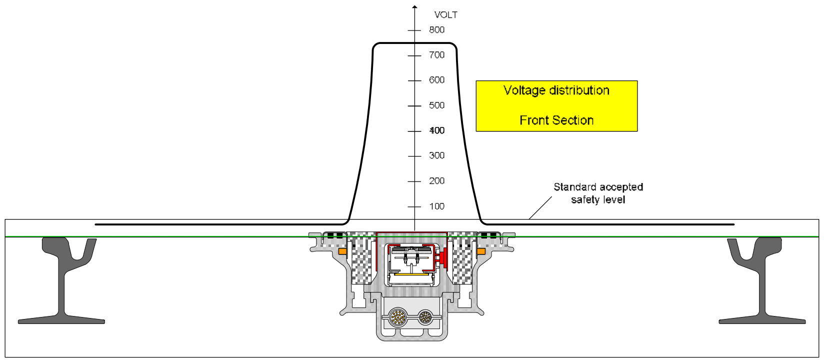
- The concept and the implementation of the safety requirements ensure the safety of the system in any normal operational condition as well as in any possible fault condition or accident.
  - The system goes "naturally" in the condition of safety
  - The absence or incorrect position of magnetic power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

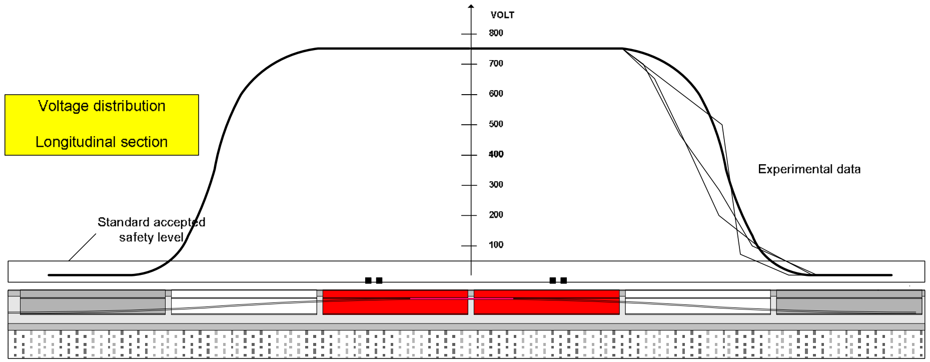


TramWave

- 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 is 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.

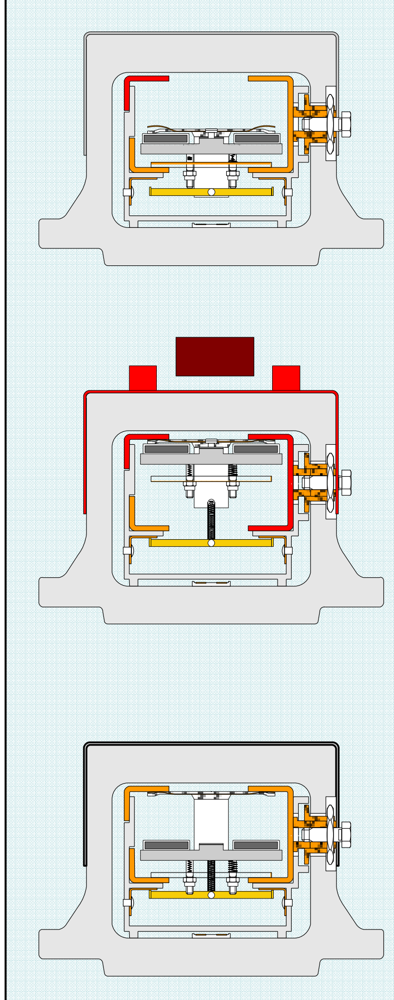




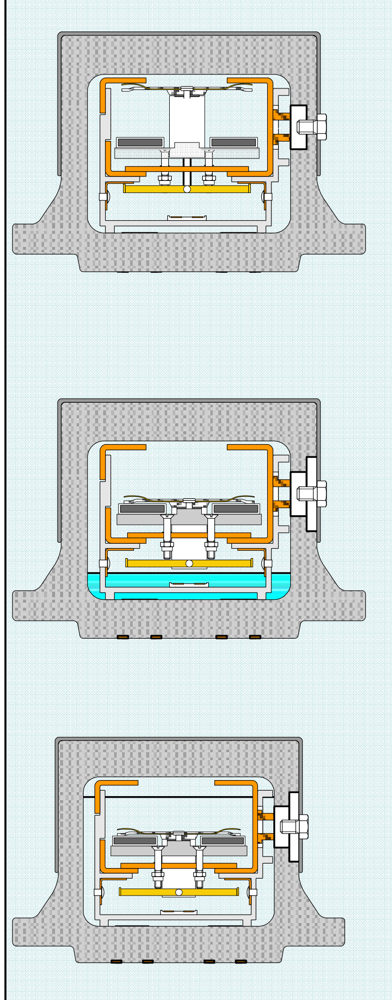


TramWave

- 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.

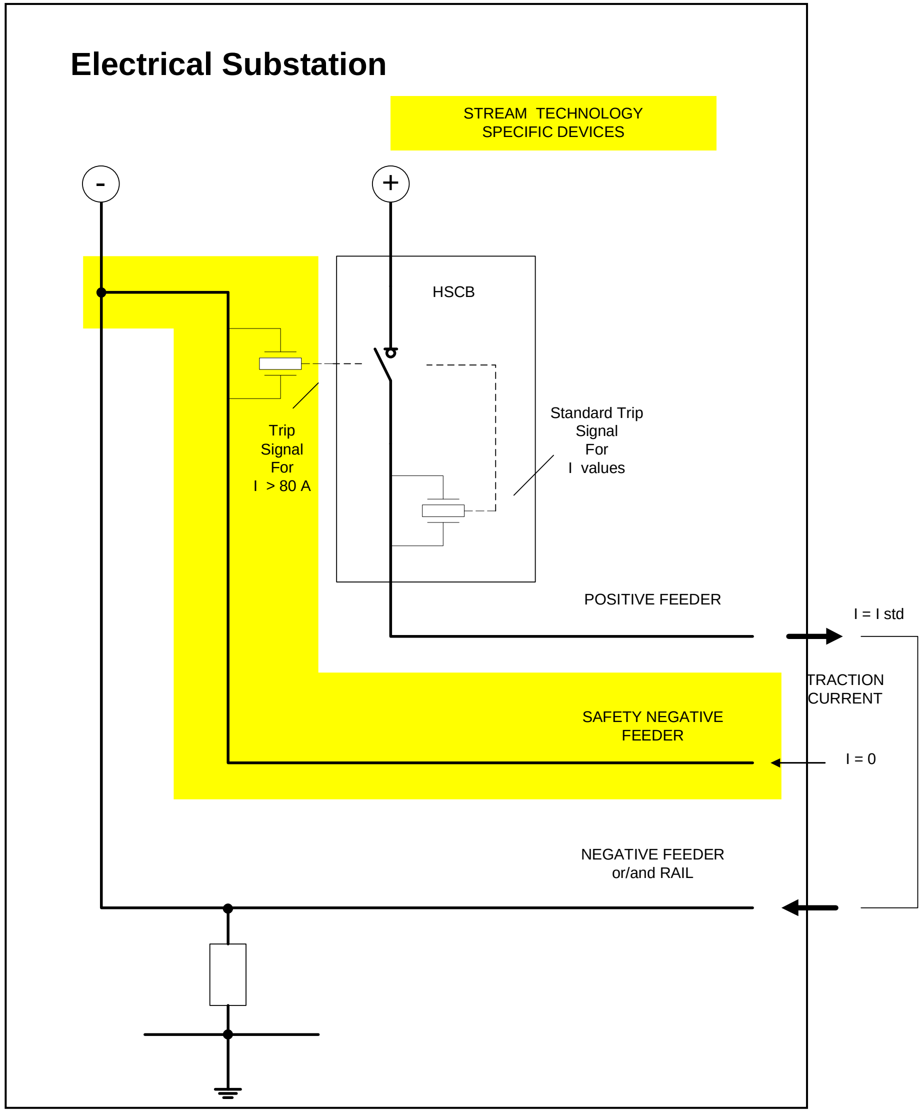


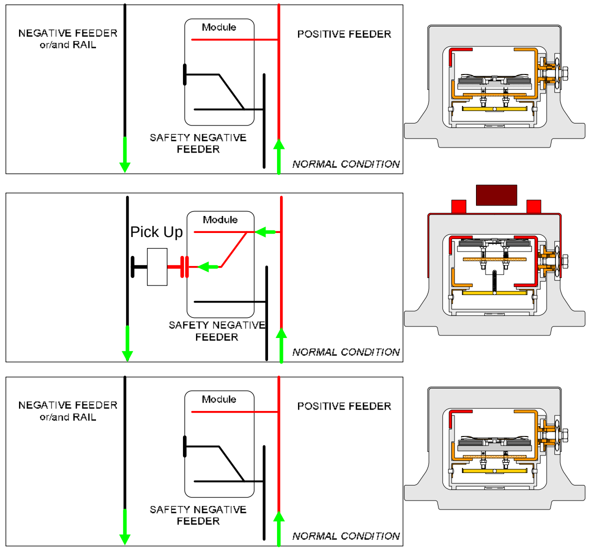
Contact Stick



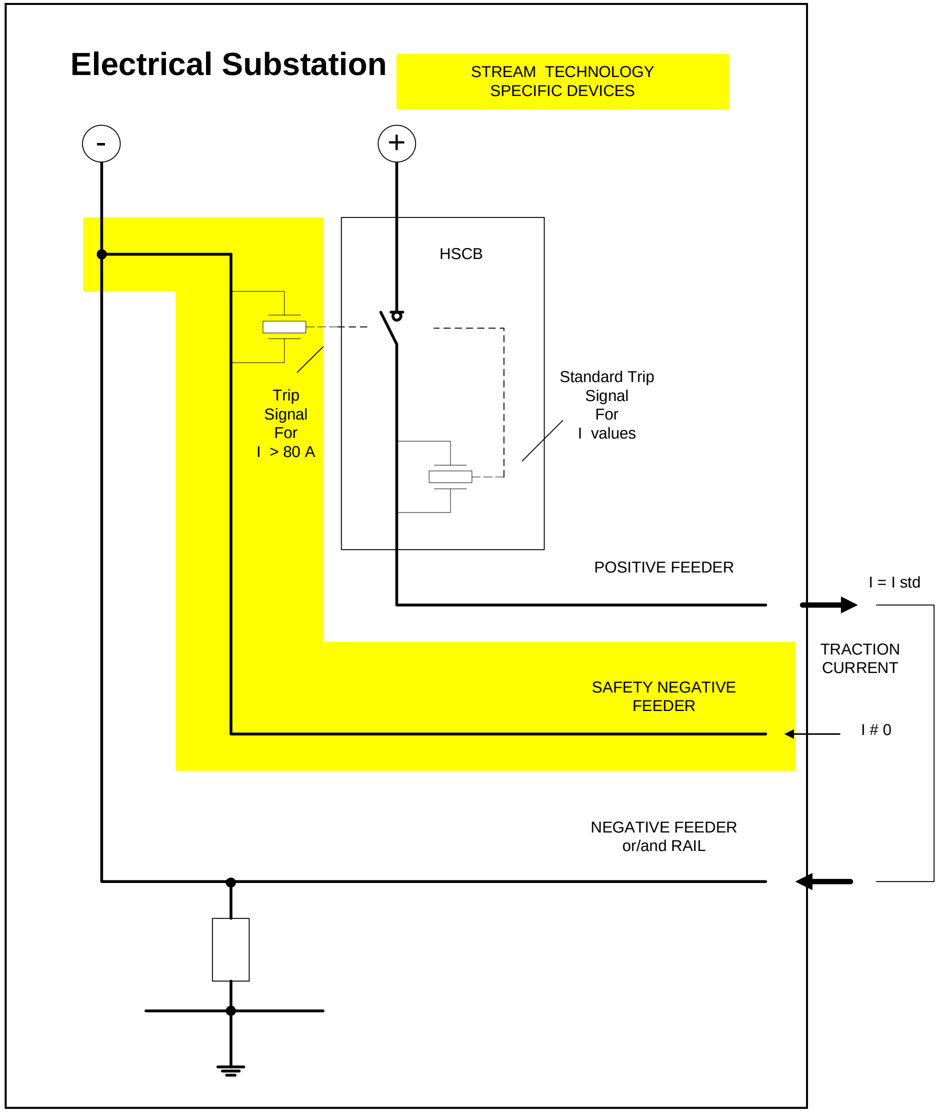
Water inside the module

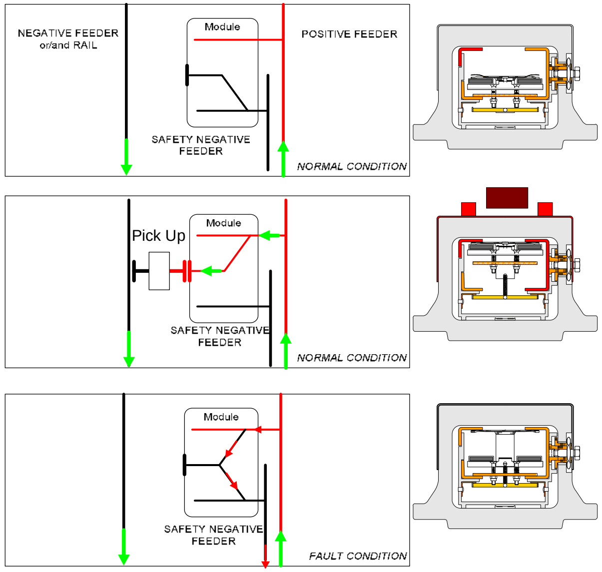
TramWave


Electrical Substation
STREAM TECHNOLOGY
SPECIFIC DEVICES
-
+
HSCB
Trip
Signal
For
I > 80 A
Standard Trip
Signal
For
I values
POSITIVE FEEDER
I = I std
TRACTION
CURRENT
SAFETY NEGATIVE
FEEDER
I = 0
NEGATIVE FEEDER
or/and RAIL


NEGATIVE FEEDER
or/and RAIL
Module
POSITIVE FEEDER
SAFETY NEGATIVE
FEEDER
NORMAL CONDITION
Pick Up
Module
SAFETY NEGATIVE
FEEDER
NORMAL CONDITION
NEGATIVE FEEDER
or/and RAIL
Module
POSITIVE FEEDER
SAFETY NEGATIVE
FEEDER
NORMAL CONDITION

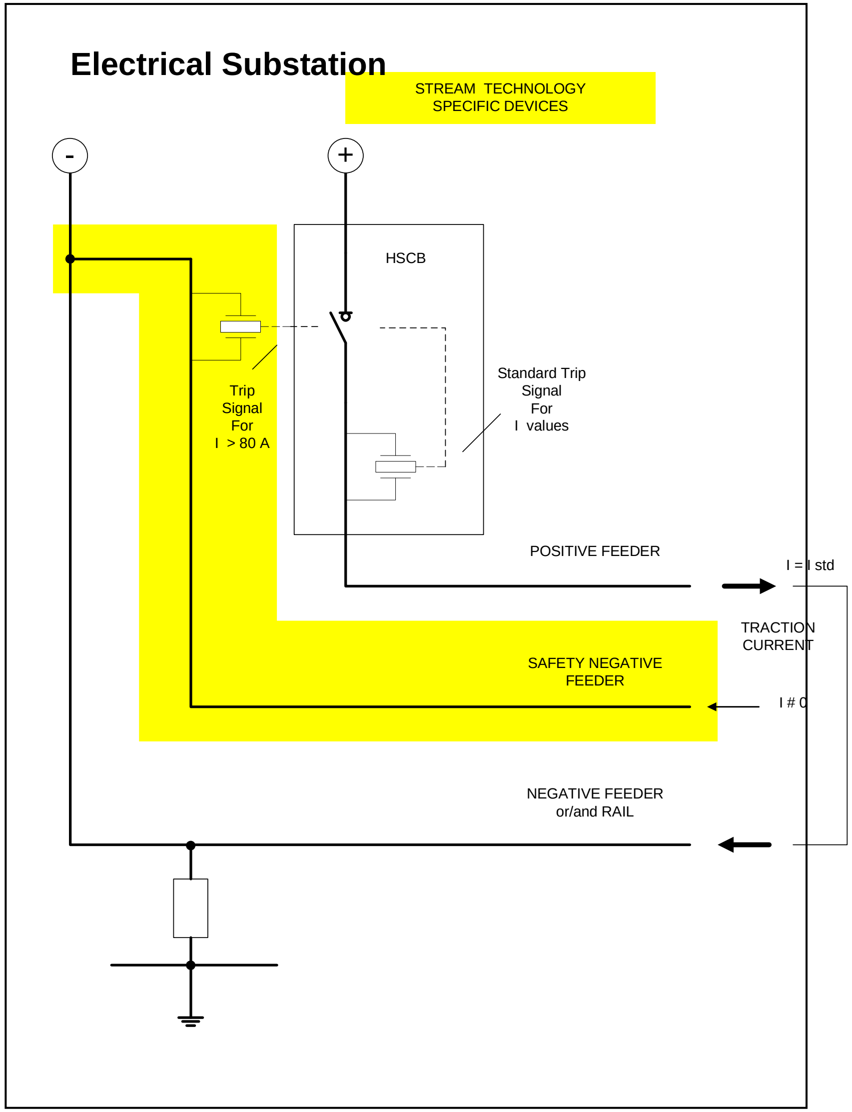
TramWave

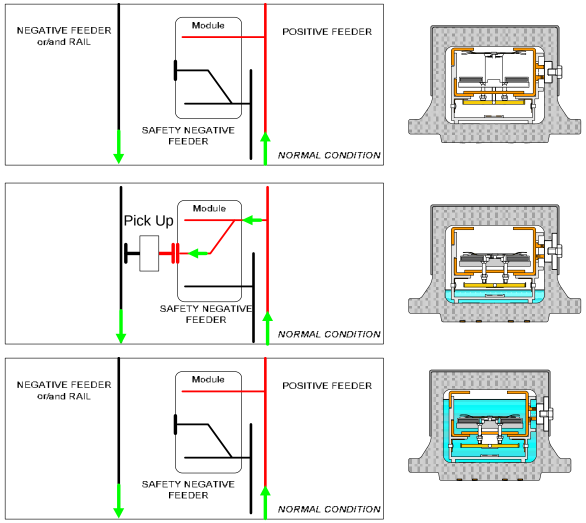




Event: Contact Stick to positive

TramWave





Event: water inside the module

TramWave

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.

TramWave

- 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

TRANSPORT

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

Why wireless trams?

To share restricted space in urban environment - no catenary posts

Why wireless trams?

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

Why wireless trams?

To preserve nature in cities

Agenda

1. Why wireless trams ?
2. Wireless systems in operation & projects
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Tram without catenary : Overview

One tram in passenger service | Line(s) in passenger service

Batteries

Supercaps

Ground level supply

- Alstom Nice →  (Line(s) in passenger service)
- Kawasaki Swimo
- Siemens HES
- Alstom STEEM →  (One tram in passenger service)
- CAF ACR →  (One tram in passenger service)
- Bombardier Primove
- Ansaldobreda Tramwave
- Alstom APS →  (Line(s) in passenger service)

Tram without catenary : Batteries

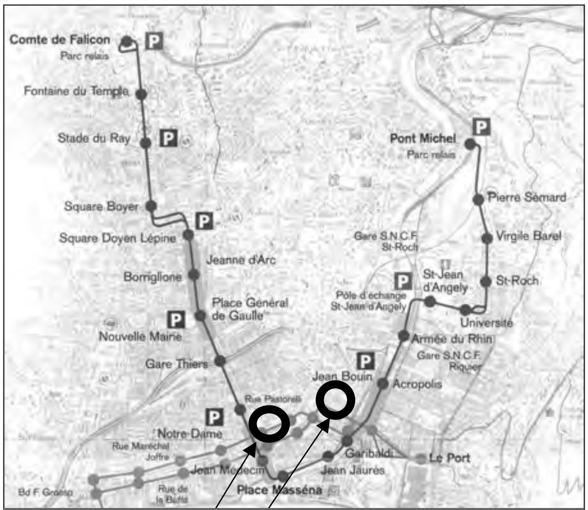
- Tramway service in Nice city since 2007
- Two 450m sections run at 30 km/h without catenary
- NiMH battery technology, with slow recharge under catenary sections : guaranteed lifetime 5 years at 25℃ operation temperature
- Battery box internal temperature regulated @ 25℃
- Return on experience on all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

Wireless solutions: a full service proven range

1. Short wireless sections: Nice

Batteries

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

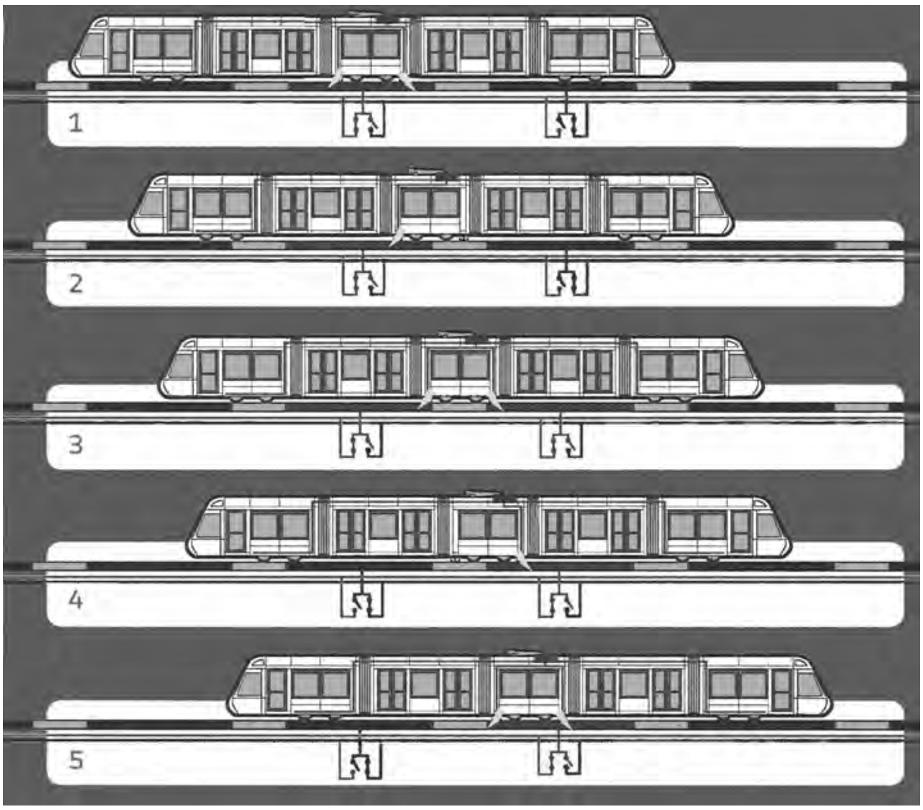


- Commercial service in 2007
- No overhead wires on 2 squares
  - *Place Masséna: ~435 m*
  - *Place Garibaldi: ~485 m*

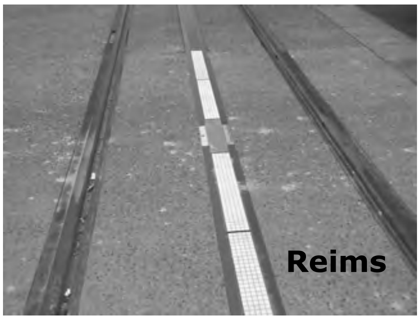
Tram without catenary : APS

Alimentation par le Sol

Ground-level Power Supply



Tram without catenary : APS



- 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

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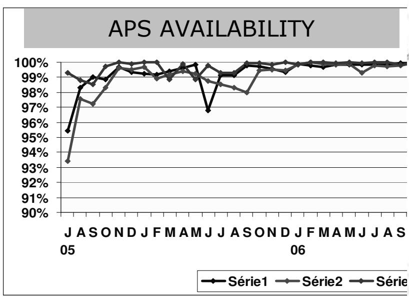
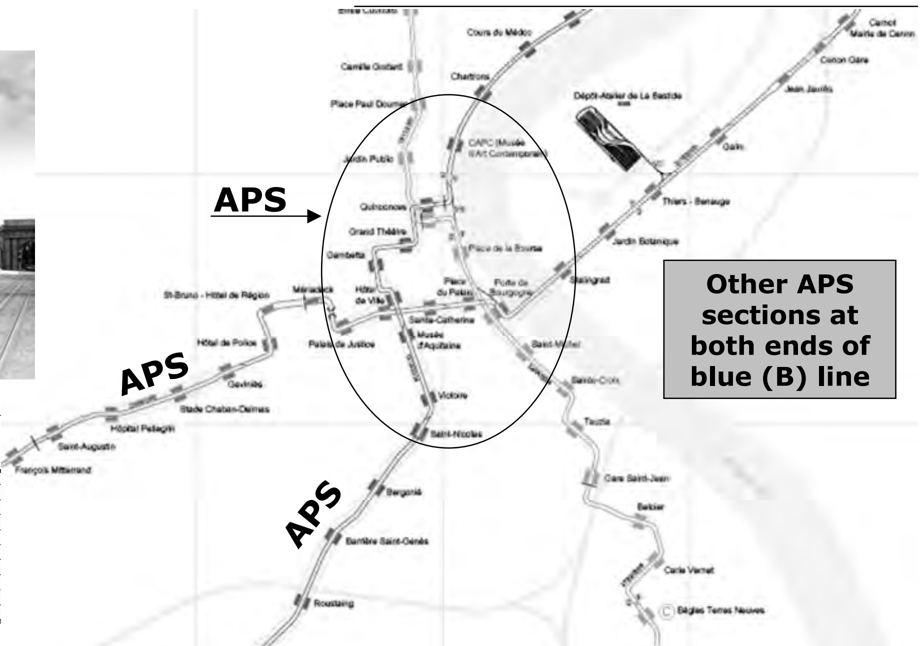
Tram without catenary : APS Bordeaux





- 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 Equipement

- 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

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 Equipement
- 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)

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)

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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

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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

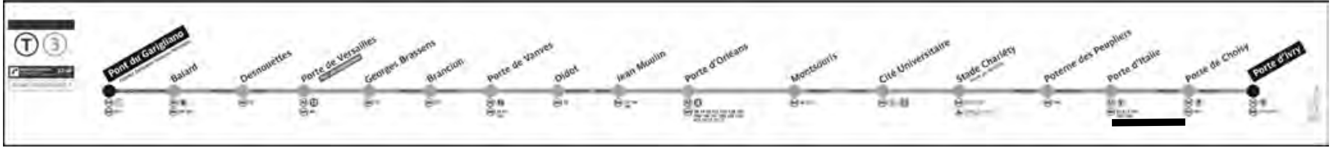
- Project start in June 2008
- 5 years warranty

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

Tram without catenary
On-board Solution : STEEM



- 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

RATP INRETS PREDIT ADEME

Agence de l'Environnement et de la Maîtrise de l'Energie

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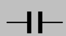
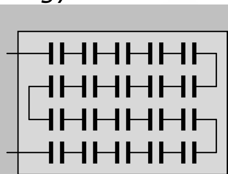
On-board Solution : STEEM

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



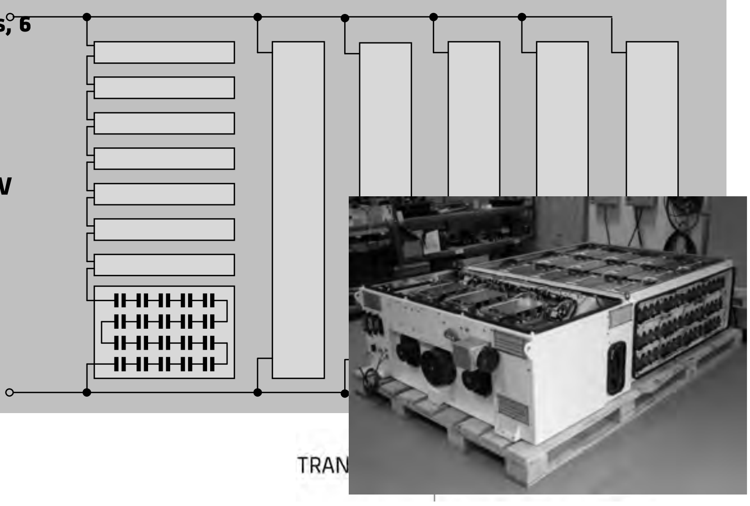
- **U = 2,5 V**
- **a single 2600F cell**



- **U = 50 V**
- **1 module = 20 cells connected in serial mode**

- **STEEM supercaps box : branches in parallel, modules in serie**

48 modules, 6 each of 8



- **U = 400 V**

E = 1,62 KWh
$P_{soc\ 0}$ = 350 KW
$P_{soc\ 1}$ = 500 KW

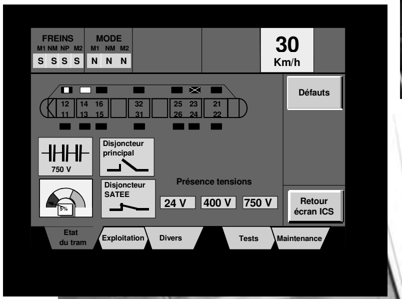
Msc=720 kg

Recharge time 20 s min

TRAN

On-board Solution : STEEM

- Integration in roof layout



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

Supercapacitors constraints

Extract of MAXWELL supercapacitors data sheet :

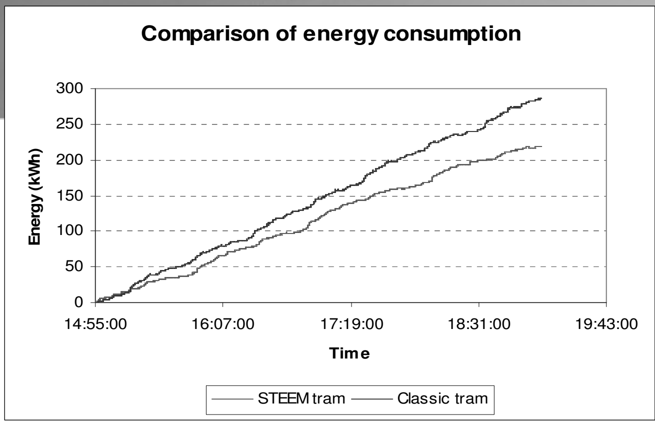
PC Family Small energy cells	BC Family Medium power cells	MC Family Large power cells
Features	Features	Features
Over 500,000 duty cycles	Over 500,000 duty cycles	Over 1 million duty cycles
2.5 volt operating voltage	2.5 volt operating voltage	2.7 volt operating voltage

- 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 !**

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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Agenda

1. Why wireless trams ?
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3. How does APS work ?
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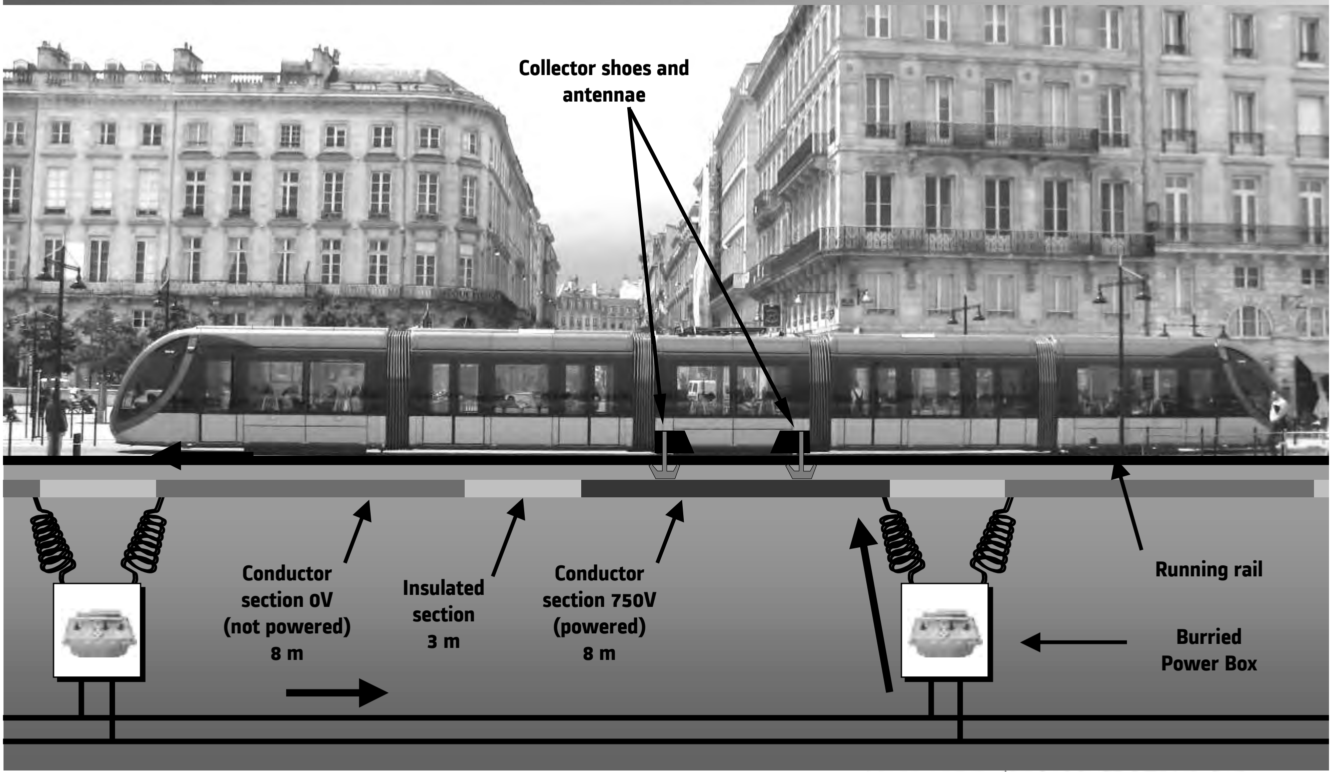
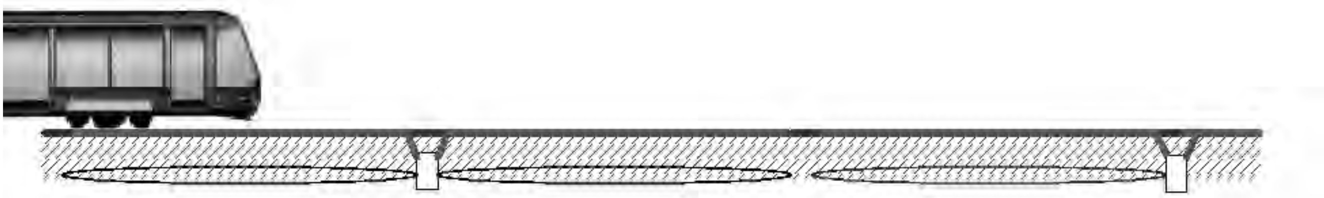
APS system: principles

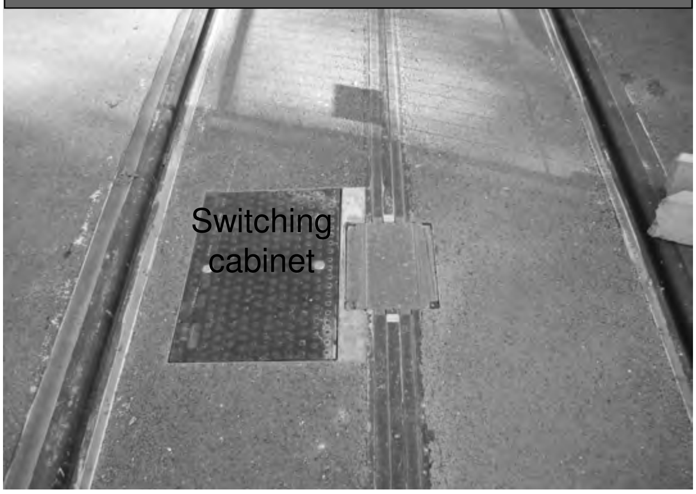


APS system: principles



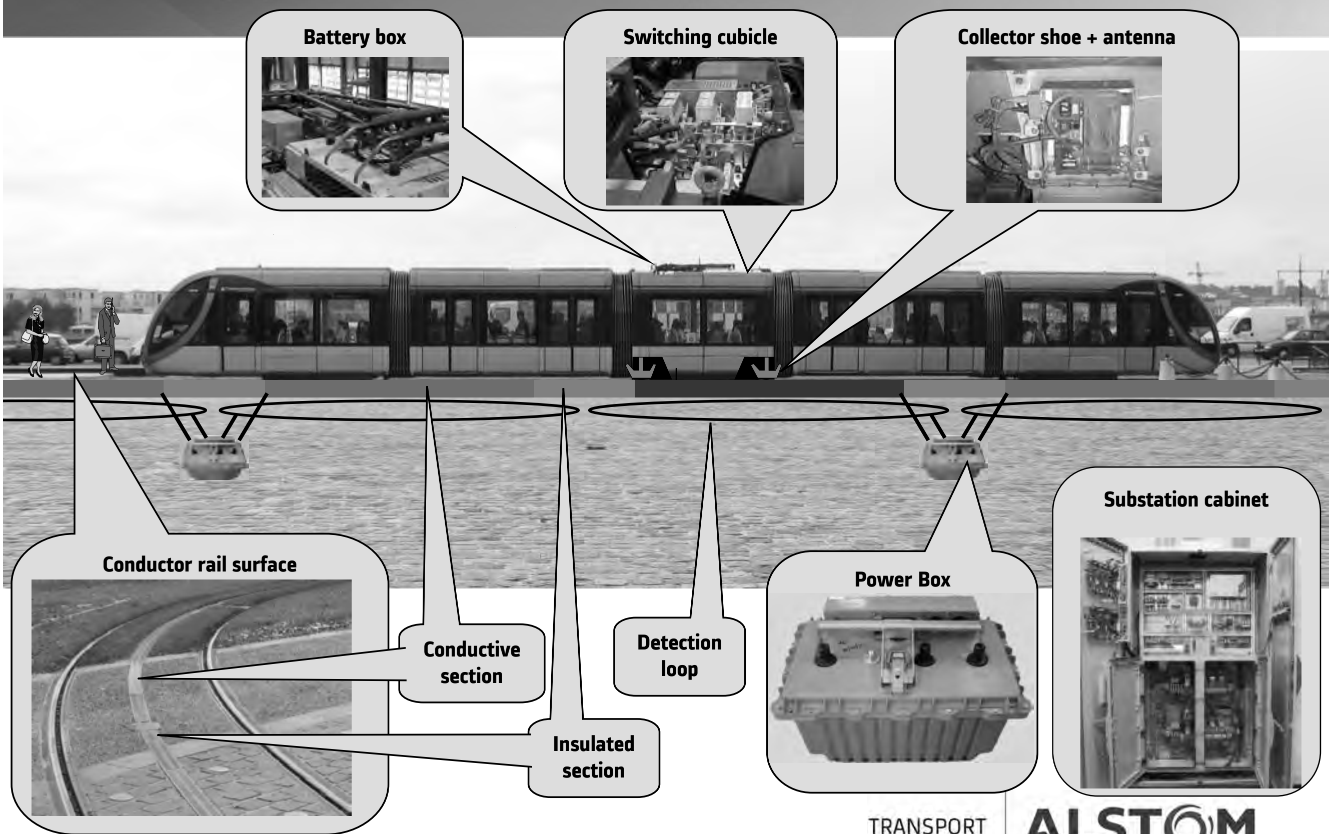
APS: Aesthetic Power Supply

- 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

APS system: main components



Agenda

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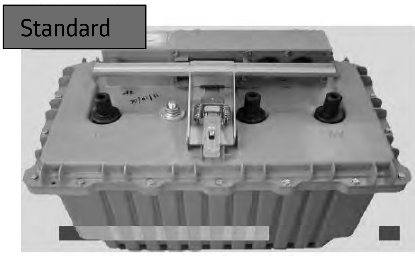
APS adaptation for hot climate

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



  - 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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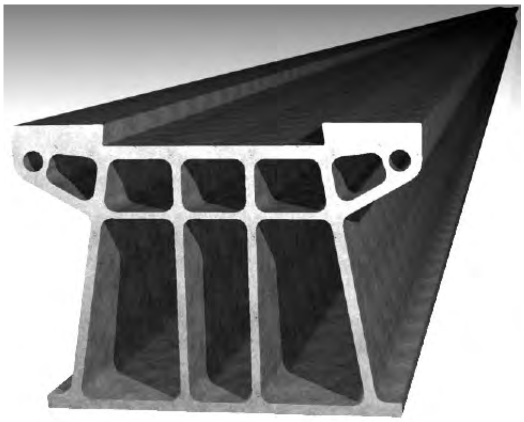
APS rail evolution

APS Bordeaux

Other APS projects

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



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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

Keeping the APS Rail Clean/ A Robust Solution

INSTALLATION ON THE VEHICLE

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Dust and Sand protection

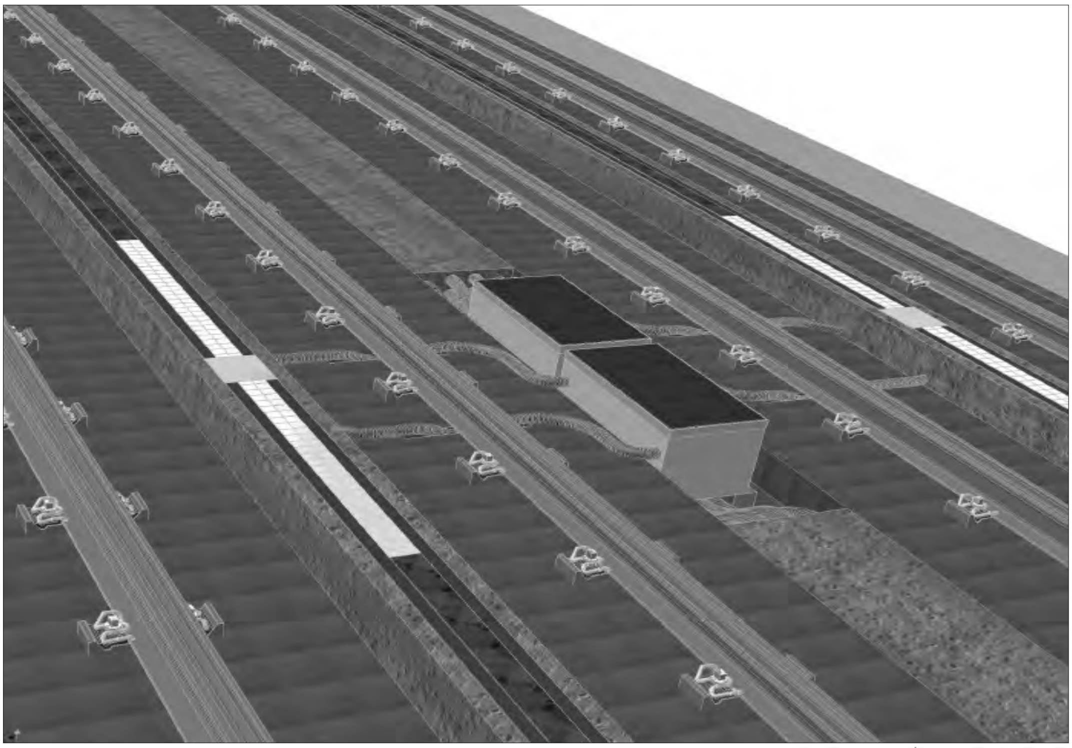
IN OPERATION in
BORDEAUX

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

Power boxes arrangement



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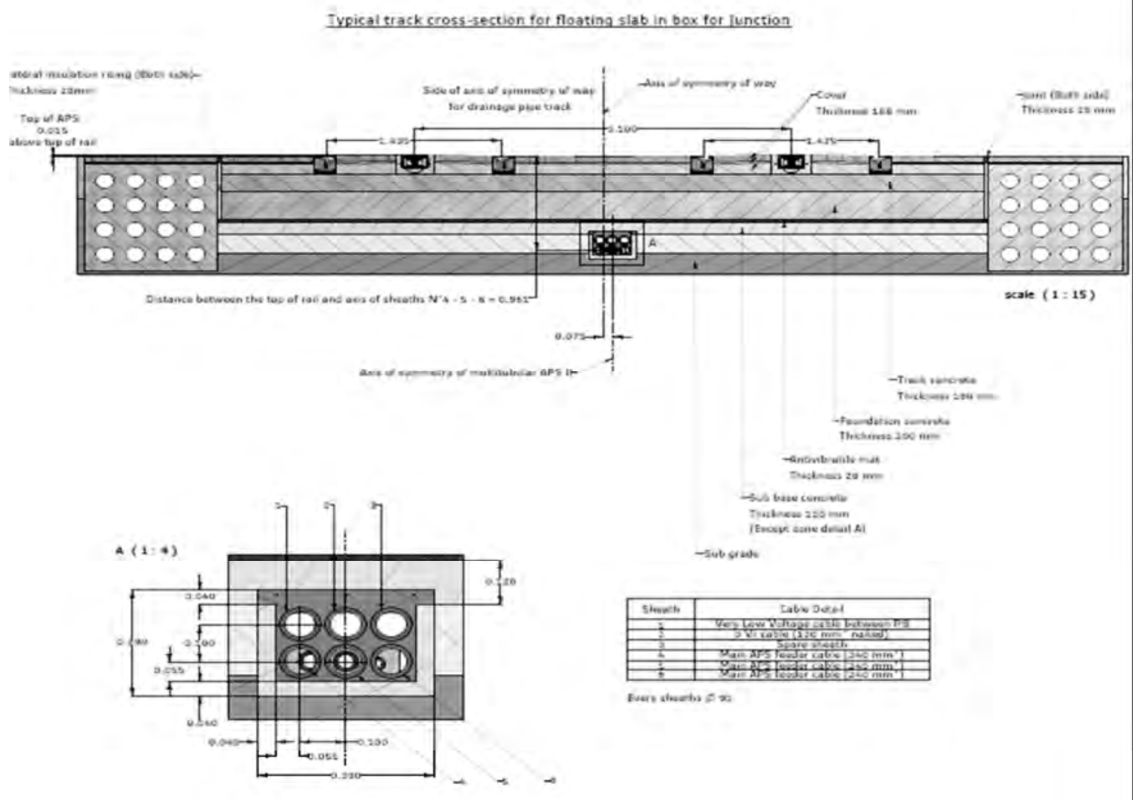
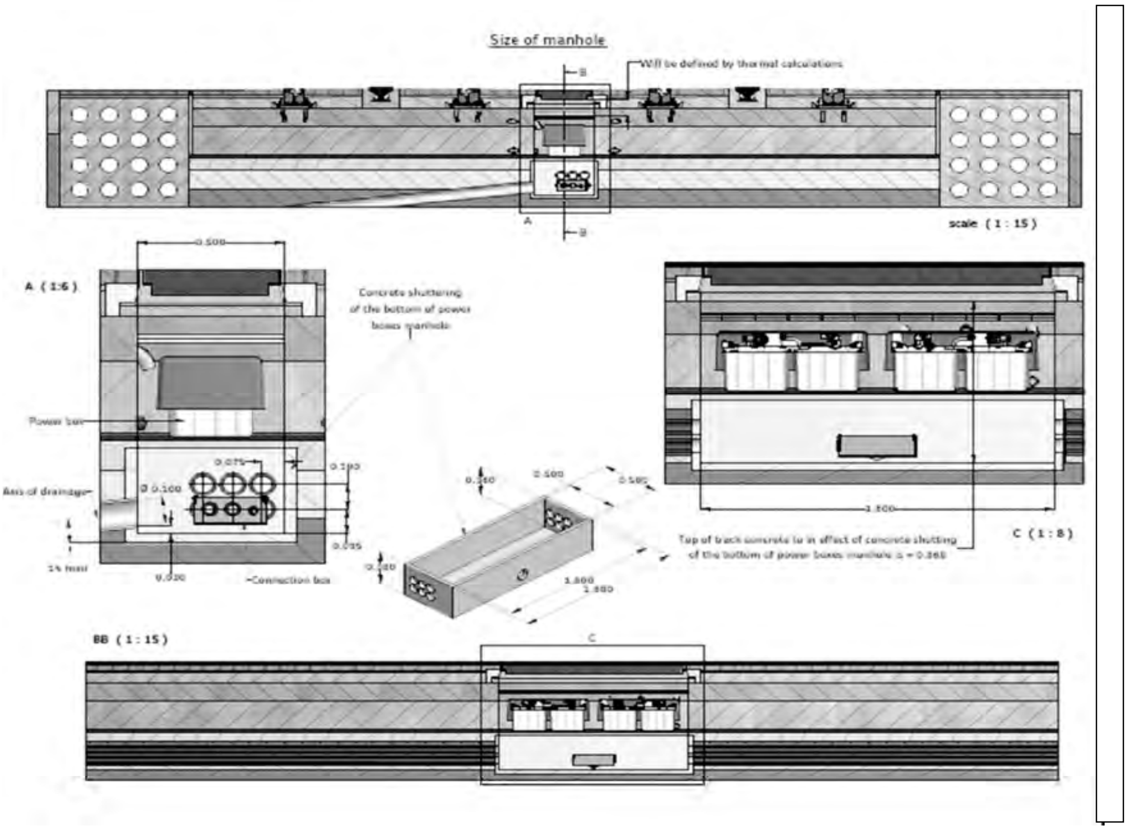
TYPICAL TRACK CROSS SECTION



TYPICAL APS TRACK CROSS SECTION



E-mail: info@waveipt.com

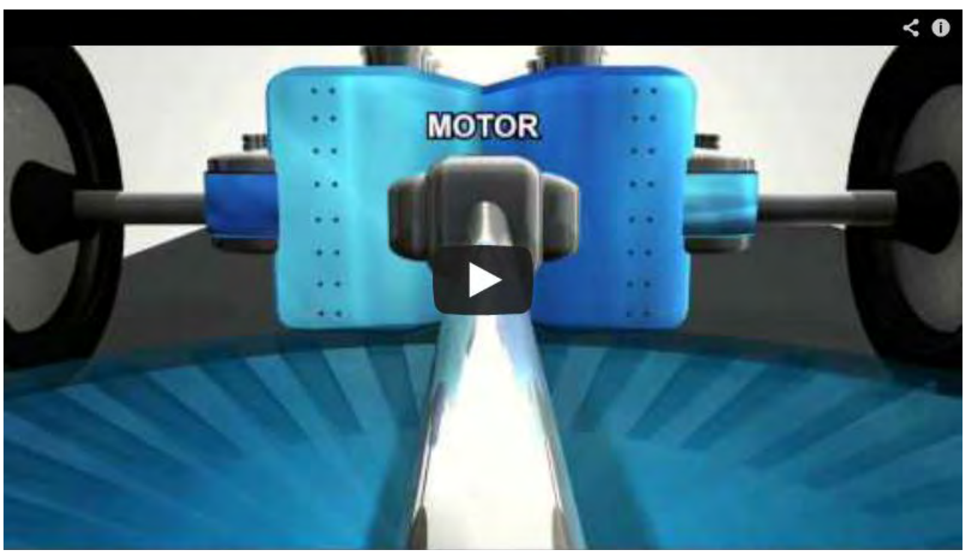
WAVE

Wireless Advanced Vehicle Electrification

PARTNERS

Many companies are already recognizing the value of utilizing 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

Projects

All Projects International State Federal




Recent News

Utah State Electric Bus Receives Energy Award

21 February, 2013 *Partners*

Utah 2012 State of the State Address Mentions WAVE

12 February, 2013 *Partners*

Induction Charging Comes to Public Transit

21 December, 2012 *Technology*

Contact Us

Swaner EcoCenter
1258 Center Drive
PO Box 680941
Park City, UT 84068

801-633-1676

info@waveipt.com

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5 days 17 hours ago

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WAVE
Wireless Advanced Vehicle Electrification

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.

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Swaner EcoCenter
1258 Center Drive
PO Box 680941
Park City, UT 84068

801-633-1676

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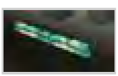


PRIMOVE: Game-changing turnkey solution for tram systems

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 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

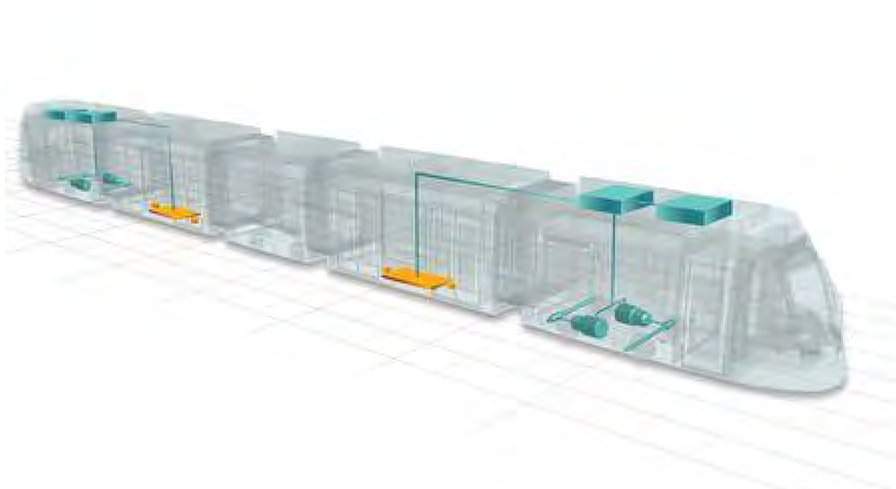
- Less land take needed than for catenary systems
- Less maintenance: no wear of pantographs and overhead lines, no risk of vandalism

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.

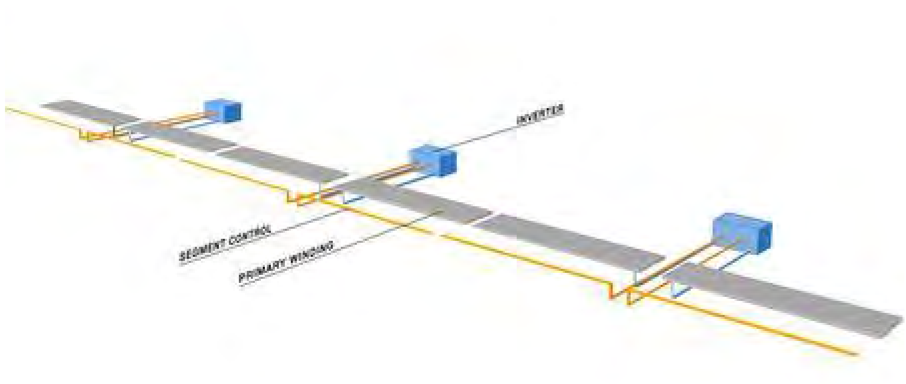


Beyond dispensing with overhead infrastructure, the PRIMOVE system also offers a whole range of further advantages. The technology is simple to install in both new and existing lines as the components easily fit between the rails. Initial investment and maintenance costs are lowered, making the overall 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

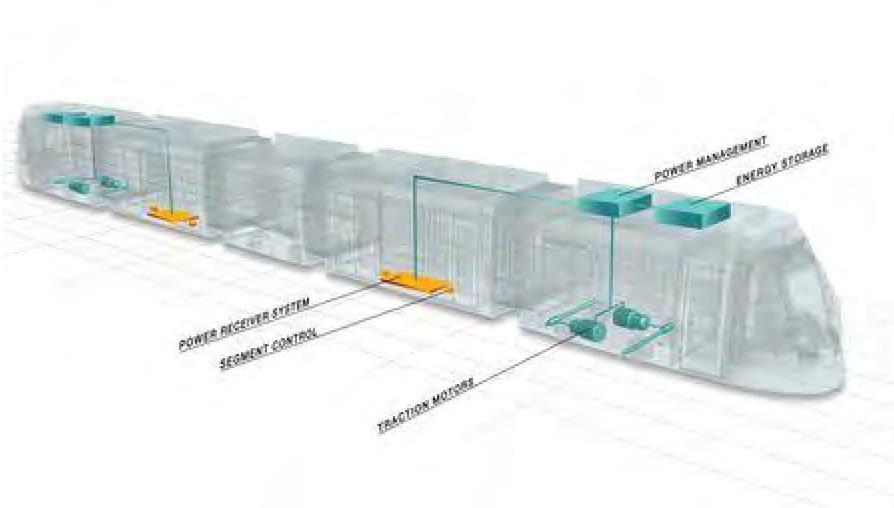
PRIMOVE wireless charging technology comprises two sets of components – wayside components that are buried underground and onboard components that are fitted onto the vehicle frame. Both sets are designed to enable maximum structural integration, as well as for energy transfer at high power and efficiency.



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

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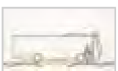
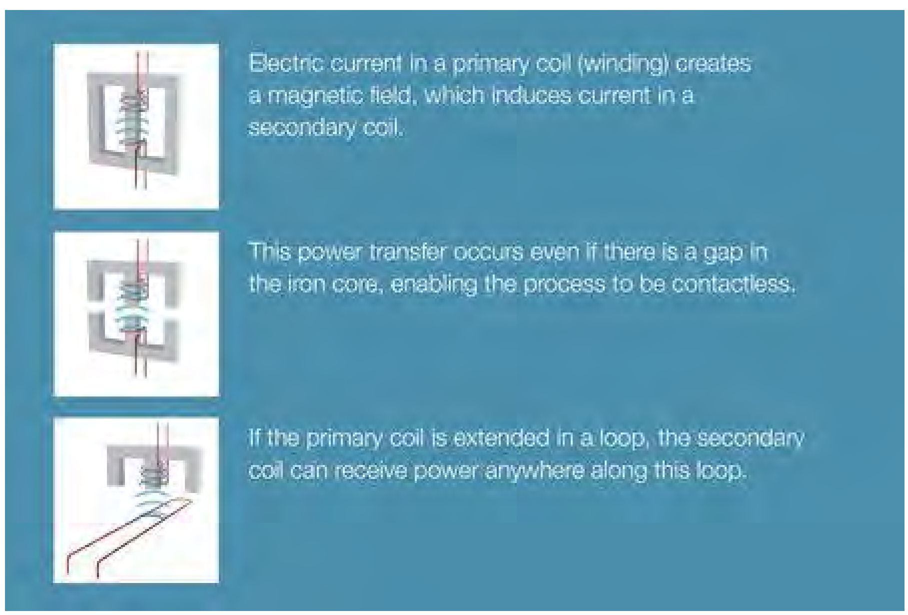

PRIMOVE: High power transfer for electric buses

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.



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.

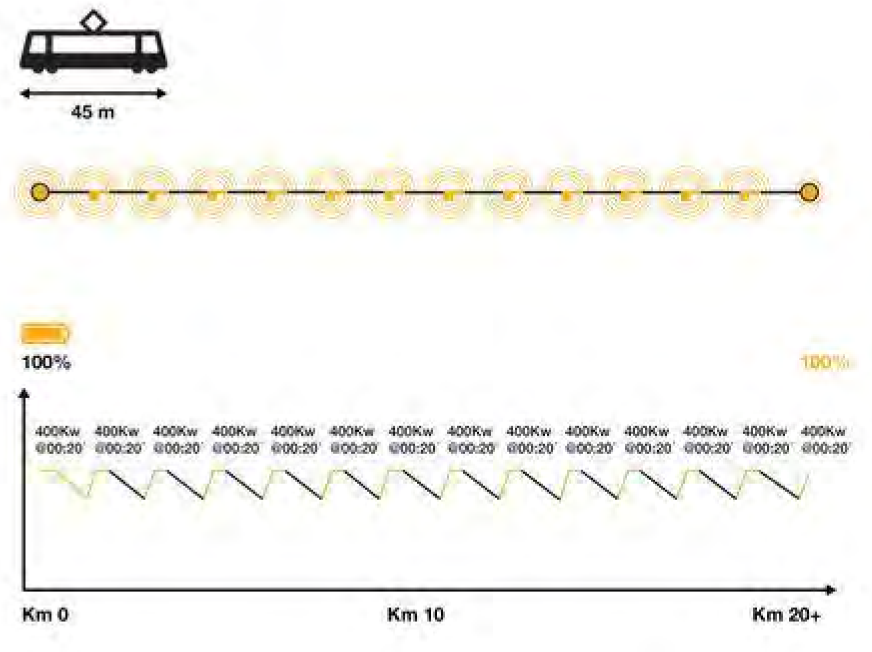
Introducing high power opportunity charging

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.

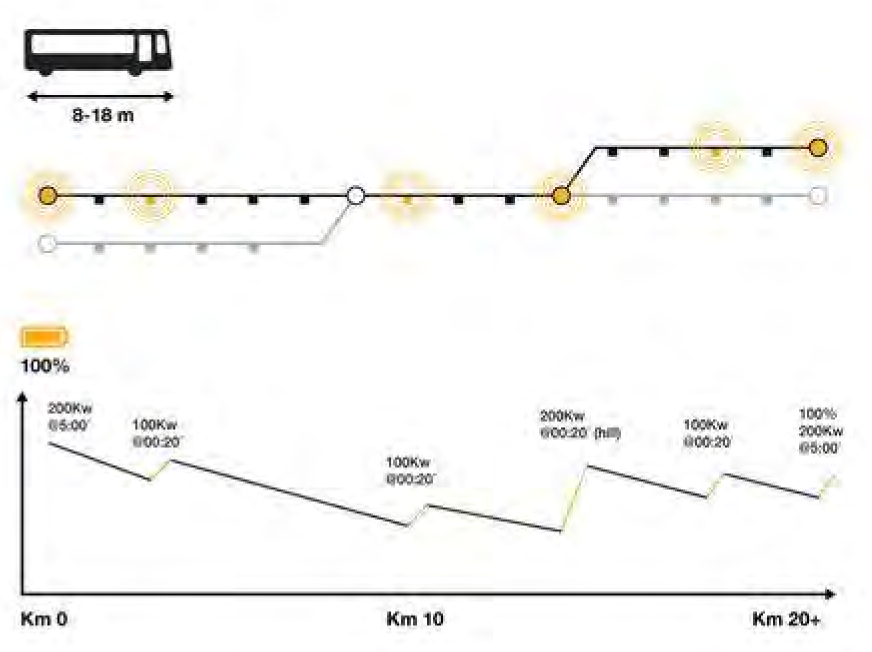
Light rail

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 setion 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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