

# CLEARSY

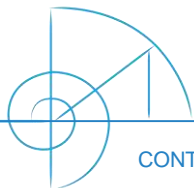
Safety Solutions Designer

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AIX  
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[WWW.CLEARSY.COM](http://WWW.CLEARSY.COM)

# DOF and COPPILOT SIL3 / SIL4 Safety critical screen doors control systems



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# COPPILOT and DOF systems: Autonomous Platform Screen Door opening and closing system

- ▶ Independent from any train control systems (ATC or only ATP) and signalling
- ▶ Can be installed on existing and new lines, existing and new trains with existing or new train control systems
- ▶ Connected to PSD controller

## SOLUTIONS FOR

### Metro authorities

- Driverless turnback project
- PSD tests
- PSD operation before commissioning of a new ATC\*
- Mixed operation during ATC deployment (new and old train mixed)
- Backup system to control PSD

\*ATC: Automatic Train Control like CBTC, ETCS,...

### PSD supplier

*Turnkey PSD project:*

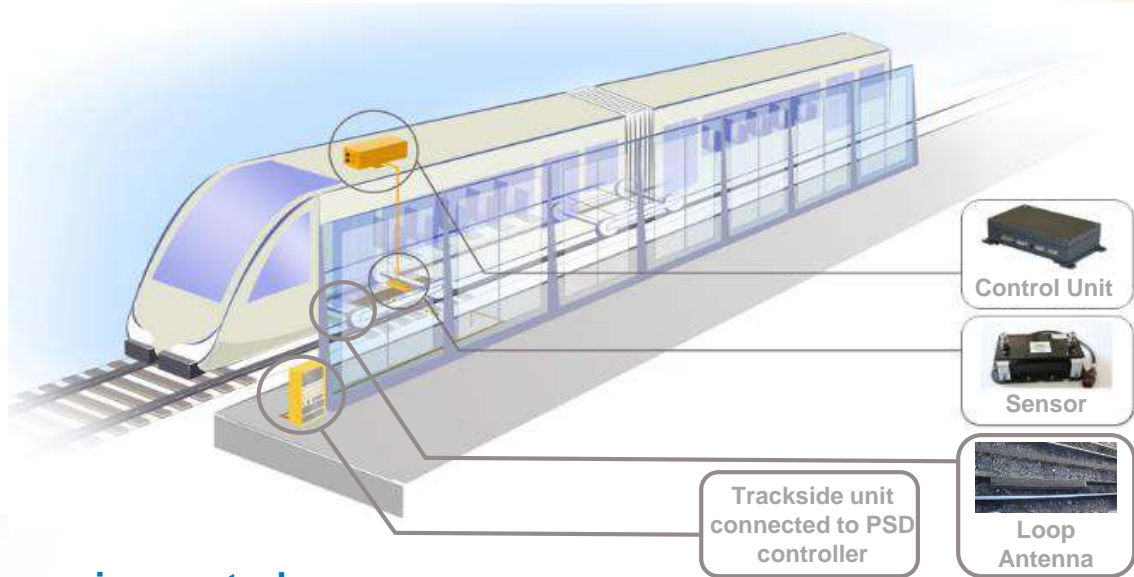
- ➔ Including safety critical control system on existing and new line
- ➔ Compatible with any types of PSD (half, semi-full, full height) and interfaces

### ATC supplier

- PSD control managed independently of the ATC

# DOF: SIL3 safety critical screen doors control system

PSD opening authorization when the train stops in the tolerance zone and train doors are opening



**SIL3: Door opening control**

**SIL4: Correct train side doors enable**

# DOF: SIL3 safety critical screen doors control system

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- ▶ **Safe train-track communication:** *based on magnetic communication*
- ▶ **No cross-talk:** *communication only possible when sensor is above loop antenna*
- ▶ **Inductive loop antenna:** *the loop location defines the stopping zone and its length defines the tolerance within the stopping zone*

# DOF: *Equipment*

## ▷ On-board



*Sensor mounted under the train (bogie)*



*Onboard unit (sensor and train doors interface)*

## ▷ Wayside

**Loop**



*Loop antenna*



*Control unit (antenna and PSD interface)*

# DOF: *proven product already in use*

Paris Metro Line 1 (four years of operation), in operation on Line 13, and into deployment on Line 4

- DOF1 (DOF for Paris line 1) is independent from the CBTC system
- CBTC doesn't manage the PSD



Upgraded version of DOF

- SIL4
- Doors selectivity: each opposite PSD and train doors are synchronized
- Opening adapted to different train lengths
- If obstructed, automatic re-opening of only concerned train doors and their related PSD
- LAN connectivity or relays interface : Interfaced with PSD controller and train network

**BOMBARDIER**  
TRANSPORT



# DOF: *RATP installation on line 13 – project named COPP*

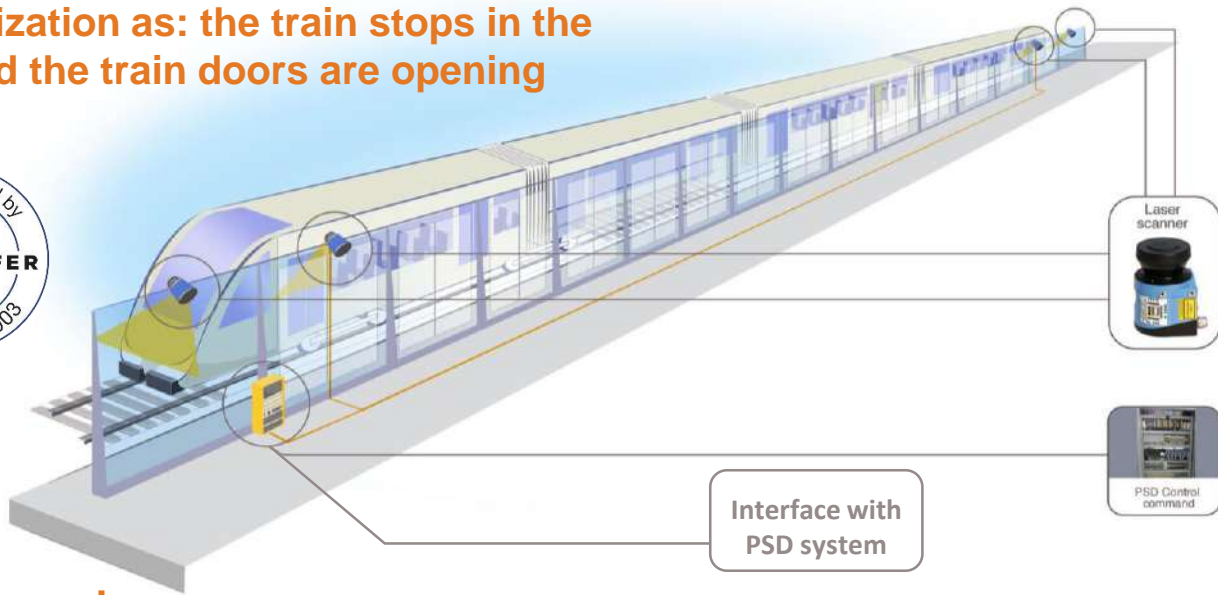


Châtillon – Montrouge



# COPPILOT: SIL3 safety critical screen doors control system

**PSD opening authorization as: the train stops in the tolerance zone and the train doors are opening**



► **No equipment on-board**  
only on the wayside

► 2 doors lasers detect: opening and closing of train doors managed by train operator

► Head and tail lasers ensure: correct train positioning & zero train speed

► **SIL3 door opening control**

► **Based on SIL4 control unit**



# COPPILOT: SIL3 safety critical screen doors control system

- ▶ **SIL3 certified:** *NO opening of the PSD if a train is not correctly berthed and stopped*
- ▶ **SIL4 certified control unit\*:** bootloader, low layers of programming
- ▶ **Detection of train position:** *adjustable accuracy tolerance of +/-1m*
- ▶ **Manual operation still possible if COPPILOT is out of order:** *Metro operator can manually operate PSD*

*\*A SIL4 system architecture was also developed but tests were not taken for SIL4 certification. Safety case is available and Certifer (ISA) gave a positive opinion for SIL4 certification.*

# COPPILOT: Easy-to-install on new and existing stations

- ▶ In service for 9 months in **Paris** during the PSD test period
  - COPPILOT was chosen to manage 3 PSD from 3 different manufacturers of mechanical PSD on 3 platforms. RATP did not want any installation on the 65 trains during the test
- ▶ In service in **Sao Paulo Metro : Tamanduatei, Vila matilde, Sacoma, Vila prudente** (1st project in South America), deployment on line 1, 2, 3
  - 143 trains shared on 3 lines, 7 train types : impossible to install equipment on-board
  - Metro wanted an **auxiliary SIL3 system** to control PSD. COPPILOT was selected and became the main system to compensate late CBTC delivery...
  - 2018: 5 more platforms to be equipped, **driverless turnback project**
- ▶ A monorail version in test for **Sao Paulo Monorail line 15**. It was upgraded for monorail application (SIL4). 13 stations will be equipped
- ▶ In service in **Stockholm**: 6 platforms in operation (2 stations)
  - additional functions: PSD individual opening, 2 trains lengths, platform berthing guidance, two way trains, and can handle 2 berthing positions
  - Adaption of PSD opening widths to where the train stopped for optimal train access
- ▶ Current project in **Los Teques Line (Caracas)**
  - additional functions: 2 trains lengths and 2 train types, 2 berthing positions...



# COPPILOT: *Vila Prudente* – *Sao Paulo*



# COPPILOT: *Sacoma – Sao Paulo*



# COPPILOT: *One of the laser scanners*





# COPPILOT: *Laser scanners in Sacoma station (Sao Paulo)*

- ▶ Installed at the first and at the last PSD





# COPPILOT: Oratorio Station Monorail L15 Sao Paulo - SIL4 version



# COPPILOT: Oratorio Station – Monorail - Head positioning sensor

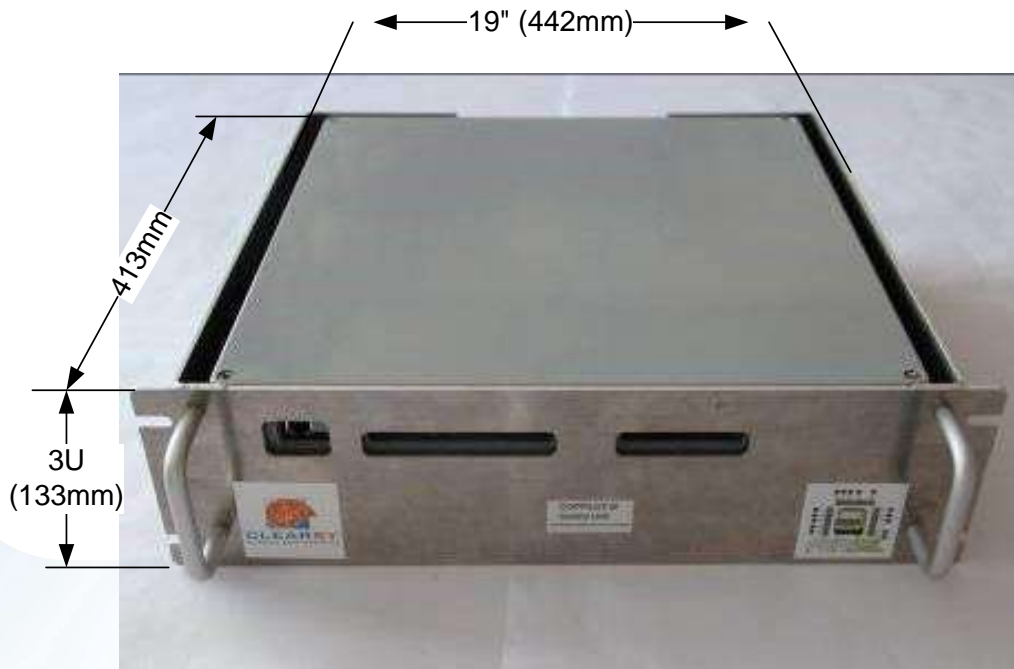
- Installed at the front and at the rear of the platform in Sao Paulo to ensure correct berthing of the train and zero train speed



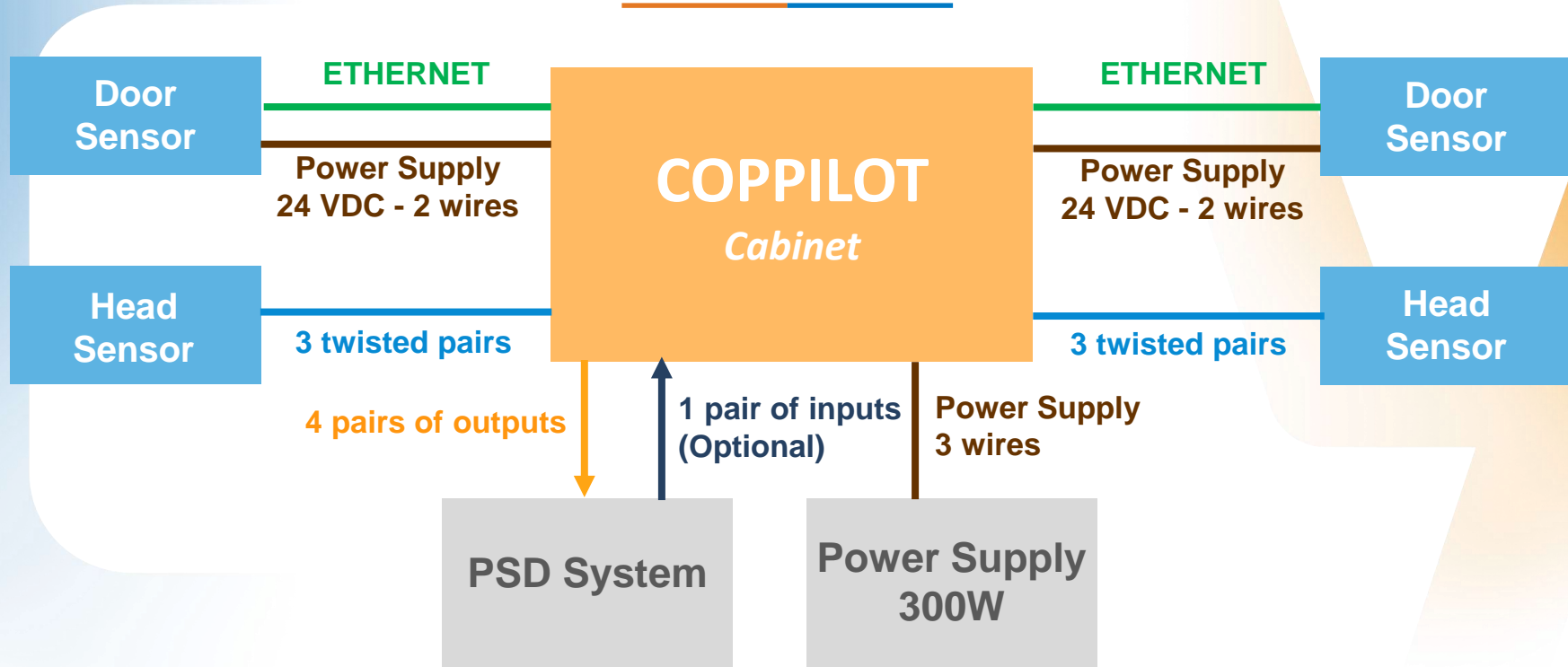
# COPPILOT Cubicle example: 4 control units (4 platforms)



# COPPILOT control unit: 1 per platform



# COPPILOT: *Global Architecture*



**Note:** Depending of the maximum length of the cable, optical fiber might be installed instead of copper wire.



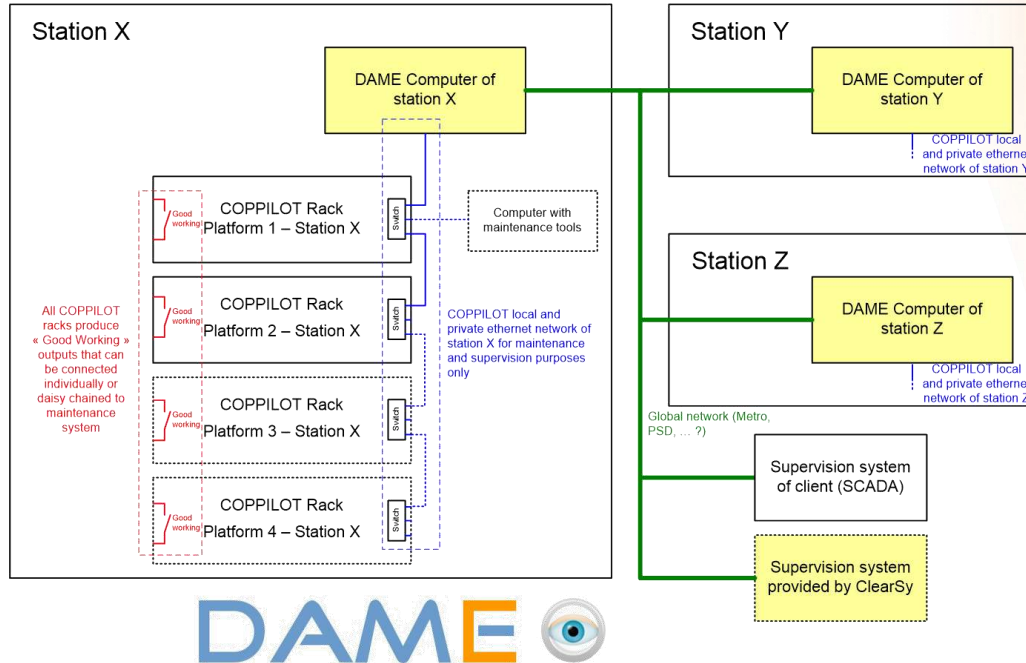
# COPPILOT: *Safety critical software SIL3/4*

- ▶ SIL3/4 System, B formal method used, mathematically proved
- ▶ SIL3/4 critical software including:
  - ▷ Image processing (laser scanner)
  - ▷ Signal processing
  - ▷ Real time treatment
  - ▷ Train speed measurement
  - ▷ Train position measurement
  - ▷ Opening and closing train doors detection
  - ▷ Generic software is configurable to take into account the local environment
  - ▷ Two-way train service management
  - ▷ Data consistency
  - ▷ Compatible with CBTC



# COPPILOT: *Maintenance and supervision tool*

Architecture of maintenance and supervision tools (named DAME) for  
COPPILOT



# Train conductor assistance to berth the train

- ▶ The distance between the train and the train berthing position is measured. The train operator is guided by the successive illumination of LED on the track side lightboard



- ▶ Detection starts 40 meters away from berthing point
- ▶ Accuracy: +/- 5 cm to the nominal berthing position

# Departure autorisation – conductor assistance

- ▶ The status closed and locked of the PSD is communicated to the train driver (by PSD system)



▲ Paris – *On the wayside*

Stockholm  
*On the wayside*



Examples - Lighted on when PSD are “closed and locked”

Train operator is responsible for starting the train when PSD are all closed and locked.

# DOF and COPPILOT

- ▶ Two systems to offer optimal solution for all environments (train fleet, signaling system, track floor equipment occupancy)

Features	COPPILOT	DOF
Onboard equipment		x
Wayside equipment	x	x
Trackside equipment		x
Response time	600ms	300ms
Affected by environment	x	
Multiple stopping positions	x	x
Individual PSD opening	x	x
Multiple train lengths	x	x
Communication with train		x

# Use case 1: Reduce dwell time against ATC system

- ▶ ATC system is often slow to command platform edge doors because of information it needs to collect from onboard systems and ATC trackside zone controller
- ▶ The opening or closing PSD command does not require to be managed by the ATC to be safe
- ▶ DOF as a sustainable solution, takes care of the function faster and safely. It greatly reduces offset time

## Flash estimate

In many metro systems, 2 second delay is observed between opening of train doors and opening of PSD. This is called the **Offset time**. The same delay is observed during the closing of the doors.

An independent PSD control system decreases the offset time to less than 300 ms.

On a line of 30 stations and 2\*2 seconds saved per stop, a train could save 120 s.

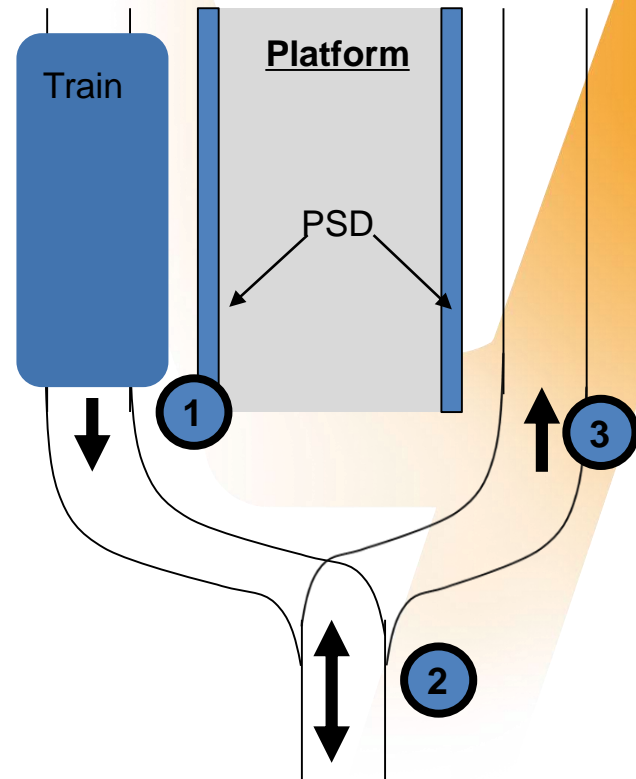
If there are 2 minutes between trains, **then for the same line capacity one less train is needed.**

## Use case 2: Automatic turnback

- ▶ RATP wanted an **automatic turn-back system** at the last station of the line 13
- ▶ No driver is in the front cab when it is coming back
- ▶ Driverless movement of train required track protection
- ▶ As long as a PSD is opened, there is no traction power
- ▶ Save time and train conductors
- ▶ There are similar systems in Hong Kong and Sao Paulo

### Operating process

- 1 Train stops at the station. Passengers leave the train then train operator activates automatic turn-back.
- 2 Train automatically moves until the end of the track (2). Traction power is automatically reversed to change direction of the train.
- 3 Train moves to 3. PSD open and during passenger exchange, new train operator accesses the cab in front of the train.





# Use case 3: Independent from Automatic Train Operation system

As a fully independent system from any ATC (including CBTC), our systems are also chosen for the following purposes:

- ▶ **Main system:** allow to have PSD even if no ATC is installed or if ATC cannot manage PSD
- ▶ **Auxiliary system:** if ATC fails to command PSD, our systems are still managing PSD to maintain normal operation – *Sao Paulo, Brazil*
- ▶ **Temporary solution:** driverless ATC system implies PSD installation. ATC commissioning may take time. During this delay, CLEARSY PSD control system permits mixed operation - *Line 1 RATP, Paris, France*



▲ Semi-Full-Height Platform Screen Doors



▲ Half-Height PSD



Full-Height PSD ▲

# Use case 4: Test of PSD

## Pilot program for Platform screen doors system:

- ▶ Platform screen doors are often necessary for driverless ATC operation, as track protection
- ▶ That is why authorities often initiate a test of the platform screen doors

## PSD testing

- ▶ RATP installed COPPILOT when they tested 3 PSD from 3 manufacturers
- ▶ The PSD were installed on 3 platforms to compare their performances. RATP chose to have a unique PSD control system: COPPILOT was chosen to avoid installing equipment on board



# PSD control project players roles

## ► Communication with stakeholders of PSD project

**CLEARSY control system purchased by either:**

Metro authority or Project consortium or PSD supplier or ATC supplier

*References: Metro Sao Paulo, RATP, CEML*

### Installation

Local partners or PSD supplier or ATC supplier

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### Interface with PSD

PSD supplier

### Interface with tracks

Certified installer or local engineering company or metro authority

**Supports for**

### Interface with train

Train manufacturer or local engineering company or metro authority

# Contact

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