CLEARSY Systems Engineering
Provides turnkey safety critical systems and software

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

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

*ATC: Automatic Train Control like CBTC, ETCS,…

DOF and COPPILOT | PSD control systems
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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
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 antenna**
- **Loop**
- **Control unit (antenna and PSD interface)**
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
DOF: RATP installation on line 13 – project named COPP
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: 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
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

- 19" (442mm)
- 3U (133mm)
- 413mm
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

Station X

- DAME Computer of station X
  - COPPILOT Rack Platform 1 – Station X
  - COPPILOT Rack Platform 2 – Station X
  - COPPILOT Rack Platform 3 – Station X
  - COPPILOT Rack Platform 4 – Station X

Station Y

- DAME Computer of station Y

Station Z

- DAME Computer of station Z
  - Global network (Metro, PSD, ...)?
  - Supervision system of client (SCADA)
  - Supervision system provided by ClearSy

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

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

Train operator is responsible for starting the train when PSD are all closed and locked.
Two systems to offer optimal solution for all environments (train fleet, signaling system, track floor equipment occupancy)

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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*
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

Interface with PSD
- PSD supplier

Interface with tracks
- Certified installer or local engineering company or metro authority

Interface with train
- Train manufacturer or local engineering company or metro authority

Supports for

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