Signalling & Control Metro Amsterdam

Project presentation

IRSE visit October 25th, 2019

October 25th, 2019

Contents

Introduction speakers

- Ir. W.C. (Wim) van Spronsen
  Senior Project Manager

- since 2014: Alstom: Project Manager SCMA project
  2001-2014: ProRail: Project Manager signalling systems
  1997-2001: Siemens: Manager Urban traffic projects
  Project Manager signalling system RandstadRail
  Project Manager substations tramway Amsterdam
  Project Manager Highspeed trains ICE3
  Project Manager Telecom projects

- Technical University Delft applied physics (optics)

Introduction speakers

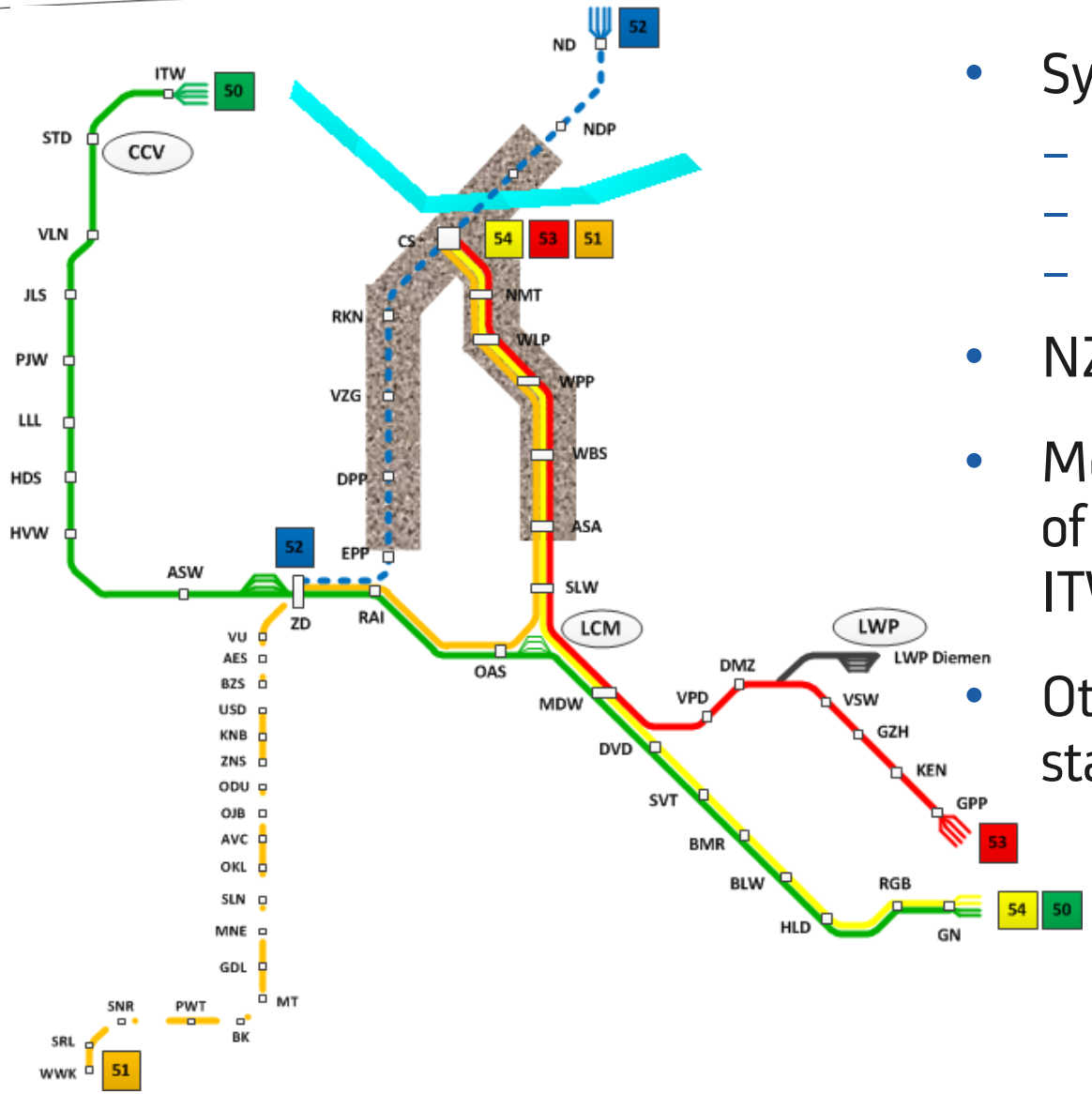
- R.H.J. (Ronald) Doeleman MSc, MIRSE
  SCMA deputy Project Engineering Manager
- Twente University : Educational Technology & Computer Science (AI)
- 1985-1992: Software engineer (Artificial Intelligence)
- since 1992: Alstom IXL specialist

  1993-1997: ERTMS (Betuweroute – mainly RBC)
  2004-2009: Safety Manager (incl. SSO)
  2010-2012: Part of tender team SCMA, WCE IXL
  2012-today: SCMA deputy Project Engineering Manager

Introduction Signalling & Control Metro Amsterdam (SCMA)

- New metro line (NoordZuidlijn)
- Signalling system needed to operate the new metro line fluidity and safe
- Also replace the existing signalling system on the existing lines
- And replace the existing traffic control system

Introduction **old** situation Metro Amsterdam



- System in use:
  - Traffic Control: VLSM
  - Interlocking: VPI / B-relay based
  - ATP: ZUB
- NZL under construction
- Modification implemented on yards of
  ITW, GPP and ASA (OMA)
- Other projects like renovation of stations Oosttunnel

Lijn 50 (Ringlijn)
Lijn 51 (Amstelveenlijn)
Lijn 52 (Noord/Zuidlijn)
Lijn 53 (Gaasperplaslijn)
Lijn 54 (Geinlijn)
Not in scope

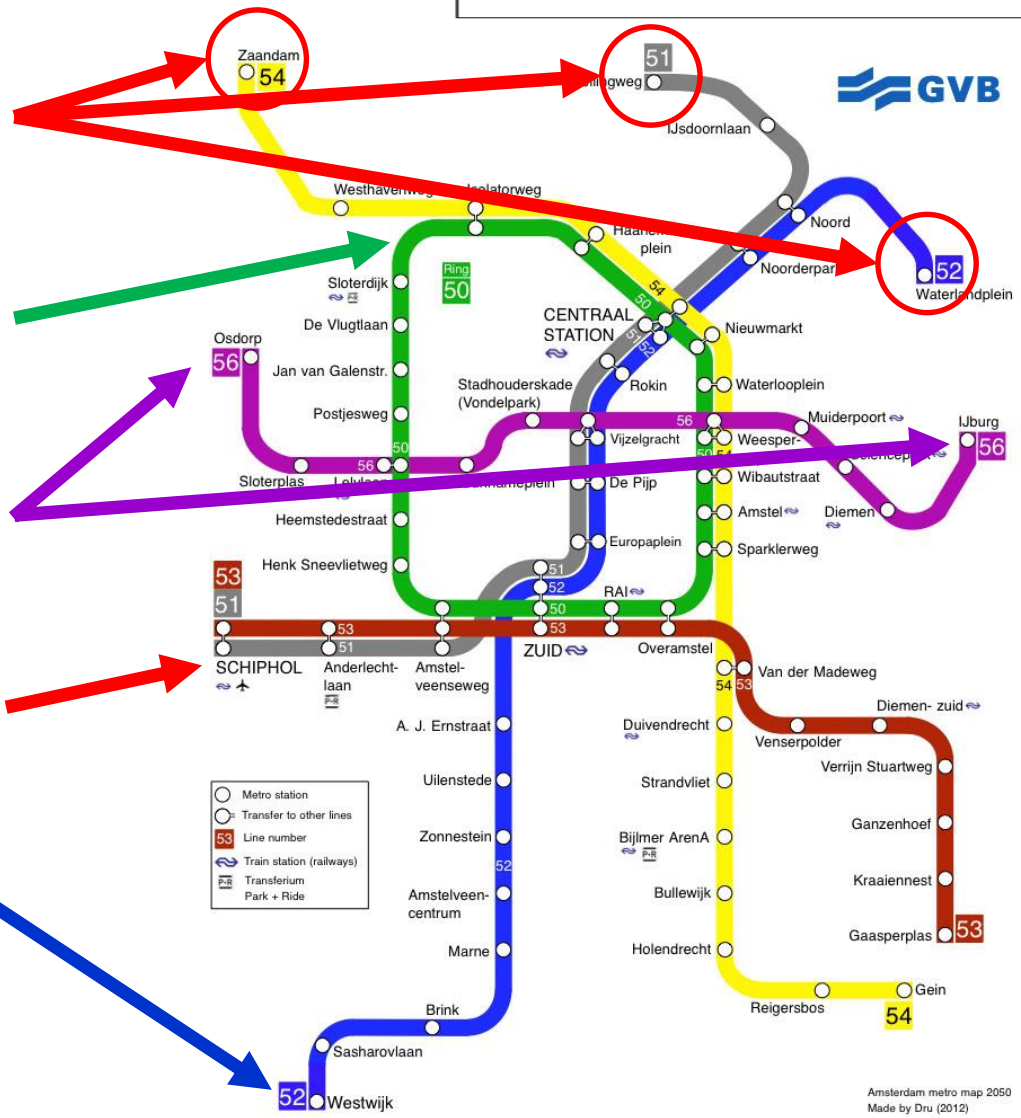
Introduction **existing** situation Metro Amsterdam

Systems in use:

- Old network:
  - Traffic Control: VLSM
  - Interlocking: VPI / B-relay based
  - ATP: ZUB
- NZL (since 22-7-2018):
  - Traffic Control: ATS (+MMS +NMS)
  - Interlocking: Smartlock
  - ATP: ATC
- New projects:
  - Zuidasdok
  - Spaklerweg
  - New M7 vehicles
  - … and many, many more

Introduction **future** situation Metro Amsterdam

- Connection to villages north of Amsterdam
- Closing Amsterdam city ring
- East/West connection
- Connect to Schiphol Airport
- Full metro line to Amstelveen



Introduction Communication Based Train Control (CBTC)

- Signalling system for Metro networks
- Communication between Train and Track by radio communication
- Driverless operation possible
- Moving block instead of fixed blocks to increase capacity

URBALIS - 124 Metro lines ordered - 78 in service

URBALIS 400 radio CBTC - ATO, DTO, UTO-ready, UTO

1.	**Beijing L2** Renovation ATO	2008
2.	**Beijing Airport Express** DTO	2008
3.	**Shanghai L10** DTO	04/2010
4.	**Shenzhen L2** ATO	12/2010
5.	**Beijing Fang Shan** ATO	12/2010
6.	**Shenzhen L5** ATO	06/2011
7.	**Milano L1** Renovation ATO	10/2011
8.	**Mexico L12** ATO	10/2012
10.	**Beijing L6 & L9** ATO	12/2012
11.	**Shanghai L13** ATO	12/2012
12.	**Wuhan L2** ATO	12/2012
14.	**Kunming L1 & L2** ATO	05/2013
15.	**Wuhan L4** ATO	12/2013
17.	**Shanghai L12 & L16** ATO	12/2013
18.	**Guangzhou L6** ATO	12/2013
19.	**Panama L1** ATO	04/2014
20.	**Wuxi L1** ATO	05/2014
21.	**Ningbo L1** ATO	05/2014
23.	**Malaga L1 & L2** ATO	07/2014
24.	**Dubai Al-Safoo** Tram	10/2014
25.	**Nanjing Ningtian** ATO	12/2014
26.	**Wuxi L2** ATO	12/2014
27.	**Ningbo L2** ATO	09/2015
28.	**Beijing L1** Renovation ATO	12/2015
29.	**Chengdu L4** ATO	12/2015
30.	**Sao Paulo L2** Renovation DTO	03/2016
31.	**Santiago L1** Renovation DTO	05/2016
32.	**Shenzhen L11** ATO	06/2016
33.	**Hong Kong SIL(E)** UTO	11/2016
34.	**Wuhan L6** ATO with LTE radio	12/2016
35.	**Suzhou L4** ATO	12/2016
36.	**Nanning L1** ATO	12/2016
37.	**Zhengzhou L2** ATO	12/2016
38.	**Kochi L1** ATO **India's 1st CBTC line**	06/2017
39.	**Lucknow L1** ATO **India's 2nd CBTC**	09/2017
40.	**Changchun L1** ATO	06/2017
42.	**Kunming L3 & L6** ATO	08/2017
43.	**Toronto YUS** Renovation ATO	11/2017
44.	**Chengdu L7** ATO	12/2017
45.	**Xiamen L1** ATO	12/2017
46.	**Guangzhou L13** ATO	12/2017
47.	**Zhengzhou L9** ATO	12/2017
48.	**Wuhan L8** ATO with LTE radio	12/2017
49.	**Nanning L2** ATO	12/2017
50.	**Wuhan L21** ATO with LTE radio	03/2018
51.	**Qingdao R1** ATO	04/2018
52.	**Amsterdam NZL** ATO	07/2018
53.	**Changchun L2** ATO with LTE radio	08/2018
54.	**Shenyang L9** ATO with LTE radio	10/2018
55.	**Lanzhou L1** ATO	12/2018
56.	**Xian L4** ATO with LTE radio	12/2018
57.	**Nanning L3** ATO with LTE radio	12/2018
58.	**Panama L2** ATO	04/2019
59.	**Sydney North West Rail Link** UTO	06/2019
60.	Lahore Orange Line ATO	2019
61.	Sao Paulo L1 Renovation DTO	2019
62.	Taichung Green line UTO	2019
66.	Amsterdam (5 lines) Renovation ATO	2019
67.	Xiamen L2 ATO	2019
68.	Mexico Guadalajara L3 ATO	2019
71.	Riyadh (3 lines) UTO	2019
72.	Zhengzhou L5 ATO with LTE radio	2019
73.	Suzhou L3 ATO	2019
74.	Bucharest L5 ATO	2019
75.	Singapore TEL UTO	2019
76.	Jinan R3 ATO with LTE radio	2019
77.	Qingdao L1 ATO with LTE radio	2019
79.	Lyon Lines B & D Renovation UTO	2019 & 2023
80.	Sao Paulo L3 Renovation DTO	2020
81.	Shanghai L15 UTO with LTE radio	2020
82.	Shanghai L18 UTO with LTE radio	2020
83.	Shenzhen L6 ATO	2020
84.	Chengdu L9 UTO	2020
85.	Chengdu L17 ATO with LTE radio	2020
86.	Chengdu L18 ATO with LTE radio	2020
90.	Qatar Lusail (4 lines) ATO	2019 to 2020
91.	Hanoi L3 ATO	2021
92.	Tel Aviv Red Line ATO	2021
93.	Montreal REM UTO	2021
94.	Zhengzhou L3 ATO	2021
96.	Mumbai L3 & L07 UTO	2021
97.	Xuzhou L3 ATO	2021
99.	Pune Metro L1 & L2 ATO	2021
100.	Mumbai L 2 A & B	2021
101.	Kunming L5 ATO	2021
102.	Taipei L7 Wanda UTO	2025

URBALIS 300 radio CBTC - UTO

1.	**Singapore NEL**	in operation	2003
2.	**Lausanne m2**	in operation	2008
3.	**Singapore Circle**	in operation	2009 & 2012

URBALIS CBTC:
2000 Km of lines in service

Renovations:
20 lines are or will be modernized with URBALIS

URBALIS 200 Distance-to-go and ATO

2.	**Delhi L1 & L2**	in operation	2004 & 2006
4.	**Shanghai L3 & L4**	in operation	2004 & 2006
5.	**Daegu L2**	in operation	2005
6.	**Santiago L4 & L4-A**	in operation	2005 & 2006
8.	**Incheon Express / Madrid ML1**	in operation	2007
9.	**Seoul L9**	in operation	2009
11.	**Bangalore L1 Ph1 & L2 Ph1**	in operation	2011 & 2014
12.	**Cairo L3**	in operation	2012
13.	**Jaipur L1**	in operation	2015
14.	**Bangalore L2 Purple Ph2**	in operation	2016

URBALIS Fluence radio CBTC DTO, UTO-ready, UTO

1.	Lille L1	Renovation from UTO to UTO	for	2021

URBALIS OCTYS radio CBTC DTO, UTO-ready (RATP)

2.	**Paris Line 5 & 9**	Rénovation	in operation	2011 & 2013
4.	Paris Line 6 & 11	Renovation	for	2020

Contents

Project Scope Signalling & Control Metro Amsterdam

Customer: Gemeente Amsterdam

Supplier: ALSTOM

End user: GVB

Scope:

- Resignalling of existing network with CBTC system
- Signalling of new Noord/Zuidline
- New single supervision system for full network
- Broadband connection track – train
  shared between CBTC and 3th party applications

ALSTOM

Top requirements

- No disturbance of normal exploitation
- 32 trains / hour / direction
- 80 sec design headway
- Automatic Train Operation (ATO / GoA 2) and
- Prepared for Unmanned Train Operation (UTO / GoA 4)

Contract

- Design & construct
  - Engineering
  - Detailed design
  - Delivery hardware including spare parts for 5 years based on LCC
  - Installation
  - Testing & Commissioning
  - Delivery Safety Case
  - General warranty 2 years
  - Specific warranty 5 years

  - Separate maintenance contract for 2nd and 3rd line
  - Note: 1st line maintenance by operator itself

  - Separate contract for delivery of onboard CBTC equipment for 30 M7 vehicles

GoA levels

Grade of Automation	Type of train operation	Setting Train in Motion	Stopping Train	Door Closure	Operation in event of Disruption
GoA 1 	ATP with Driver	Driver	Driver	Driver	Driver
GoA 2 	ATP and ATO with Driver	Automatic	Automatic	Driver	Driver
GoA 3 	Driverless	Automatic	Automatic	Train Attendant	Train Attendant
GoA 4 	UTO	Automatic	Automatic	Automatic	Automatic

PROJECT SIGNALLING & CONTROL (SYSTEM)

Traffic Control Centre

Signalling Equipement Rooms (SER)

Cables and cabletrays

Track Elements

Radio

Beacons

Axlecounter

Signs

Vehicles

M5/M6

S3/M4

S1/S2

Project Phasing (contract)

- Test Track Pilot Line (phase 1)
- Pilot line with commercial operation (phase 2)
- Connection of new line (Zuid) (phase 3a)
- Noord/Zuidlijn (phase 3)
  - Test Track Noord (3b)
  - Full NZL (3c)
- Roll-out rest of network (phase 4)
- Removal of old systems (phase 5)

Project Phasing (October 2019)

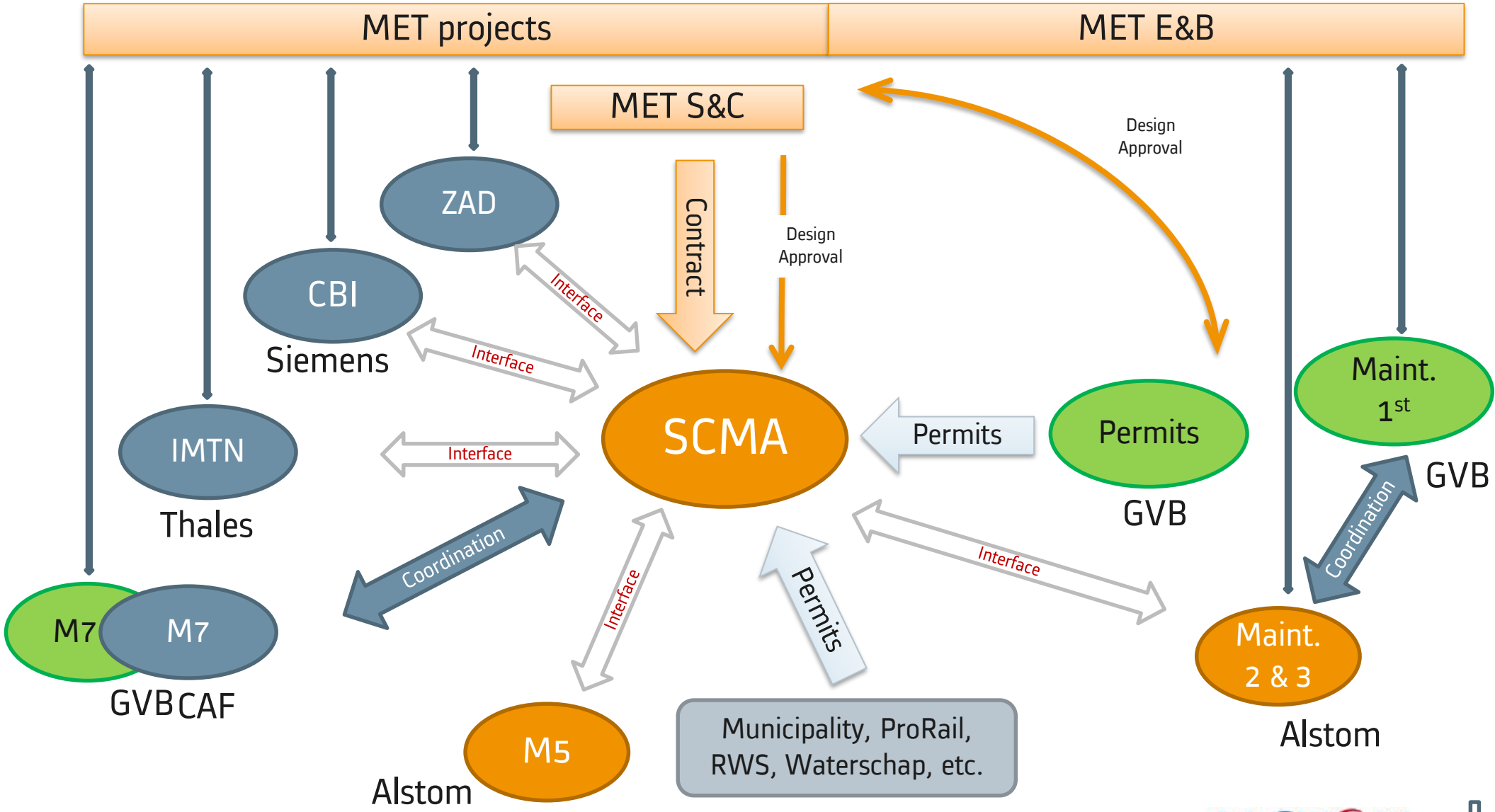
• ~~Test Track Pilot Line (phase 1)~~	cancelled
• Connection of new line (Zuid) (phase 3a)	ready
• Pilot line ~~with commercial operation~~ (phase 2)	ready
• Noord/Zuidlijn (phase 3)	
– Test Track Noord (3b)	ready
– Full NZL (3c)	ready
• Roll-Out rest of network (phase 4)	ready (*)
• Removal of old systems (phase 5)	To be defined

Main Project milestones

- 05-04-2012 Contract signature
- 15-08-2015 Connection of new line (Zuid) to existing network
- 30-09-2016 Safety Case and ISA report Pilot Line submitted
- 22-07-2018 Start passenger operation on Noord/Zuidline
- **30-09-2019 Submit safety Case and ISA report RO**
- 27-10-2019 NZL Revenue service (RO Baseline)
- 01-11-2019 Start trial operation RO (MET/GVB)
- 15-05-2020 New Baseline RO (passenger operation)
- Sep 2020 Start Passenger Operation with CBTC on full network

Contents

Project environment from 22-7-2018



Life goes on… even after September 30st

- Work on postponed scope
- Clean up LOP
- Support MeT and GVB in their test- and training program
- Work on SyDb 4.6.2
  - Quick Service and Washing: changes in objects position & TMS logic update to reach / exit.
  - Removing Amstelveenlijn
  - Infrastructural change at Spaklerweg including stopping positions.
  - Traction gaps
  - ZAD 2019
- Alarms / Events tuning
- Handle a lot of future (yet unknown) changes in Amsterdam metro system

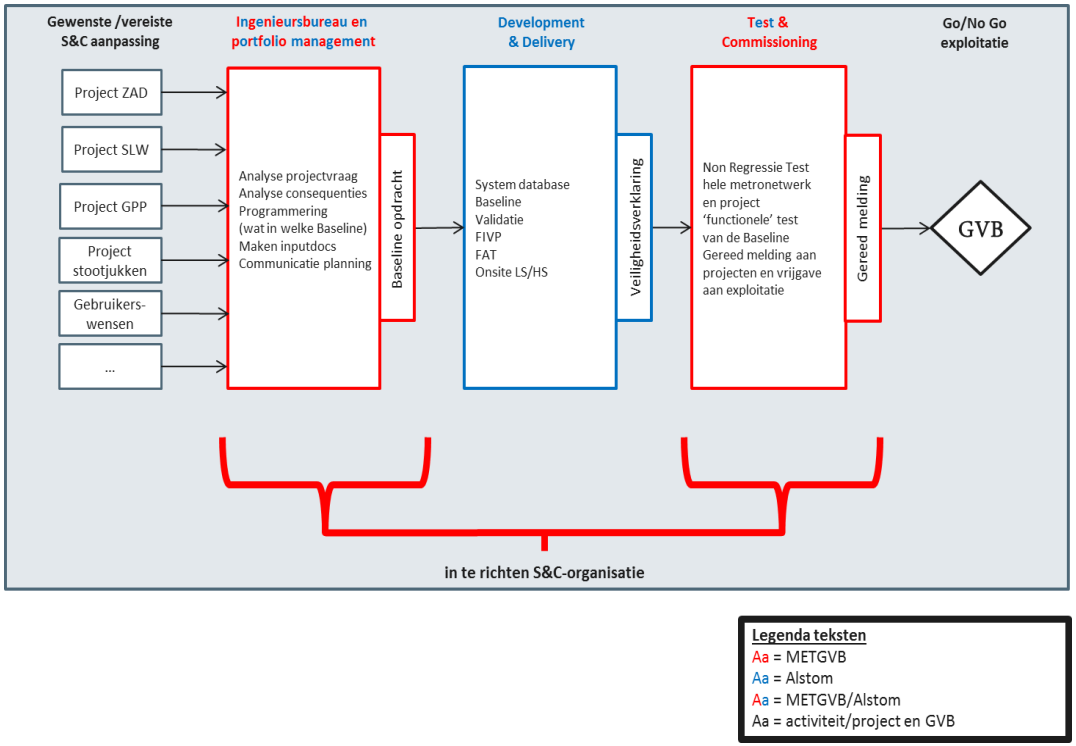
How to handle that?

- Number of projects, complexity and uncertainty in schedules are increasing risk profile for municipality of Amsterdam

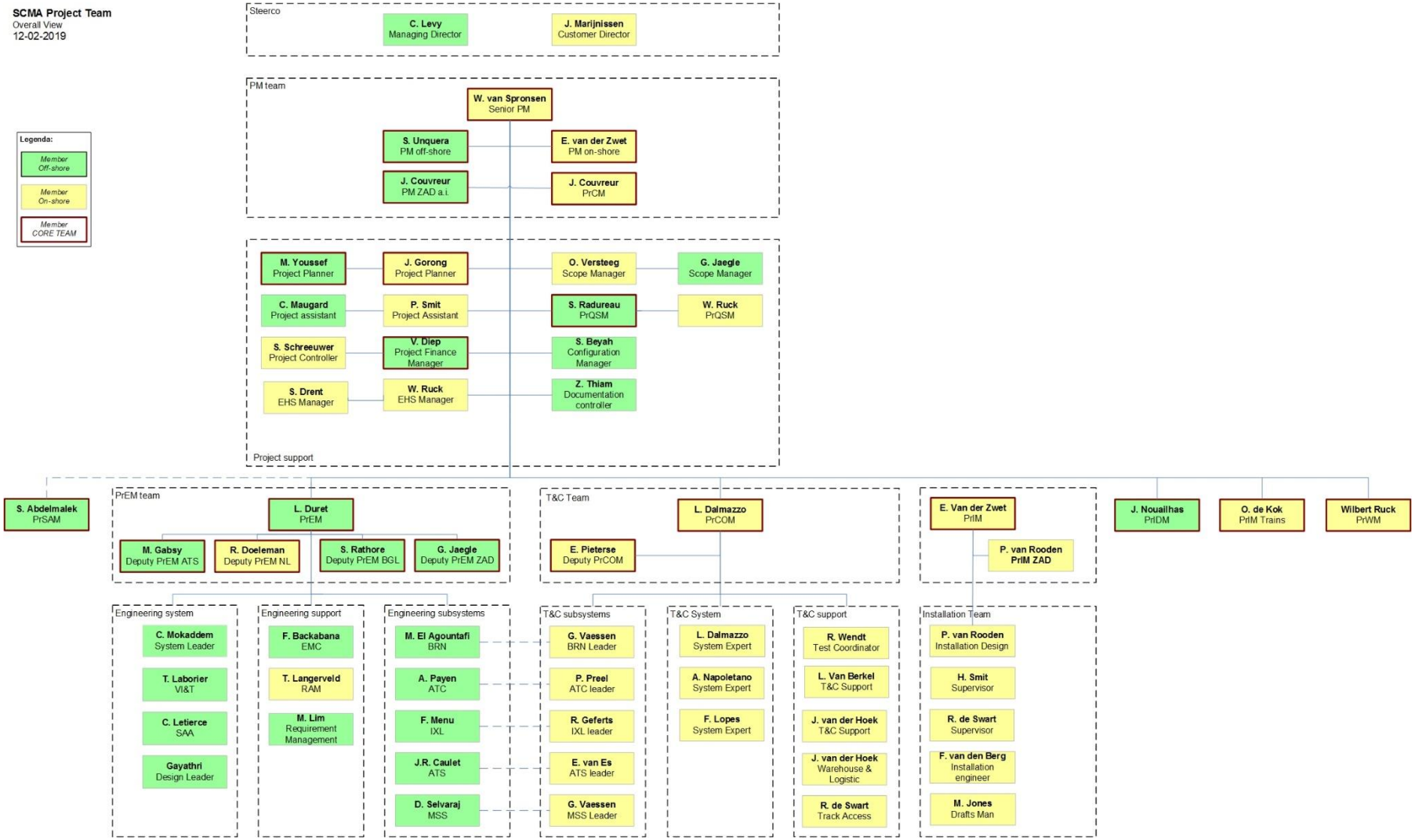
- MeT recognizes added value of Alstom in early project phases

Shared Service Center

- MeT and Alstom a very motivated to agree on a new way to work together through a collaboration agreement



Project Organisation



Project Team

Located at:

Netherlands:

- Duivendrecht
- Utrecht
- Diemen
- Ridderkerk

France:

- St Ouen
- Villeurbanne

Others:

- Bangalore
- Bologna
- Sao Paulo

Project Organisation

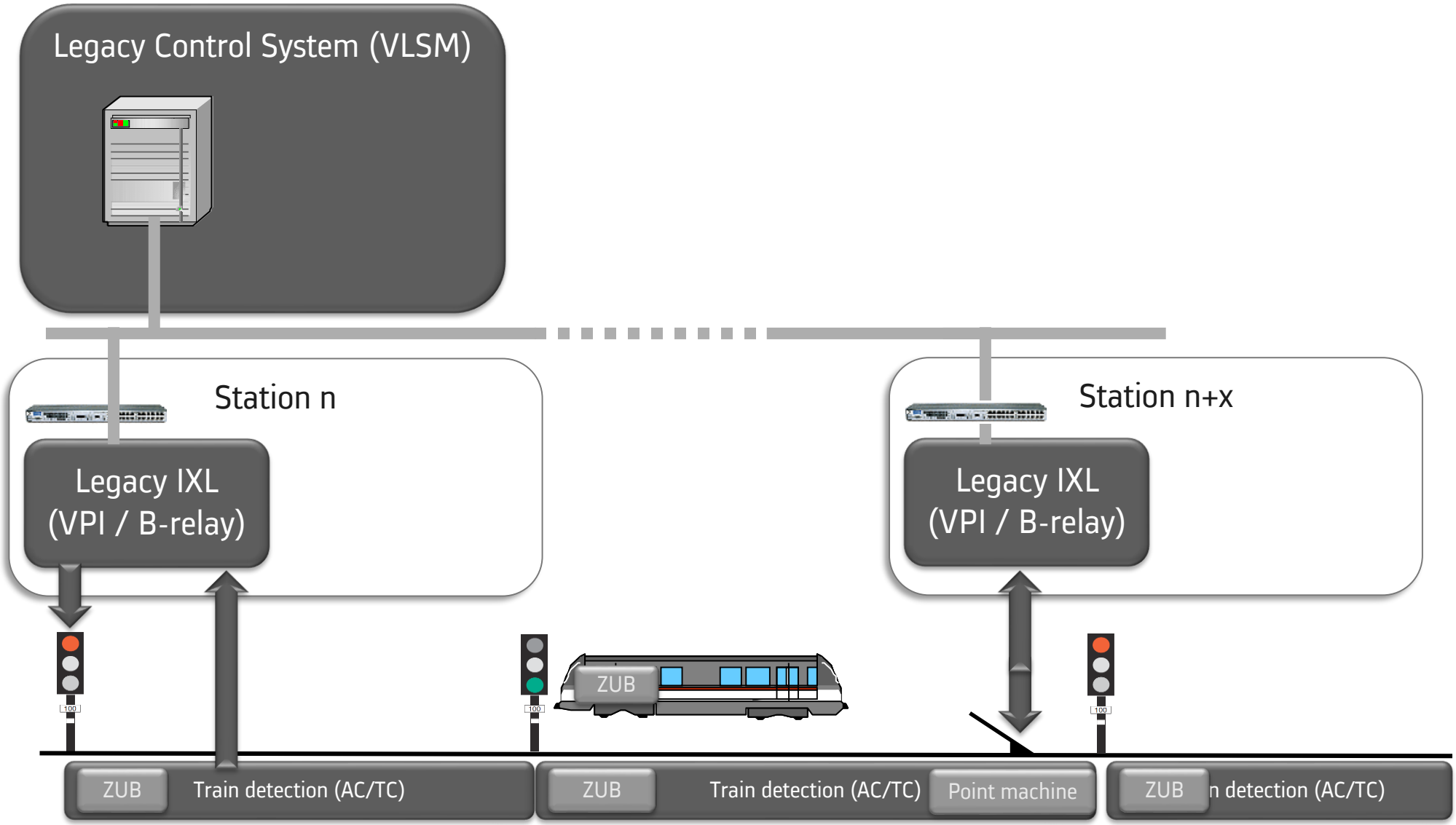
Contents

Migration principles

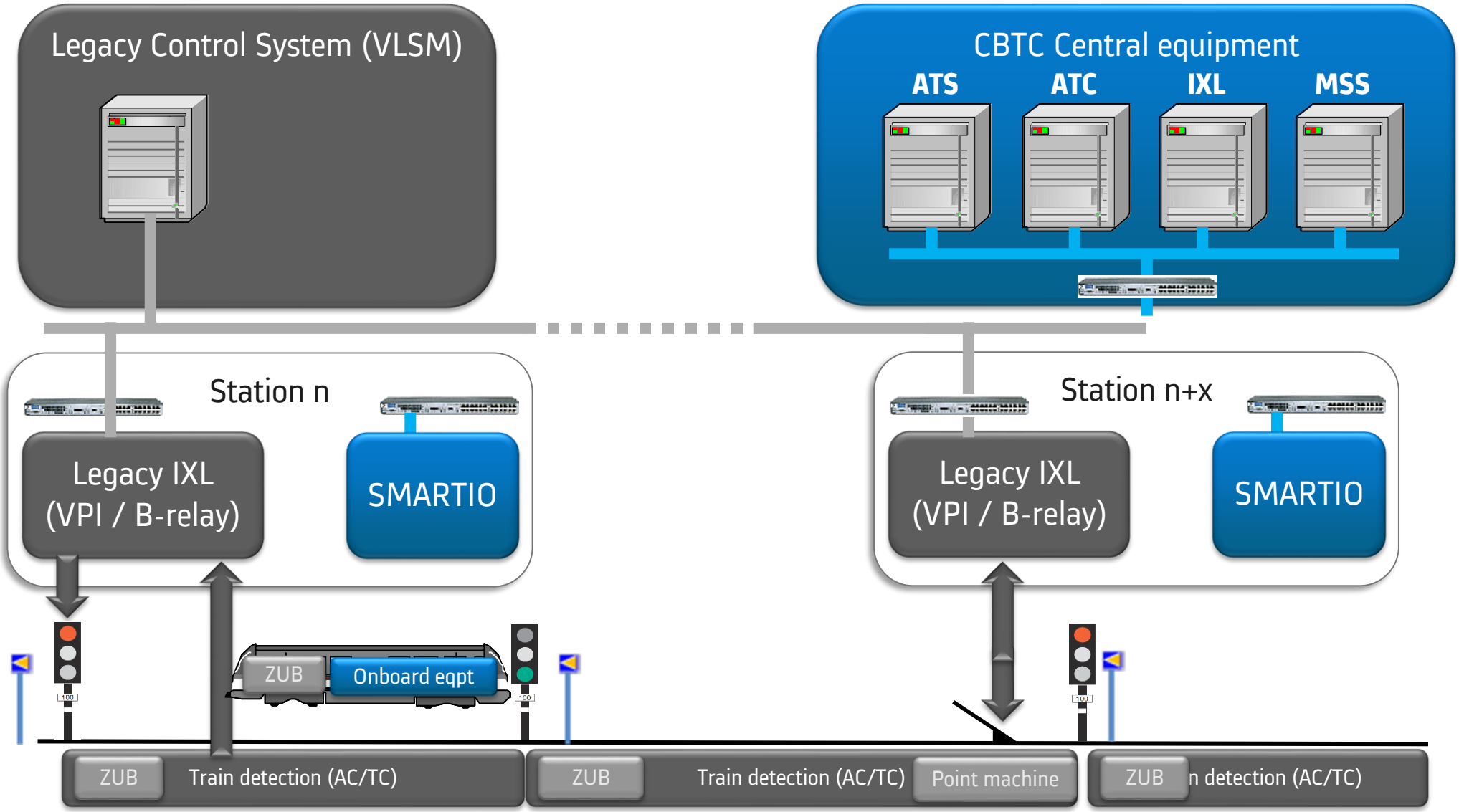
- Trackside
  - Per track segment either old or new system in control
  - Switch-over needed during testing period of new system (day/night switch)

- Trains
  - Both systems present in trains
  - Switch over done by driver at fixed platforms in the network

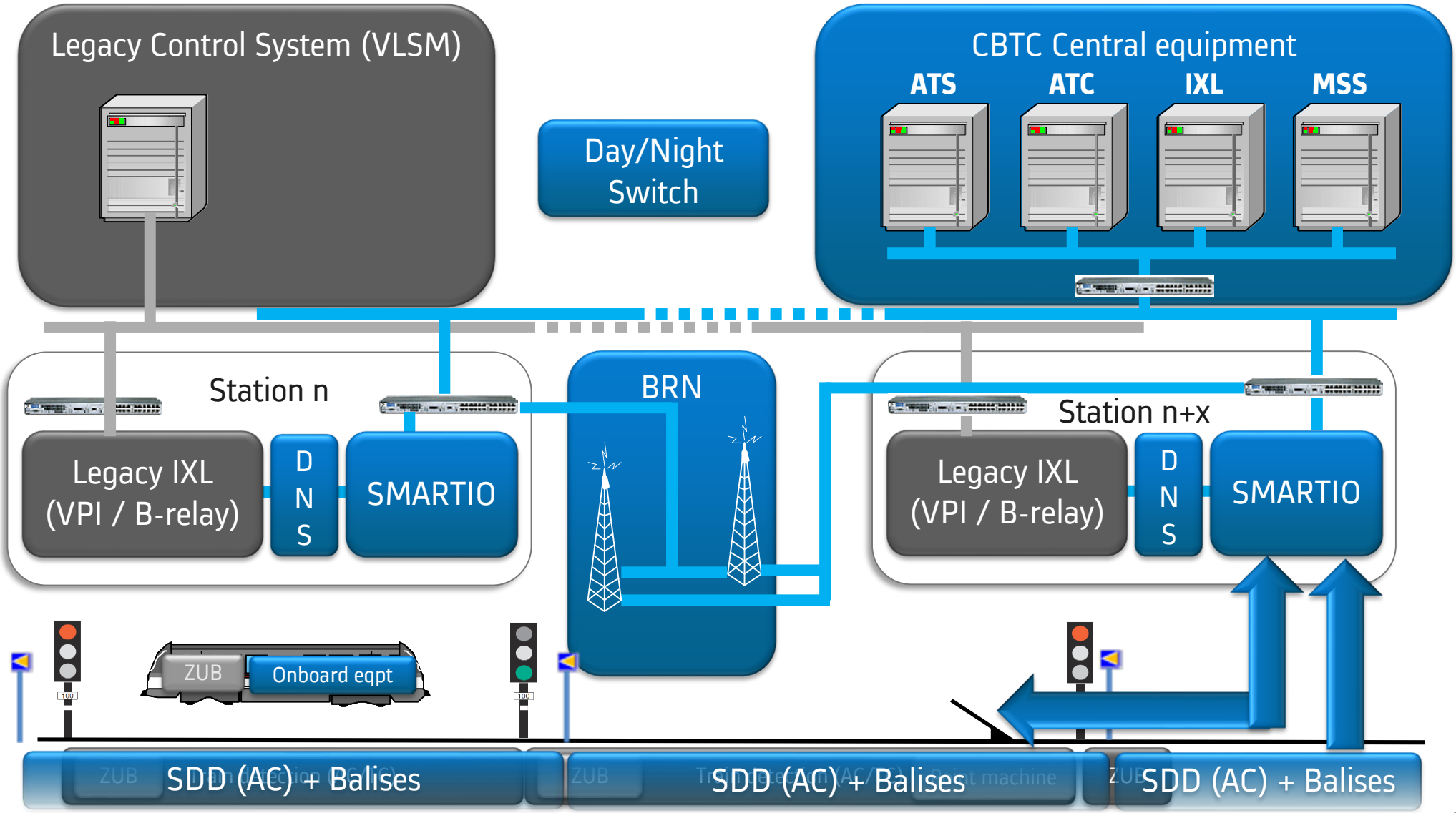
Two parallel systems (1/6: legacy system)



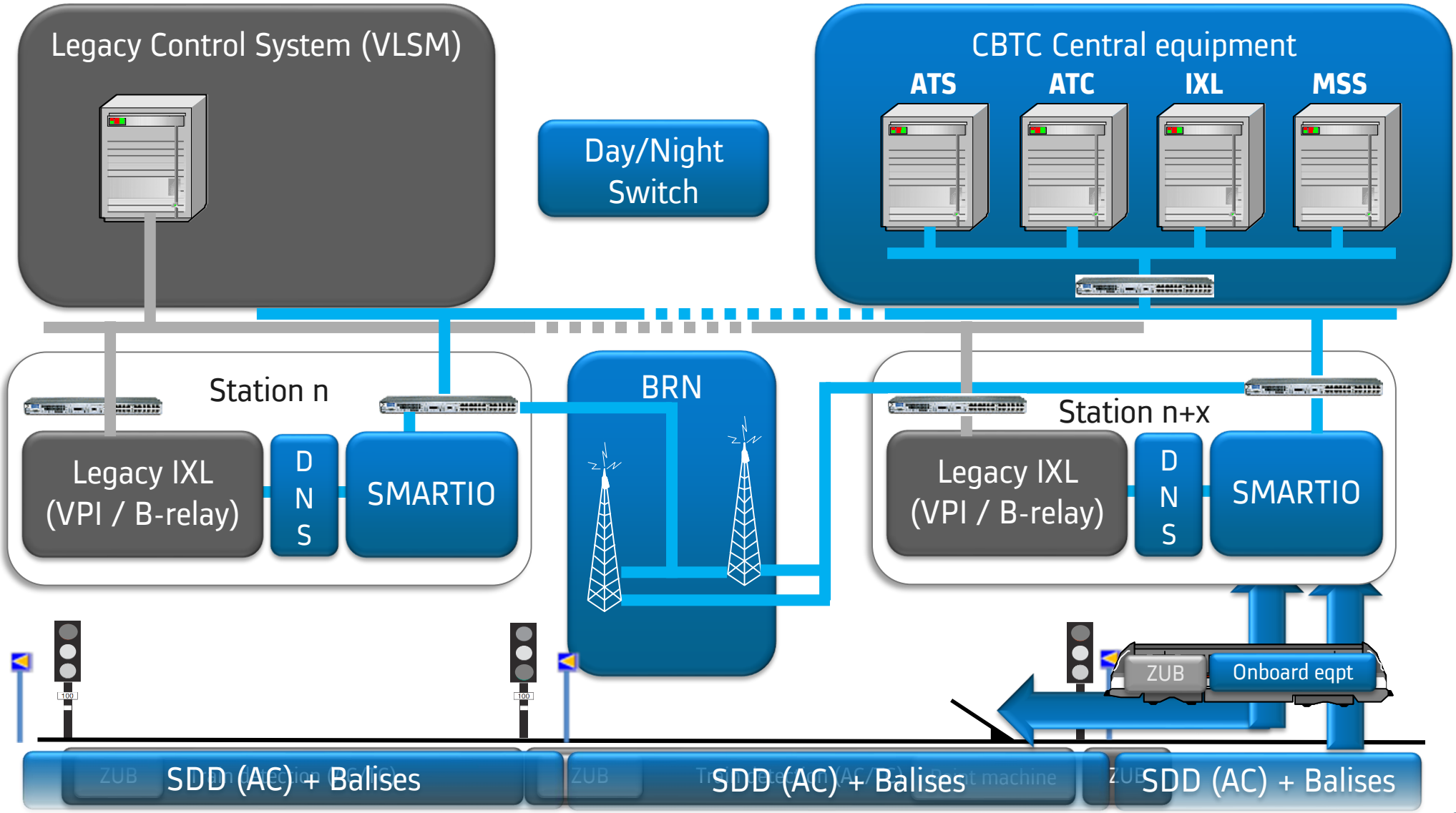
Two parallel systems (2/6: installation during day)



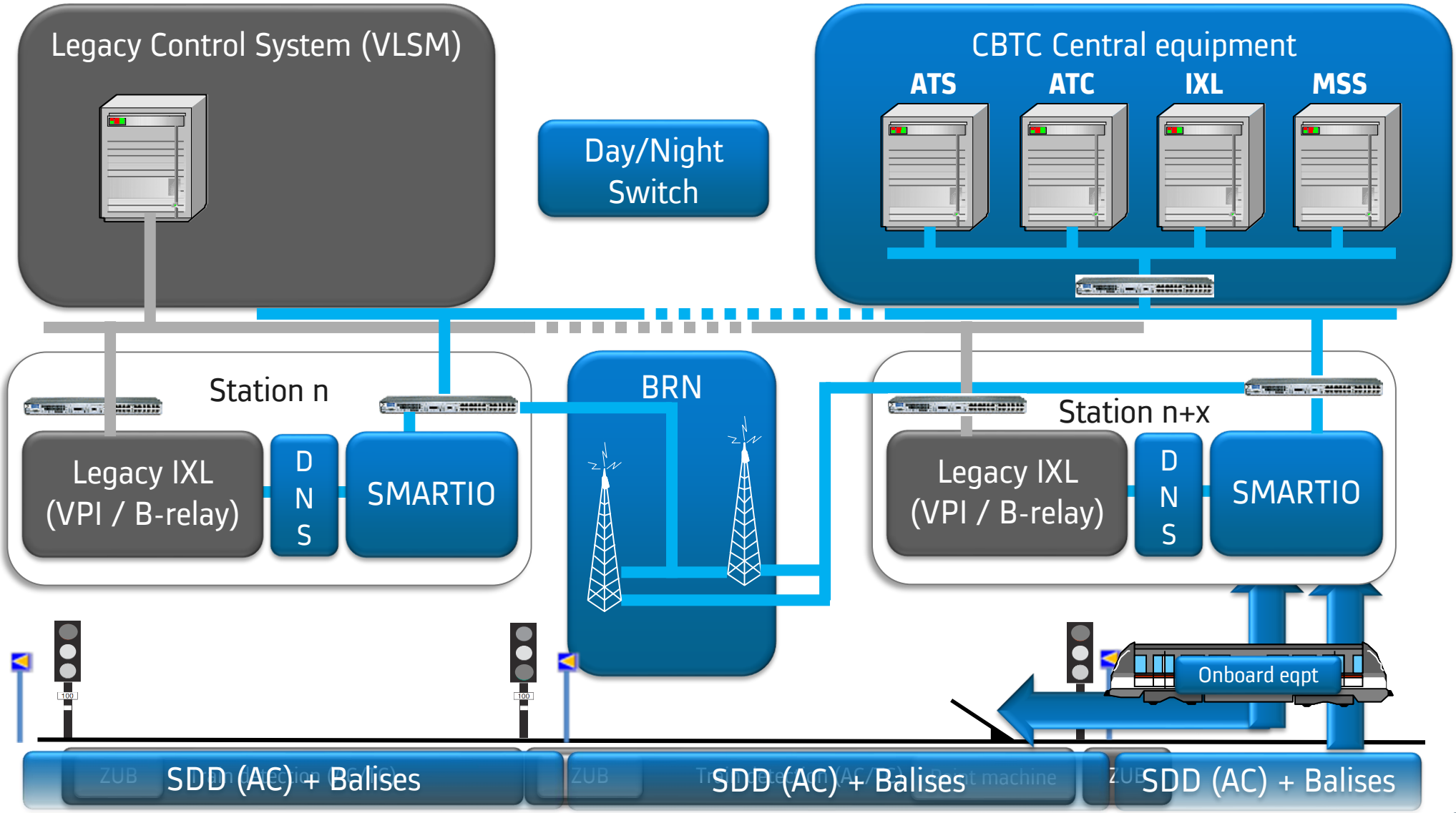
Two parallel systems (3/6: installation during night)



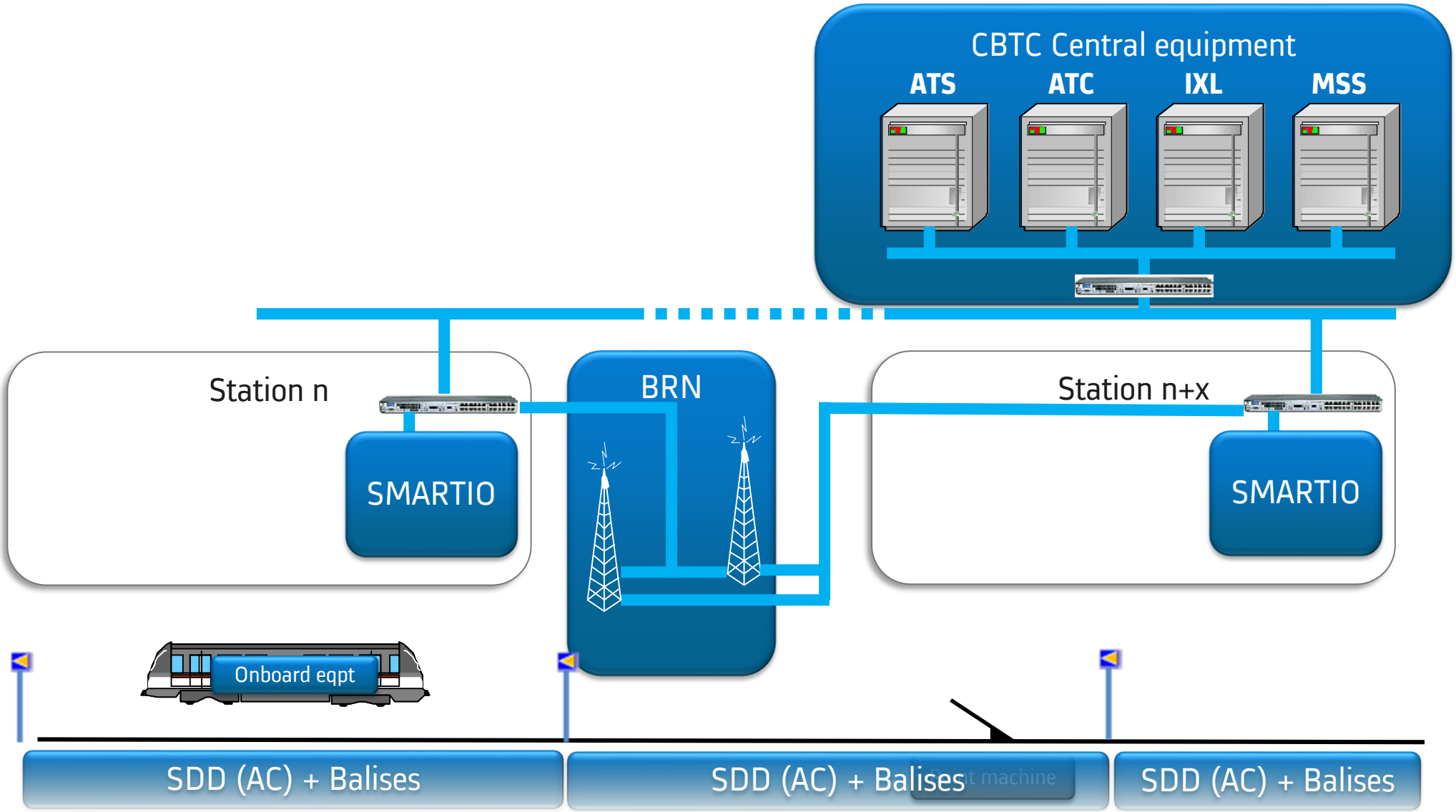
Two parallel systems (4/6: testing during night)



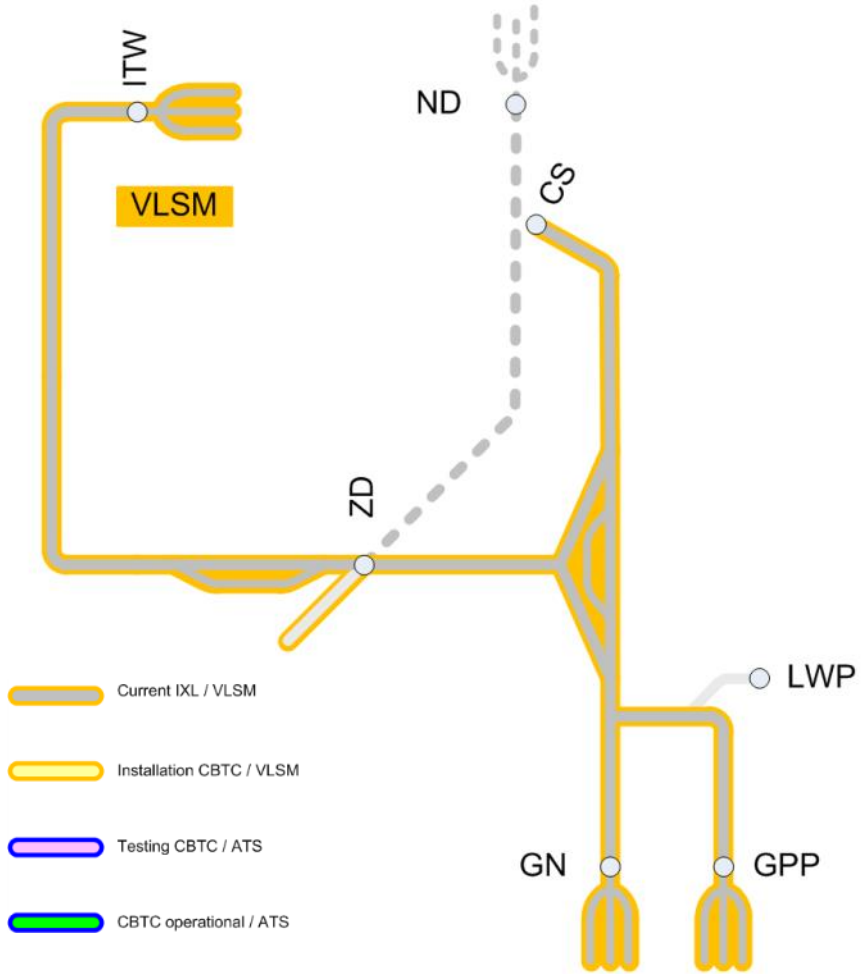
Two parallel systems (5/6: removal legacy)



After Phase 5 (6/6)

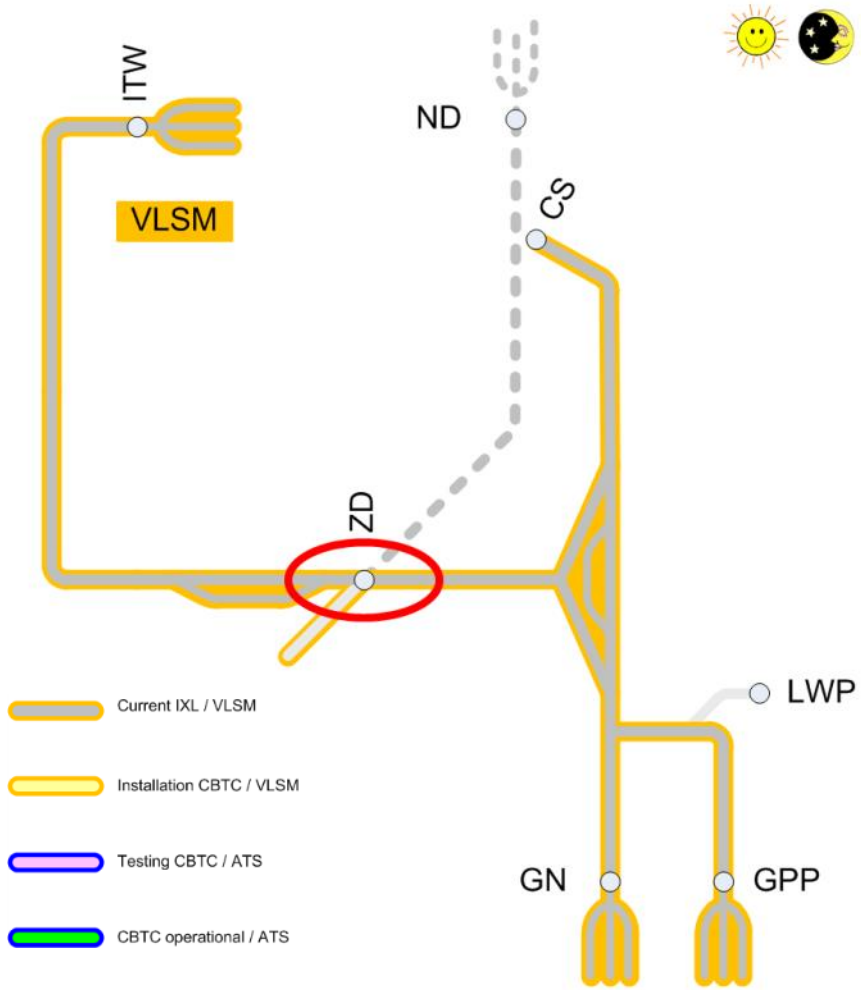


Start situation



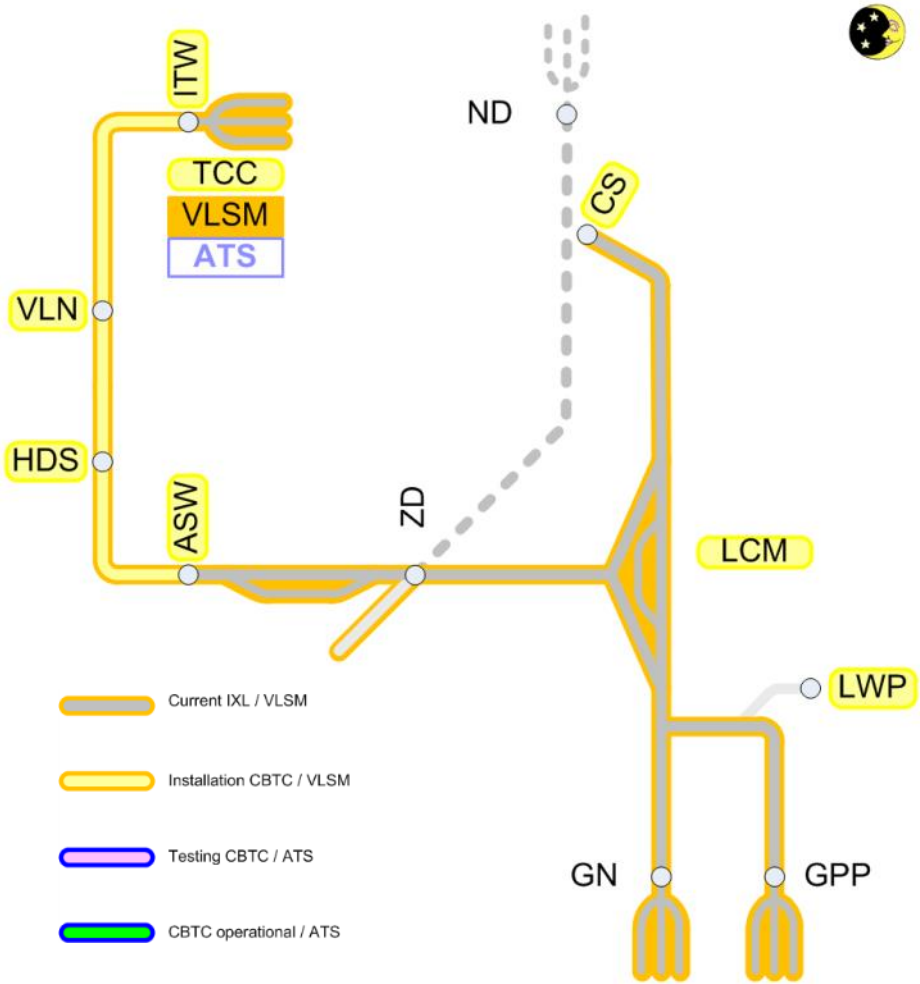
- Simplified network drawing
- Adding yards to diagram
- And area controlled by VLSM

Phase 3a: Connection of NZL



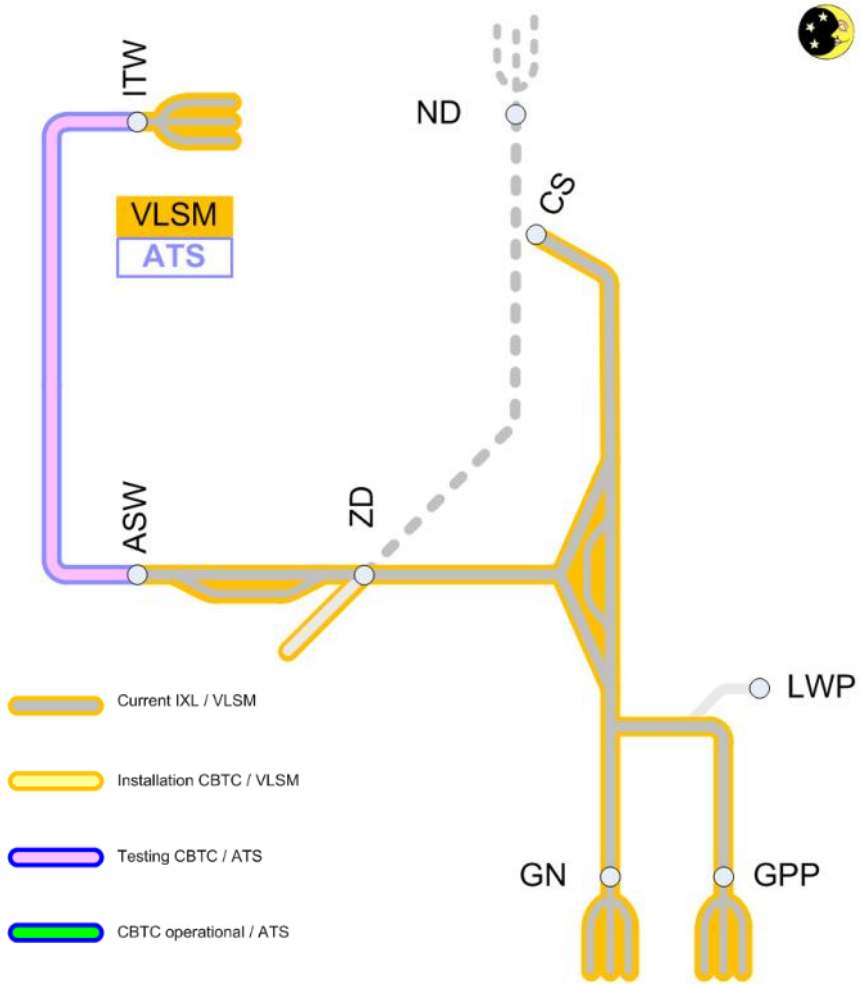
- Modification done in existing IXL
- Done in 7-weeks out-of-service in summer 2015

Phase 2: Pilot Line



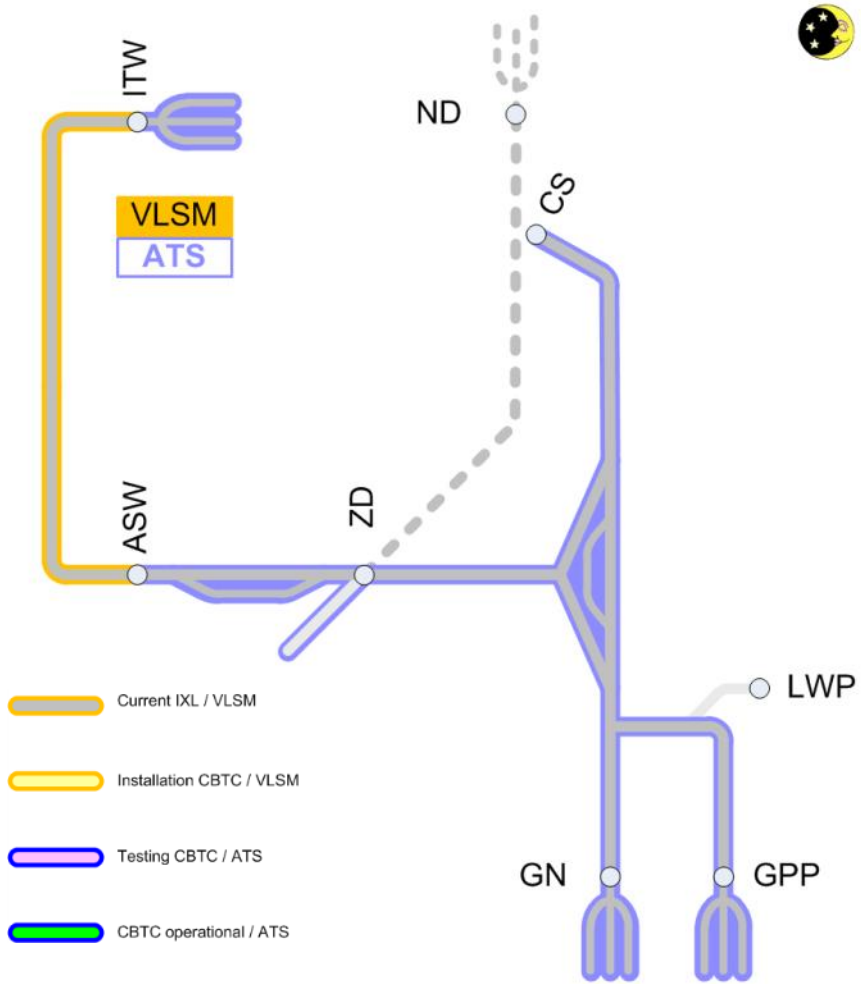
- Installation activities

Phase 2: Pilot Line



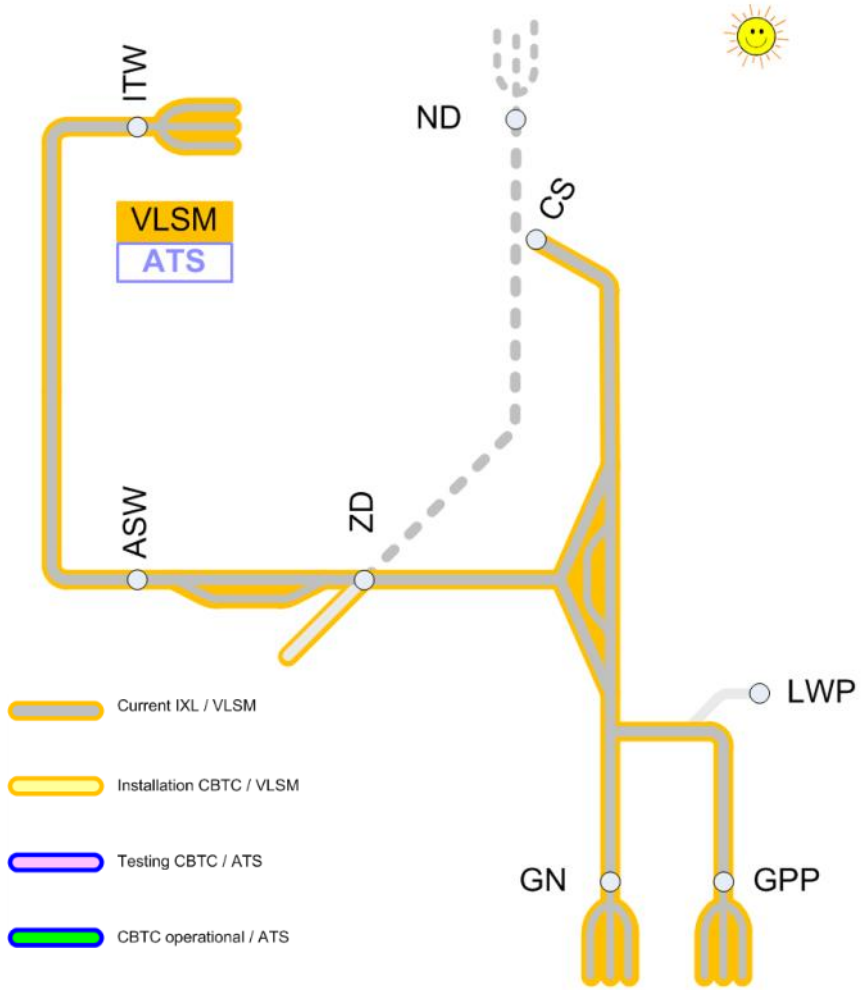
- Installation activities
- Testing CBTC on Pilot Line

Phase 2: Pilot Line



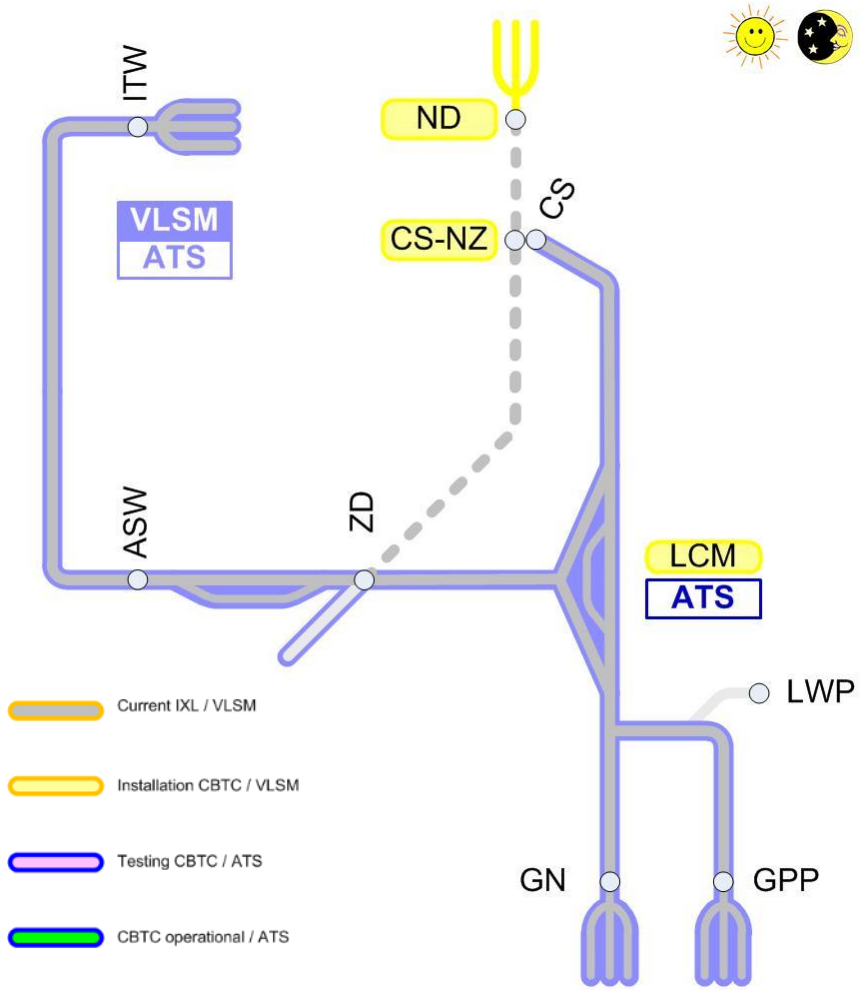
- Installation activities
- Testing CBTC on Pilot Line
- Testing ATS for rest of network

Phase 2: Pilot Line



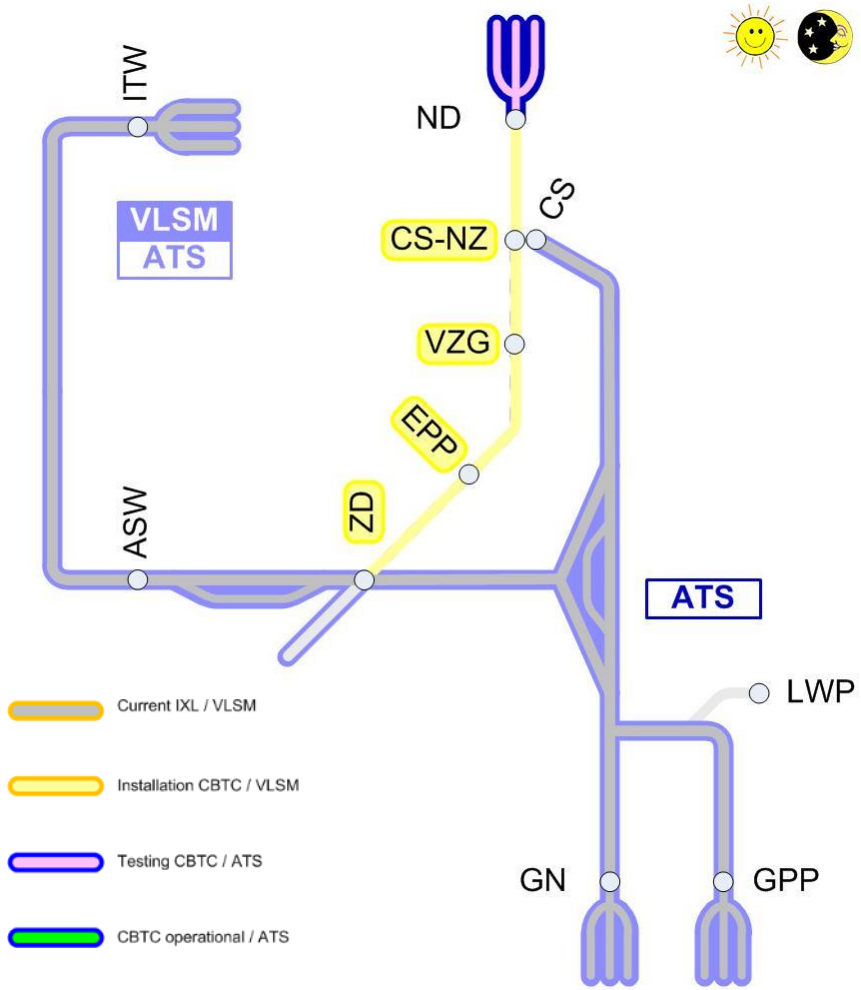
- Installation activities
- Testing CBTC on Pilot Line
- Testing ATS for rest of network
- Pilot Line ready since 30-9-2016 including Safety Case and ISA, but not in commercial operation.

Phase 3: Noord/Zuidline



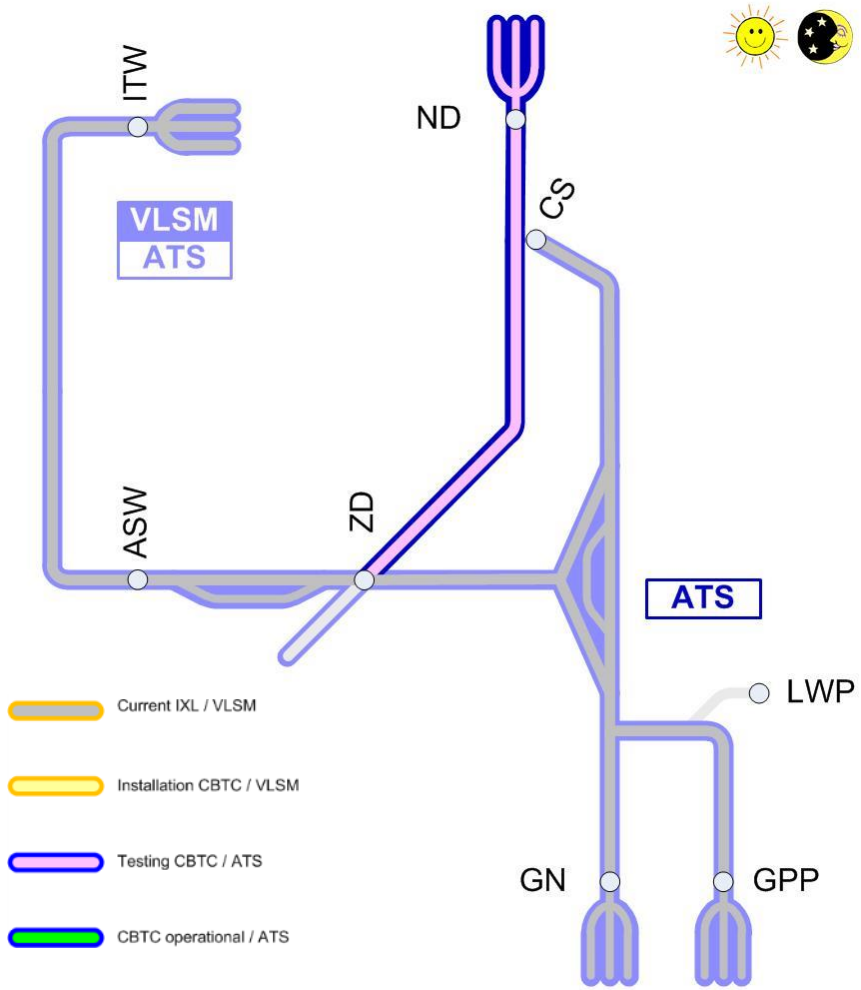
- Installation activities on Test Track

Phase 3: Noord/Zuidline



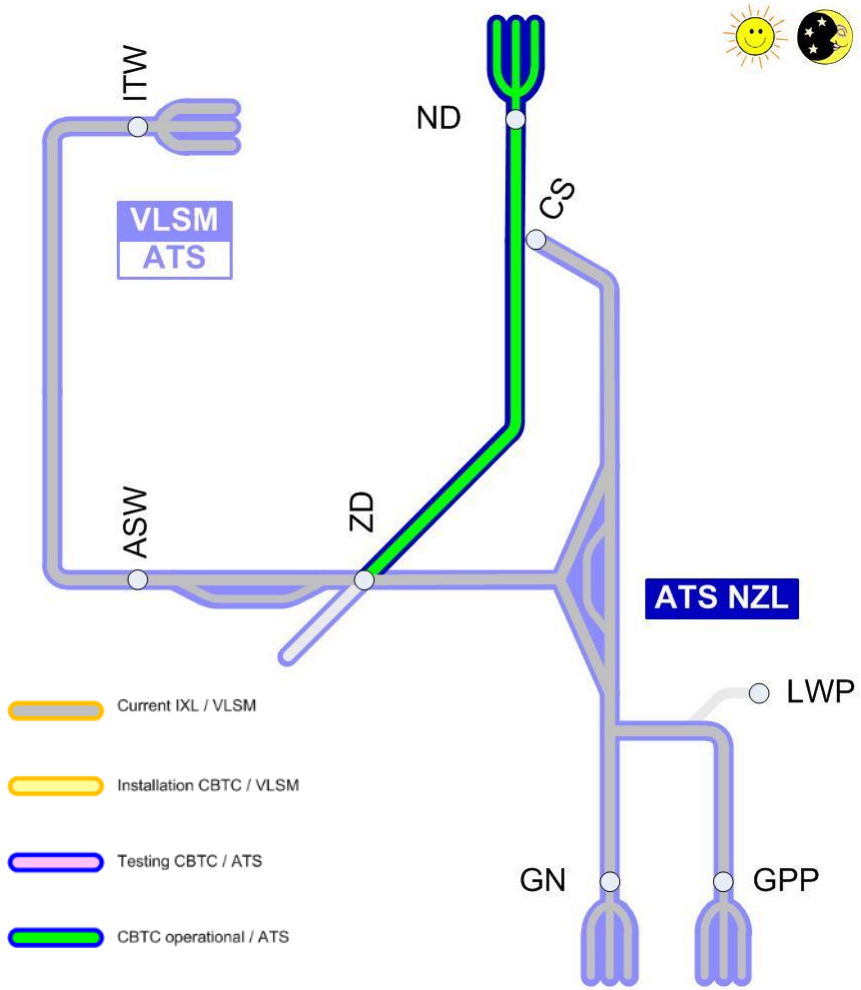
- Installation activities on Test Track
- Testing on Test Track
  Installing rest of line

Phase 3: Noord/Zuidline



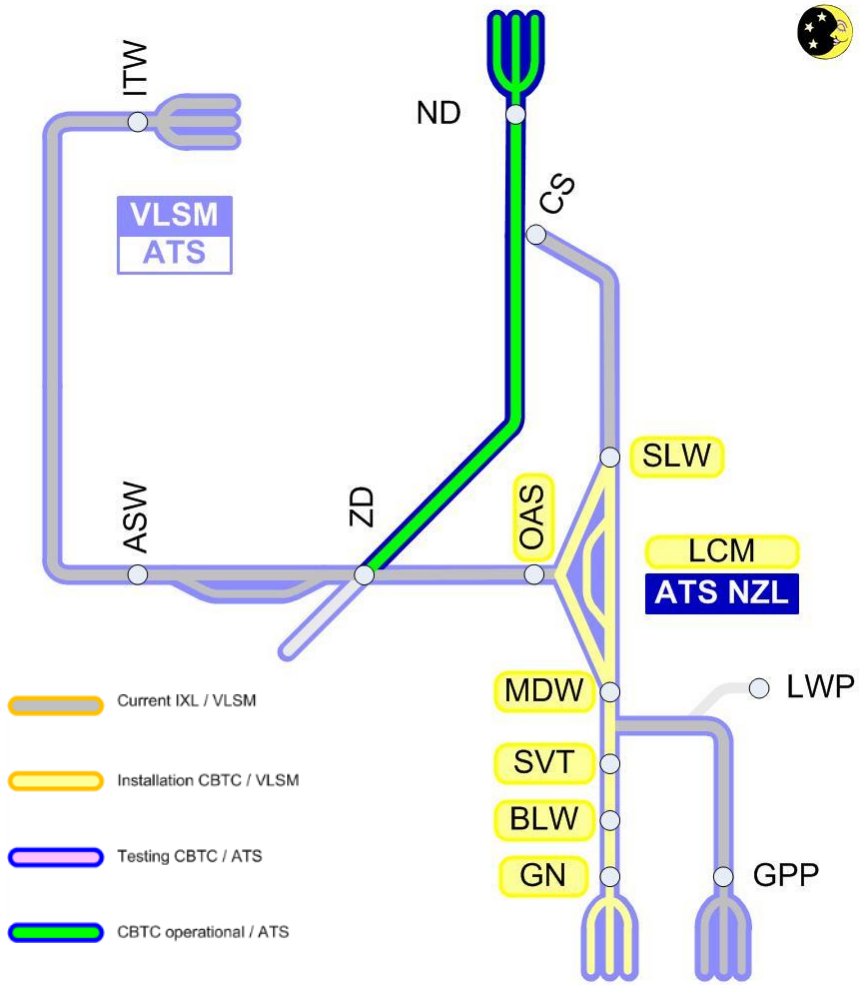
- Installation activities on Test Track
- Testing on Test Track
  Installing rest of line
- Testing full NZL

Phase 3: Noord/Zuidline



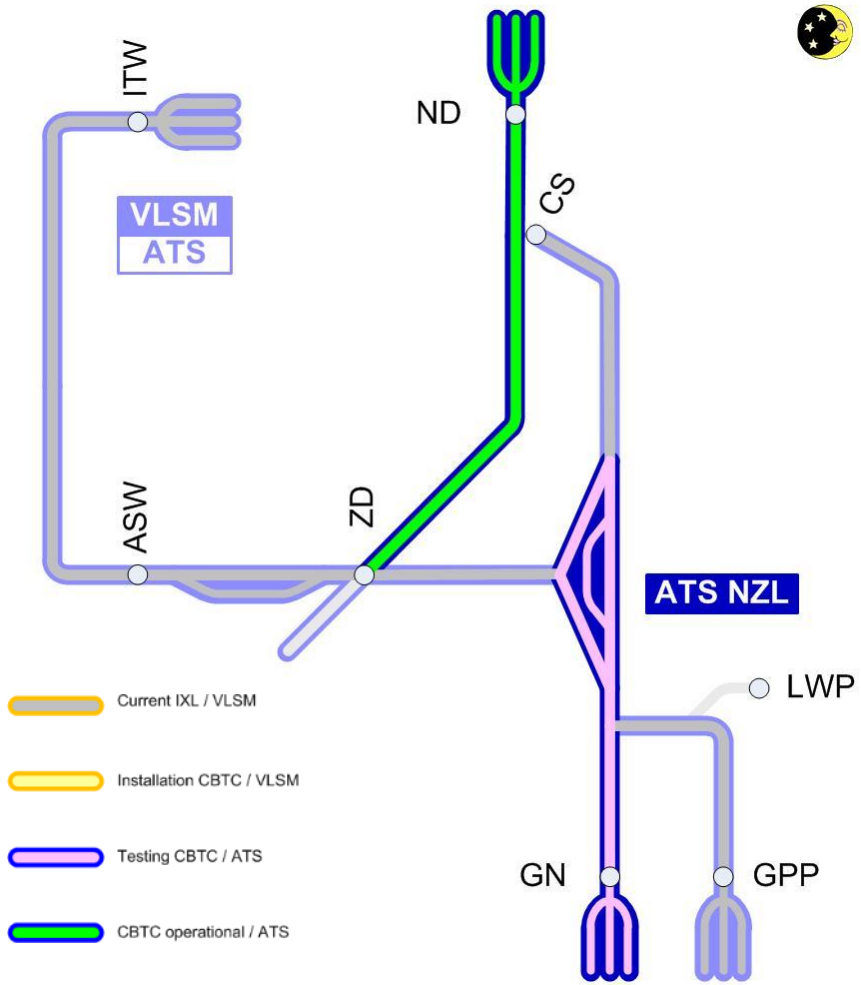
- Installation activities on Test Track
- Testing on Test Track
  Installing rest of line
- Testing full NZL
- NZL put in revenue service (July 2018)

Phase 4: Roll-Out



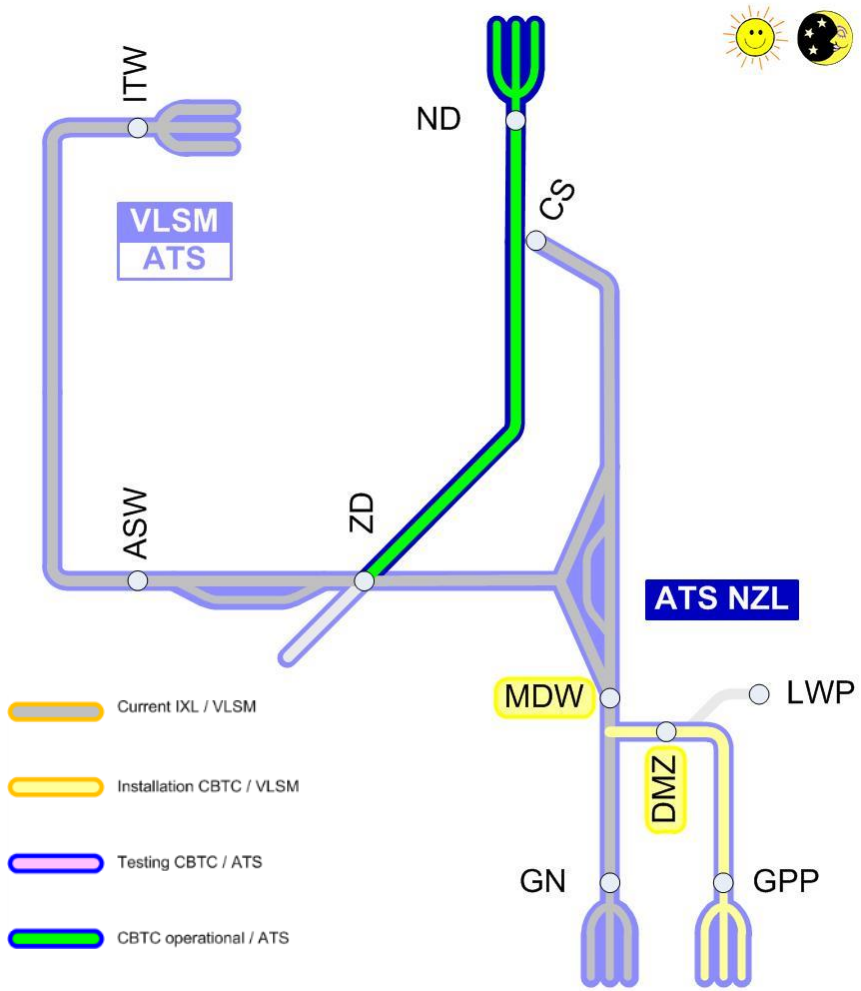
- Installation activities section 1

Phase 4: Roll-Out



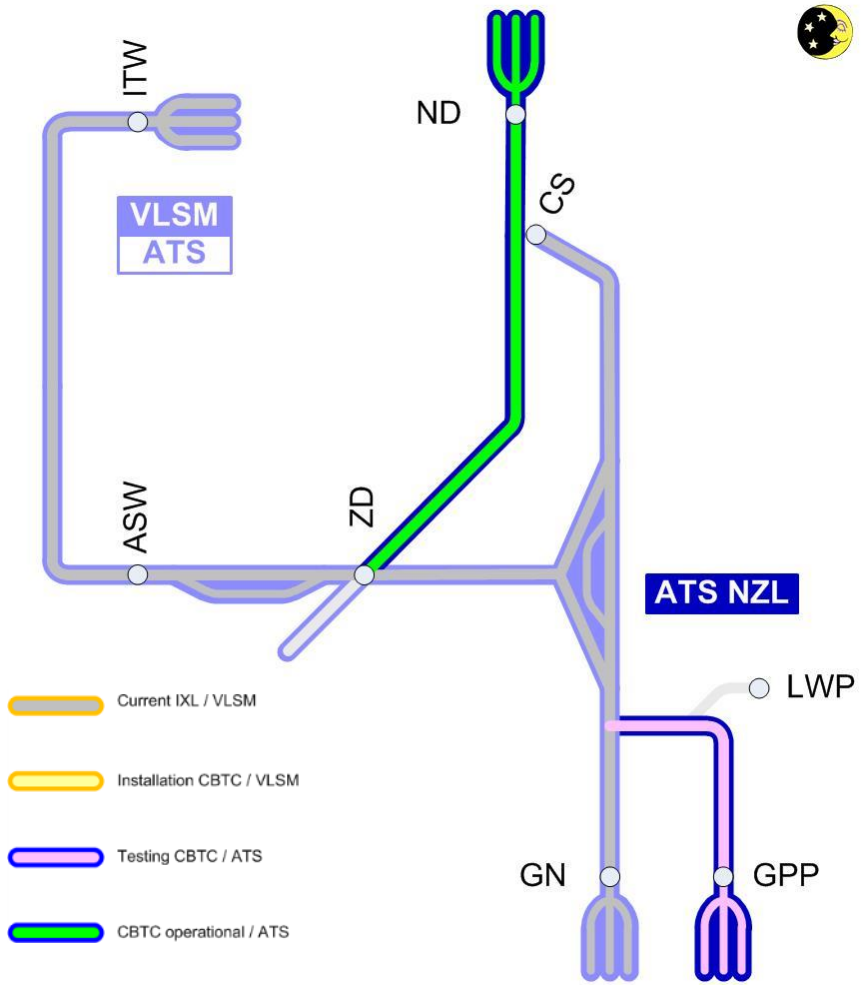
- Installation activities section 1
- Testing section 1

Phase 4: Roll-Out



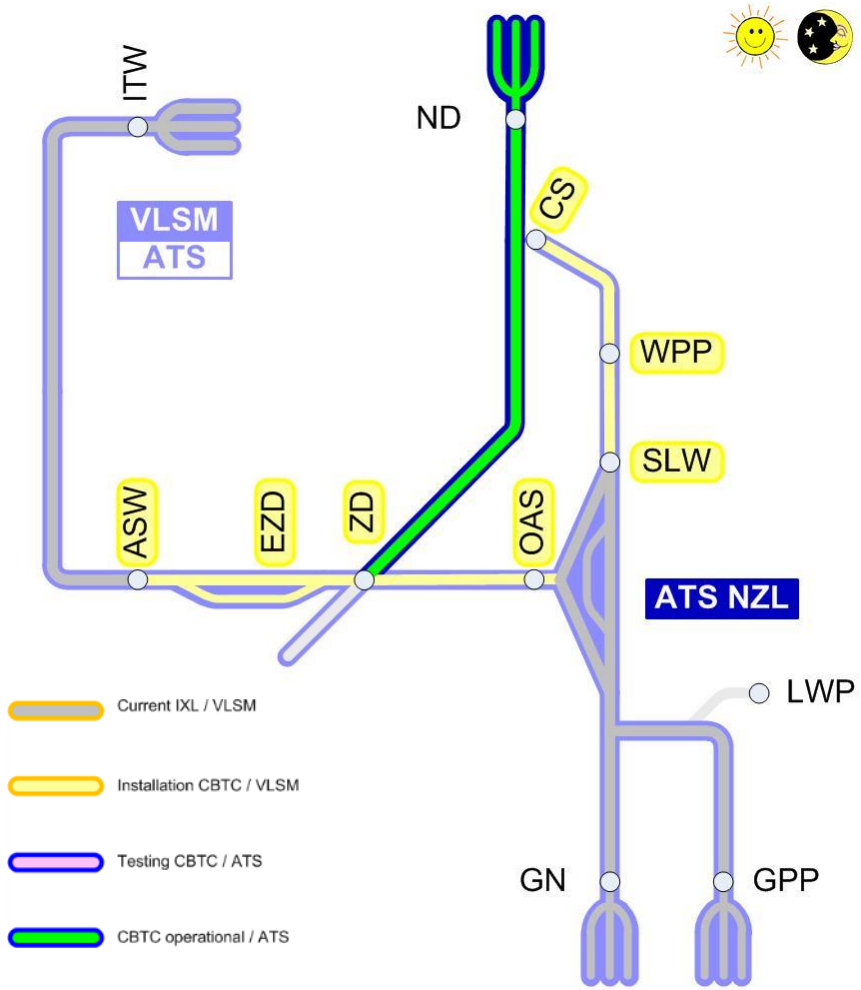
- Installation activities section 2

Phase 4: Roll-Out



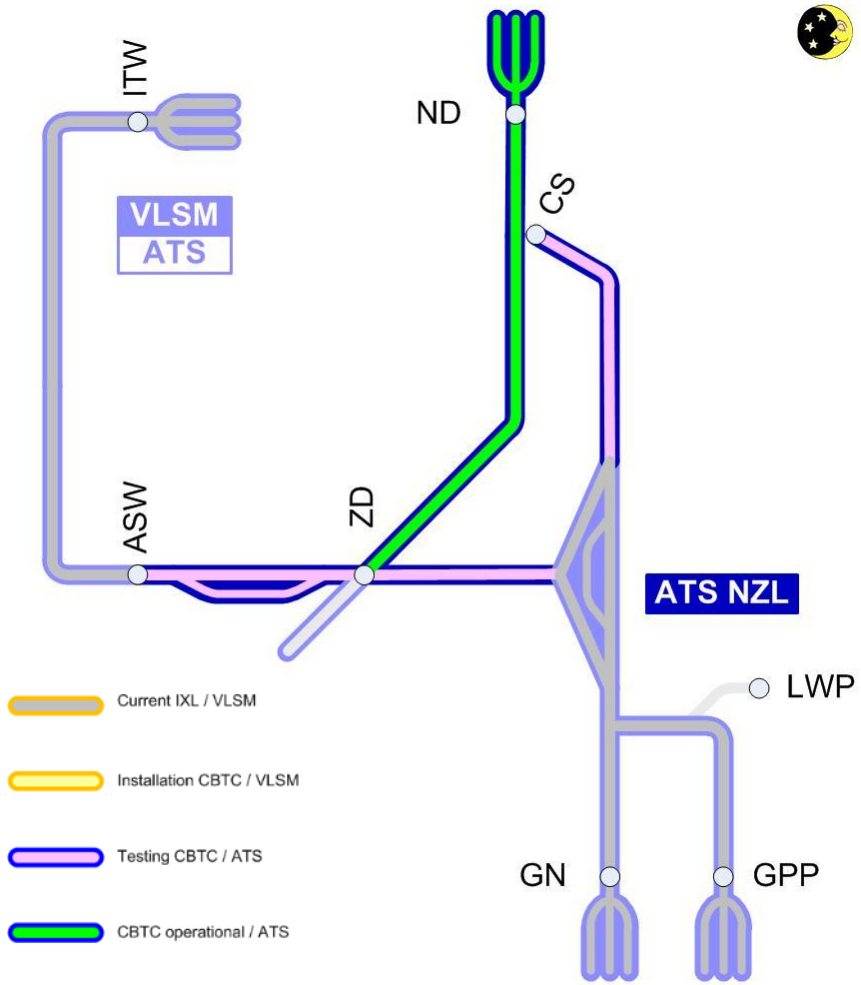
- Installation activities section 2
- Testing section 2

Phase 4: Roll-Out



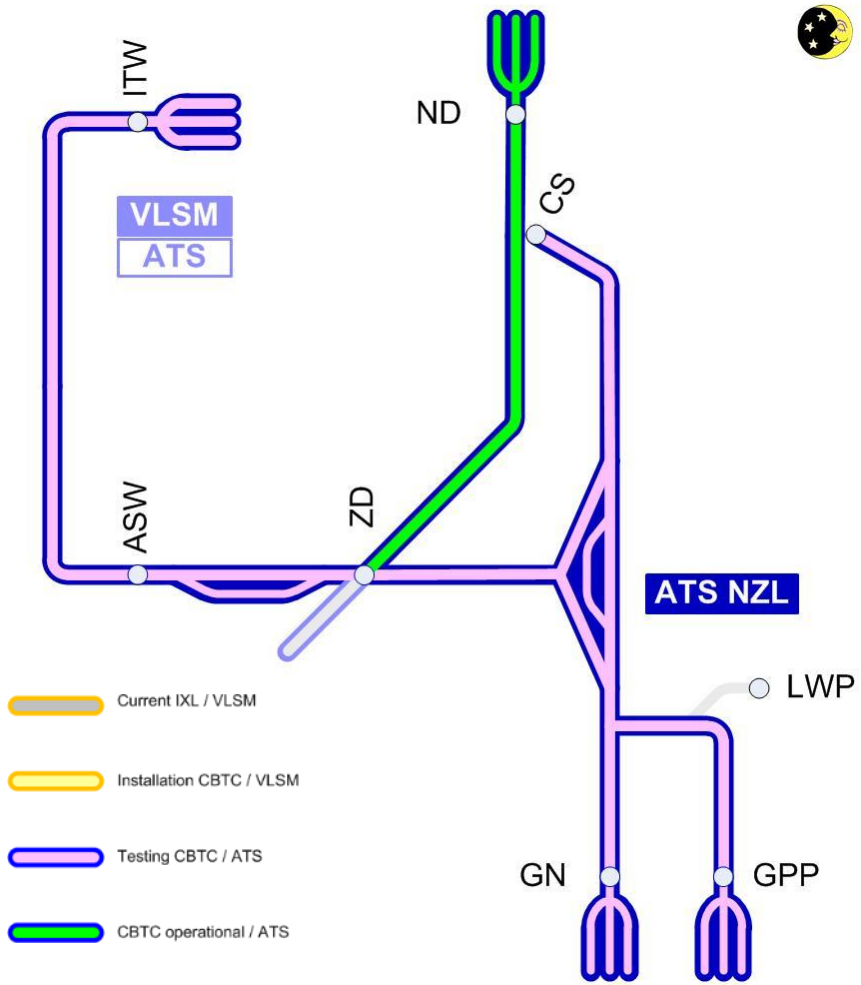
- Installation activities section 3 & 4

Phase 4: Roll-Out



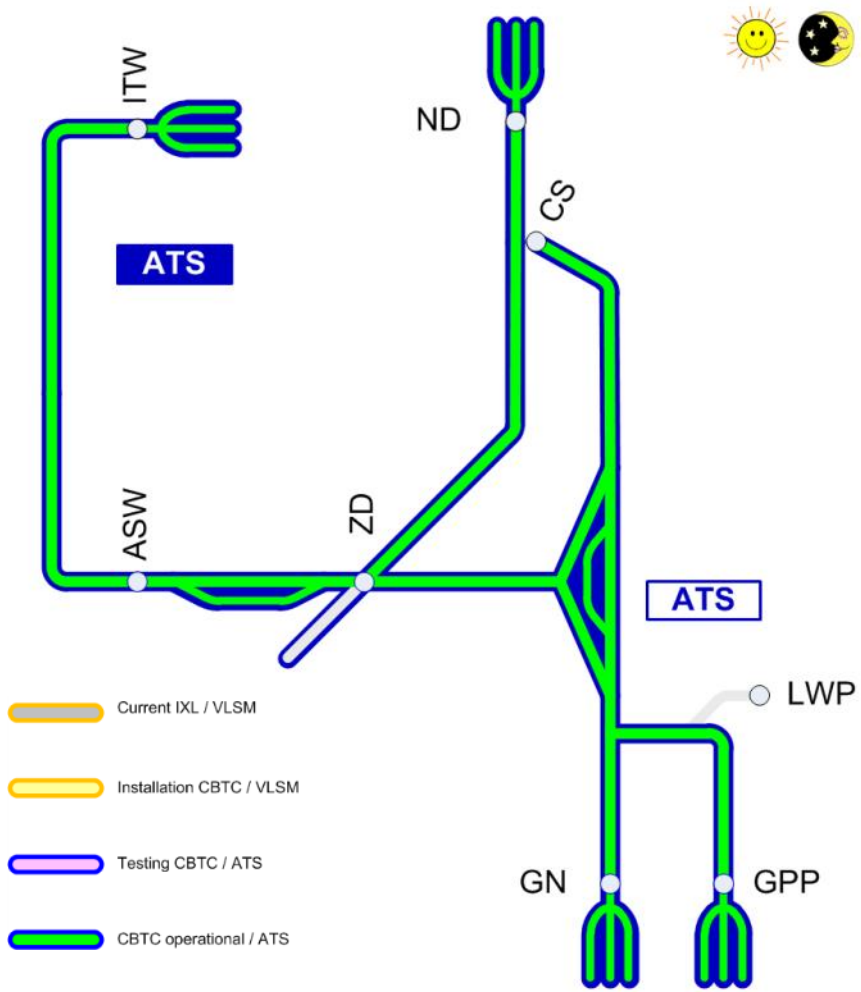
- Installation activities section 3 & 4
- Testing section 3 & 4

Phase 4: Roll-Out



- Integral testing (ongoing)

Phase 4: Roll-Out



- Integral testing (ongoing)
- Full network under CBTC
- ATS
  - both same configuration
  - 1 active
  - 1 cold standby

Actual situation

Trackside phases:

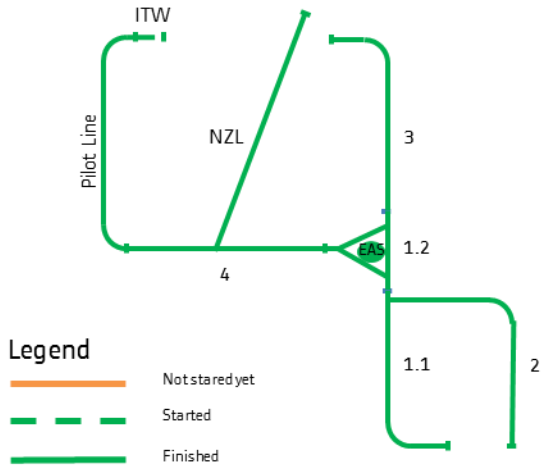
- NZL is put into operation
- Roll Out completed / SC delivered

Trains:

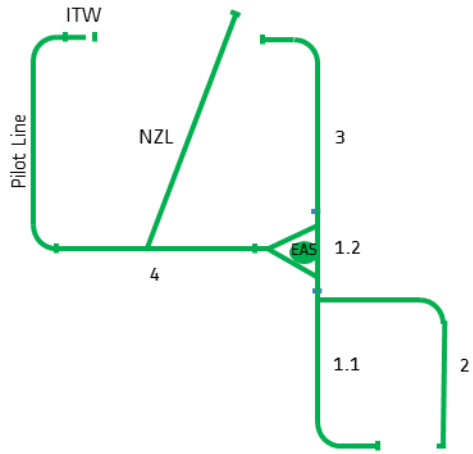
- 33 of 33 M4 trains ready
- 28 of 28 M5 trains ready
- 29 of 29 S1/S2/S3 trains ready

Actual situation

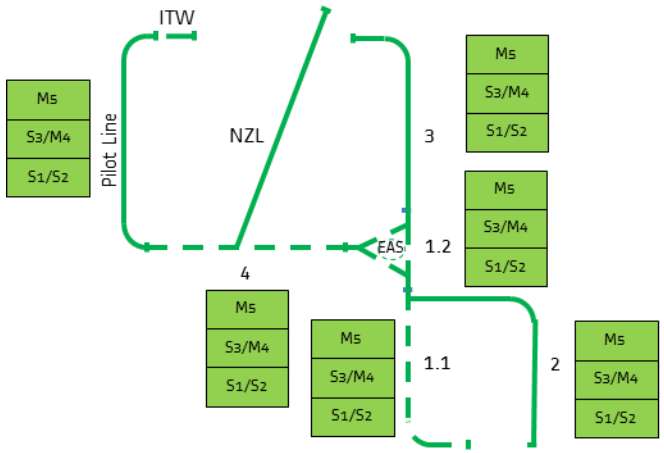
Static tests



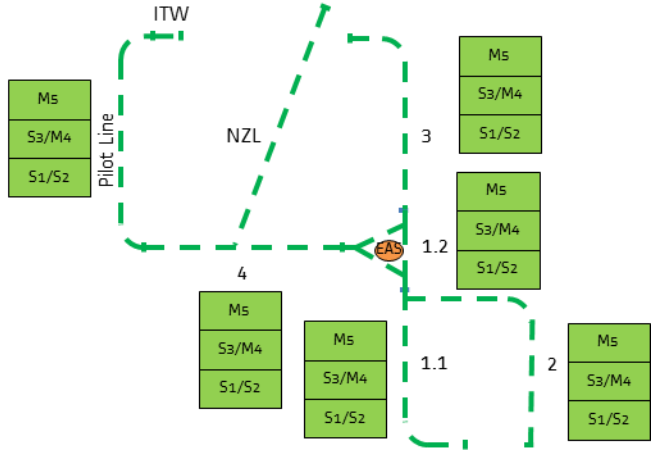
Track Survey



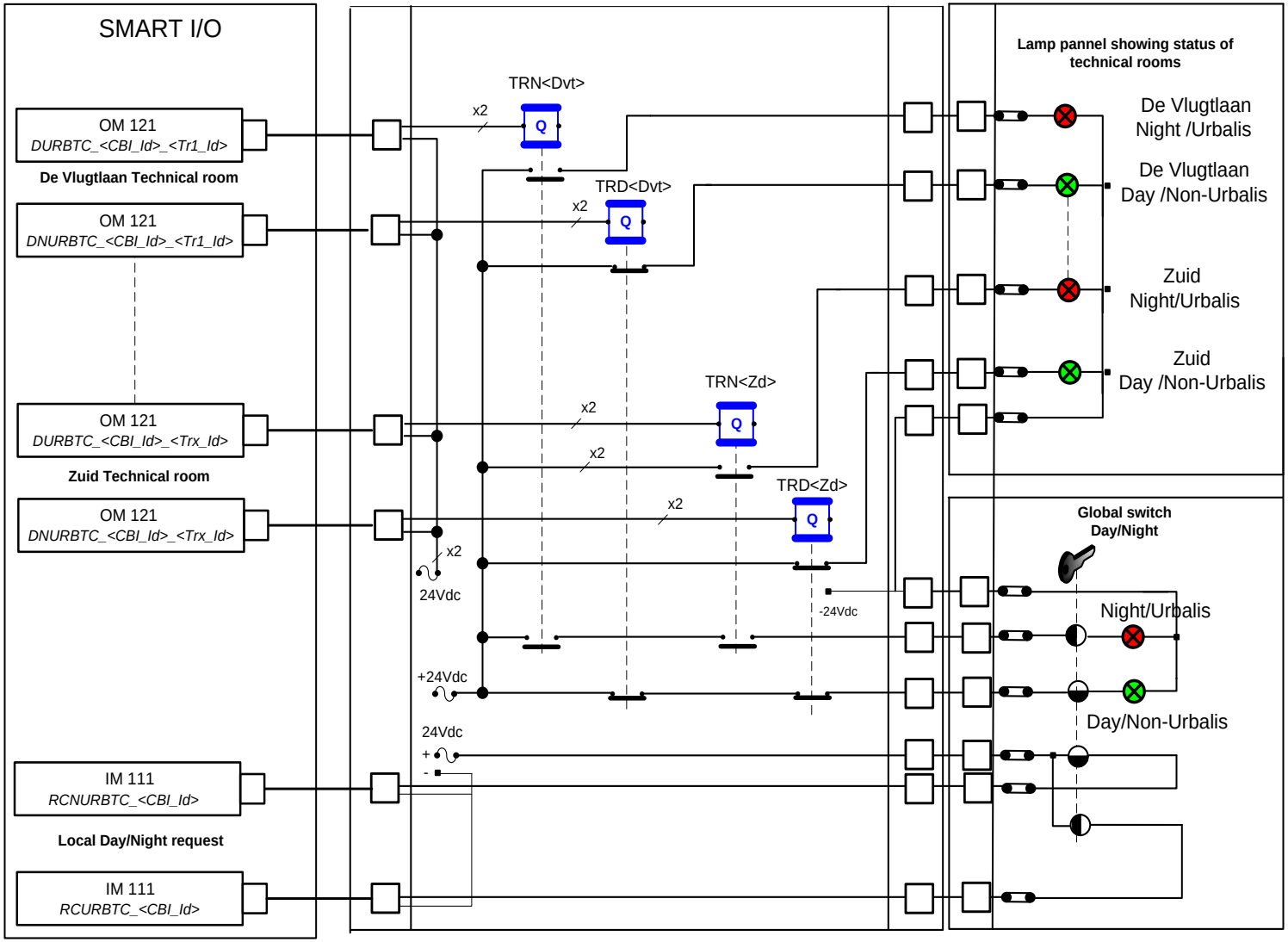
Low Speed Test
Baseline 4.6.2.2



High Speed Test
Baseline 4.6.2.2

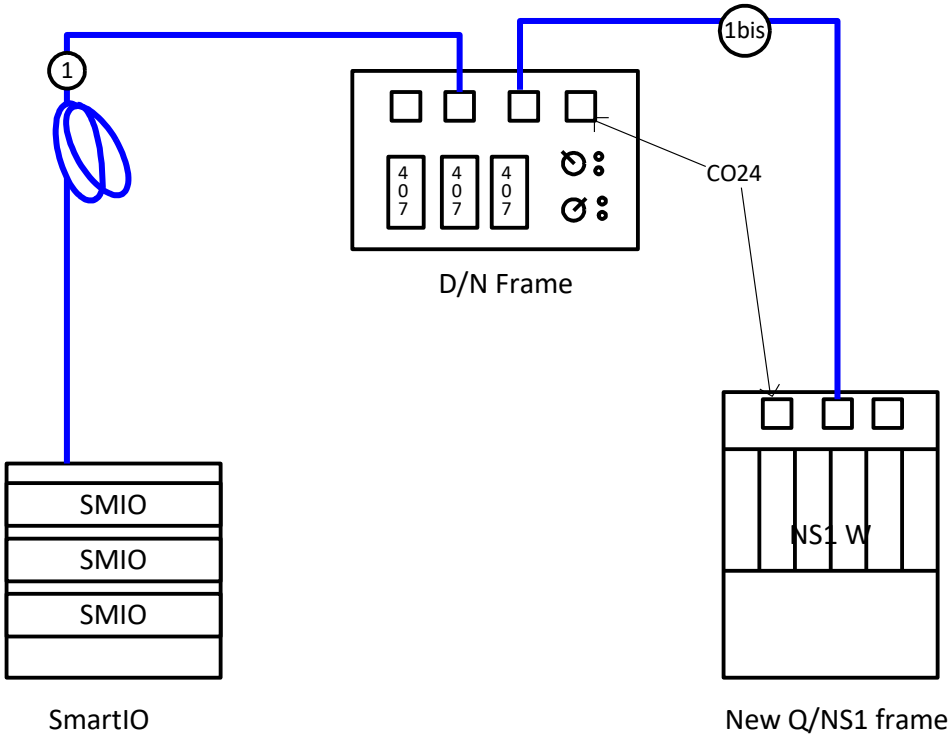


Migration - Some examples (Day / Night Switch)



Migration - Some examples

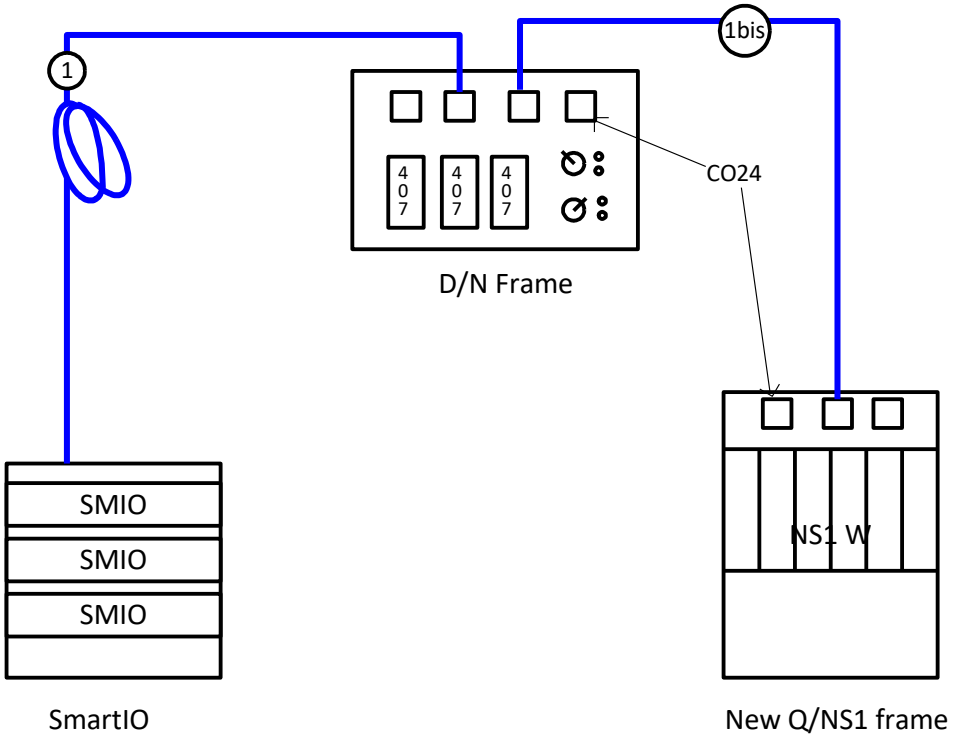
- Day / Night Switch



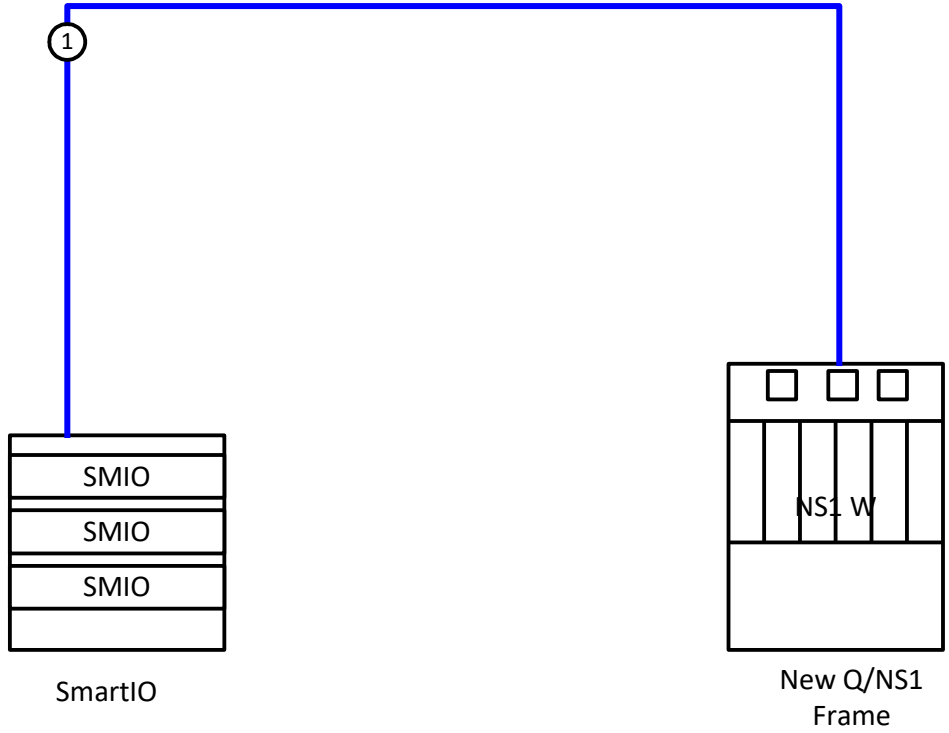
During migration

Migration - Some examples

- Day / Night Switch



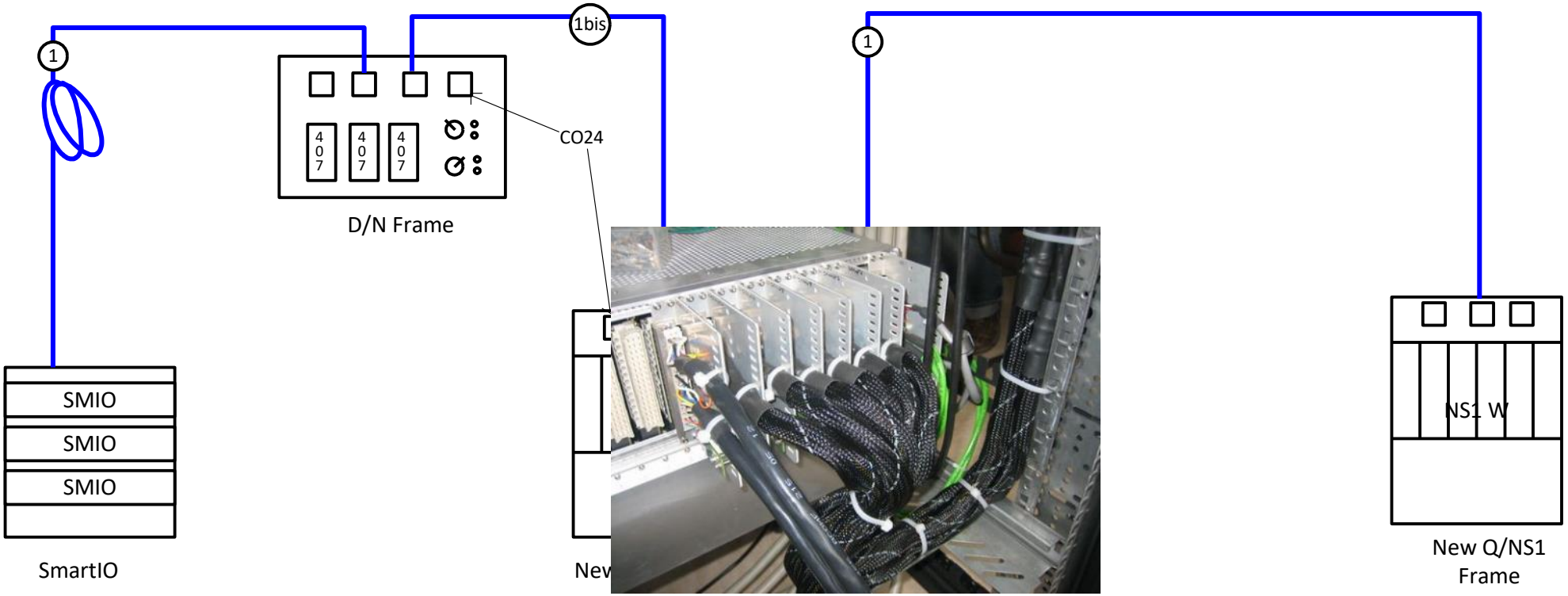
During migration



After migration

Migration - Some examples

- Day / Night Switch

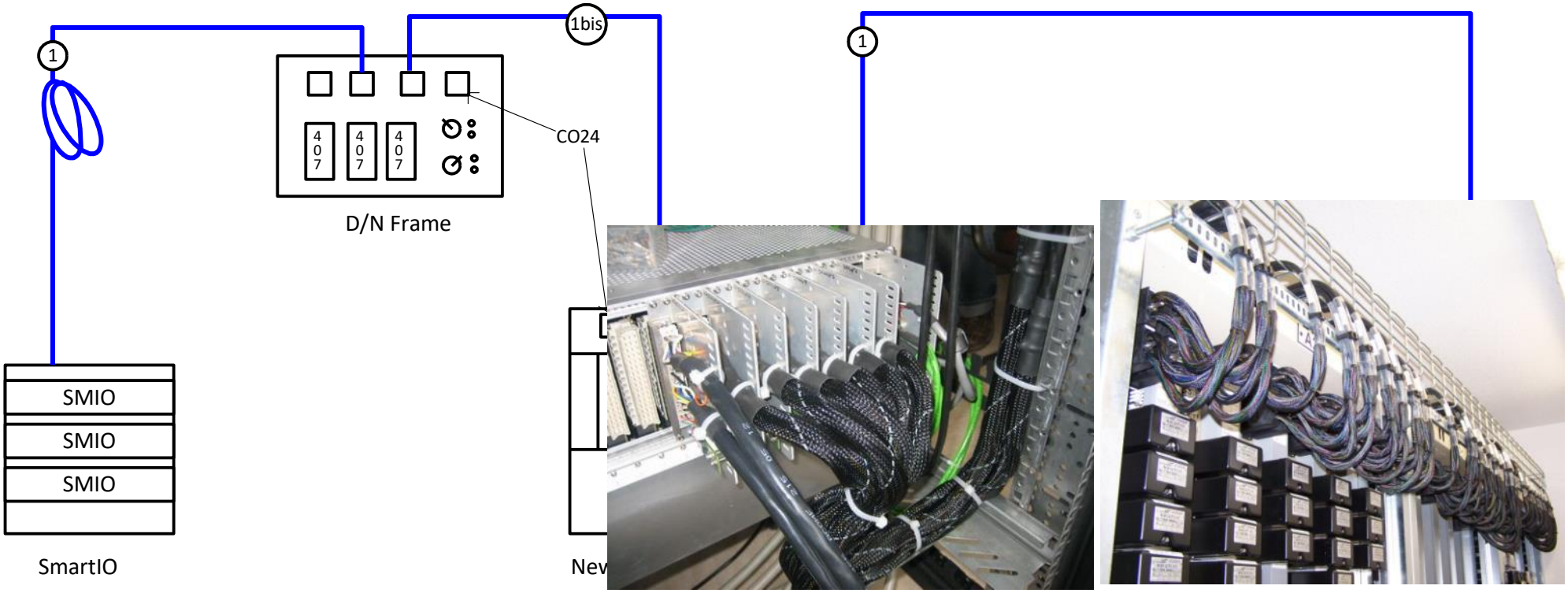


During migration

After migration

Migration - Some examples

- Day / Night Switch



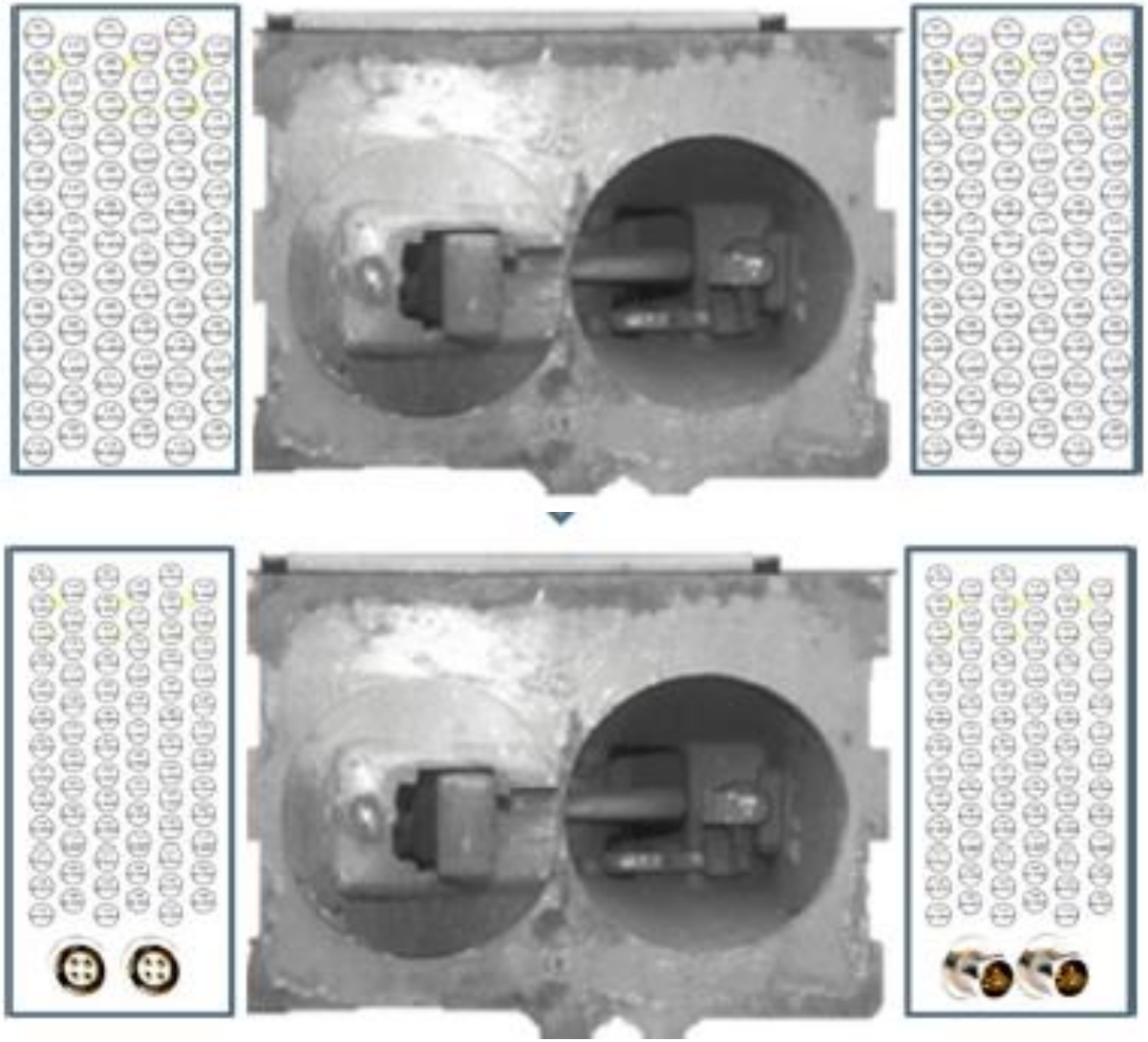
During migration

After migration

Migration examples - Vehicles

Before migration

Migration examples - Vehicles



Before migration

After migration

Contents

Trains (1/2)

M5 23+5 (Metropolis)

- GoA 2 including ATB
- GoA 4 demonstration
- Only rescue coupling
- Redundant CC
- MultiMedia Network

S3/M4 4/33 (CAF)

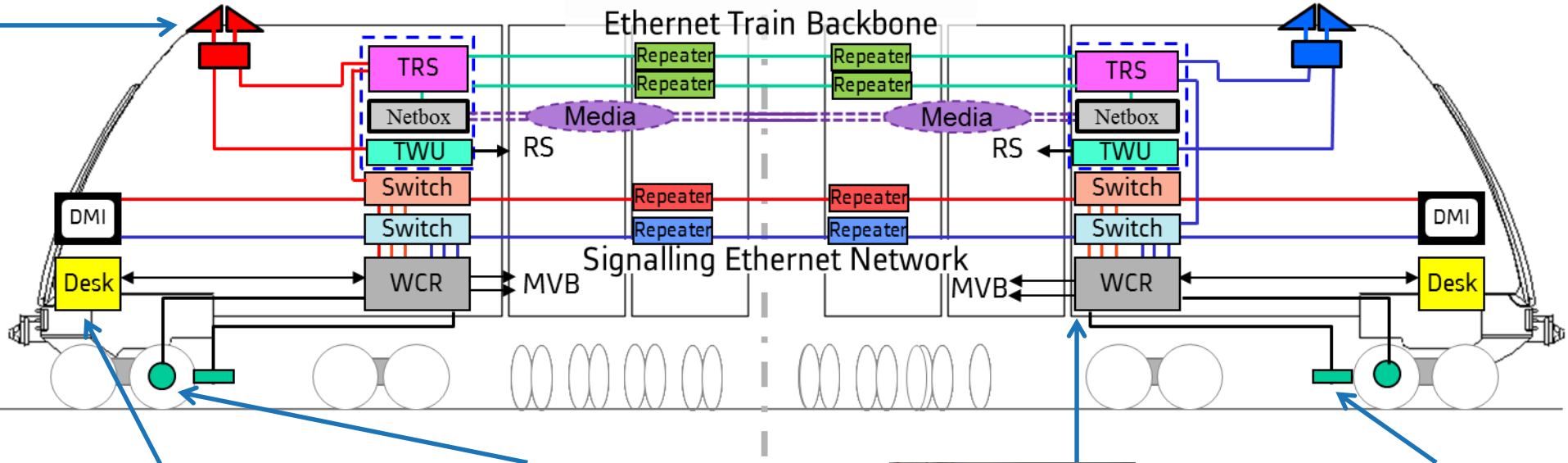
- GoA 2
- Coupling up to 4 units
- Redundant CC
- MultiMedia Network

Trains (2/2)

S1/S2 12/13 (Sneltram)

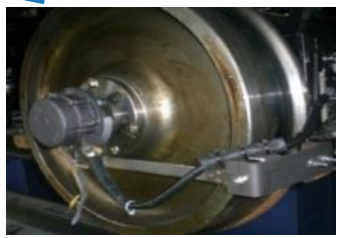
- in use till 2020 → prolongued
- GoA 1
- Coupling up to 4 units
- Single CC
- No MultiMedia Network
- CBTC installed on 1st S2

ARCHITECTURE M5



BRN Antenna

Driverdesk

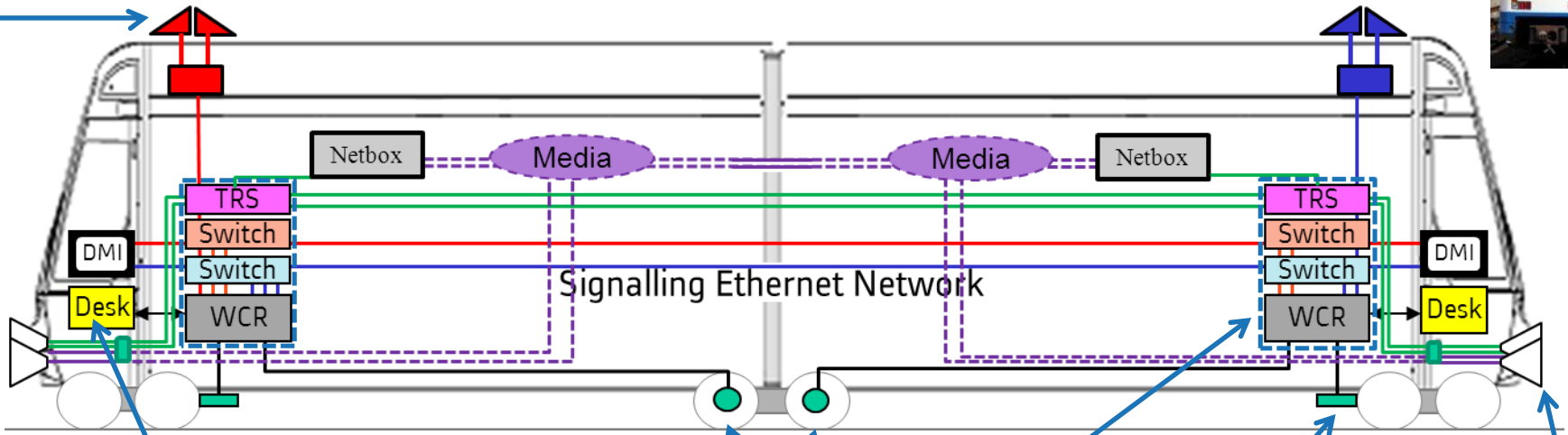


Odometer

ATC Cabinet

Beacon Antenna

ARCHITECTURE S3/M4



BRN Antenna

Driverdesk

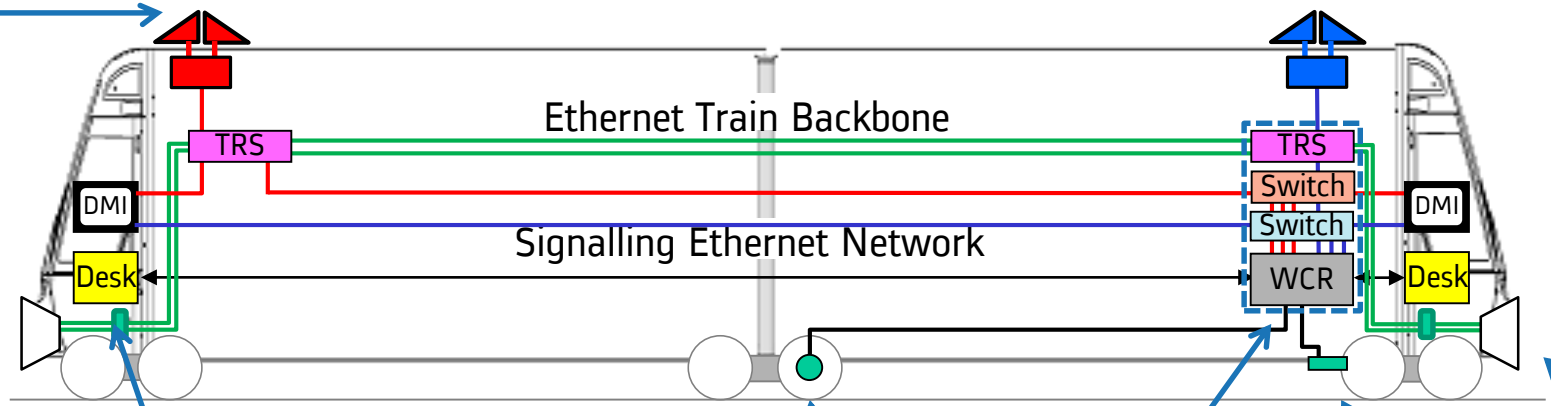
Odometer

ATC cabinet

Beacon Antenna

Coupler

ARCHITECTURE S1/S2



BRN Antenna

Driverdesk

Odometer

ATC cabinet

Beacon Antenna

Coupler

Dedicated Driver Desk per train type

S3/M4 Train

M5/M6 Train

S1/s2 Train

TRAIN DRIVING MODES

- Restricted Manual Reverse (RMR)
- Restricted Manual Forward (RMF)
- Protected Manual Forward (PMF) : GoA level 1
- Automatic Mode Forward (AMF) : GoA level 2
- Automatic Turnback without driver (ATB) : GoA level 2
- Driverless Mode Forward (DMF) : GoA level 4

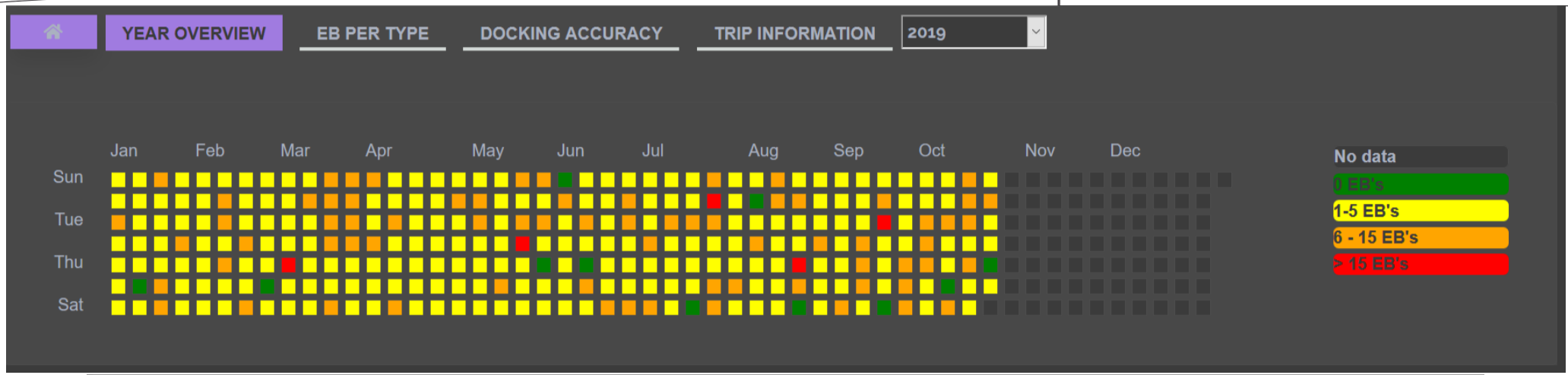
Train Type / Mode	M5	S3/M4
RMR	X	X
RMF	X	X
PMF	X	X
AMF	X	X
ATB	X	
DMF	X	

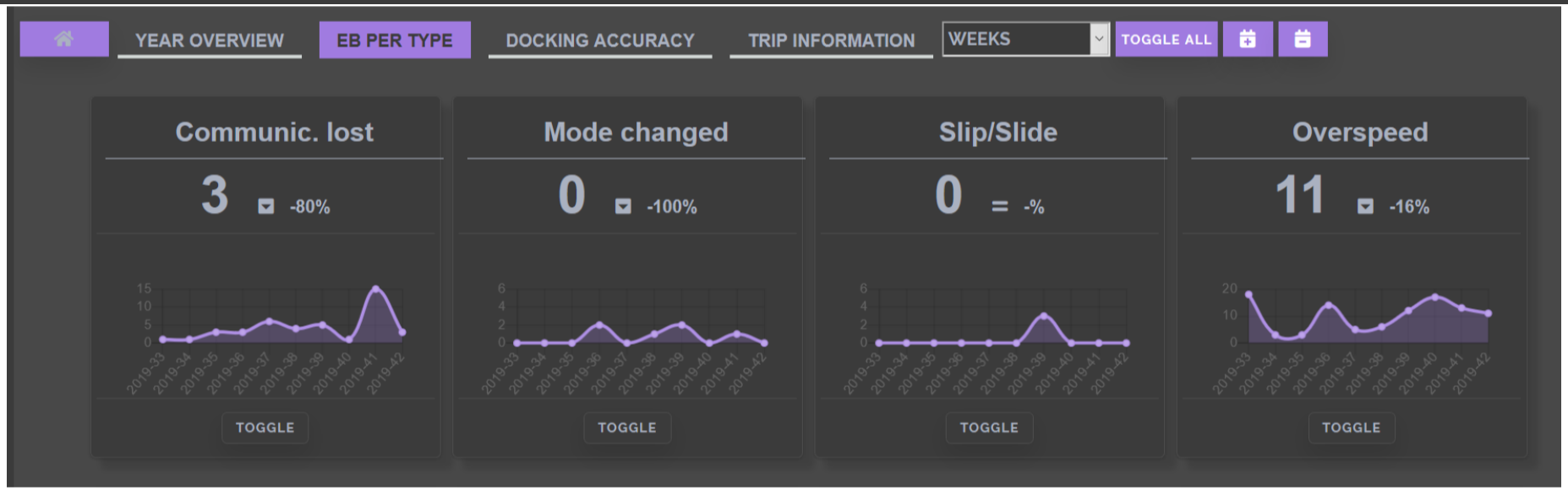
In blue : CBTC modes

Some NZL statistics

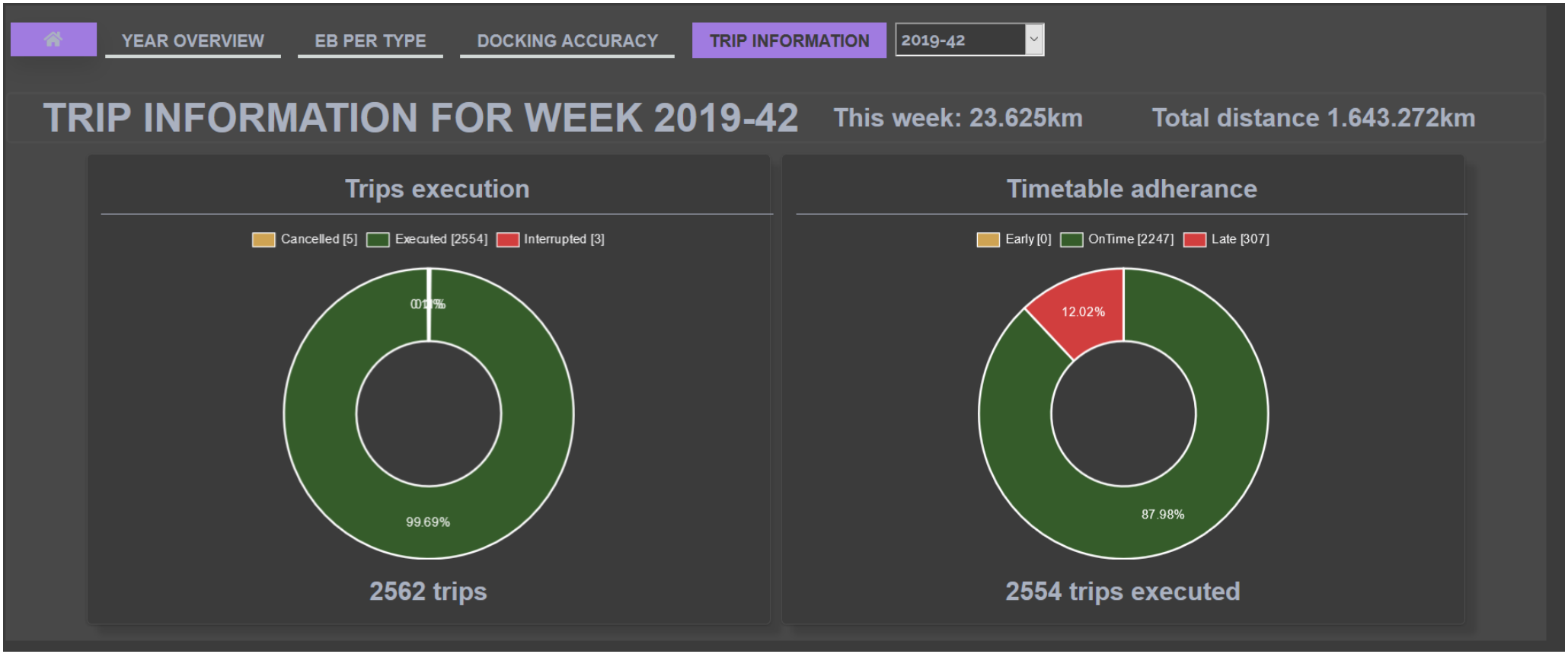
- 15 minutes from Noord to Zuid
- 121.000 passengers/day
- 10 metros/hour/direction on opening
- 8 stations of which 7 completely new (Zuid was modified to accommodate connection to NZL)
- Track length: 9.7km – 3.2km above groud, 6.5km tunnel
- M5: 116m long, 24 double doors on each side (height: 208cm)
- Tallest metro in the world (the Dutch are tall!)

REX EB NZL (example 1/2)





REX EB NZL (example 2/2)



Contents

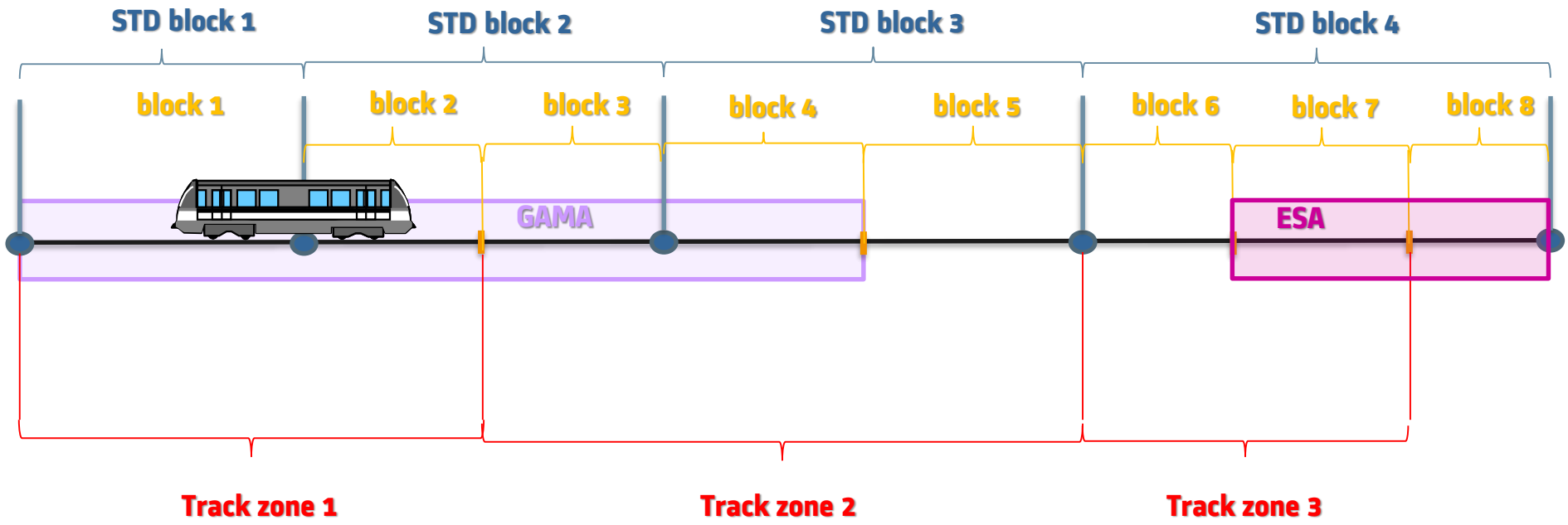
U400

CBTC PRINCIPLES

CBTC TERRITORY : GENERAL RULES (1/4)

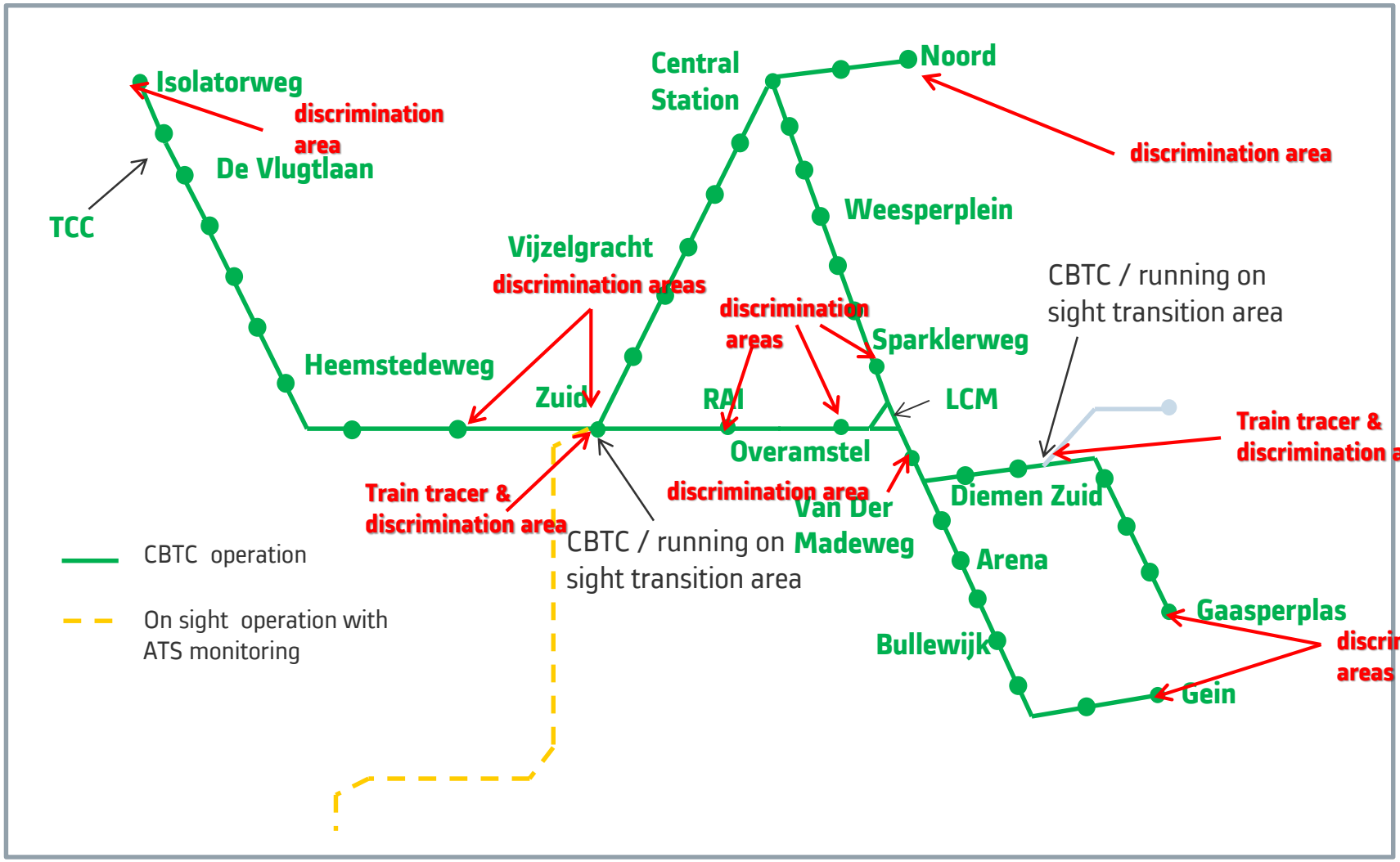
- Signals :
  - Real signals installed at the entrance / exit of the territory : ~~Zuid~~, LWP Diemen.
  - Fixed panels installed within the territory to represent route signals
    - Notion of virtual signal : route signals are still managed dynamically by the CBTC system
    - Dynamic status of signals displayed by ATS
    - Information on driver display if train in CBTC mode
- Track subdivisions :
  - Train position & interlocking management :
    - Block : basic subdivision of the track.
    - Secondary train detection (SDD) block : portion of track located between two (or more) axle counter heads. An SDD block can be subdivided into several blocks.
    - Track zones : a set of blocks on which specific protection functions can be applied. Track zones can be protected by SPKS or locked by external devices (moving bridges, flood & gas gates)
  - CBTC mode initialization :
    - Discrimination zone : area where CBTC modes can be granted for the first time.
    - Train tracer & discrimination zone : area used to manage entry / exit to the CBTC territory
  - Protection zones :
    - ESA : track area (usually near station platforms) provision for PSD
    - GAMA zones : track area where CBTC modes are enabled / disabled by ATS

CBTC TERRITORY : GENERAL RULES (2/4)

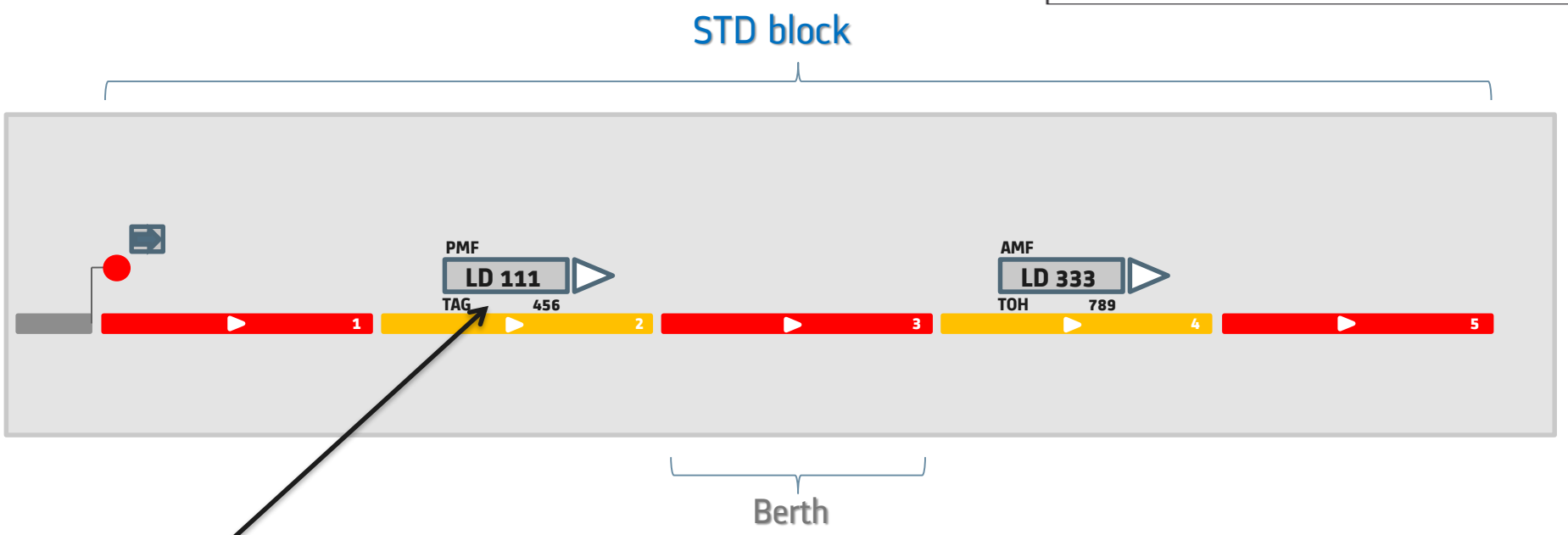


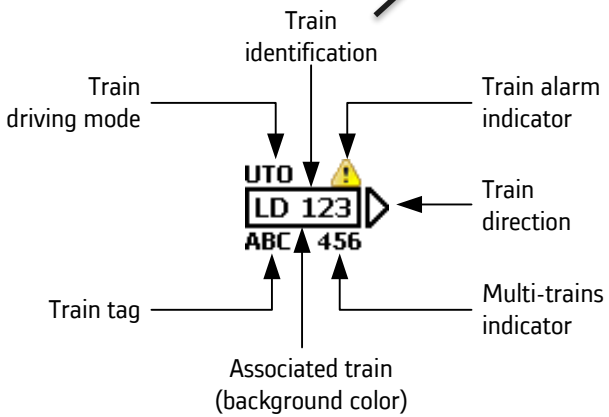
- Occupancy :
  - The axle counter system sees **STD block 1** and **STD block 2** occupied and reports the STD block status to the IXL
  - The IXL reports the STD block status to the ZC
  - The ZC reports to the IXL that only **Block 1** and **Block 2** are occupied (if train is communicating)
  - The IXL can perform the logic accordingly

CBTC TERRITORY : GENERAL RULES (3/4) : PRELIMINARY LAYOUT



CBTC TERRITORY : GENERAL RULES (4/4)



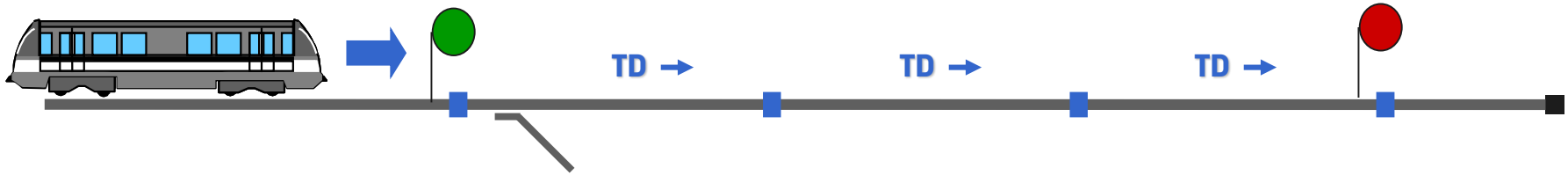


- Train tracking :
  - STD blocks are subdivided into berths
  - Communicating train progress is tracked through berths
  - STD block occupancy is shown in the background

CBTC SYSTEM : ROUTE & SIGNAL MANAGEMENT

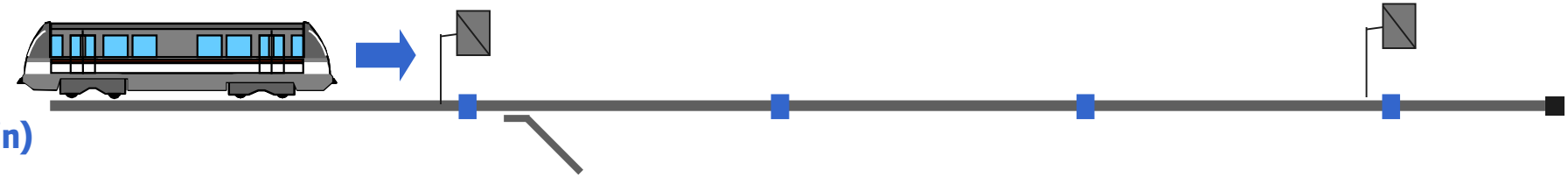
1 – To run on a route, a train in CBTC mode needs : a permissive route signal, consistent traffic directions and controlled switches. This information is provided to the ATC by the IXL.

System View



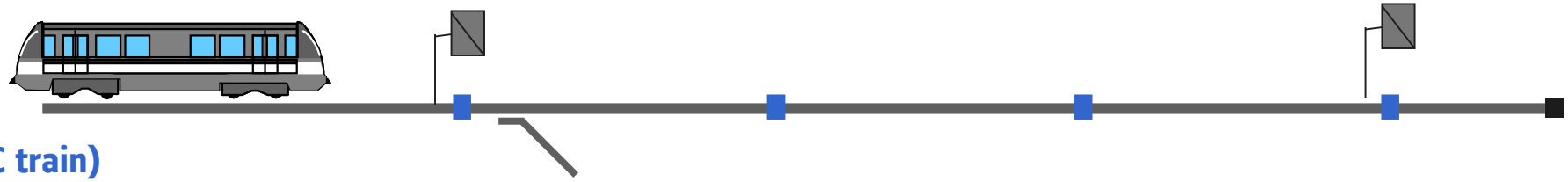
2 – For a CBTC train within the CBTC territory, the driver sees a fixed panel at the signal position. The driver knows from the HMI display whether he / she can proceed or not (see scenario).

Driver View (CBTC train)



3 – A non-CBTC train has to stop before each fixed panel and establish voice radio communication with The TCC in order to get authorization to cross the panel

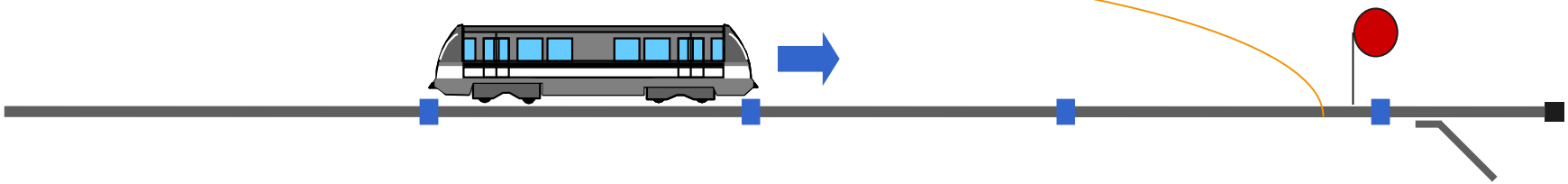
Driver View (non-CBTC train)



CBTC SYSTEM : ROUTE SETTING PRINCIPLES

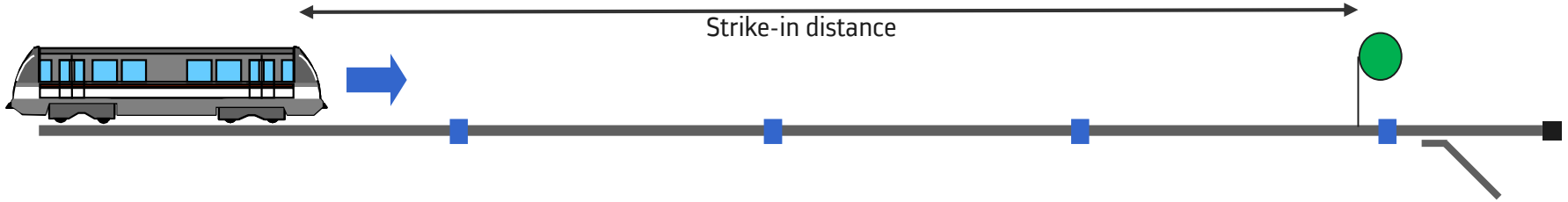
1 – Manual route setting : ATS command from the TCC Operator. No guarantee from the system that the train has not to reduce its speed in front of the signal before it becomes permissive.

Manual



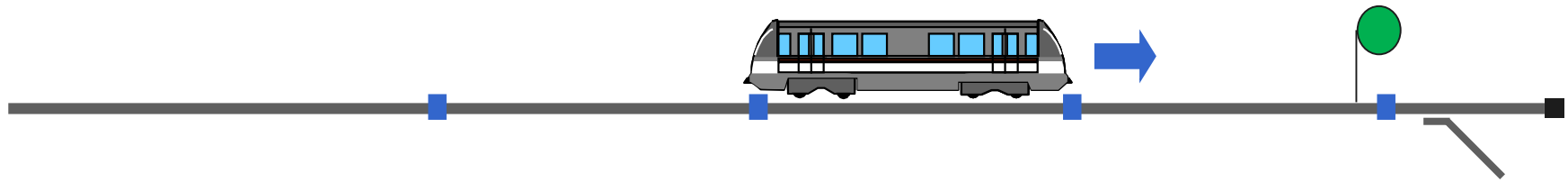
2 – Automatic route setting : the route is set according to a strike-in distance in order that the train does not have to reduce its speed.

Auto



3 – Fleet mode : the signal clears as soon as the train ahead has crossed it

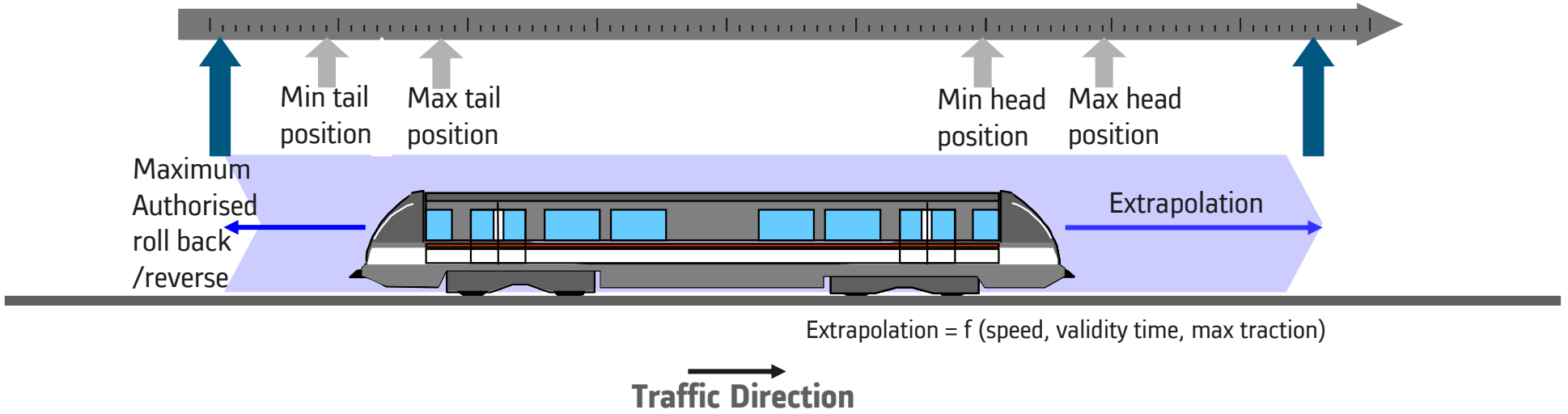
Fleet



CBTC MOVING BLOCK : GENERAL PRINCIPLES

- Primary train detection : Bi-directional radio communication between on board ATC (CC) and trackside ATC (ZC)
  - Each communicating train CC (in a specific zone) send a Loc. Report to the ZC (in control of the zone) defining the train localization and speed.
  - The ZC computes an Automatic Protection envelope (AP) for each communicating train (in the zone) on the basis of each of the Loc. Reports.
- Secondary train detection : axle counter blocks
  - Non communicating trains (non equipped trains or equipped trains which are unable to communicate) are tracked by the ZC through axle counter block occupancy.
  - The ZC computes a Non Identified Automatic Protection envelope (NIAP) around a train which has never communicated.
  - The ZC computes a Non Talkative Automatic Protection (NTAP) around a train which has communicated but is either unable to communicate anymore or is unable to compute it's position.

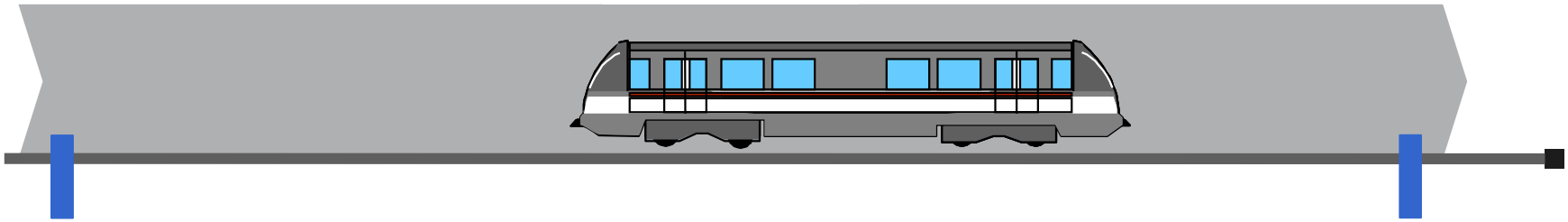
CBTC MOVING BLOCK : AP



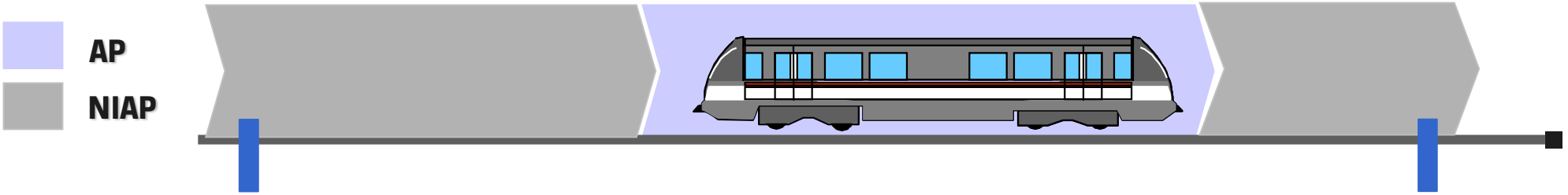
- The trackside ATC (ZC) deduces the AP from Loc. Report messages received from the onboard ATC (CC)
- The AP position is dynamically updated Independently from the secondary train detection mechanism (axle counter blocks)

CBTC MOVING BLOCK : DISCRIMINATION PROCESS

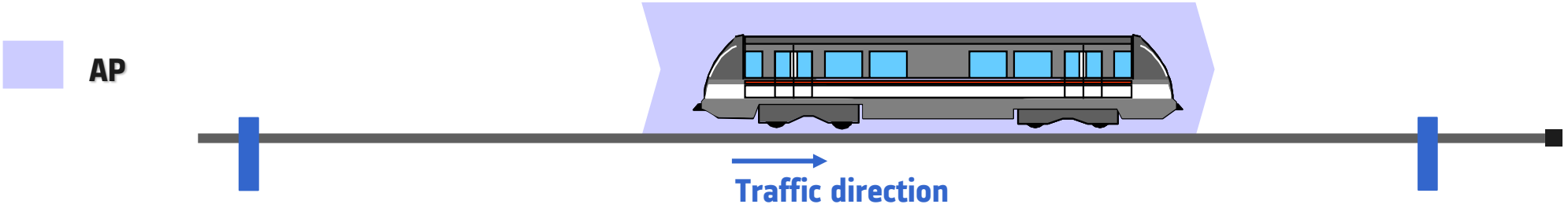
1 – A train has entered a block at the boundary of the CBTC territory : a NIAP has been created on the bloc



2 – Train has localized and reached standstill : after it starts communicating, the NIAP is replaced by A tail NIAP, an AP and a front NIAP

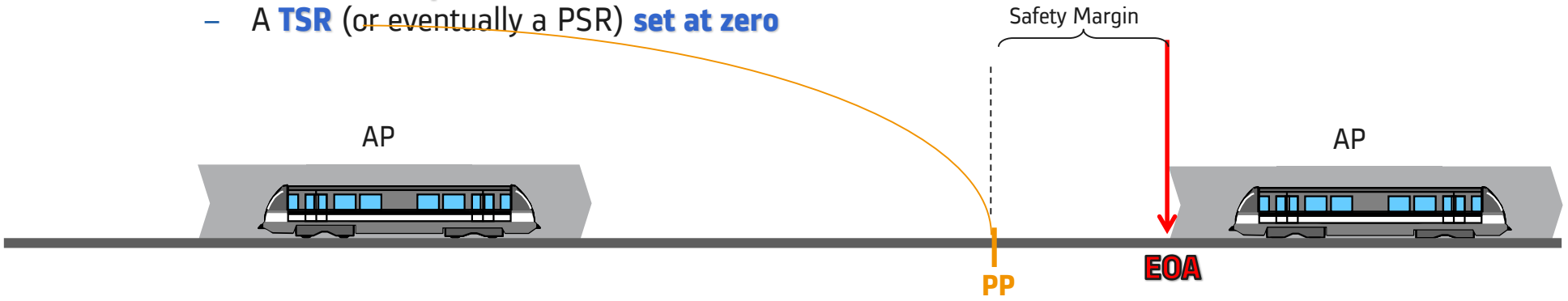


3 – If the NIAPS are smaller than the smallest train (and adjacent blocks clear) they are removed



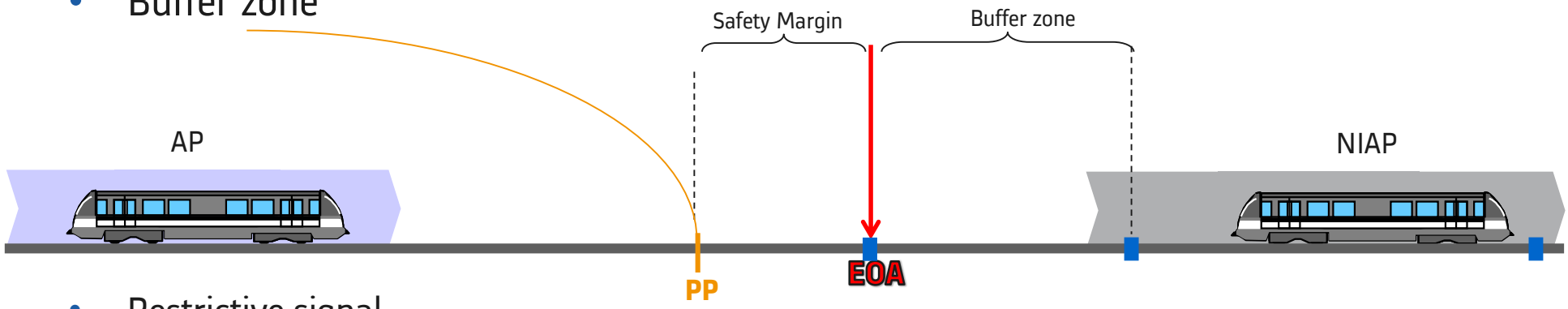
MOVING BLOCK : END OF AUTHORITY (EOA) AND POINT TO PROTECT (PP)

- The ZC computes the **EOA** for communicating trains, determined for each train by either :
  - The rear-end (eventually front-end) position of a protection envelope : **AP, NTAP or NIAP**
  - The extremity of a **buffer zone** (see next slide)
  - An **Incompatible traffic direction** (opposite or unknown), except on permissive overlap
  - The position of an **uncontrolled switch**
  - A **ZC boundary** (if adjacent ZC not in operation) **or** the **end of the CBTC territory** (Zuid, Diemen-Zuid, RAI / Until final phase)
  - **Maximal EOA distance**
- The CC computes a PP at which it needs to be at zero speed, considering the closest restriction (minus a safety margin) amongst:
  - The **EOA** sent by the ZC
  - A **restrictive signal ahead** without overlap (or with restrictive overlap)
  - The **extremity of the permissive overlap** of a restrictive signal ahead
  - A **restrictive protection zone ahead** (GAMA zone or ESA)
  - A **TSR** (or eventually a PSR) **set at zero**

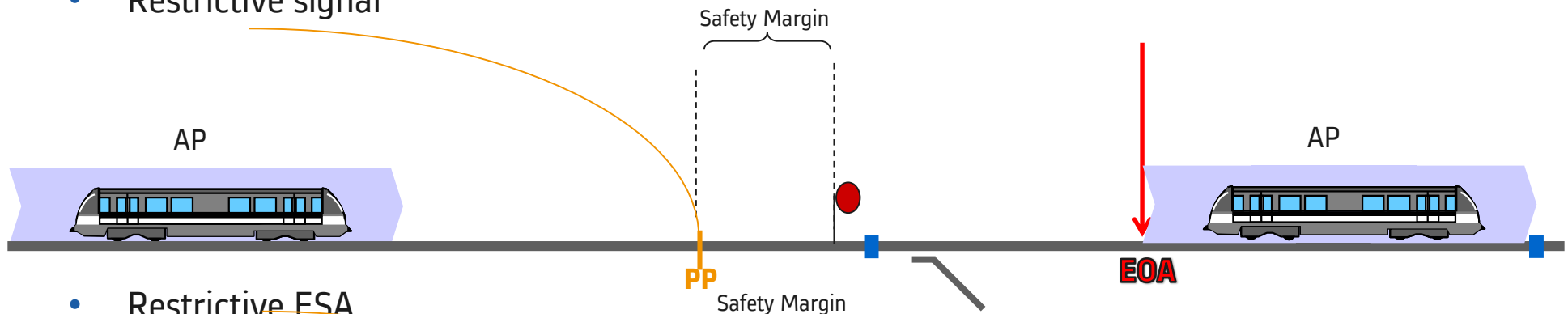


Examples of Point to Protect (PP)

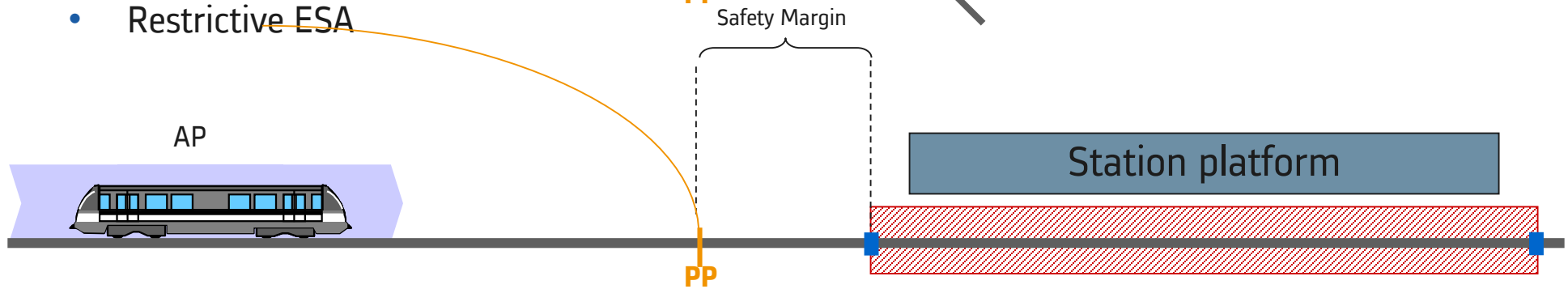
- Buffer zone



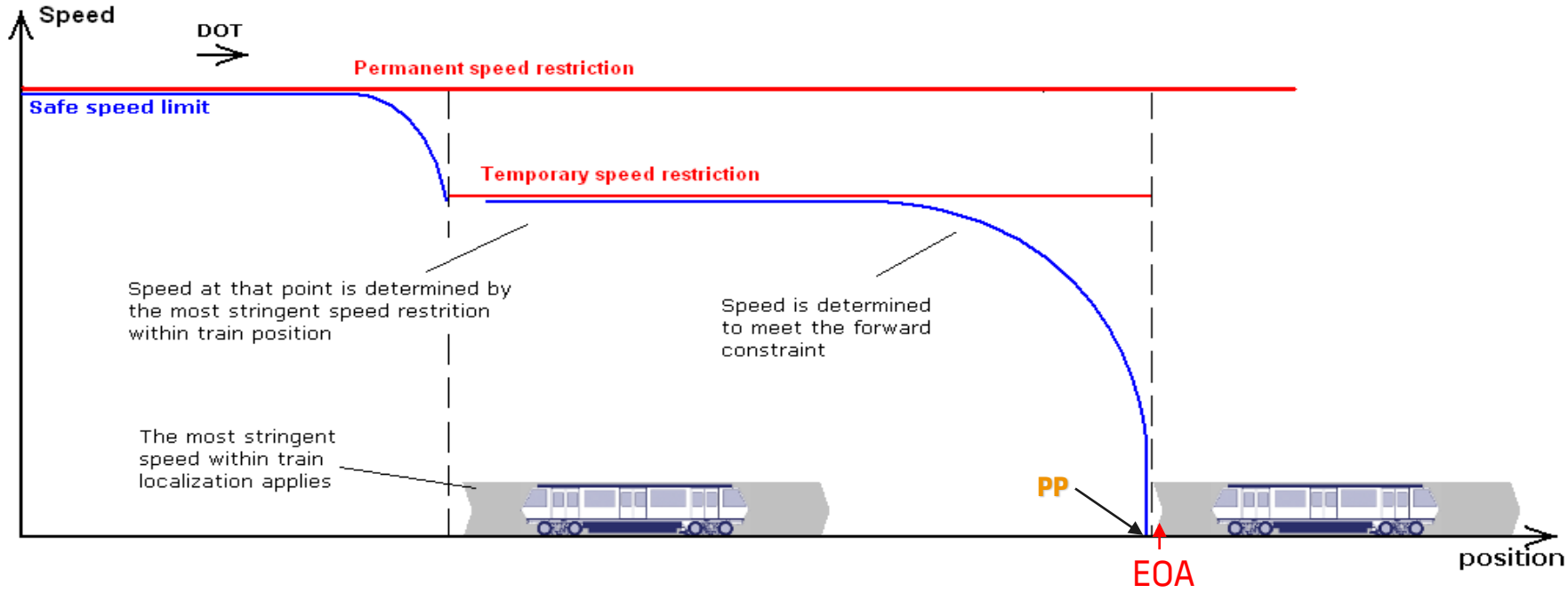
- Restrictive signal



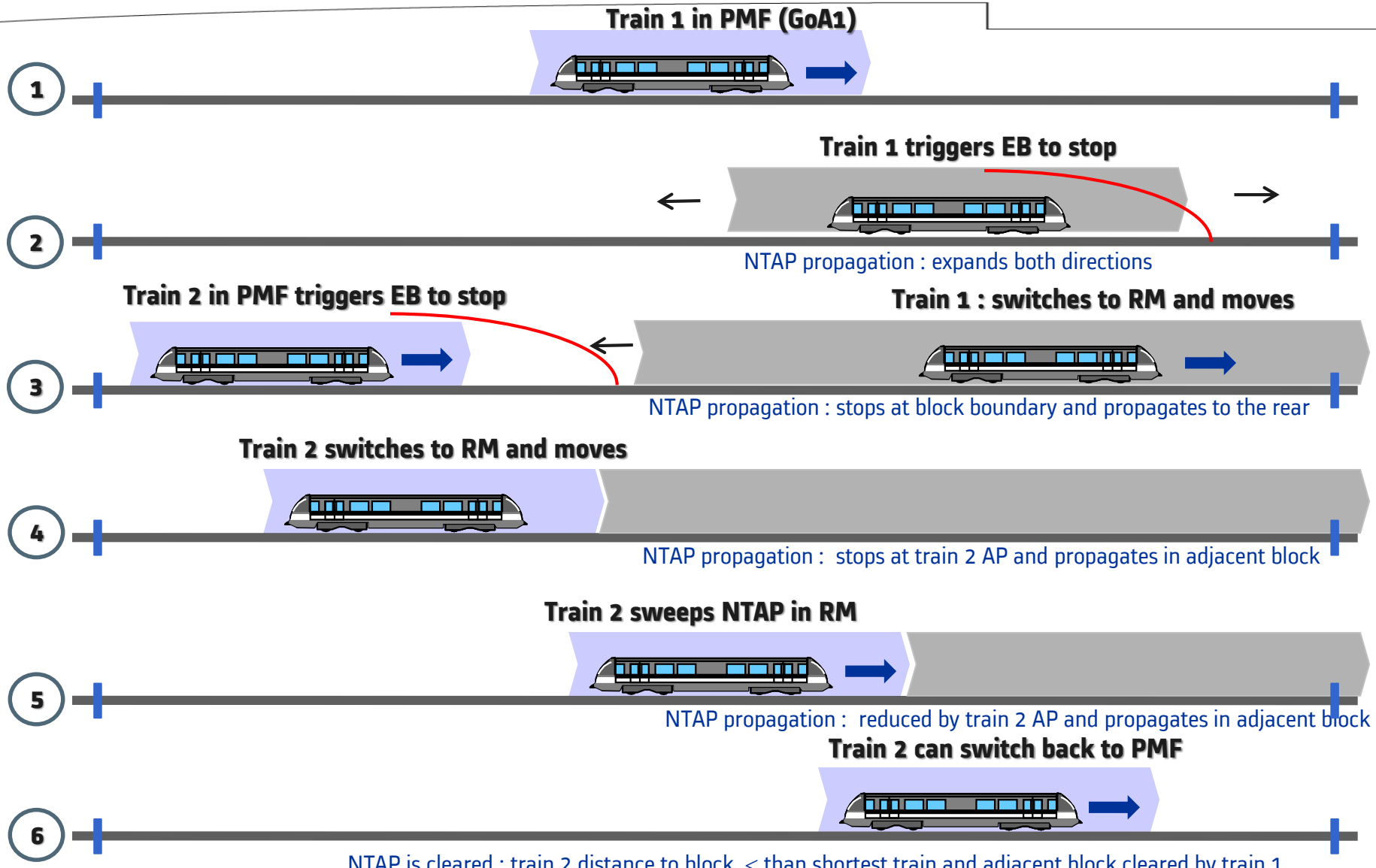
- Restrictive ESA



- CBTC system computes the safe speed profile, determined for each train by:
  - Permanent (or temporary) speed limit applicable to the train position
  - Maximum speed that allows the train to stop before its point to protect
  - Maximum speed that allows the train to comply to the next speed restriction (whether permanent or temporary)



TRAIN LOSS OF COMMUNICATION

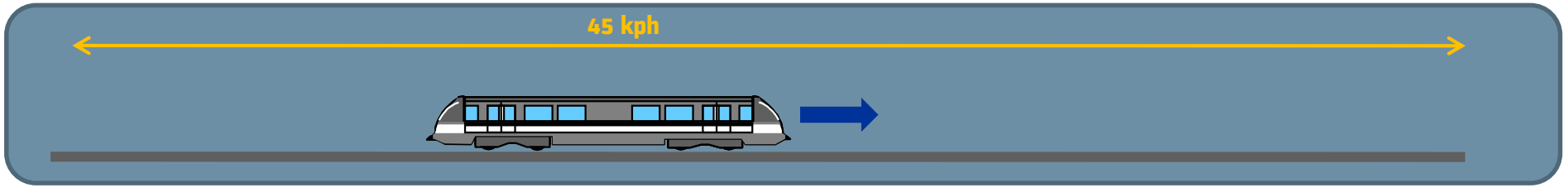


NIAP AP

ALSTOM

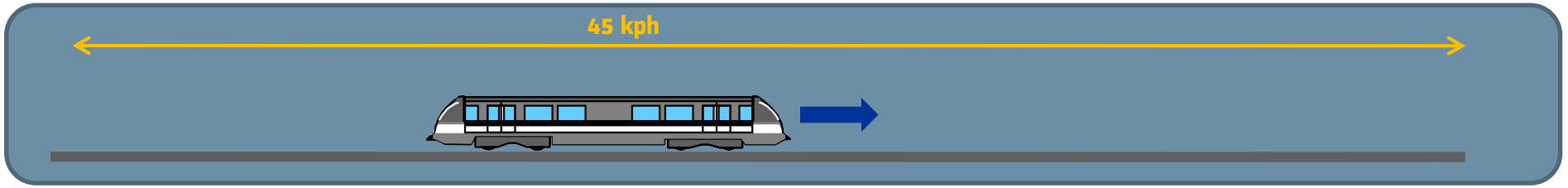
Train running interstation: over-speed in PMF without EB triggering speed infringement

- Displayed speed limit is at 45 kph
- Driver infringes value (but stays below EB triggering speed)
- Orange warning displayed + sound
- If no driver reaction : FSB is triggered until train reaches speed within safe boundaries



Train running interstation: over-speed in PMF with EB triggering speed infringement

- Displayed speed limit is at 45 kph
- Driver infringes value (and hits EB triggering speed)
- FSB cannot be used by system as EB triggering speed is reached
- Red display + sound
- ATP triggers EB



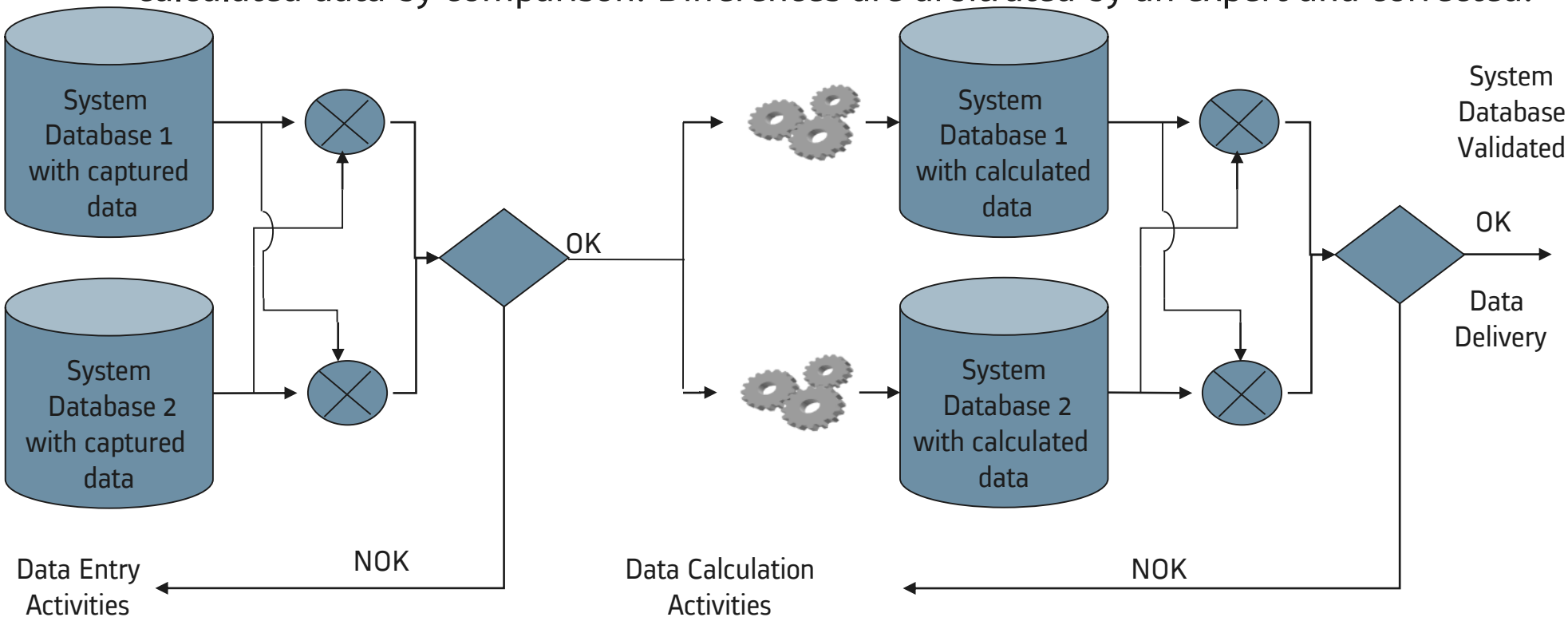
Contents

System Database

- Application data for all subsystem generated from 1 database (SyDB)
- multi step approach to refine content of SyDB
  - Initial filling base on customer data
  - Track data measurement after installation (laser measurement)
  - Consistency check between layout and on-board database (track data checking)
  - Low speed testing
  - High speed testing

System data production and validation: common repository

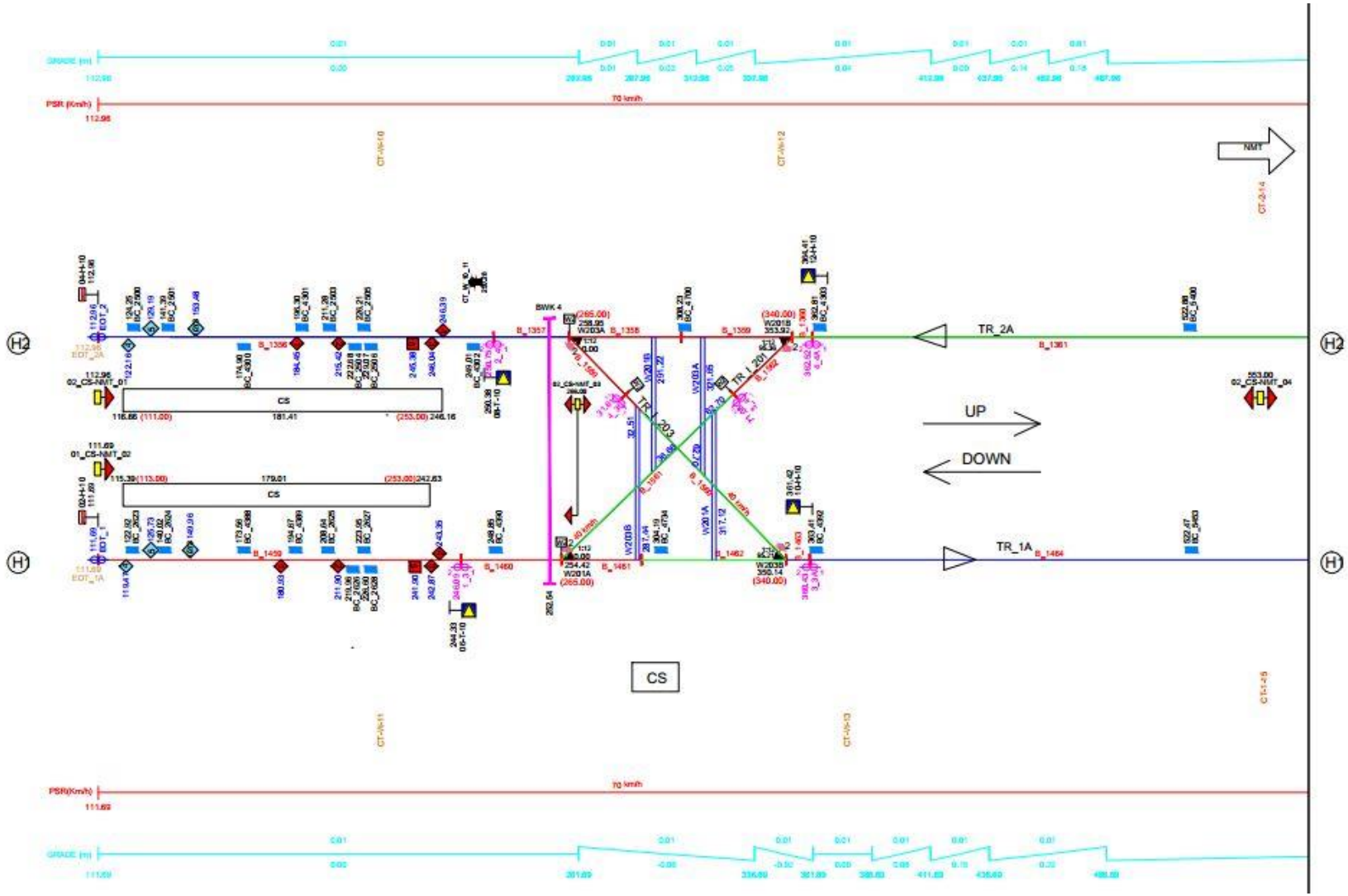
- Inputs from TMS, RTI, Scheme Plan, System Data Table.
  Semi-automatic verification by a tool
- The system data is produced by two teams working independently
- The validation of the database is realised continuously on the captured data and calculated data by comparison. Differences are arbitrated by an expert and corrected.



Sub system data production and validation

- The system data base produces outputs for each sub-system which are used to produce the corresponding sub-system data. It also produces interface formats
- ATS
  - Data produced and validated manually with partial automation support
- IXL
  - Data produced and validated automatically
- ATC
  - Data produced automatically and validated with tool support
- DCS
  - Data produced and validated manually with partial automation support

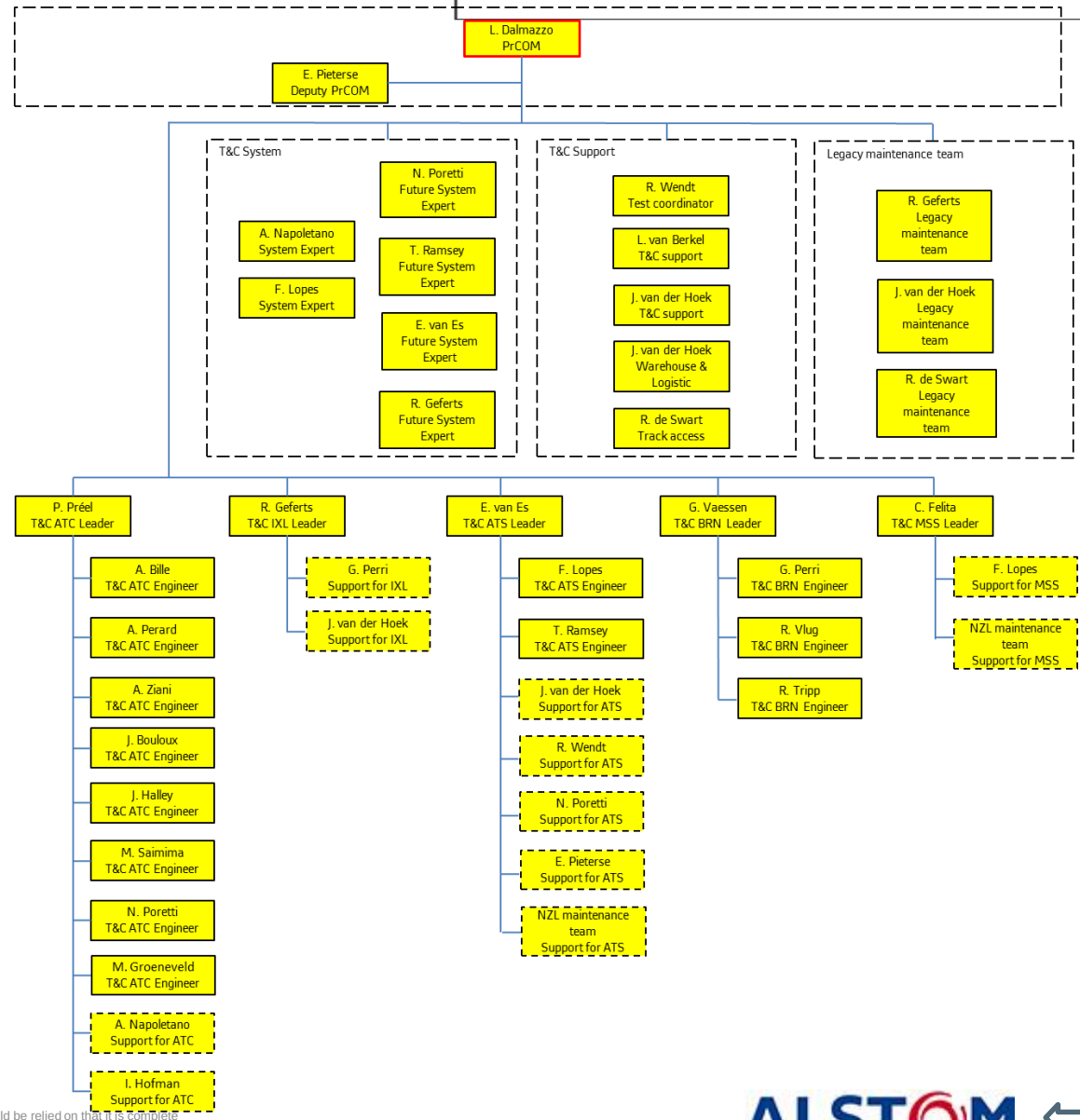
CBTC Scheme Plan



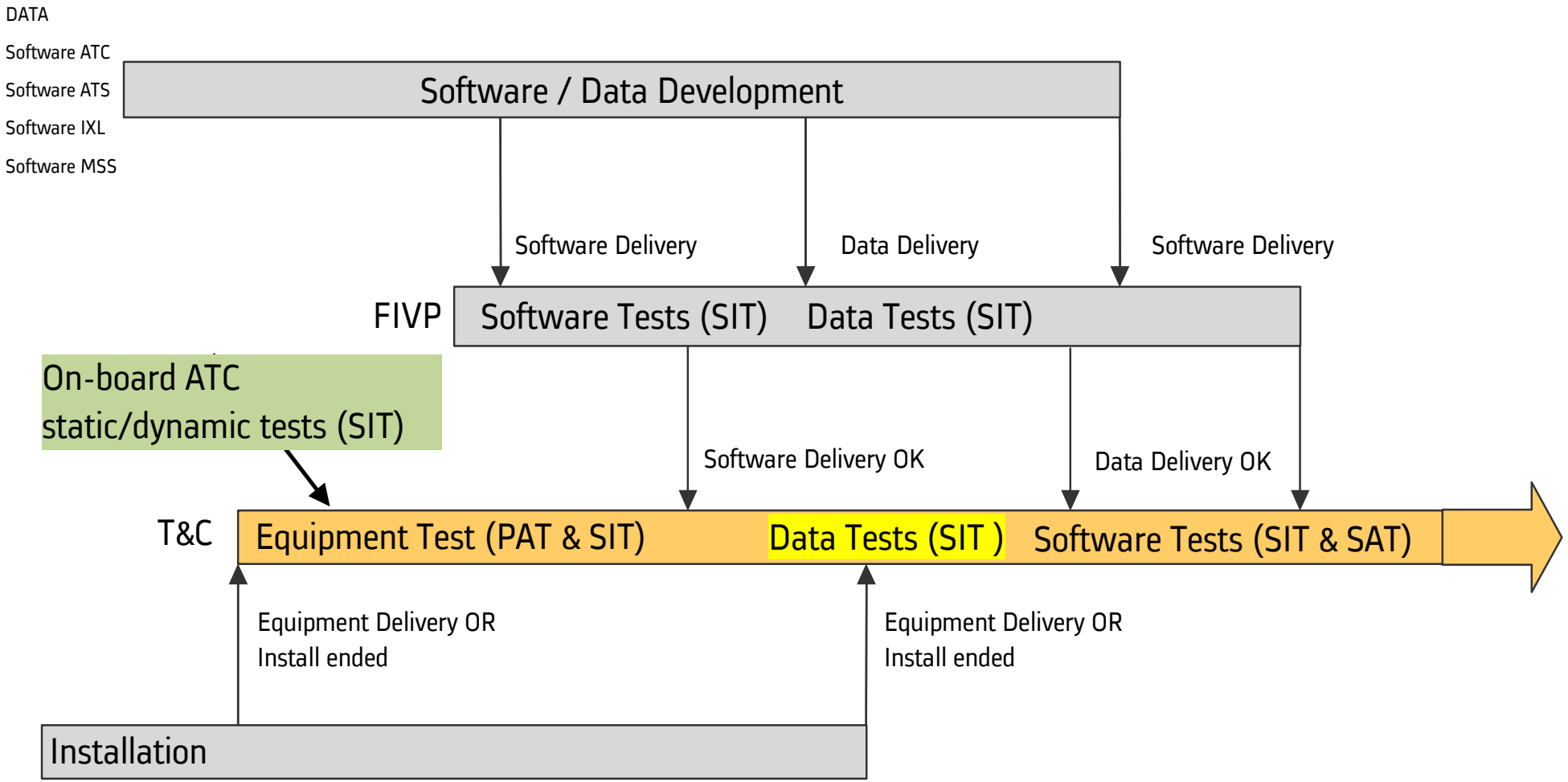
T&C – team organisation

Duivendrecht project office:

- 25 engineers in the SCMA T&C team;
- Entire team has local contract;
- Personnel are from different countries (the Netherlands, France, Brazil, Italy, Indonesia);
- 5 subsystems leaders + System experts poll + T&C support team;
- Main PrCOM interfaces are with -> STO T&C metier department + STO design + SCMA customer (MeT/GVB).



T&C - Project System on-site Validation



T&C - Project System on-site Validation

Partial Acceptance Tests (PAT) : static tests

- Test trains static tests
- Track measurement
- Trackside static tests (post-installation checks, power on, …)
- Backbone tests, radio tests, end to end tests

System Integration Tests (SIT) : low speed tests

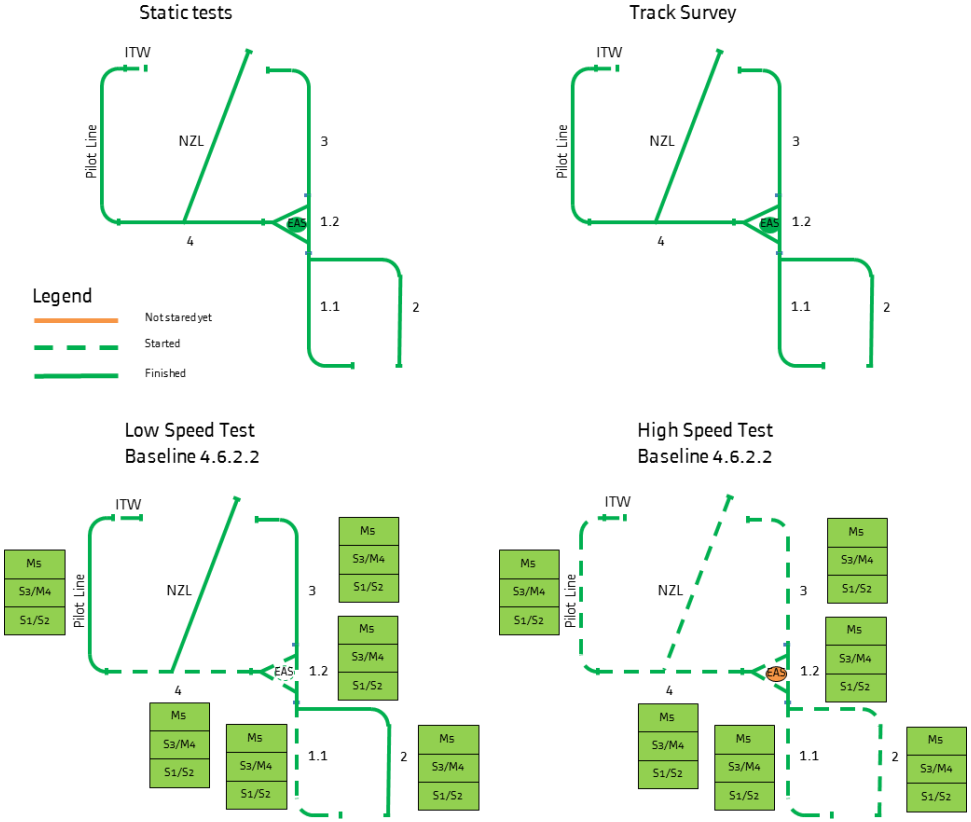
- Track data checking
- Test train dynamic tests at low speed
- Low speed dynamic tests (one train at the time only) : radio coverage, Trackside / On-board correspondence, test of routes…
- External interface tests

Internal System Acceptance Tests (internal SAT) : high speed tests

- High speed dynamic tests with one then several trains : ATO tuning, sub-system level function tests, system level function tests
- Serial static and dynamic tests on all trains

T&C – main activities

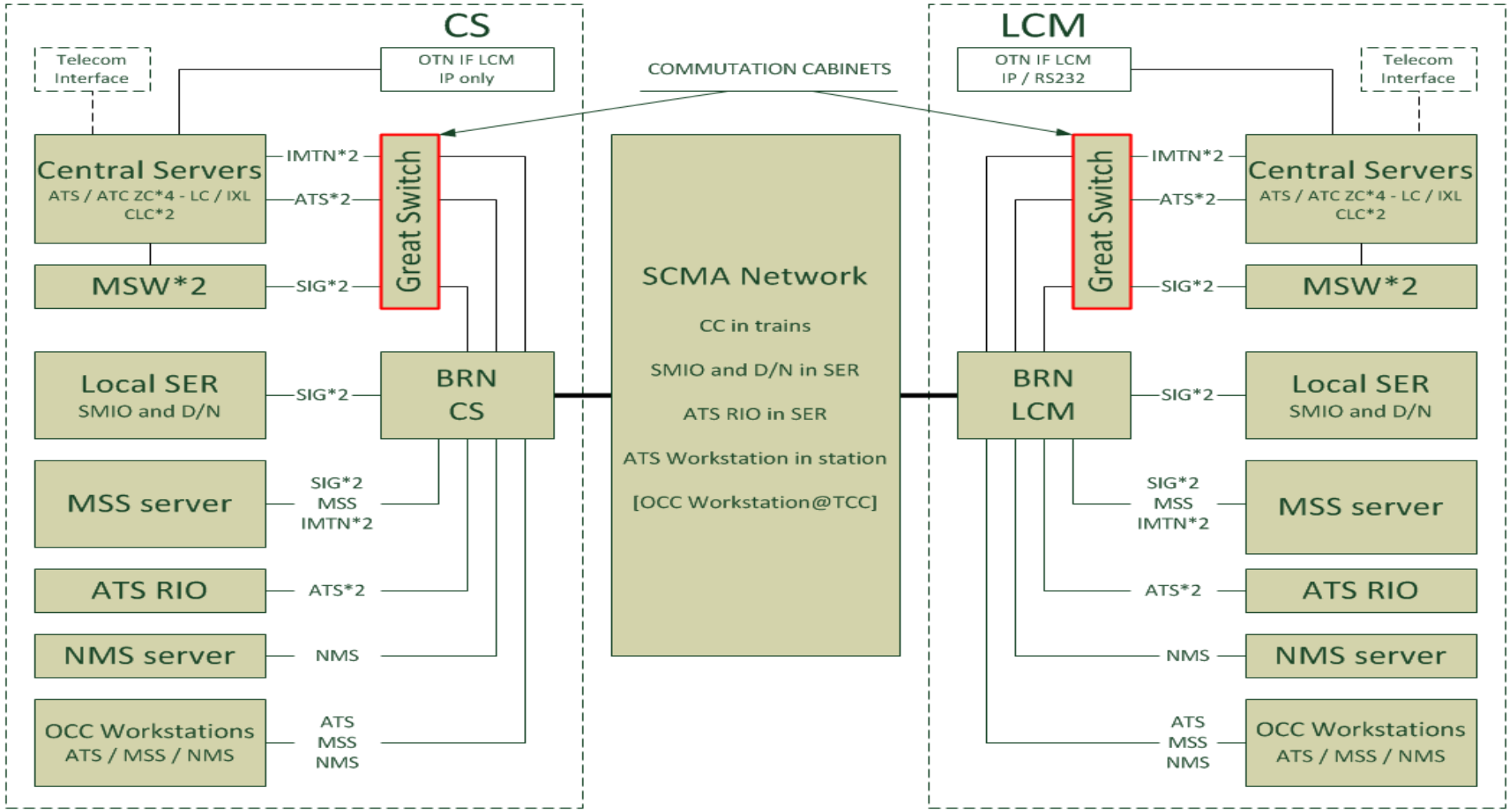
- **Type of tests (PAT, SIT and SAT);**
- **Others special tests – on demand for problem investigations or new features/requirements required;**
- **Analysis of the tests done + customer findings;**
- **SW FIVP tests that can be done in DVD project office;**
- **Planning and preparation in advance together with customer.**



T&C - Great Switch principles

- **Location: at 2 Central Equipment Rooms:**
  - LCM (Logistiek Centrum Metro) – NZL operation;
  - CS (Amsterdam Centraal Station) – testing Baseline.
- **Reason:**
  - LCM has SW baseline authorized for NZL REVENUE SERVICE;
  - CS has SW baseline authorized for T&C;
- **Modes: Independent and local selection:**
  - A: ISOLATED
  - B: CONNECTED

T&C - Great Switch connection scheme



T&C - Great Switch cabinet

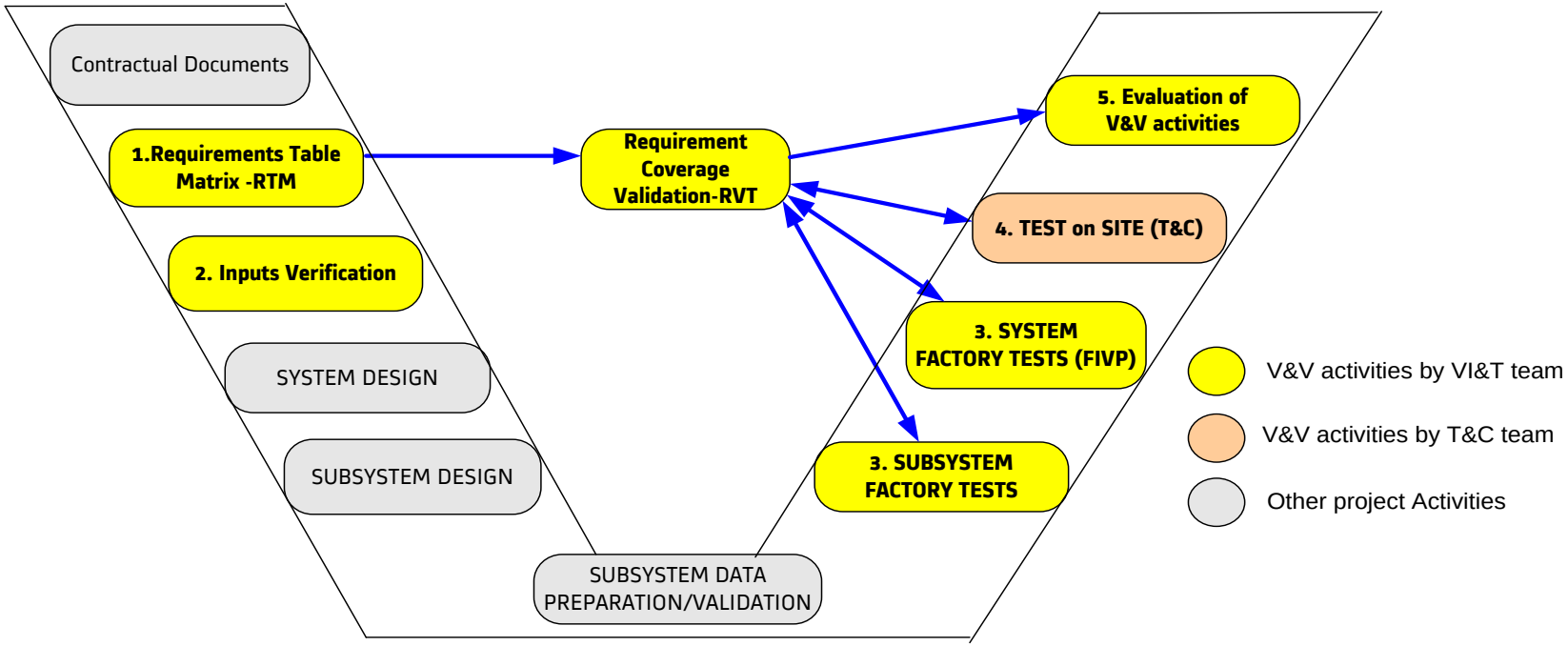
- **Basics:**
- Locked cubicle (BRN key)
- Mode selector
- 10 Switch boxes (A or B)
  - Ethernet
  - Optical Fibre
- Main Power breaker
- Switch Box breakers

T&C NZL - Status

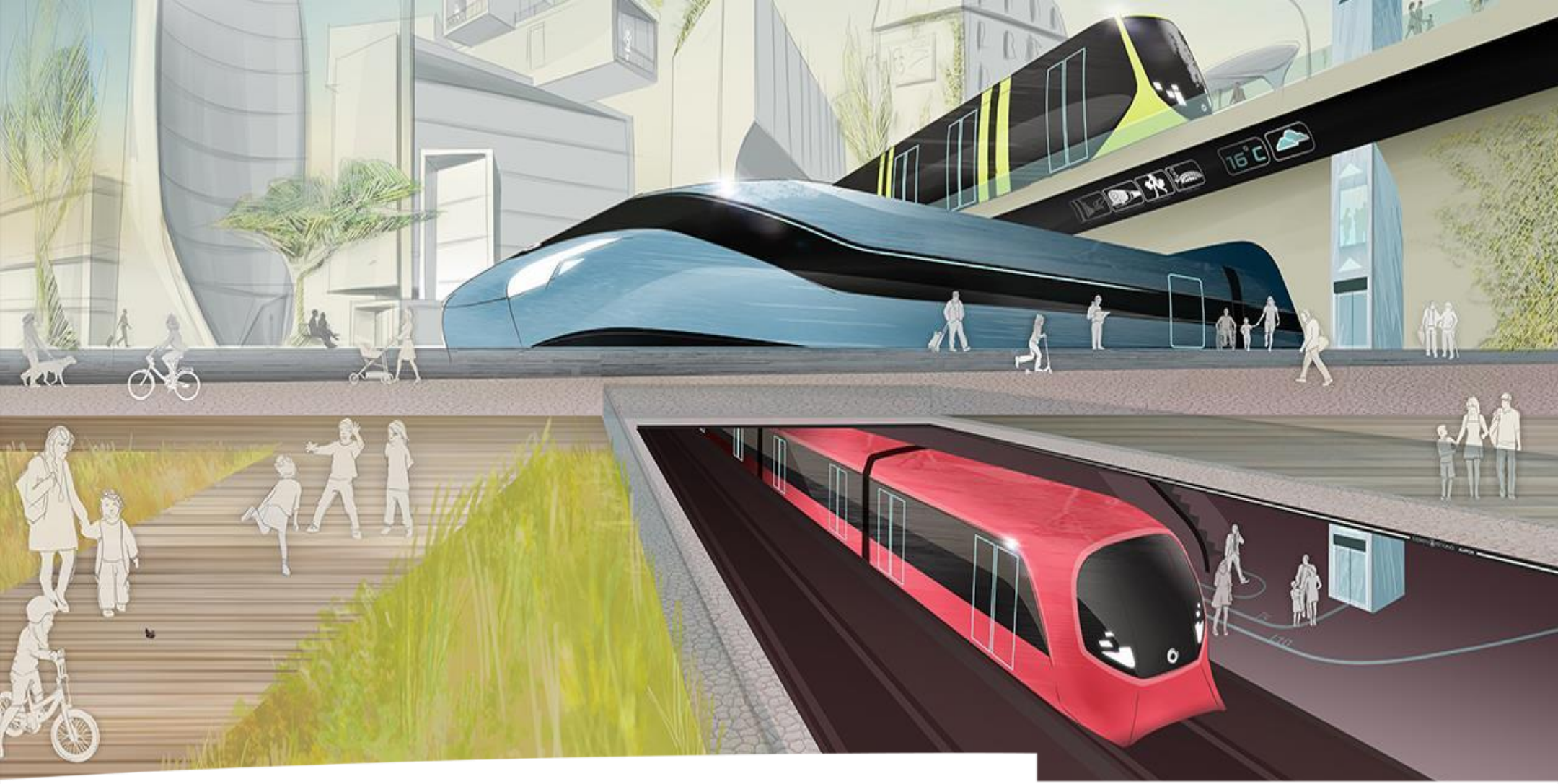
- **NZL is in operation with CBTC since July 2018;**
- **ATC patch management procedure (M5 trains driving outside NZL);**
- **Customer findings meeting, in order to give the feedback of customer findings analysis, on-going weekly basis.**

V&V activities

V&V activities covers all the development cycle of the project:



1. Requirements coverage verification → Verification of Requirements Table Matrix (RTM)
2. Input Verification → Verification of inputs for data generation
3. Factory Testing → Factory Tests (subsystem/system)
4. Site Testing (T&C) → Site Tests (subsystem/system)
5. Requirement coverage Validation → Requirement Validation Table (RVT)
6. Evaluation of VI&T Activities → VI&T Reports



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