FA6 T8.3 Dissemination Workshop ATSA HTD Demonstrator

08/07/2026

Online - Teams

Europe's Rail

This project has received funding from the Europe's Rail Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 101101962

Agenda of the Workshop

1) Overview & Scope of Work
2) HTD concepts and main design principles applied to T8.3 Demo
3) Demonstrator's test environment & architecture
4) Methods & Tools for Test reporting
5) Main Takeaways
6) KPI Assessment
7) Tests Witnessing
8) Questions & Answers

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Overview & Scope of Work

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Overview

Source: FutuRe Grant Agreement / Project 101101962

Task 8.3: Development of individual demonstrator for ETCS L3 on G1 regional lines (Leader: ATSA; Participants: ADIF, CAF, FS, INDRA, MERMEC, ÖBB-INFRA) (M19-M48).

Based on the preparatory activities developed in WP3 Task 3.2, possible enhanced versions of specifications, guidelines and any other deliverables coming from WP2, Destination 2 and the System Pillar system architecture in regards of ETCS L3, and prototypes/Generic Application products developed in Destination 2, this task will:

- Develop and test selected uses cases for demonstrators on one or more available potential locations (e.g. Austria, Italy and Spain), taking into consideration the specificities and variances from one regional line and location to another;
- Integrate CCS solution (including RBC, interlocking functions and interfaces with TMS) based on ETCS level 3 with fixed virtual block (virtual section and virtual track circuits) and a minimal number of trackside train detection systems, level crossing treadles and cables to command-and-control movable devices, shall be explored. Performed tests adapted to Regional Lines reaching TRL 5 on a representative environment, used to assess and report the actual benefits of this technology;
- With at least one railway operator/infrastructure manager (e.g. bringing specific data and requirements for the selected regional line) and at least one supplier (e.g. providing technology/prototypes and specific application preparation) develop, test and validate the demo;
- Deliver a report describing the system requirements covered, a high-level design of the test set-up, tests specification/ use cases and tests result report.

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Scope of Work

The objectives of this demonstrator are to:

- Showcasing the positive impacts of the HTD principles and other technical solutions to the achievement of the main Socio-Economic Objectives (SEO) identified in the Grant Agreement and associated to this task;
- Identifying and describing possible improvements of the HTD principles to support acceptable operational performances on a G1 Regional line without TTDs on some specific sections, recommending also possible specific updates of these concepts to be adopted for improving the operational performances, yet providing an acceptable level of safety;
- Showcasing an innovative technical solution for reducing the trackside assets linked to the Level Crossings management;
- Evaluating the potential benefits coming from the adoption of an ASTP solution for decreasing the number of recalibration balise groups;
- To verify these objectives through the execution of tests derived from the Use Cases defined within D3.2, aiming at a TRL5 target.

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HTD concepts and main design principles applied to T8.3 Demo

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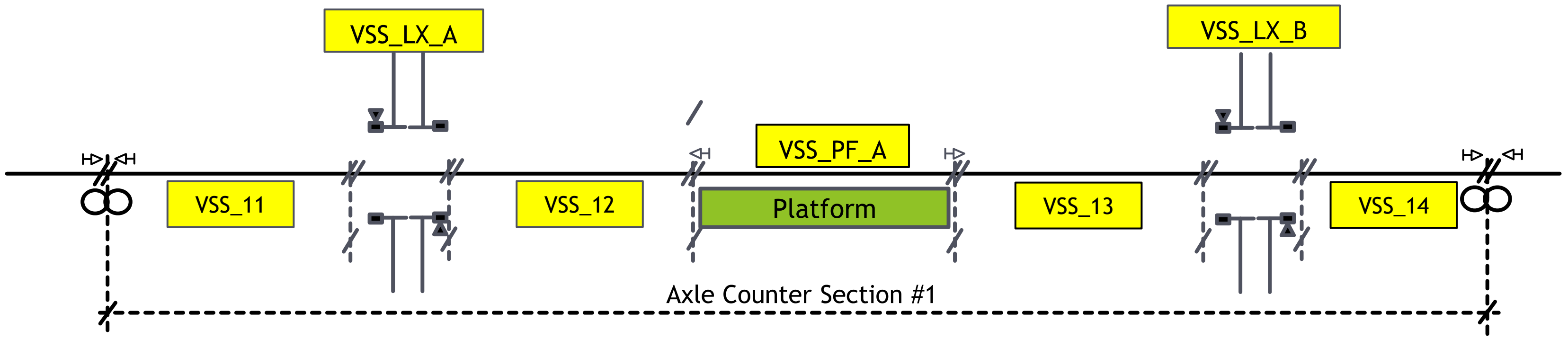
Rules for VSS configuration in plain line

- Single axle counter section configured in plain line, split in several VSS;
- VSSs are configured according to the following rules:
  - A VSS covering each LX area;
  - A VSS for each platform where operational stops are foreseen;
  - A VSS shall not exceed 2km in length;



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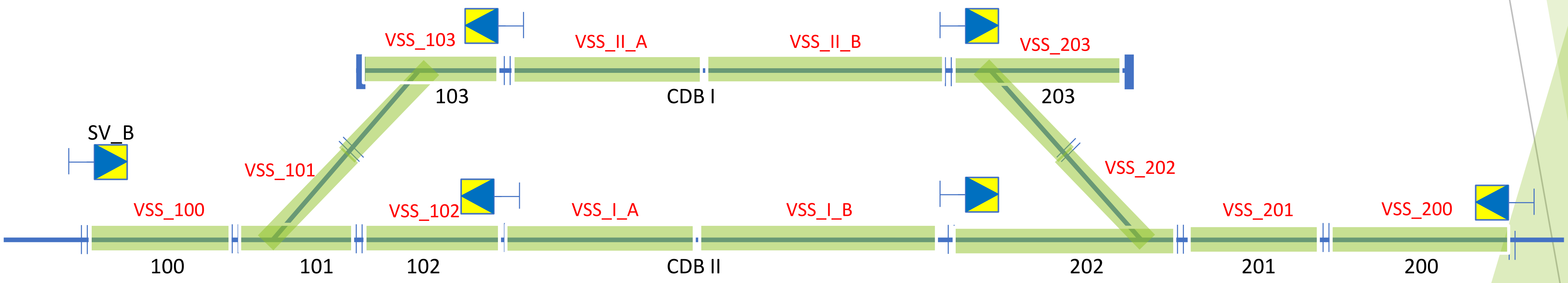
Rules for VSS configuration in station

- VSS are configured inside stations according to the following rules:
  - One VSS covering the extension of the original track circuits, with few exceptions for specific needs: one physical track circuit on a berth track has been split in 2 VSSs;



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Original state machine for HTD

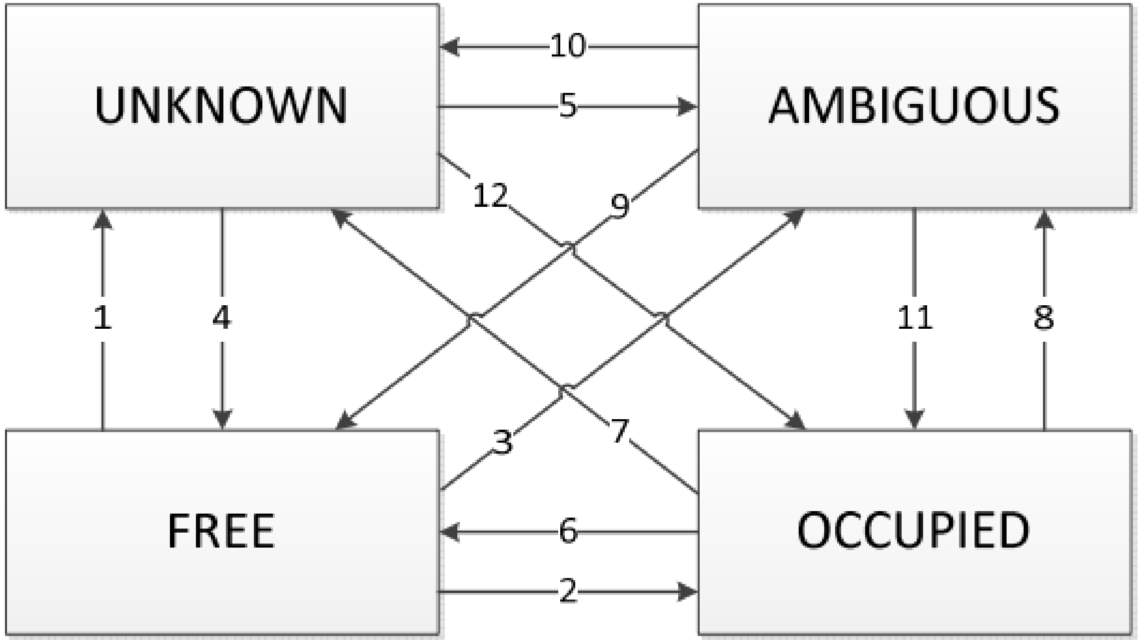

Figure 7: VSS section state diagram

Source: ERTMS/ETCS Hybrid Train Detection Ref.16E042

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Main design principles #1

PLAIN LINE	STATION
▪ VSS FREE: Train enters in Full Supervision ▪ VSS UNKNOWN : Train can enter in On Sight ▪ VSS OCCUPIED / AMBIGUOUS : Train cannot enter with a MA - only SR (after Override EoA) ▪ Start of Mission on VSS UNKNOWN / OCCUPIED / AMBIGUOUS : MA with OS mode	▪ All VSS FREE in a route: Train enters in Full Supervision ▪ At least one VSS UNKNOWN in a route: train runs in On Sight on the entire route ▪ At least one VSS OCCUPIED / AMBIGUOUS in a route: no MA possible - only SR (after Override EoA) ▪ Exception on special routes for joining/parking purposes ▪ First MA after a Start of Mission : MA with OS mode

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Main design principles #2

- Exit Route signal : set to proceed if first VSS in plain line is FREE/UNKNOWN;
- Signal protecting a route does not check the protection status of any LX inside the route or in plain line;

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Main design principles #3

- ETCS trackside supports the operational stop of the train on a passenger stop, setting a temporary EoA at the end of the platform; the EoA is removed and the movement authority extended when the train is detected standstill at the platform;
- Train must approach a standstill train on a berth track, for joining purposes, in SR mode;
- Route release is supported by a “Request to shorten MA” function: route is fully released only if train grants the request to shorten the MA at the signal protecting the route itself; otherwise, the route remains locked;

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Engineering rules

- To support the approaching phase of a train to a stopping point, the following engineering rules and principles have been proposed in the demonstrator:
  - Line Signal : overlap covering the first VSS beyond the MB, release speed calculated onboard ➔ sent to the train only if the VSS is FREE;
  - Station Entry Signal : overlap covering the first VSS beyond the MB, release speed calculated onboard; ➔ sent to the train only if the VSS is FREE;
  - Station Exit Signal : overlap covering :
    - the length of the first VSS beyond the signal in case of no lockable/moveable element located on such VSS, or
    - the distance between the marker board and the position of the lockable element in case it is located on such VSS.
  - Buffer Stops : fixed release speed (*value to be engineered at project level*);

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LX activation / deactivation

- Activation of the LX (barriers down) is performed by ETCS subsystem based on the actual location/speed of the train and the calculation of the minimum approaching time of the train to the LX;
- Only trains with a Movement Authority will trigger the LX activation; activation of a Level Crossing (local/remote) for a train in SR is manual;
- Deactivation of the LX is performed by ETCS subsystem detecting the correct sequence of occupation/liberation of the VSSs close to the LX area, through the elaboration of the confirmed rear end of the train localized beyond the VSS covering the LX area, in the correct direction;
- This innovative method would allow reducing the LX treadles and optimizing the LX blocking time as well;
- Remark: If the automatic deactivation is not possible (e.g. train integrity not available/lost) an alternative operational solution is needed ➔ for each LX a safe manual control should be configured; the command is active only if the VSS under the LX is UNKNOWN;

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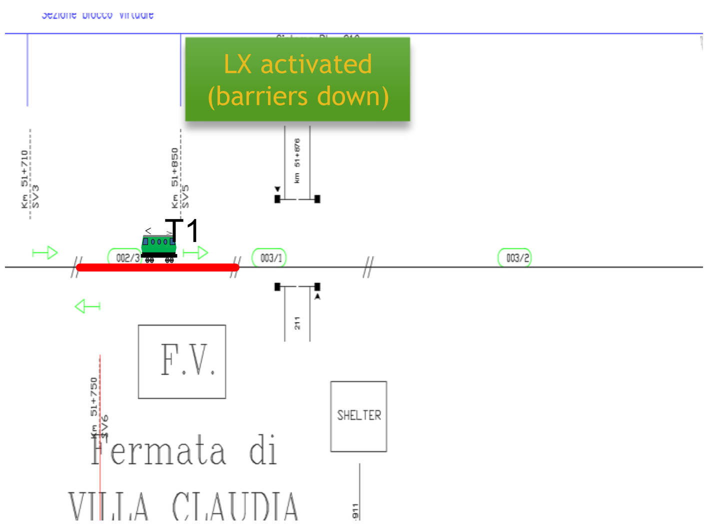
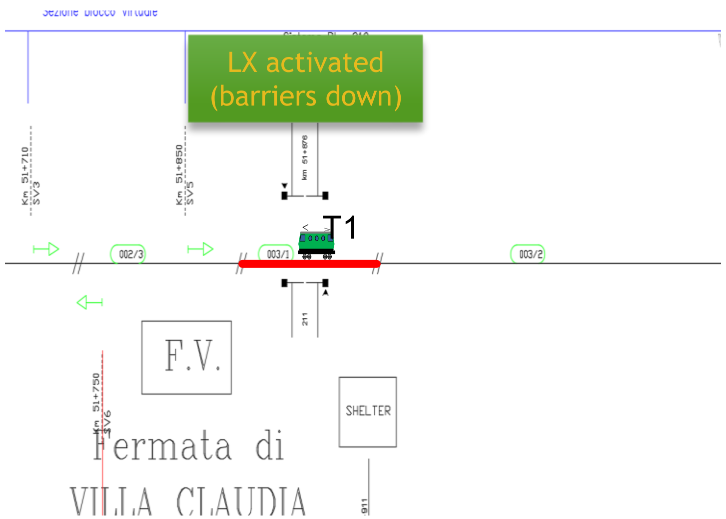
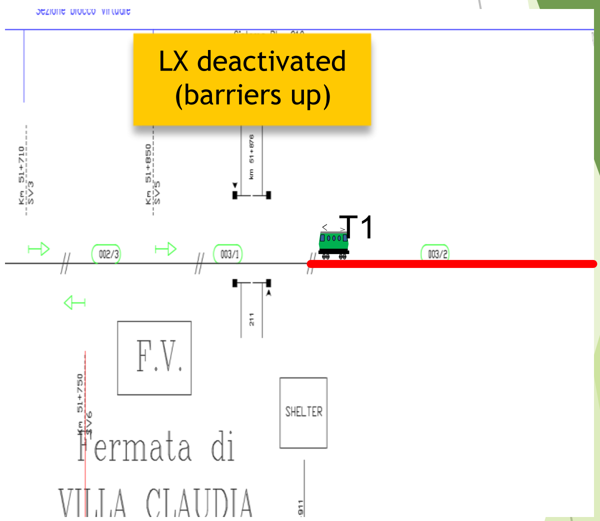
LX deactivation sequence



Step #1



Step #2



Step #3

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Approach to a LX

- VSS FREE:
  - LX protected : FS at full speed
  - LX unprotected : FS at low speed (with packet 88 – *Level Crossing information*) [*]
- VSS UNKNOWN:
  - LX protected : OS at OS speed
  - LX unprotected : OS at reduced speed (with packet 88)
- VSS OCCUPIED / AMBIGOUS
  - LX protected /unprotected: SR after pre-authorized Override EoA at speed imposed by European Instruction. LX **is not** activated automatically in this case by the system

[*] in line with the current status of harmonized operations currently underway in System Pillar – Operational Domain

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Main technical challenges

- Absence of physical trackside train detection devices would necessitate a different VSSs management approach, mainly in the following operational cases:
  - Start of Mission on berth track / siding
  - ETCS trackside subsystem first start-up or controlled shutdown
  - Working Area / Shunting Area hand over to operations
  - Radio disconnections due to Radio Hole
- Level Crossing activation in case of train in SR and Level Crossing deactivation in case of train with train integrity not available / lost;
- ETCS L2 management of remote Level Crossings: how to protect them if LX is controlled only locally?;
- Management of trains not equipped with ETCS and/or without TIMS;
- Uncertainties on how train integrity lost information is managed by TIMS;
- Shadow Train management: could a dedicated safety assessment lead to considered this risk as negligible in a Regional low density operational context? At least on some specific areas?
- What is the optimal trade-off between system simplification and increased operator/staff involvement in operations?

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Enhancements

- Update of VSS state machine

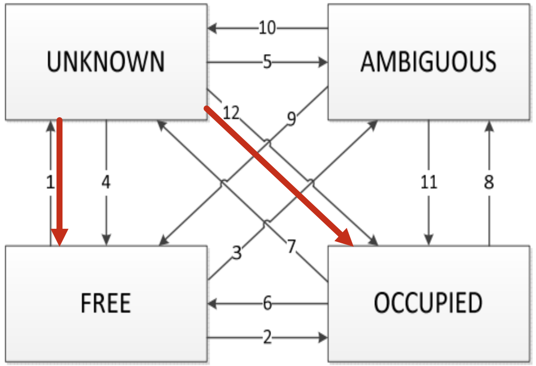

Figure 7: VSS section state diagram

- Train joining to be performed in OS instead of SR, under the assumption that the system applies specific commands for such kind of procedures;
- Management of radio holes;
- Optimization of passenger stops procedure with the involvement of TMS;

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Focus on manual VSS reset

- In some degraded operational scenarios one or more VSS unduly remain UNKNOWN;
- A manual command to recover the nominal condition has been foreseen, with the following constraints:
  - The command is configured only for the VSS without a TTD underneath;
  - The command is accepted only if the VSS is UNKNOWN; not accepted if VSS is OCCUPIED/AMBIGUOUS;
- The command will be executed by the Signaller after a proper checking on the effective freedom of the area covered by the VSS;
- A cumulative command applicable for several VSSs (e.g. one entire station) could be configured;

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Demonstrator’s test environment & architecture

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G1 Regional line's feature

- The real G1 Regional line hosting the demonstrator is the Padiglione-Nettuno line. It is in Central Italy inside region Lazio, not so far from Rome
- Its main characteristics are:
  - Single track line;
  - One single Axle Counter section between 2 adjacent stations;
  - Stations equipped with track circuits;
  - Simple stations, with one siding;
  - Presence of several LXs, both in station and plain line;
  - Presence of operational stops in plain line.

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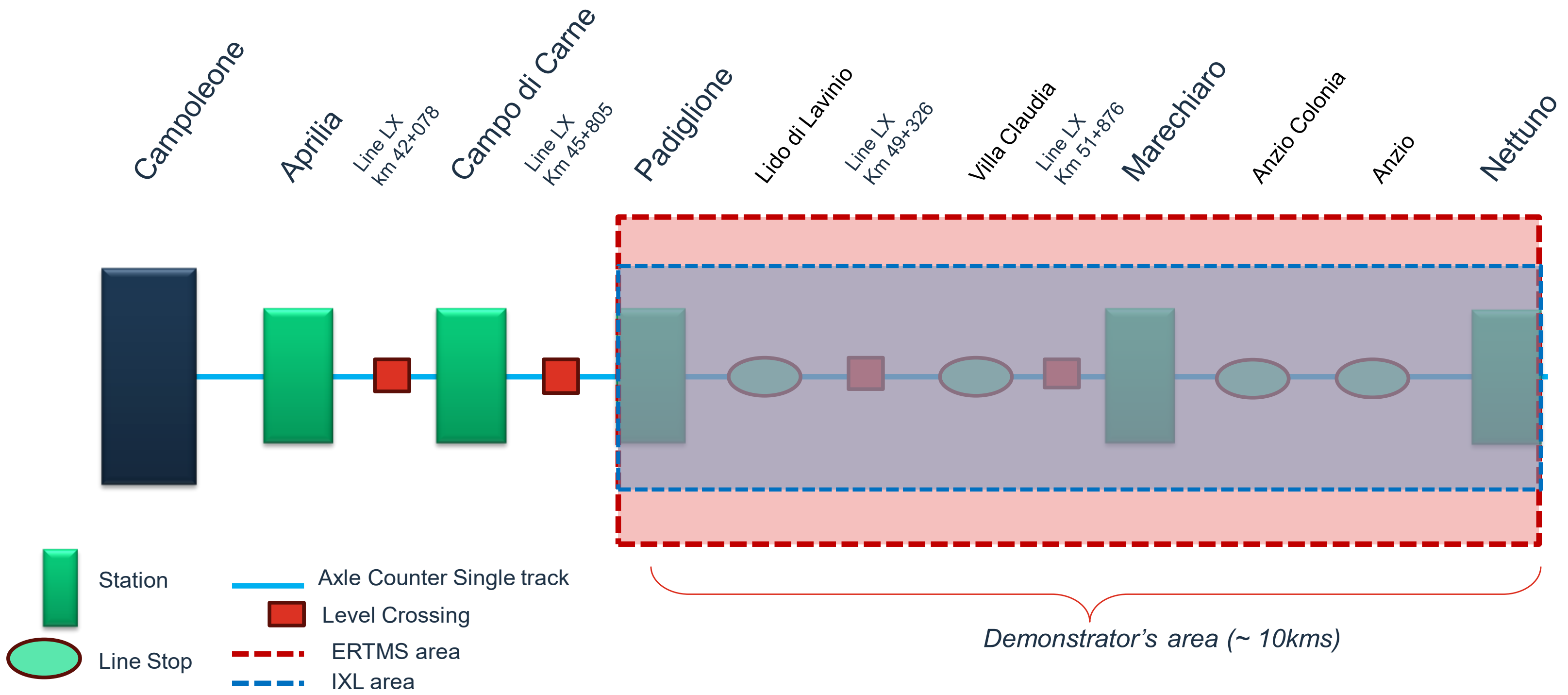
Track layout



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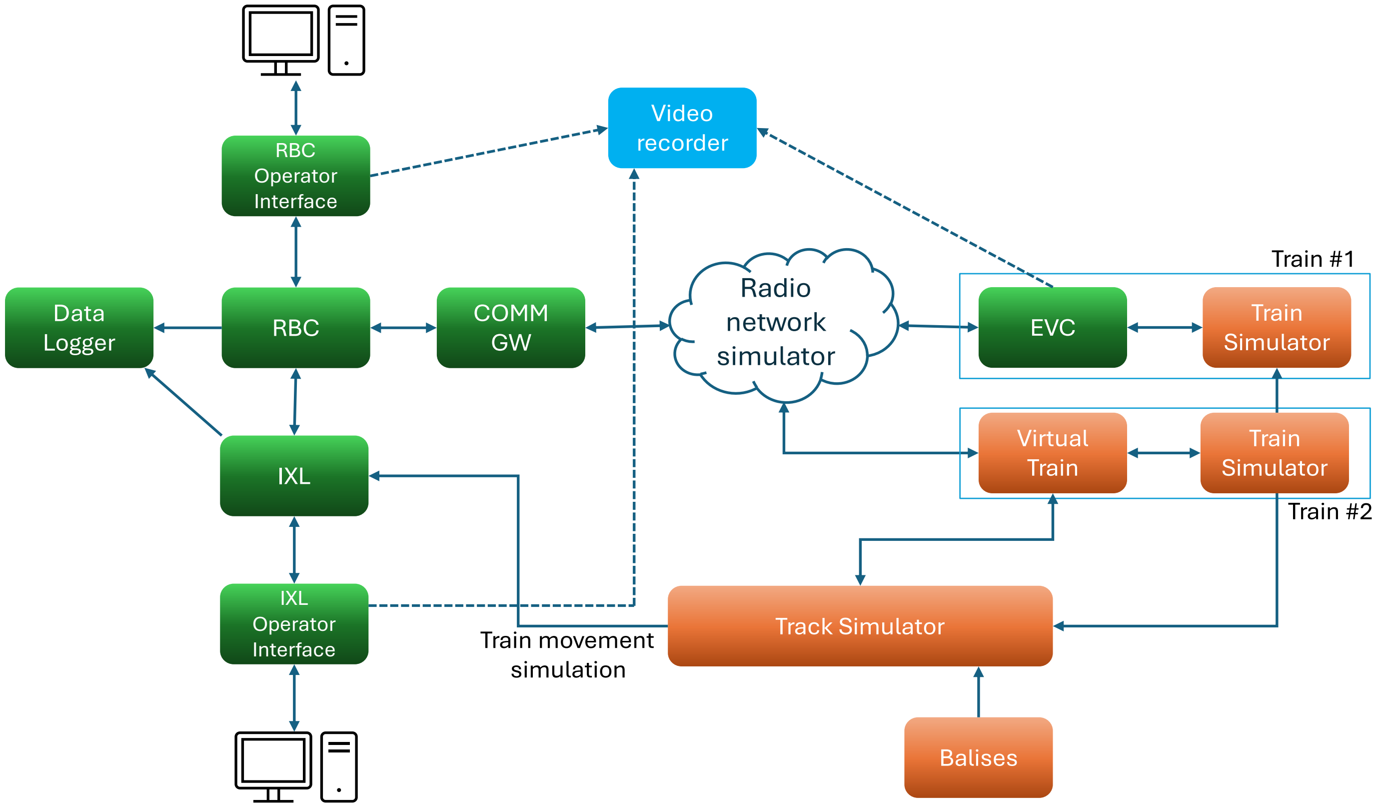
Test bench architecture

RESTRICTED



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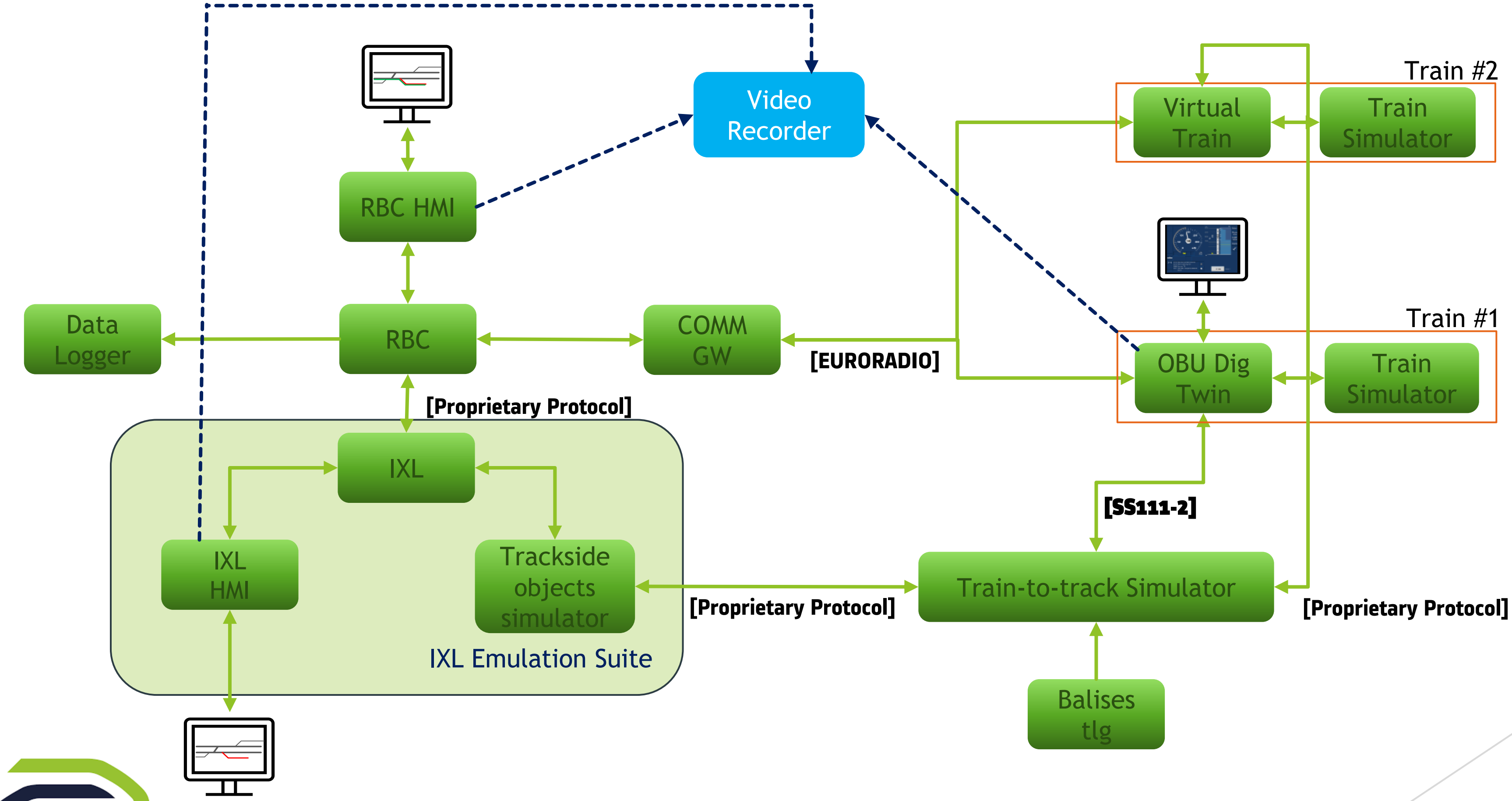
«All-in-one» testbench



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Methods & Tools for Tests reporting

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Methods & Tools

During the execution of each test, the following data have been logged and recorded:

- Log files of RBC
- Log files of ETCS Twin
- Video capture, integrated on one single display, of :
  - Driver's DMI
  - ETCS Trackside operator's HMI
  - IXL Trackside operator's HMI

Test Engineers usually execute the following actions:

- Decoding the RBC log file in a readable format
- Extracting evidences to be reported inside the test report;
- Analysing the videos and identification of any relevant events:
  - For the driver: operating modes and transitions between them, train speed and status of radio communication with RBC, distance from EoA, speed restrictions, track conditions, LX icons, etc
  - For the ETCS/IXL operator: commands executed, train localization (when known), status of VSS, status of routes, status of virtual signals, activated TSRs, train operating mode & speed, status of radio connection, etc.

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Decoded ETCS log files

```
          --- 3.6.0 track => train  :
  Raw => 03 1F C0 00 1D 69 A8 AF AA A1 E8 16 00 1F F8 33 54 10 00 00 03 68 29 04 AB A0 06 04 B0 45 83 2C
                     Nid_Message : Movement Authority                            [3=0x03]
                       L_Message : 127                                  (Bytes)  [127]
                         T_Train : 301.18                                        [30118]
                           M_Ack : Acknowledgement required
                        Nid_Lrbg : 4554069  -> 277_15701                         [4554069]
                --------------------   ----------------------------------------
          Raw => 0x 0F 40 B0 00 FF C1 9A A0 80 00 00    ( LG 11 )
                      NID_Packet : Level 2/3 Movement Authority                  [15=0x0F]
                           Q_Dir : Nominal                                       [1]
                        L_Packet : 88                                   (Bits)   [88]
                         Q_Scale : 10 cm scale                                   [0]
                           V_Ema : 0                                    (km/h)   [0]
                           T_Ema : Infinite                                      [1023]
                          N_Iter : 0
                    L_Endsection : 2628.00                              (m)
                  Q_Sectiontimer : No Section Timer information                  [0]
                      Q_Endtimer : No End section timer information              [0]
                   Q_Dangerpoint : Danger point information                      [1]
                            D_Dp : 0.00                                 (m)
                     V_Releasedp : 0                                    (km/h)   [0]
                       Q_Overlap : No Overlap information                        [0]
                --------------------   ----------------------------------------
          Raw => 0x 1B 41 48 25 5D 00 30 25 82 2C 19 62 4B 22 51 22 C1 83 5F FC 01   ( LG 21 )
                      NID_Packet : International Static Speed Profile            [27=0x1B]
                           Q_Dir : Nominal                                       [1]
                        L_Packet : 164                                  (Bits)   [164]
                         Q_Scale : 10 cm scale                                   [0]
                          N_Iter : 1
                        D_Static : 956.50                               (m)
                        V_Static : 0                                    (km/h)   [0]
                         Q_Front : Train length delay on validity end point      [0]
                          N_Iter : 6
                           * 1
                               Q_Diff : 0
                                 Nc_CdDiff : 1
                               V_Diff : 110                             (km/h)   [22]
                           * 2
                               Q_Diff : 0
                                 Nc_CdDiff : 2
                               V_Diff : 110                             (km/h)   [22]
                           * 3
                               Q_Diff : 0
                                 Nc_CdDiff : 3
                               V_Diff : 110                             (km/h)   [22]
                           * 4
                               Q_Diff : 0
                                 Nc_CdDiff : 9
                               V_Diff : 110                             (km/h)   [22]
```

```
          --- 3.6.0 train => track  :
  88 06 00 00 09 E7 00 00 00 40 00 E4 22 BD E2 80 A8 50 10 60 20 C0 A9 3F
                     Nid_Message : POSITION_REPORT                                       [136=0x88]
                       L_Message : 24                                           (Bytes)  [24]
                         T_Train : 101.40                                                [10140]
                      Nid_Engine : 1                                                     [1]
                --------------------   ----------------------------------------
          Raw => 0x 00 03 90 8A F7 8A 02 A1 40 41 80 83 02 A4 FC
                      NID_Packet : Position Report                                       [0=0x00]
                        L_Packet : 114                                          (Bits)   [114]
                         Q_Scale : 10 cm scale                                           [0]
                        Nid_Lrbg : 4553669  -> 277_15301                                 [4553669]
                          D_Lrbg : 16.80                                        (m)
                       Q_Dirlrbg : Nominal                                               [1]
                         Q_Dlrbg : Nominal                                               [1]
                     L_Doubtover : 13.10                                        (m)
                    L_Doubtunder : 13.10                                        (m)
                        Q_Length : No train integrity information available              [0]
                         V_Train : 25                                           (km/h)   [5]
                       Q_Dirtrain : Nominal                                              [1]
                          M_Mode : Staff Responsible                                     [2]
                         M_Level : Level 2                                               [3]
                --------------------   ----------------------------------------
 Return       (00                          )      MOONAPI_NOERROR                (0)
```

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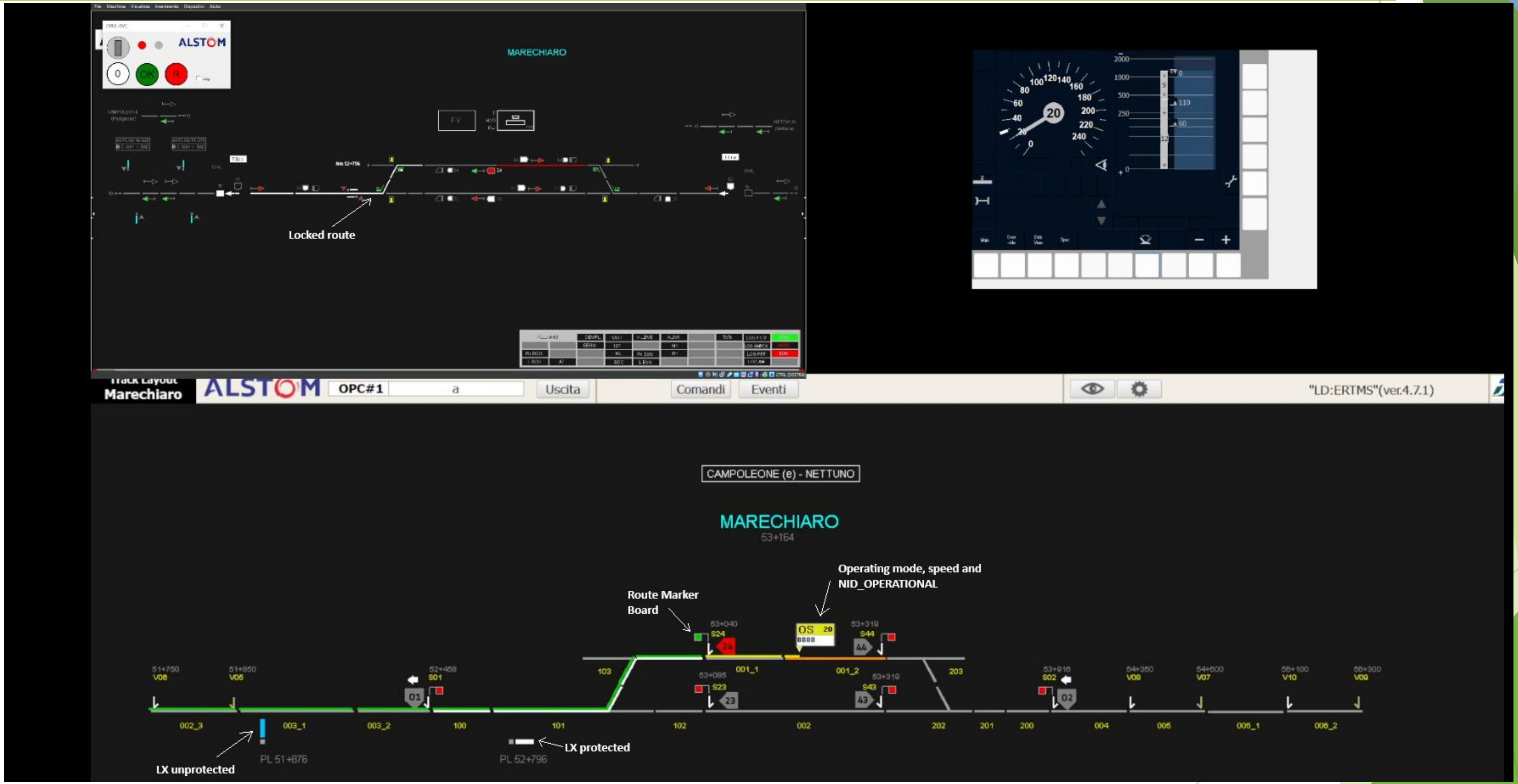
Captured Video #1



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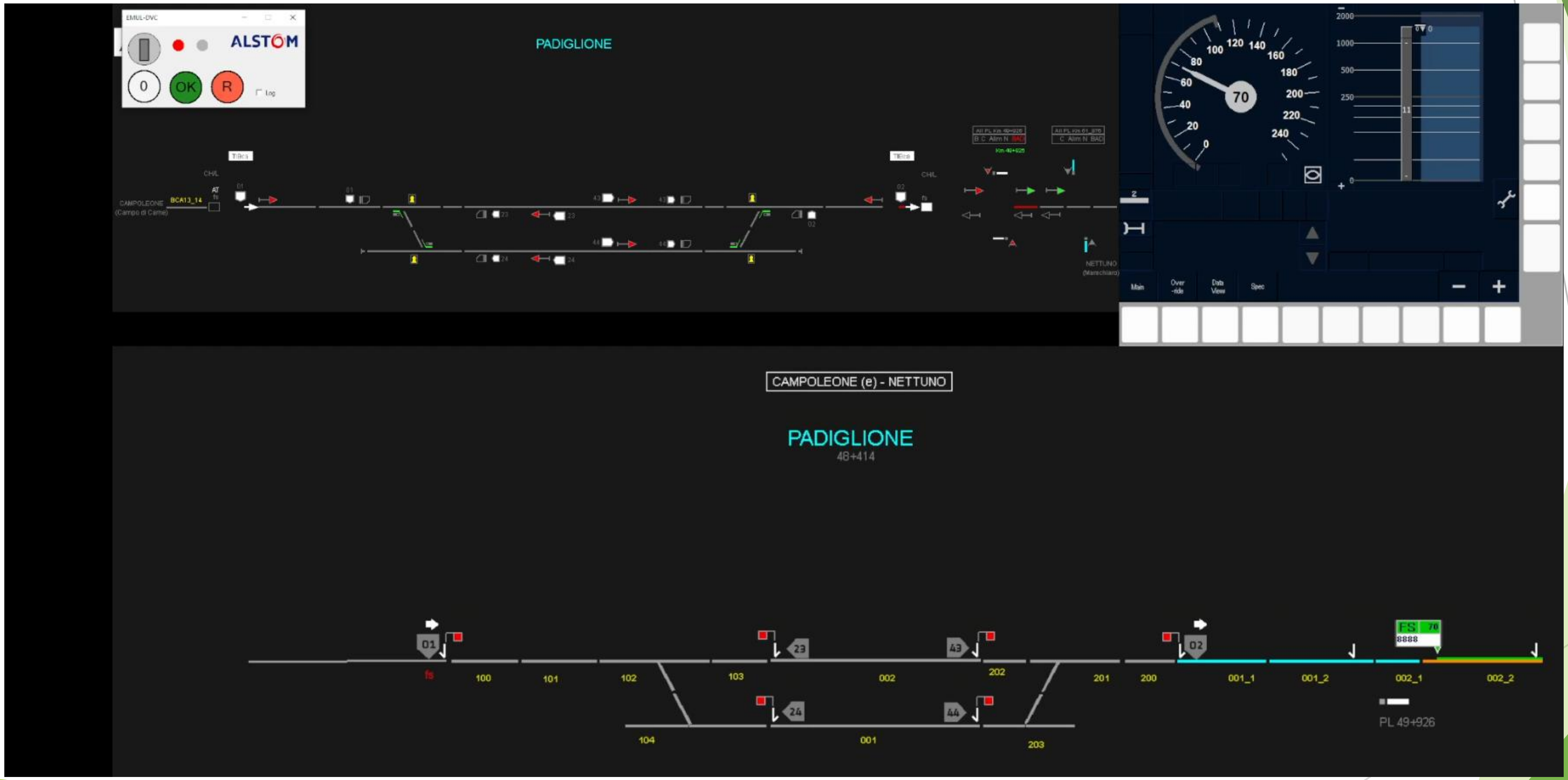
Captured Video #2



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Main Takeaways

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Achievement of TRL 5

According to the following definition:

*“**TRL 5: validation in a simulated environment** → the prototype is tested in simulated environments and contexts that reflect those in which it is expected to be used later. This level aims to demonstrate that the technology also works in real-world conditions; therefore, statistically significant results must be available.”*

It can be stated that:

- The demonstrator has been tested in a lab but using either target hardware or target applications SW running on hosts for both ETCS and IXL subsystems and their HMIs;
- The configuration data are from a real regional line, with the same infrastructure inputs used for the ongoing ETCS L2 project;
- Same basic signalling principles applied as for the real lines, both for train separations and IXL functions.

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Summary list of tests results

Use Case Group	# of tests	Tested	PASS/ FAIL
01_xx - Start of Mission	6	6	PASS
02_xx - Train Movement - nominal conditions	6	6	PASS
03_xx - Completion of the mission	8	8	PASS
04_xx - Degraded operational scenarios	9	9	7 PASS 2 FAIL
05_xx - Radio communication issues	4	4	PASS
06_xx - Level Crossing (LX) management	7	7	PASS
07_xx - Temporary Speed Restriction	2	2	PASS
08_xx - Emergency Stop Request	2	2	PASS
09_xx - Joining / Splitting	2	2	PASS
10_xx - Level transitions / Handover	3	0	N/R
11_xx - Degraded technological scenarios / system faults	5	3	PASS
12_xx - Miscellaneous	9	4	PASS
Total	63	53	51 PASS 2 FAIL

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Main considerations

- The HTD demonstrator achieved a very high level of validation, with most of operational and degraded-mode use cases successfully tested;
- The demonstrator confirmed that architectures based on ETCS L2 and advanced HTD concepts can support regional line operations while significantly reducing dependence on conventional trackside train detection systems;
- The tested solutions demonstrated the capability to maintain safe train separation through Virtual Sub-Sections (VSS), train integrity supervision and radio-based train localisation, enabling a substantial simplification of the signalling infrastructure;
- The demonstrators confirmed substantial progress towards the project KPIs, including reductions in Total Cost of Ownership (CAPEX and OPEX), improvements in system availability, lower maintenance effort per kilometre of infrastructure, this relying on enhanced onboard train integrity and positioning performances;
- The demonstrator also validated innovative ETCS-driven level crossing control concepts, reducing crossing blocking times while maintaining safety and the reduction of recalibration balise groups thanks to the adoption of ASTP-like solutions onboard;
- Areas for future developments and improvements have been identified. These include further optimisation of degraded-modes handling, improved transitions and management of VSS states, and deeper integration between HTD concepts and conventional interlocking systems;

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KPI Assessment

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SEOs & KPIs for Demostrator D8.3

- The following KPIs have been associated to HTD Demonstrator:
  - **SEO/KPI 01** : Overall reduction of the Total Cost of Ownership (CAPEX and OPEX) of the CCS system
  - **SEO/KPI 03** : Increased system availability due to reduced trackside asset failure and more reliable CCS
  - **SEO/KPI 04** : Reliable cost-effective fail-safe on-board train integrity, train length detection and train positioning
  - **SEO/KPI 05** : Overall reduction of OPEX and CAPEX
  - **SEO/KPI 08** : Reduced OPEX costs/km for trackside railway assets

For all the SEO/KPIs the selected type of assessment is : **QUANTITATIVE**

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Summary Table

SEO/KPI Identifier	Expected improvement
SEO/KPI 01 Overall reduction of the Total Cost of Ownership (CAPEX and OPEX) of the CCS system	-15%
SEO/KPI 03 Increased system availability due to reduced trackside asset failure and more reliable CCS	-10%
SEO/KPI 04 Reliable cost-effective fail-safe on-board train integrity, train length detection and train positioning	-15%
SEO/KPI 05 Overall reduction of OPEX and CAPEX	-15%
SEO/KPI 08 Reduced OPEX costs/km for trackside railway assets	-30%

N.		Contribution (% reduction)
1	Reduction of track circuits in station (§ 6.1.7.6)	~45%
2	Replacement of track circuits with AxCo sections in station – best performant case (§ 6.1.7.8.1)	~60%
3	Replacement of track circuits with AxCo sections in station – best operational case (§ 6.1.7.8.1)	~50%
4	Station and Line Level Crossings equipped with overlay track circuits (§ 6.1.7.8.1)	100%
5	Plain line with single AxCo section	Not predictable but relevant
6	Plain line with N AxCo sections	Relevant benefit - from N to 1 but contribution not predictable
7	Reduction of Level Crossing treadles	At least 80%, if removal applied only to line LXs
8	Reduction of Balise Groups [1]	~20% (demo line) ~55% (other line)

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Tests Witnessing

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Selected set of tests

- Nominal run (including LX activation / deactivation)
- LX missing deactivation after train passage
- Train integrity not available
- Operational Stop in plain line
- Start of Mission – Line / Known position
- Joining / parking
- Arrival at buffer stop

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Questions & Answers

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