OCORA

Open CCS On-board Reference Architecture

Proof of Concept “Train Display System”

Concept description

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Revision history

Version	Change Description	Initial	Date of change
1.00	▪ First version	GH	01.07.2024

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1 Context

OCORA has initiated work to standardize the TDS. It is performed as part of a WP on the TWS01 Architecture and has started beginning of 2022. The first results are contained in the document OCORA-TWS01-201_Train Display System - Discussion Paper.pdf as part of the OCORA Release 4 and Release 5.

This discussion paper describes the first concepts of the TDS:

- Function allocation between TDS and Systems (EVC, TCMS, CVR…).
- Preliminary architecture proposal submitted to Industry.
- Logical concepts for sharing the displays between different systems (TCMS, ETCS, Voice Communication, others…).
- Definition of major software and graphical components.
- Management of degraded modes.

OCORA aims at having these concepts being integrated as part of a TSI or as part of a Standard.

The industry is also interested in this standardization so that they can broaden the number of suppliers for these components. In fact, TDS should ensure a clear separation between systems and displays. This will allow the use of displays from different suppliers.

ERJU and ERA meanwhile require that new elements shall be mature enough so that they can be included in a Standard or TSI.

The supply of documents such as FFFIS, SRS and demonstrators are key elements to demonstrate the maturity.

The demonstrators can be implemented as part of the Innovation Pillar or outside of this program.

It is proposed to initiate POCs on the TDS.

2 POCs and their objectives

The current work performed by OCORA is at the stage of defining concepts and preliminary architecture.

This work is today not sufficiently detailed and mature enough to be able to start writing detailed technical document such as a FFFIS.

Besides, this work is currently performed only by Railway Undertaking without the support of the industry. It is essential that the industry and suppliers endorse the approach to design and industrialize the TDS. Therefore, it is essential to share the results with the industry or better to involve them in the realization of the POC.

It is suggested to perform a 2-step POC:

POC #1: Feasibility of the Concepts proposed by OCORA

- Demonstrate the feasibility of the concept drafted by OCORA.
- The aim of this POC is not to validate the functions of the applications.
- Involve, if possible, some suppliers in the realization of this POC.
- Provide the results to the System Pillar Train CS Domain to convince of continuing in this direction: redaction of FFFIS / SRS ….

The PoC 1 should last the whole year 2024.

Depending on the results of PoC 1, the PoC 2 may also start in 2024.

POC #2: Prototyping for the sake of inclusion in TSI or Standard

- Prototyping with Industry according to the detailed specification (FFFIS, SRS…)
- Promote evidence of the maturity: test specifications, test reports.

3 Overview of the POC #1

3.1 Concepts to be demonstrated

The purpose of the POC will be to demonstrate the TDS concepts developed for OCORA Release 5.

The first requirements to be demonstrated, as expressed in the TDS discussion paper, are “Modularity” and “Active Configuration”. These requirements are listed below as a reminder.

OCORA-10017, D-Level – Modularity
The TDS shall enable systems to link all their input/output to any touch/display panel based on a pre-approved configuration.

Status	In Review
Classification	Requirement
Rationale	• Enhance flexibility for configuration • Rationalise the number of display panels in the cab for space and costs saving
Category	Functional
Acceptance Method	Design Review
Acceptance Criteria	-
Remark	Limitation to physical characteristics

	The modularity concept should be weighted depending on the pre-approved configuration ([OCORA-10015]) which takes under consideration the location of the display panel in the cab. Indeed, some systems could be only displayed in some location (e.g. ETCS in front of the driver).
Linked Work Items	has parent: OCORA-10289 - General requirements , defines: OCORA-7587 - Train Display System (TDS) , is refined by: OCORA-10280 - Control the flow and layout elements , is refined by: OCORA-10282 - Generate View

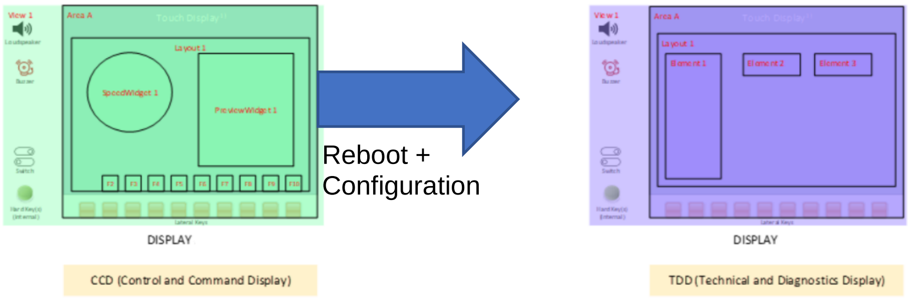
OCORA-10015, D-Level - Active configuration
The TDS shall set the active configuration automatically (by events) or manually (by the driver) among a list of preapproved configurations.

Status	In Review
Classification	Requirement
Rationale	Only one configuration is active at a time.
Category	Functional
Acceptance Method	Certification
Acceptance Criteria	-
Remark	TDS should consider a nominal configuration by default and other configurations when required: - Nominal configuration (with all systems and HMI elements operational) - Event based configuration (e.g. driver selection, train in motion/at standstill...) - Degraded configurations (in case of system or HMI element failure) The configuration shall take under consideration the mandatory systems for operation (e.g. ETCS in a front location) and the optional systems. For each system, an evaluation of the possible location on the desk shall be performed with the associated events. The driver can select only pre-approved configuration. In case of failure, the TDS shall switch the active configuration in a fully transparent way for systems. This reconfiguration shall not require a reboot of TDS, systems or HMI elements.
Linked Work Items	Has parent: OCORA-10289 - General requirements , defines: OCORA-7587 - Train Display System (TDS) , is refined by: OCORA-10285 - Manage configuration , is refined by: OCORA-10286 - Failover configuration

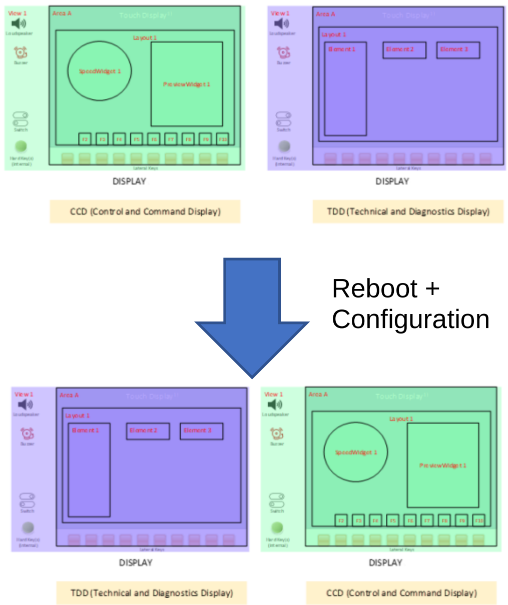
This POC will consider a single architecture as a basis. This architecture may not be the final one. In fact, the selection of the final architecture is still ongoing in the specification work package of OCORA. Furthermore, the selection of the architecture is OCORA's view, but has to be shared with industry as part of dialogue with the DMI suppliers and through the dialogue with the Train CS domain WG on the subject.

The purpose of the POC is not to demonstrate all possible application use cases and all possible associated screens. Few use cases would be sufficient to demonstrate the concepts. The following use cases would be demonstrated:

<u>Use case 1:</u> The ability to display the specific view of any system on a single display (modularity requirement). In a first step, the change of view would be done by rebooting the TDS and powering up a single system. The reboot and configuration are done manually by a tester.



<u>Use case 2:</u> The ability to manage a nominal configuration (active configuration requirement).
Two systems have to be displayed on different displays in relation to a preapproved configuration. For example, system A on display 1 and system B on display 2.
In the absence of power, a configuration file could be modified to show system A on display 2 and system B on display 1. The reboot and configuration are done manually by a tester.

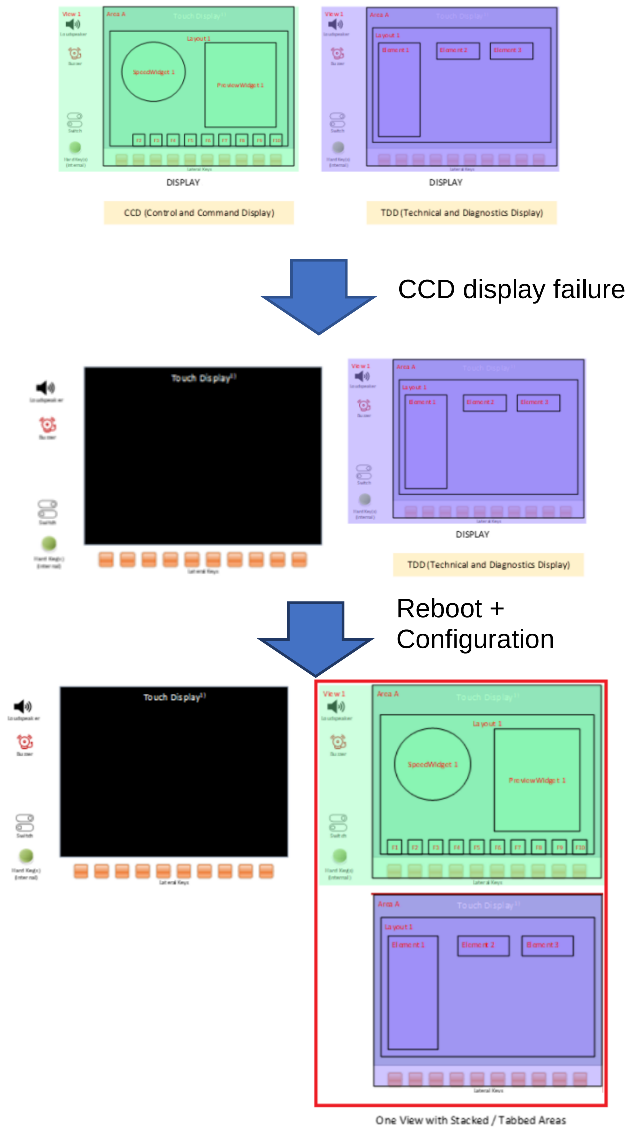


<u>Use case 3:</u> The ability to manage a display failure (active configuration requirement).
If a display supporting a mandatory system fails, TDS shall reallocate the system's view to another display used by an optional system.
For instance, mandatory system A uses display 1 and optional system B uses display 2. If display 1 becomes unavailable, TDS will apply a degraded configuration. System A will use display 2 and system B's view won't be displayed.

The failure and reboot commands are done manually by a tester. The reconfiguration is done automatically by the TDS.

a) Use case 3.1: Cold redundancy.

Closely related to Use Case 2, in the event of a fault, reconfiguration should be performed when all systems are shut down. In a train, for example, the driver can activate a switch to change the configuration and restart all systems and the TDS. In other words, the TDS doesn't manage health monitoring of TDS units and systems. The master Display Manager only considers an external logical input that is activated by tester. The ergonomy applied to inform the driver about the presence of a stacked view will be a rectangle displayed on the top right of the view. When present, the driver will be able to swap the view by a command (touch the screen or external button activation: to be discussed).

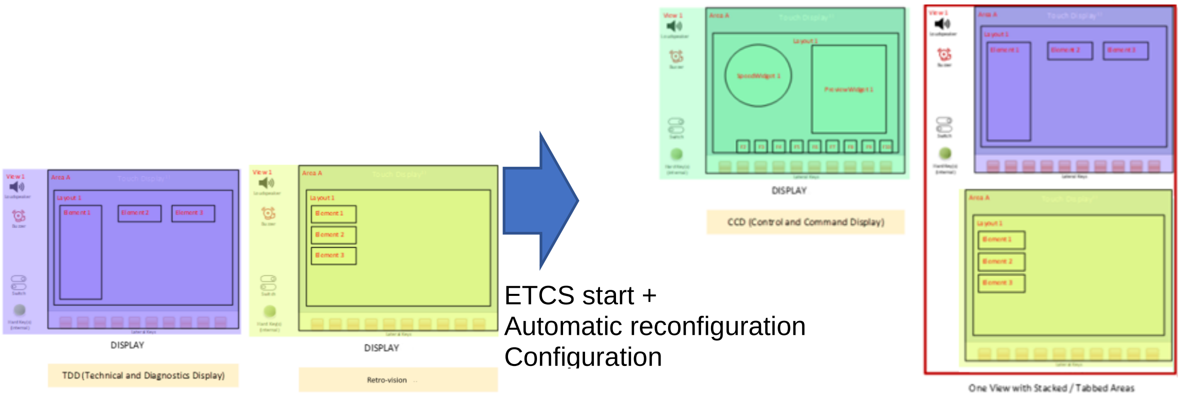


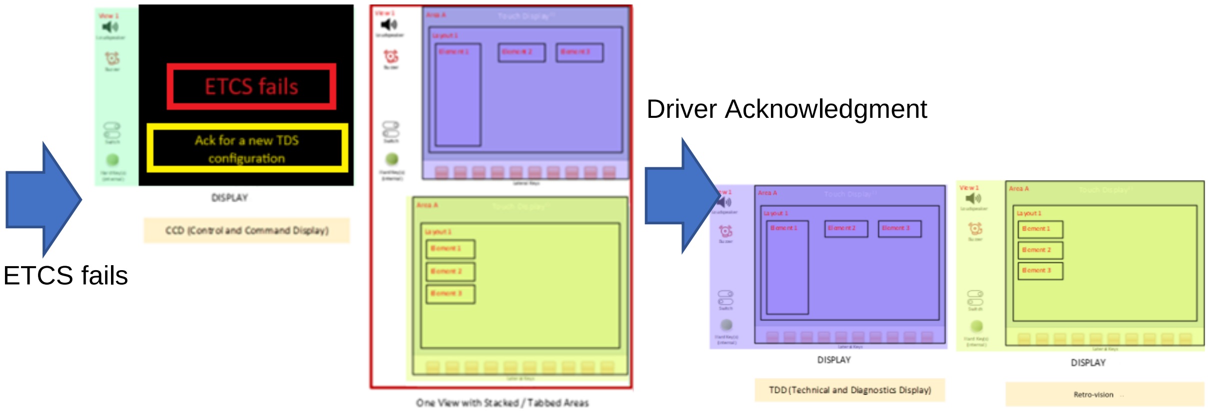
b) Use case 3.2: Hot redundancy

As in Use Case 3.1, reconfiguration is required in the event of a failure. In this Use Case, the reconfiguration is performed automatically by the TDS without disturbing the systems. In other words, the TDS manages health monitoring of TDS units and systems. Depending on their states, TDS selects the appropriate configuration and applies it. In this use case, no driver action and systems reboot are needed.

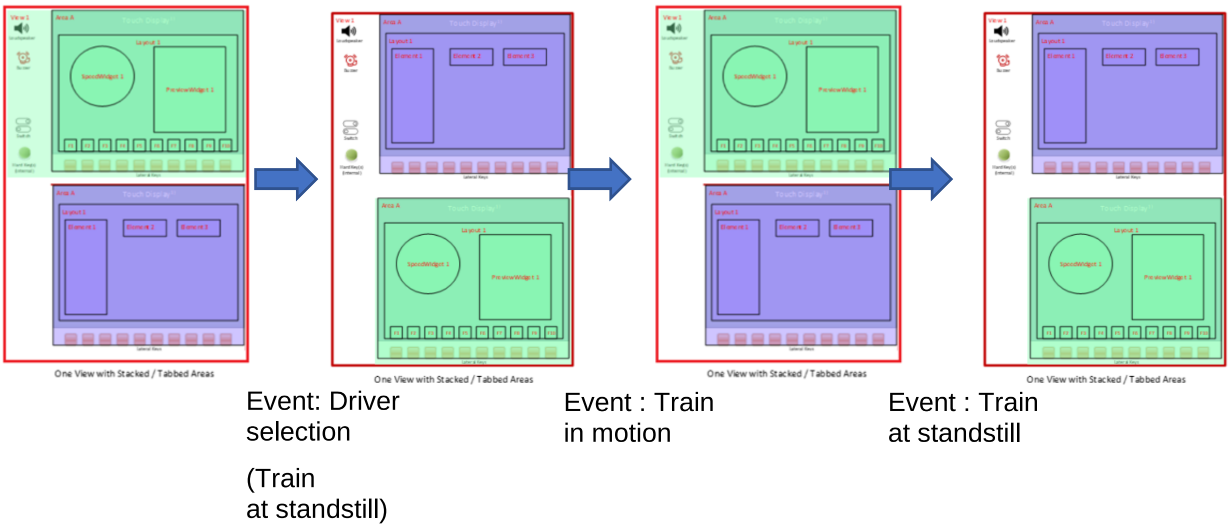
<u>Use case 4:</u> Reconfiguration on a system start or failure

In this use case, three systems (ETCS, TCMS and rearview system) are considered, even though only two displays are present. The aim of this use case is to show how an event can affect several displays in series (cascade reconfiguration). First, the ETCS is in No Power, TCMS and Rearview system use existing displays. Then ETCS starts by means of a command from the tester. As ETCS is a mandatory system, configuration shall automatically adapt to display it. So TCMS view is moved to the right screen and rearview system view is stacked behind it. If ETCS fails, TDS shall warn the driver. When driver acknowledges this information, a new configuration is applied.





Use case 5: Reconfiguration depending on events (driver selection or external events).
With two systems using a single display, the configuration could be changed depending on driver selection or events related to speed (detection of standstill or motion).
For instance, if a system A shall be displayed in motion, the configuration shall change in case motion is detected and if system B is originally displayed.



3.2 Systems

To support the use case demonstrations, at least three systems need to be implemented.

- ETCS system should be considered as a minimum, since this work is performed in relation to Task 2 of System Pillar related to CCS. Since the release of TSI CCS 2023, it is proposed to display ETCS information according to ERA_DMI_15560 version 4.0.0. A touch screen display is considered. One scenario is presented as mission in ETCS level 2 with speed increase and decrease.

Figure 1: ETCS mission in level 2

In this PoC, for ETCS mission in level 2, only the speed pointer (analog and digital) is developed using dynamic data. Other elements will be static. The aim is to represent a train in motion, then to decelerate until the train stops.

The communication protocol between ETCS and TDS follows the subset 121 version 4.0.0.

- A second system such as Cabin Voice Radio, FRMCS or TCMS would be welcome. After discussion, the simulation of TCMS was chosen. In fact, this system is mastered by the SNCF and gives better visual effects with ETCS. SNCF therefore proposes to show the Technical Diagnostic Display (TDD) view of a 25kV electric Regiolis.

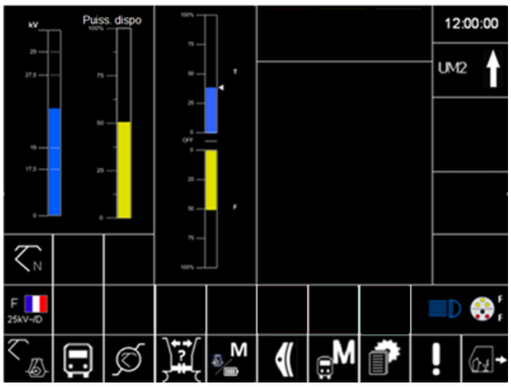


Figure 2: Regiolis TDD view

Icons and data considered are:
  - States of front and rear lights (static icon)
  - Pantograph selection and state (static icon)
  - Number of consists in train Single/Multiple Units + direction of travel (static icon)
  - Time (dynamic data)
  - Traction effort (dynamic data)
  - Electrical power in catenary (dynamic data)

Two options are considered for the communication protocol between TCMS and TDS. The first option is an extension of Subset 121. The aim is to find out if there are synergies between process data and message data used for ETCS in the context of other systems (e.g. connection...). The second option is to use another standard, to be discussed (e.g. HTTP). Both options should be tested in order to provide feedback on the most suitable option for OCORA workstream definition.

In addition, the PoC is considered in the context of new trains compliant whit CCN where TCMS can directly communicate to TDS. In case of a gateway between CCN and TCMS, or TDS integration in a legacy train with a train adaptor for CCS (FVA), latency behavior should be introduced to improve the meaningfulness of the system. Since time-sensitive networks can afford latencies of 10 to 500 us (0,01 to 0,5 ms), the latency behaviour should allow latencies in the range of 0 to 1000 us (500 us * 2). The aim is to analyse the impact of such latency on TDS functionality even for non-time sensitive networks.

- The third system to be implemented is the Rearview system, which displays the lateral doors when train is at standstill. For the sake of simplicity, this will be only implemented by using a static picture when the train is at standstill. When the train is in motion, no view is displayed.

Figure 3: Rearview system view

The communication protocol and latency problems are identical to TCMS information.

- For all of these systems, the same ergonomics shall be applied in case of views stacked on the same display. A solid square or rectangle should be added on the view presented. The position of this information shall be on the top right of the view. For instance, the square or rectangle could be on D14 cell for ETCS view.

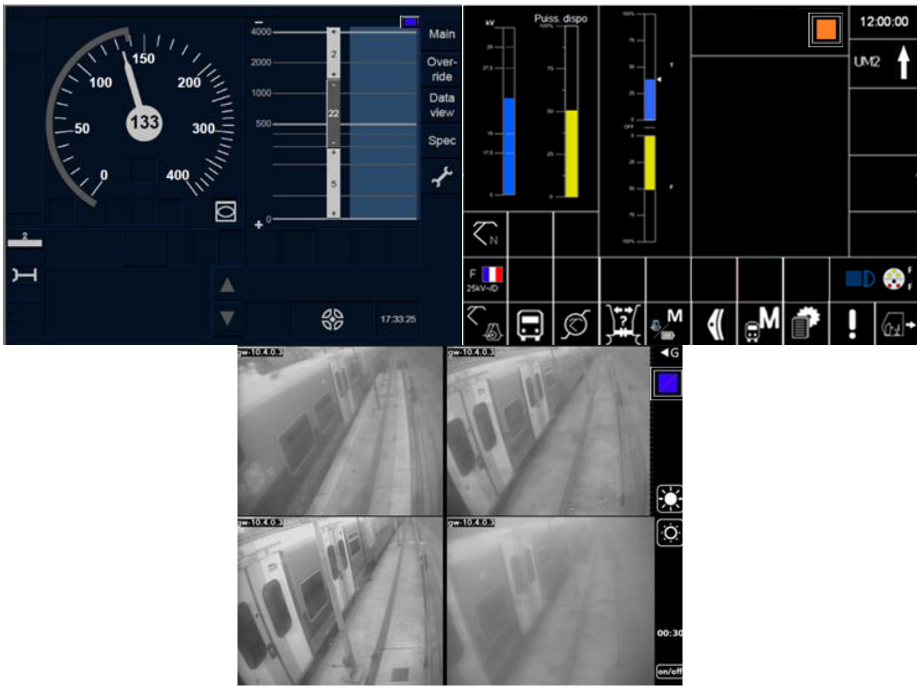
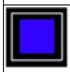
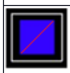
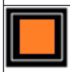
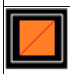
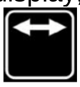


Figure 4: ETCS, TCMS and Rearview system views stacked with another view on the same display

The meaning of this information is given below.

Single screen button	**Size**	**Description**
	30*30	Swap possible No warnings on other view(s)
	30*30	Swap **not** possible No warnings on other view(s)
	30*30	Swap possible Warnings on other view(s)
	30*30	Swap **not** possible Warning on other view(s)

For touch display, pressing the button leads to a swap. For softkey display, the button K1.10 could be used to perform this swapping action as it is already defined in UIC 612-01. 

3.3 Use of the CCS One-Common Bus

The TDS could possibly use the One-Common Bus as a means of communication with EVC.

Therefore, implementing the one-common bus on this POC could be an opportunity to test an actual application, the TDS, that uses this bus.

However, the one-common bus is currently under development until mid-2024 regarding the Network Foundations and basic functionality and until mid-2026 regarding the network management functionality.

It is suggested to not consider the One-Common Bus development in the TDS POC because they will be both developed at the same time. The specification on layer 6 of the One Common Bus might impact implementation at the application level.

In a first step, the TDS would not consider the results of IP WP23 and 24. It would consider the use of proprietary format or other standards for data transmission (TRDP for instance could be a candidate, DEUTA intends to use this format). The implementation of layer 6 according to WP 23 & 24 would be done at a later stage.

Recall of the Communication layer:

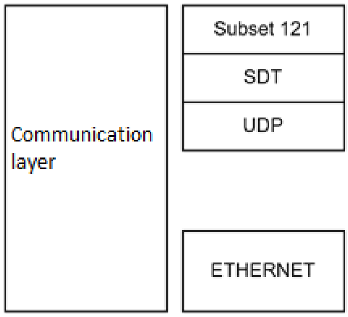


Figure 5: Communication layer

3.4 SIL demonstration

For the sake of simplification, it is proposed to not consider any SIL constraint for this POC. In fact, the aim of this PoC is to demonstrate how configuration, swapping function works. SIL capabilities are only requested for systems. Thus, it is not relevant to develop them in this first PoC.

It is suggested to address the SIL level in POC #2.

3.5 Logical configuration

Following the architectural choice made in the OCORA specification workstream, the POC aligns its logical development to evaluate this choice. The aim is to demonstrate the feasibility of this architectural choice and to point out mandatory requirements or recommendations for its realisation.

In yellow, Systems and Presentation logics elements are represented. These elements are modelled with Simulink.

In orange, display manager and layout engine from TDS are depicted. Requirements related to these last elements are included in the TDS discussion paper of the OCORA specification workstream version 3.

As required in chapter 3.2, the communication between system model and a Layout Engine is subset 121 compliant for ETCS. For TCMS, two options are available: extend subset 121 or use another standard.

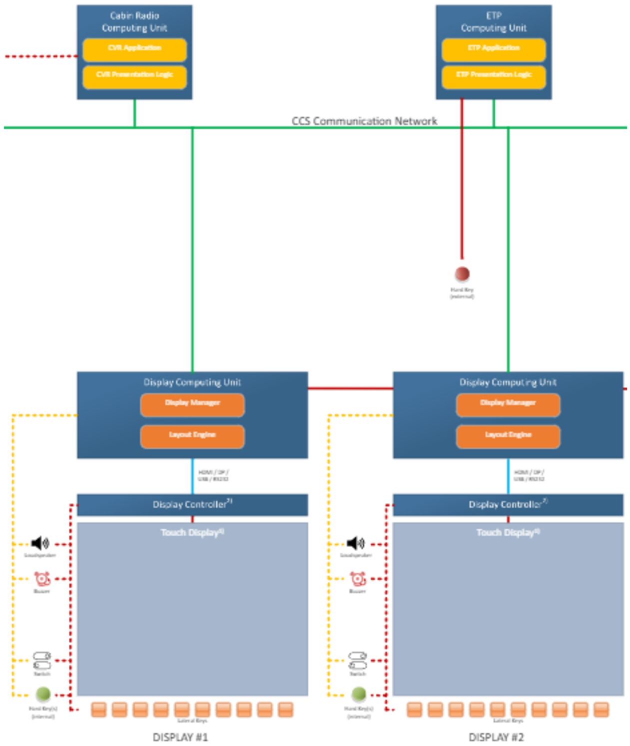


Figure 6: Logical architecture

3.6 Proposed hardware configuration

The following schematic gives the hardware configuration used for the PoC.

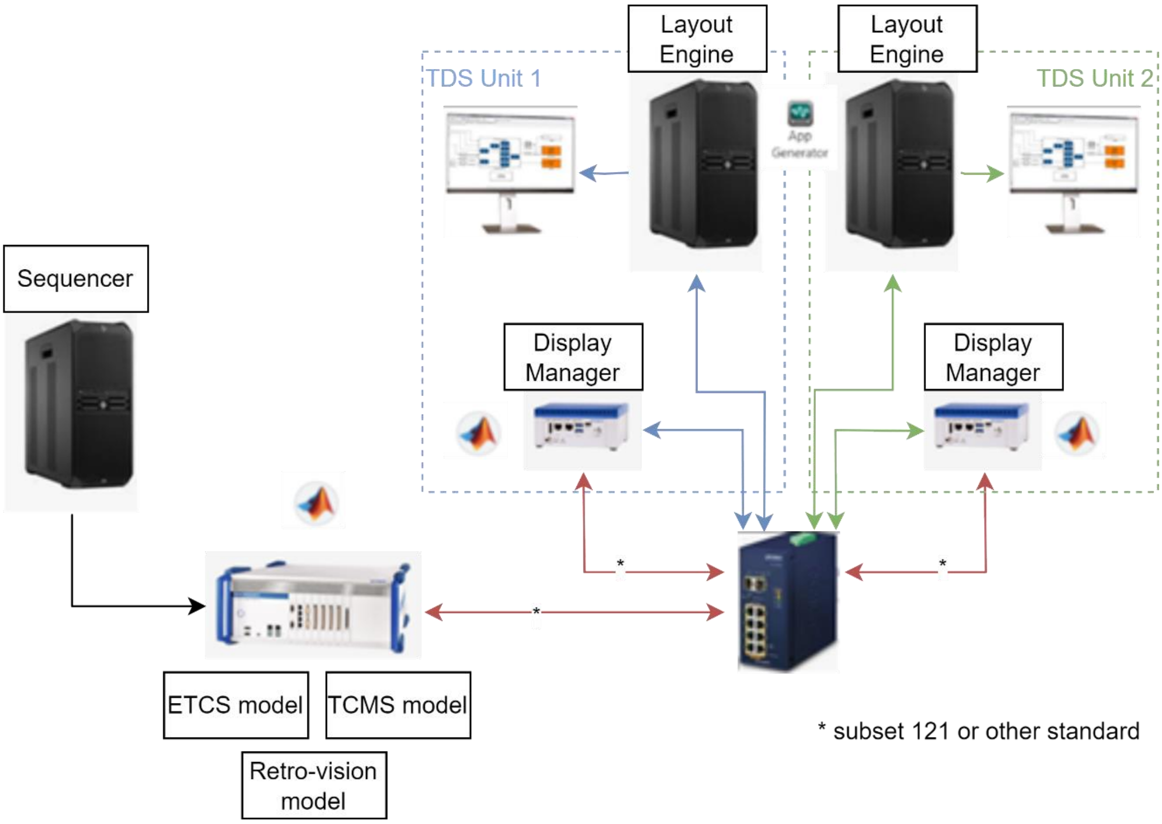


Figure 7: Hardware configuration

3.6.1 Systems

The use of a genuine System (such as EVC or TCMS) is not needed. Indeed, there is a need of managing only a few use cases (Data entry and Start of mission for instance). Thus, the use of a simulator like Simulink is sufficient to manage the associated data exchanges.

These systems are modelled and hosted in Mobile Real-Time Target Machine, Speed Goat: Allows to run Simulink model (ETCS and TCMS) in real-time. See following link for information: https://www.speedgoat.com/products-services/real-time-target-machines/mobile-real-time-target-machine

3.6.2 TDS units

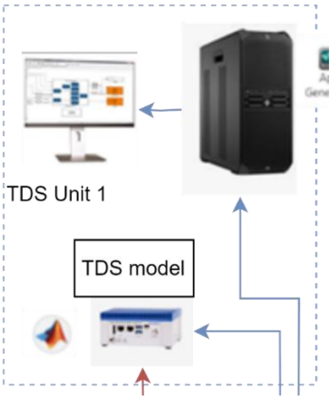


Figure 8: TDS unit

The TDS unit consists of three pieces of equipment that enable an image to be rendered: a real-time target, a generic PC and a display.

Real-time target:

The Real-time target unit is a hardware device. It hosts one TDS model generated by Simulink and provides all the facilities to communicate with the hardware used by the systems and the generic PC.

It hosts the display manager and a part of the layout engine.

Generic PC:

As the real-time target unit can't generate a view, the generic PC is needed. It contains all the elements to create the appropriate view required by the TDS model and send it to the display panel.

This generic PC partly hosts the Layout Engine (view generator).

Display Equipment:

To simplify the development, two display devices are considered for the PoC.

1) Firstly, the display devices are casual PC screens of 24'' or 27''. These screens are directly connected to the generic PC.
2) Secondly, it is suggested to use displays as close to displays in the train as possible. So, 10'' displays will be purchased to increase the meaningfulness of the PoC.

In both cases, a single display is present in the test setup. Two displays are needed to demonstrate the principles developed by OCORA (use cases 2, 3 and 4).

- A single display is sufficient to demonstrate the modularity: One display can show information from several applications.
- A second display is required to demonstrate a nominal configuration, a degraded configuration (e.g. display failure) and an event-based configuration.