

OCORA

Open CCS On-board Reference Architecture

Train Display System (TDS)

Discussion Paper

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Management Summary

In today's cab architecture, there are at least three main screens in a cab supporting three systems: European Train Protection (ETP), Train Control and Management System (TCMS) and Cabin Voice Radio (CVR). Each screen is usually dedicated to one system. The screen embeds only one business logic to enable data exchange with the appropriate system and elaborates the associated view. This paradigm leads to two main pitfalls:

- Firstly, a screen failure will result in a loss of the system. For instance, if the ETP's DMI fails, the ETP will go into system failure and apply an emergency brake. This will cause a delay to the train and can affect all the trains on a line. The availability of the screen is therefore a key factor in the overall availability of the train and the line.
- Secondly, space in the cab is limited especially since ergonomics for the driver needs to be ensured. By introducing new functionalities with the OCORA architecture, new building blocks and services (DAS, MDCM-OB, UID-Reader...) may require space for their dedicated screen... However, the introduction of new display panels in both existing and new trains can be difficult for integrators due to the lack of space.

To solve these problems, OCORA is proposing the introduction of a new building block in line with the vision of ERA/European Commission for the future of the CCS-OB: the Train Display System (TDS). Other needs are also expressed with the introduction of TDS such as management of multiple systems on one display...

The second version of this document consolidates TDS requirements and architectural analysis. It introduces operational and functional analysis and gives a cross-industry analysis of displays.

Revision History

Version	Change Description	Initials	Date of change
1.0	Official version for OCORA Release R4	GH	23.06.2023
2.0	Official version for OCORA Release R5 affords <ul style="list-style-type: none"> • Operational analysis introduction • Requirements supplements • Functional analysis introduction • Architecture analysis supplements • Cross-industry analysis of displays • Train CS domain review 	GH	23.11.2023
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References

Reader's note: please be aware that the document ids in square brackets, e.g. [OCORA-BWS01-010], as per the list of referenced documents below, are used throughout this document to indicate the references to external documents.

Wherever a reference to a TSI-CCS SUBSET is used, the SUBSET is referenced directly (e.g. SUBSET-026). OCORA always reference to the latest available official version of the SUBSET, unless indicated differently.

[\[OCORA-BWS01-010\] – Release Notes](#)

[\[OCORA-BWS01-020\] – Glossary](#)

[\[OCORA-BWS01-030\] – Question and Answers](#)

[\[OCORA-BWS01-040\] – Feedback Form](#)

[\[OCORA-BWS02-020\] - Program Slide Deck](#)

[\[OCORA-BWS02-030\] - Technical Slide Deck](#)

[\[OCORA-BWS02-040\] - Program Posters](#)

[\[OCORA-BWS02-050\] - Technical Posters](#)

[\[OCORA-BWS03-010\] - Introduction to OCORA](#)

[\[OCORA-BWS03-020\] - Guiding Principles](#)

[\[OCORA-BWS04-010\] - Problem Statements](#)

[\[OCORA-BWS05-010\] - Road Map](#)

[\[OCORA-TWS01-010\] – Design Requirements](#)

[\[OCORA-TWS01-011\] – System Requirements](#)

[\[OCORA-TWS01-020\] – System Capabilities](#)

[\[OCORA-TWS01-030\] – System Architecture](#)

[\[OCORA-TWS01-035\] – CCS-On-Board Architecture](#)

[\[OCORA-TWS05-020\] – Stakeholder Requirements](#)

[\[OCORA-TWS05-021\] – Program Requirements](#)

[\[OCORA-TWS05-022\] – Design Requirements](#)

[\[ERA ERTMS 015560\] – ETCS Driver Machine Interface](#)

[\[NF EN 1686\] integration of displays, controls and indicators / design of display](#)

[\[CLC/TR 50542\] - Driver's cab train display controller](#)

1 Introduction

1.1 Purpose of the document

This document is the OCORA Train Display System (TDS) discussion paper. This document introduces the problem statement of the current HMI situation in the cabin. To solve this problem, the TDS concept (terminology and main characteristics of the architecture) and high level requirements are presented. All the concepts are still under discussion.

The requirements listed in this document are developed from a TDS building block perspective. According to the OCORA definition, they are part of the OCORA D-Level requirements (refer to [1.4 - Requirements Engineering Process](#)). The building block requirements (OCORA D-Level requirements) are detailing the OCORA system requirements [\[OCORA-TWS01-011\]](#).

The building block requirements captured in this document are developed to reach a common understanding and communicate a precise OCORA view of the functional and non-functional requirements towards future TDS.

The building block requirements listed in this document are prepared as an input for:

- EU-Rail and OCORA system architecture and design activities, shaping future TSI specifications, other legal frameworks, and other specifications
- Contracting entities, preparing tenders, and executing testing / certification activities for TDS

This document is addressed to experts in the CCS domain and to any other person, interested in the OCORA requirements for TDS. The reader is invited to provide feedback to the OCORA collaboration and can, therefore, engage in shaping these requirements. Feedback to this document and to any other OCORA documentation can be given by using the feedback form [\[OCORA-BWS01-040\]](#).

If you are an organisation interested in developing TDS according to the OCORA requirements, information provided in this document can be used as input for your development.

1.2 Applicability of the document

The document is currently considered informative but may become mandatory at a later stage for OCORA compliant on-board CCS solutions. Subsequent releases of this document will be developed based on a modular and iterative approach, evolving within the progress of the OCORA collaboration.

All requirements listed in status "Draft" are still under discussion within OCORA while the requirements in status "Approved" are agreed between the OCORA member organisations.

1.3 Context of the document

This document is published as part of an OCORA Release, together with the documents listed in the release notes [\[OCORA-BWS01-010\]](#). Before reading this document, it is recommended to read the Release Notes [\[OCORA-BWS01-010\]](#). If you are interested in the context and the motivation that drives OCORA we recommend to read the Introduction to OCORA [\[OCORA-BWS03-010\]](#), and the Problem Statements [\[OCORA-BWS04-010\]](#). The reader should also be aware of the Glossary [\[OCORA-BWS01-020\]](#) and the Question and Answers [\[OCORA-BWS01-030\]](#).

In addition to the requirements listed in this document, it is referencing the applicable ERA TSI CCS 2023 and TSI LOC & PAS 2023 documents. Requirements that are in conflict with the CCS TSI 2023 are highlighted in the remark section of the respective requirement.

1.4 Requirements Engineering Process

This OCORA requirement document is developed, using the Requirements Management Guideline [OCORA-TWS05-010]. The requirements are engineered in a top-down manner:

- As a starting point all **"Stakeholder Requirements"** towards the OCORA initiative (**A-Level requirements**) are captured and formalised.
- In a second step, the **"Program- and Design Requirements"** (**B-Level requirements**) are developed. These requirements define tools, processes, methodologies and design rules to be used within the program and to be considered during the system analysis and the system design/architecture work.
- As a next step, the A- and B-Level requirements are further developed in the MBSE analysis to become **"System Requirements"** (**C-Level requirements**).
- As part of the MBSE architecture work, building blocks are identified taking into account the MBSE analysis (C-Level requirements). All applicable requirements (A-Level, B-Level, and C-Level) are apportioned to the identified building blocks, resulting in **"Building Block Requirements"** (**D-Level requirements**), forming the OCORA tender templates, together with the applicable program & design requirements.

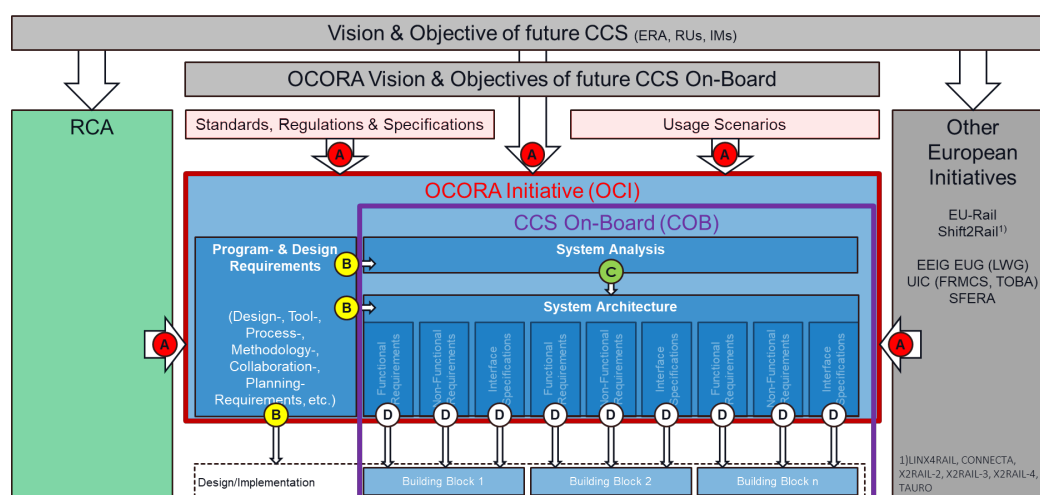


Figure 1 OCORA Requirements Engineering Process

Please note, that the A-Level requirements are applicable to the OCORA Initiative (OCI) while the B- and C-Level requirements are targeted towards the CCS On-Board System (COB) and its architecture. D-Level requirements are applicable to the respective building blocks.

2 Operational analysis

2.1 Problem statement

In today's cab architecture, there are at least three main screens in a cab supporting three systems: European Train Protection (ETP), Train Control and Management System (TCMS) and Cabin Voice Radio (CVR). Each screen is usually dedicated to one system. The screen embeds only one business logic to enable data exchange with the appropriate system and elaborates the associated view.

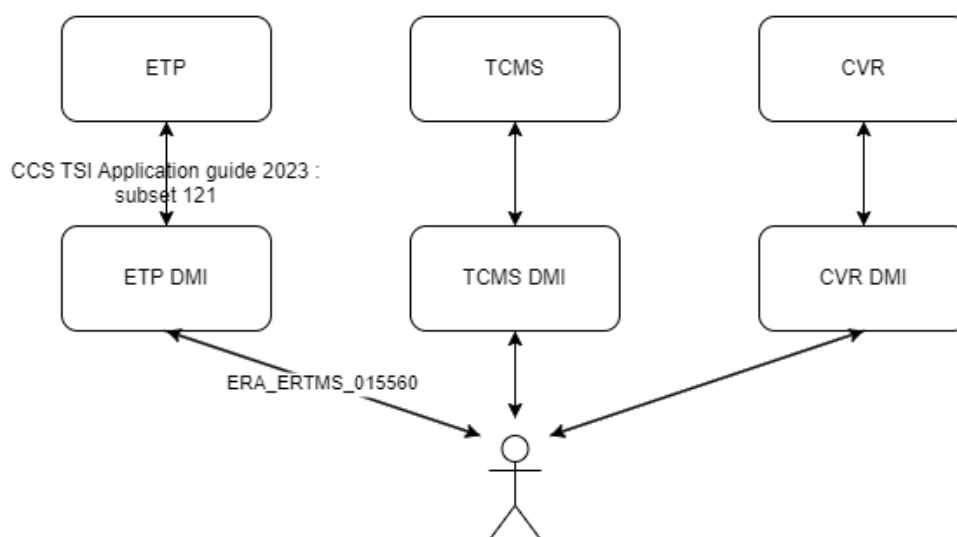


Figure 2 Problem statement

This paradigm leads to some pitfalls:

- Firstly, a screen failure will result in a loss of the system. For instance, if the ETP's DMI fails, the ETP will go into system failure and apply an emergency brake. This will cause a delay to the train and can affect all the train on a line. The availability of the screen is therefore a key factor in the overall availability of the train and the lines. To continue mission with a screen failure, supplier have created proprietary solutions. For instance, TCMS information can be displayed on ETP DMI when TCMS screen fails. This failure management meets an operational needs for Railway Undertaking. However, the lack of standardisation leads to non-portable solutions between trains.
- Secondly, space in the cab is limited especially since ergonomics for the driver needs to be ensured. By introducing new functionalities with the OCORA architecture, new building blocks and services (DAS, MDCM-OB, UID-Reader...) may require space for their dedicated screen. However, the introduction of new display panels in both existing and new trains can be difficult for integrators due to the lack of space.
- Thirdly, an update of the ergonomics systems or the system itself leads to an update of both parts. This interdependency increases cost, effort and downtime involved in maintenance (update). This is more problematic for components with different SIL levels. For example, an ergonomic enhancement to the DMI of the ETP (SIL2 component) leads to an update of the ETP (SIL4 component).
- Fourthly, data exchanged between the system and its ergonomics are supplier specifics. As a consequence, screens are not exchangeable and modular. This issue creates a vendor lock-in situation. Despite the introduction of subset 121, which specifies the exchanges between the EVC and the DMI, the links between the other systems (CVR, DAS, MDCM-OB, TCMS, UID-Reader...) and their displays need to be standardised. To date, two options are being considered: extending the use of subset 121 to all systems and their HMIs or dedicated standardisation between each system and its HMI.

To solve these problems, OCORA is proposing the introduction of a new building block: the Train Display System (TDS). This block provides independancy between systems (ETP, TCMS, CVR...) and DMIs. As the exact boundary of TDS is not yet clearly defined, the rectangle associated with this system is deliberately dotted. However, the main characteristics envisaged for the TDS are presented in [6 - TDS architecture](#) and the high levels requirements are given in [4 - Requirements](#).

Other needs are also expressed with the introduction of TDS such as management of multiple systems on one display.

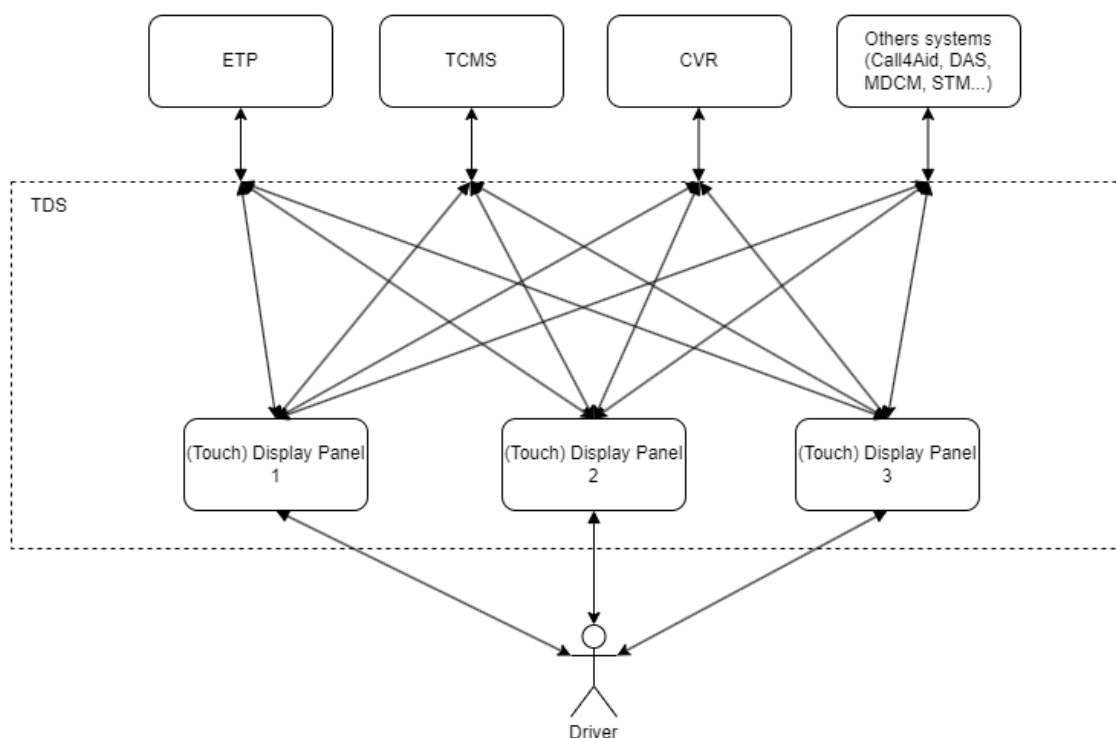


Figure 3 TDS principle

The figure above is limited to three (touch) display panels to depict the difference with the current situation. However, TDS shall not be limited to three (touch) display panels: one (extra-large) to n (touch) display panels might be managed by configuration. The amount of (touch) display panel is an operator choice.




2.2 Operational Epics

In the following section, identified key operational epics related to Train Display System are listed. These epics tackle down the pitfalls expressed above. All epics descriptions follow the same pattern :







- initially it is stated, who benefits from the epics (e.g. infrastructure manager, railway undertaking and/or supplier);
- then the epics itself is formulated;
- and finally the rationale of the epic is provided.

Also, the derivation of the Operational Epics from the Common Business Objectives from ERJU are shown. This link will ensure a continuity with System Pillar activities.







OCORA-10277 - As a railway undertaking, I want to keep or increase the availability of all systems in my train that are using displays in order to increase the overall availability of my train: e.g not to stop the train and ensure a continuity of service.

Linked Work Items	has parent:  OCORA-10263 - Operational Epics , refines:  OCORA-8805 - availability, robustness, reliability , refines:  OCORA-8820 - overall CAPEX/OPEX optimisation(1)
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OCORA-10268 - As a railway undertaking, I would like to add systems which require display in train without integrating dedicated display panels in the cabs, in order to manage the available space and limit the integration effort.

Linked Work Items	has parent:  OCORA-10263 - Operational Epics , refines:  OCORA-8813 - independent lifecycle, simple exchange , refines:  OCORA-8816 - Changeability and upgradeability(1) , refines:  OCORA-8818 - Changeability and upgradeability(3), simplified integration , refines:  OCORA-8829 - modularity , refines:  OCORA-8856 - reduce time to market
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OCORA-10276 - As a railway operator, I want to establish distinct segregation between systems and their Human-Machine Interface (HMI) functions to safeguard their individual functionalities. This strategy is vital to prevent any unintended side effects during future updates and to mitigate the risk of display loss resulting from failures in other interconnected systems.

Linked Work Items	has parent:  OCORA-10263 - Operational Epics , refines:  OCORA-8805 - availability, robustness, reliability , refines:  OCORA-8816 - Changeability and upgradeability(1) , refines:  OCORA-8817 - Changeability and upgradeability(2) , refines:  OCORA-8818 - Changeability and upgradeability(3), simplified integration , refines:  OCORA-8829 - modularity
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OCORA-10269 - As a railway undertaking, I would like to change display solution without vendor lock-in for spare parts in order to minimise OPERational EXpenditure (OPEX) and Mean Time To Repair (MTTR).

Linked Work Items	has parent:  OCORA-10263 - Operational Epics , refines:  OCORA-8813 - independent lifecycle, simple exchange , refines:  OCORA-8816 - Changeability and upgradeability(1) , refines:  OCORA-8818 - Changeability and upgradeability(3), simplified integration , refines:  OCORA-8819 - automate lifecycle processes, independent lifecycle , refines:  OCORA-8846 - standardized architecture(2)
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OCORA-10267 - As a railway undertaking, I would like to manage the least possible number of display solutions in order to reduce cost, effort and downtime involved in maintenance (update).

Linked Work Items	has parent:  OCORA-10263 - Operational Epics , refines:  OCORA-8816 - Changeability and upgradeability(1) , refines:  OCORA-8819 - automate lifecycle processes, independent lifecycle
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OCORA-10275 - As a railway undertaking, I want to minimise the impact of any ergonomic enhancement in order to lower OPERational EXpenditure (OPEX):

- avoid/reduce certification process effort in case of "ergonomic" update,

- reduce time to market in case of this kind of update.

Linked Work Items	<p>has parent:  OCORA-10263 - Operational Epics ,</p> <p>refines:  OCORA-8813 - independent lifecycle, simple exchange ,</p> <p>refines:  OCORA-8816 - Changeability and upgradeability(1)</p>
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3 TDS terminology

In order to better understand the environment associated with managing the driver-machine interface in the driver's cab, the OCORA team needed to represent physical and logical views. Although these views do not offer an exhaustive list of possible integrations, nor the final architecture retained, they illustrate the key concepts used in this document.

3.1 Overview

The aim of the representation below is mainly to list all elements in the TDS context and to use it for the definition of the terms used in this document. This overview represents the link between systems such as Cabin Voice Radio, European Train Protection and TCMS to Controller unit dedicated to HMI. These control units use a set of HMI elements (buzzer, display panels, hard keys...) to guarantee the interface with the driver.

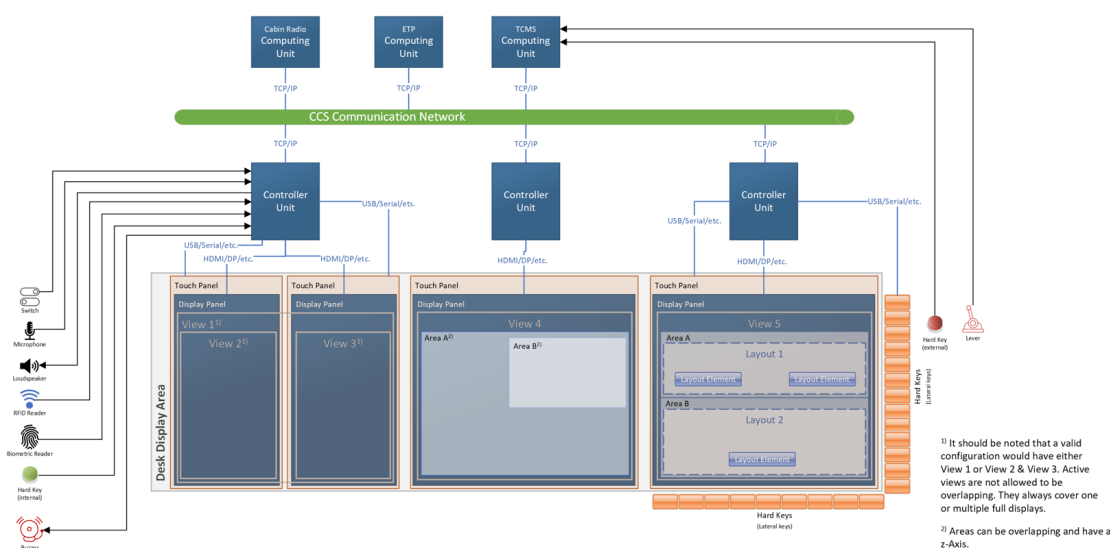


Figure 4 TDS context overview

Here, the communication between the computing units of systems are granted by the CCS Communication Network as OCORA consider mainly the integration of TDS for new train.

Switch, microphone, RFID Reader, Biometric Reader, Hard key and buzzer are connected to a central controller unit. A distributed configuration is also possible.

3.2 Physical terminology

This view represents the physical breakdown of the train down to the HMI elements integrated into a desktop.

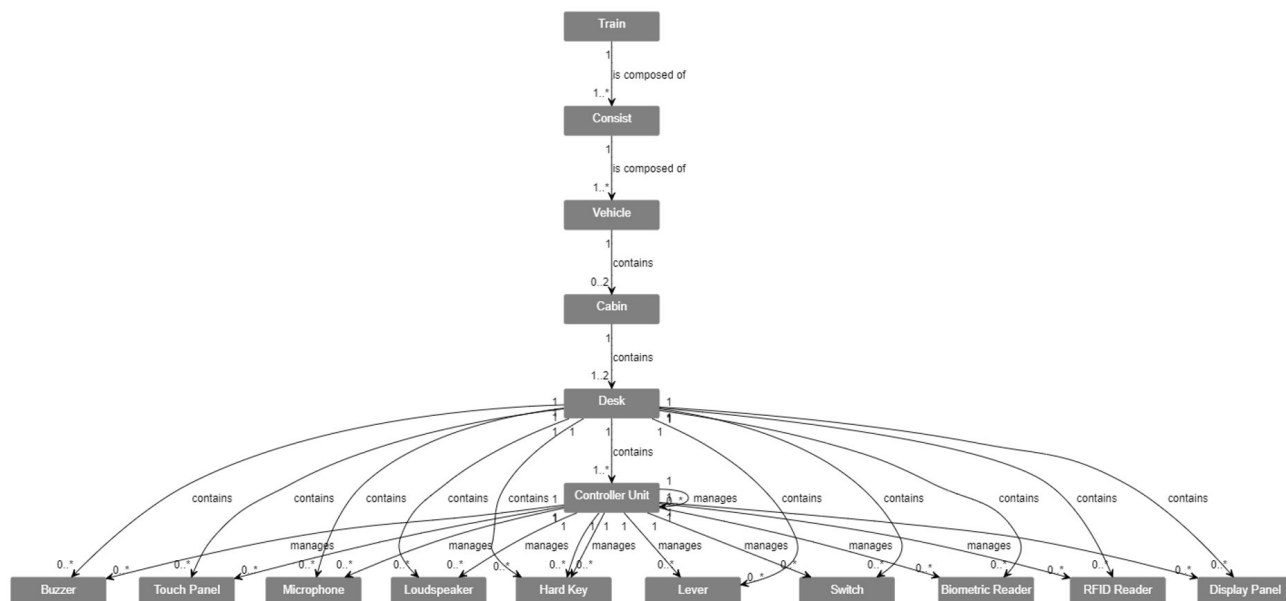


Figure 5 Physical terminology tree

The idea of OCORA is to limit the perimeter of TDS to the management of two desks:

- two desks in the same cabin e.g., in a shunting engine
- one desk per cabin limited to two cabins e.g.,) centralised CCS integration in a consist

3.3 Logical terminology

This logical view represents in details all the logical and configuration elements involved in the elaboration of the view for a system (ETP, TCMS,...). Physical input and output devices are also represented in this view for contextual understanding.

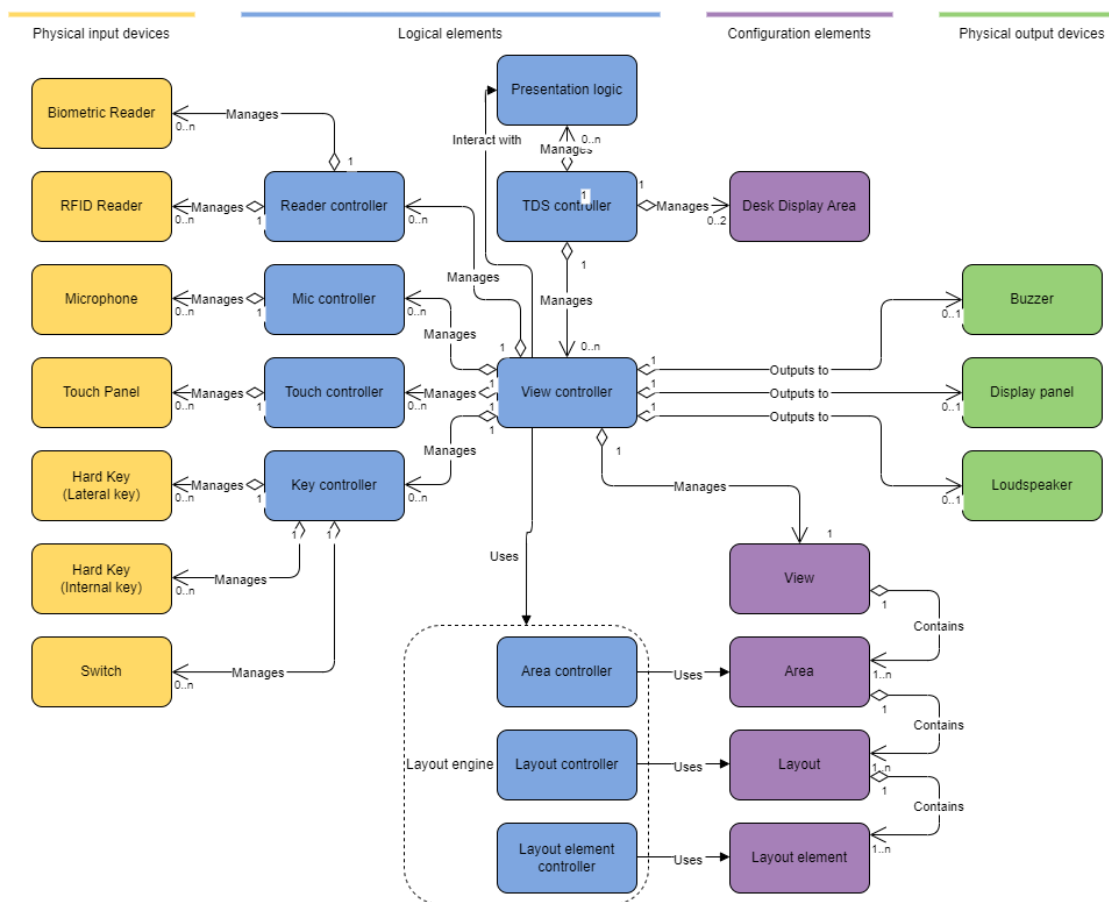


Figure 6 Logical terminology view

3.4 Definitions

The following definitions are used in the context of the TDS concept. Other definitions can be found in the Glossary documentation. [\[OCORA-BWS01-020\]](#)

Title (Abbrev.)	Description	Status
Area Controller ()		draft
	The <i>Area Controller</i> manages areas for the <i>View</i> .	
Biometric Reader ()		draft
	Device that reads the identity of a person by comparing some attribute of their physiological being or behavioral traits against a sample database. This reader permits the authentication of the actor.	
Button ()		draft
	A <i>Hard Key</i> allocated to a dedicated system on a cab. It's designed with a dedicated SIL level. It allows a selection from two states and keeps one state as long as it is pressed.	
Buzzer ()		draft
	Electrical device that makes a buzzing noise and is used to provide an audible warning.	

Title (Abbrev.)	Description	Status
Controller Unit ()		draft
	<p>The <i>Controller Unit</i> is a hardware component which embeds logical controller(s).</p> <p>There may be only one Hardware or distributed to several HMI elements.</p>	
Desk ()		draft
	<p>Inside a cab, the set of operating controls*, which is dedicated to preferred movements in a given direction (i.e. forward movements, in which visibility from the cab is provided to the driver).</p> <p>Exception: some single cab locomotives are fitted with one single desk, allowing normal movements in both directions.</p> <p>*set of operating controls: screens, buttons, traction/brake lever, direction controller, radio control, switches, ...Desk</p>	
Desk Area ()		draft
	<p><i>Desk Area</i> is a location attribute (left, center...) associated to <i>HMI Element</i> for <i>TDS Controller</i> to allocate elements to a <i>View</i>.</p>	
Desk Display Area ()		draft
	<p>The <i>Desk Display Area</i> identifies the desk controlled by TDS (in case of multiple cabins controlled only by one TDS such as locomotive or centralised integration).</p>	
Display ()		draft
	<p>Display is the combination of a display panel and a controller unit.</p>	
Display Area - Area ()		draft
	<p>A Zone displaying a piece of visual information of particular system and defined by a size (in cells) and an absolute position (x ,y, z axes). It is more commonly named <i>Area</i> in this specification.</p>	
Display Panel ()		draft
	<p>Glass (LCD) showing pixels without controller.</p>	
External Button ()		draft
	<p>A button which is not directly managed by TDS.</p>	
Hard Key ()		draft
	<p>Physical key not part of view. This key can also have a text label or symbol.</p>	
HMI Element ()		draft
	<p>An <i>HMI Element</i> is a physical component that interacts with the driver: <i>Buzzer</i>, <i>Display Panel</i>, loudspeaker, <i>Hard Key</i>...</p>	
Internal Button ()		draft
	<p>The <i>Internal Button</i> is a button which is managed directly by TDS.</p>	
Key Controller ()		draft
	<p>Controller which manages states and failures of <i>Hard Keys</i> (internal and <i>Lateral Key</i>) and switches.</p>	

Title (Abbrev.)	Description	Status
Lateral Key ()		draft
	<i>Hard Key</i> located close to a <i>Display Area</i> allowing soft key technology.	
Layout ()		draft
	Layout is a list of layout elements which is displayed in an area.	
Layout Controller ()		draft
	The <i>Layout Controller</i> manages the <i>Layout</i> for an <i>Area</i> .	
Layout Element ()		draft
	Every element to be shown on the screen like button, speed gauge, video stream, symbol and text with their characteristics (size, position, type, color, associated icon...).	
Layout Element Controller ()		draft
	The <i>Layout Element Controller</i> manages <i>Layout Elements</i> of a <i>Layout</i> . It knows how to present itself and how to react on events.	
Layout Engine ()		draft
	The <i>Layout Engine</i> is a generic piece of software able to generate any <i>View</i> based on <i>Areas</i> , <i>Layouts</i> and <i>Layout Elements</i> as defined in a configuration.	
Loudspeaker ()		draft
	Device that converts an electrical audio signal into a corresponding sound.	
Microphone ()		draft
	Device that translates sound vibrations from the air into electronic signals and scribes them to a recording medium or over a loudspeaker.	
Microphone Controller ()		draft
	The <i>Microphone Controller</i> manages states and signals of <i>Microphone</i> .	
Presentation logic ()		draft
	The presentation logic controls the flow (dialogue sequence) and layout elements of the User interface using system specific layouts based on generic layout elements. The presentation logic may also include data validation.	
Reader Controller ()		draft
	The <i>Reader Controller</i> manages states and failures of the <i>Biometric Reader</i> and/or the <i>RFID Reader</i> .	
RFID Reader ()		draft
	Radio Frequency Identification (RFID) refers to a wireless system comprised of two components: tags and readers. The reader is a device that has one or more antennas that emit radio waves and receive signals back from the RFID tag. This reader permits the authentication of the actor.	

Title (Abbrev.)	Description	Status
Soft Key ()	Context-dependent key which consists of a <i>Hard Key</i> with an associated label on the <i>Display Area</i> . When using a soft key technology, the driver action is done via the <i>Hard Key</i> adjacent to the label.	draft
Switch ()	Physical component which allows a selection of 2 to N states and keeps the state until its position is changed.	draft
Touch Controller ()	Controller which manages the states and failures of a <i>Touch Panel</i> .	draft
Touch panel ()	Hardware detecting where the finger touch the panel.	draft
Train Display System (TDS)	The Train Display System is the train cab display system that comprises and manages one or more displays on the driver desk and a driver interface. It is composed of at least one display with the associated input devices, at least one loudspeaker and at least one Train Display System Controller. It offers a standardised communication interface to systems that need driver interaction.	draft
Train Display System Controller (TDS Controller)	The <i>TDS Controller</i> interacts with system (CCS, TCMS,CVR) and manages the <i>Desk Display Area</i> .	draft
View ()	Aggregation of <i>Areas</i> required for systems (CCS, TCMS, CVR...). A <i>View</i> can represent <i>Areas</i> of different systems at the same time.	draft

View Controller ()

draft

The *View Controller* aggregates the *View*, the output devices and the controller of each input device.





4 Requirements

OCORA has expressed high-level requirements for the building block: Train Display System.

4.1 General requirements





OCORA-10011, D-Level - Managing input and output devices

The TDS shall manage a defined set of input and output devices that are used for user interaction on a desk.

Status	 In Review
Classification	Requirement
Rationale	Reduce the number of HMI elements on the desk.
Category	Functional
Acceptance Method	Certification
Acceptance Criteria	
Remark	
Linked Work Items	has parent:  OCORA-10289 - General requirements , defines:  OCORA-7587 - Train Display System (TDS) , is refined by:  OCORA-10285 - Manage configuration





OCORA-10012, D-Level - Managing desks

The TDS shall manage at most two desks.

Status	 In Review
Classification	Requirement
Rationale	Limit the scope of TDS.
Category	Functional
Acceptance Method	Certification
Acceptance Criteria	
Remark	Allowing to manage shunting engine and centralised integration in a consist.
Linked Work Items	has parent:  OCORA-10289 - General requirements , defines:  OCORA-7587 - Train Display System (TDS) , is refined by:  OCORA-10284 - Manage the Desk Display Area





OCORA-10308, D-Level - One desk activation

The TDS shall activate only one desk at a time.

Status	 In Review
Classification	Requirement
Rationale	Avoid simultaneous activation of desks in the same consist.
Category	Functional
Acceptance Method	Certification
Acceptance Criteria	
Remark	<ul style="list-style-type: none"> • The activation of the desk command the wake up of all systems embedded in it. • The commands from the non active desks shall not command systems.
Linked Work Items	has parent:  OCORA-10289 - General requirements , defines:  OCORA-7587 - Train Display System (TDS) , is refined by:  OCORA-10284 - Manage the Desk Display Area






OCORA-10013, D-Level - Allocating input/output devices to dedicated system

The TDS shall allocate input and output devices to a dedicated system.

Status	 In Review
Classification	Requirement
Rationale	Provide necessary devices to a system.
Category	Functional
Acceptance Method	Certification
Acceptance Criteria	
Remark	Devices allocated to a system shall not be used by another system. In a configuration with systems that share output devices (e.g. displays), each system must have a zone or events that guarantee dedicated use of the device.
Linked Work Items	has parent:  OCORA-10289 - General requirements , defines:  OCORA-7587 - Train Display System (TDS) , is refined by:  OCORA-10285 - Manage configuration


OCORA-10014, D-Level - Allocations registered as configuration





The TDS shall manage all device allocations as configuration.

Status	 In Review
Classification	Requirement
Rationale	One configuration gives all input/output devices allocations for the systems.
Category	Functional
Acceptance Method	Certification
Acceptance Criteria	
Remark	<p>Some configuration parameters are given as proposal. Nonetheless, a deeper analysis should be performed in a next release.</p> <ul style="list-style-type: none"> • IP address of HMI elements allocated to a system, • the type of the HMI elements (e.g. touch keys or soft keys for display panels) • the size and position of the area allocated to the system • A priority parameter to avoid conflicts in case of multiple systems in one display • To be more investigated (e.g. reconfiguration without triggering an EB - hot redundancy?)
Linked Work Items	<p>has parent:  OCORA-10289 - General requirements ,</p> <p>defines:  OCORA-7587 - Train Display System (TDS) ,</p> <p>is refined by:  OCORA-10285 - Manage configuration ,</p> <p>is refined by:  OCORA-10286 - Failover configuration</p>

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 pre-approved configuration.

Status	 In Review
Classification	Requirement
Rationale	Only one configuration is active at a time.
Category	Functional
Acceptance Method	Certification
Acceptance Criteria	

Remark	<p>TDS should consider a nominal configuration by default and other configurations when required:</p> <ul style="list-style-type: none"> • 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) <p>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.</p> <p>The driver can select only pre-approved configuration.</p> <p>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.</p>
Linked Work Items	<p>has parent:  OCORA-10289 - General requirements ,</p> <p>defines:  OCORA-7587 - Train Display System (TDS) ,</p> <p>is refined by:  OCORA-10285 - Manage configuration ,</p> <p>is refined by:  OCORA-10286 - Failover configuration</p>


OCORA-10016, D-Level - Extended view concept





The TDS shall allow by configuration a view that extent on multiple display panels which are adjacent to each other.

Status	 Deleted
Classification	Operator Choice
Rationale	<ul style="list-style-type: none"> - Save space in comparison to two full grid screens i.e., two half grid screens are smaller (1.5 vs. 2) - Keep the screen in a central area for drivers - Being resilient to a failure in order to continue a mission (by displaying only "speed" half-grid part in case of screen failure)
Category	Functional
Acceptance Method	Test
Acceptance Criteria	
Remark	<p>example :</p> <p>ETCS information is extended on 2 half-grid screens (one screen display the "speed" half-grid part and a second screen display the "planning area" half-grid part).</p> <p>OCORA review :</p> <p>As displaying speed and planning area are mandatory in ETCS level 1 and 2 in mode FS, SM and AD and has to remain adjacent for operational and safety reason, extended view concept is no longer acceptable. In deed, in degraded configuration, only speed is displayed. The planning area remain accessible but with a lower priority given to speed half-gird.</p> <p>As the ERA analysis is ongoing and the removal of this concept facilitates the architectural analysis, this requirement is deleted in this version.</p> <p>It could be re-opened if needed.</p>
Linked Work Items	has parent:  OCORA-10289 - General requirements

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	<ul style="list-style-type: none"> • 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	<p>Limitation to physical characteristics</p> <p>The modularity concept should be weighted depending on the pre-approved configuration ([OCORA-10015]) which take 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).</p>
Linked Work Items	<p>has parent:  OCORA-10289 - General requirements ,</p> <p>defines:  OCORA-7587 - Train Display System (TDS) ,</p> <p>is refined by:  OCORA-10280 - Control the flow and layout elements ,</p> <p>is refined by:  OCORA-10282 - Generate View</p>





OCORA-10018, D-Level - Systems management

The TDS shall manage the HMLs of multiple systems (e.g., ETP, TCMS, CVR, etc) in parallel.

Status	 In Review
Classification	Requirement
Rationale	Enhance availability, concurrency management, prioritisation
Category	Functional
Acceptance Method	Design Review
Acceptance Criteria	
Remark	Legacy train: multiple means limited to specific systems supporting TDS. New train: multiple means all systems
Linked Work Items	has parent:  OCORA-10289 - General requirements , defines:  OCORA-7587 - Train Display System (TDS) , is refined by:  OCORA-10283 - System application interactions


OCORA-10019, D-Level - Multiple systems on one display


The Train Display System may display areas from different systems on the same display panel.

Status	 In Review
Classification	Optional Requirement
Rationale	Depending the size of the display panel (e.g. wide screen), several areas might be displayed on the same panel. It may decrease the number of panel embedded in cab.
Category	Functional
Acceptance Method	Test
Acceptance Criteria	
Remark	In case of Multiple systems on one display area, SIL level supervision should be done accordingly to system needs. A priority parameter should be used to avoid conflicts in case of simultaneous display.
Linked Work Items	has parent:  OCORA-10289 - General requirements , defines:  OCORA-7587 - Train Display System (TDS) , is refined by:  OCORA-10282 - Generate View

OCORA-10114, D-Level - Supporting Testing tools

The TDS shall be able to support testing tools that emulate driver interactions with systems e.g., ETP, TCMS, etc.

Status	 Deleted
Classification	Operator Choice
Rationale	For testing purposes, it is interesting to automatically interact with systems e.g., ETP, TCMS, etc. For instance, start of mission of the ETP can be performed automatically before a test run.
Category	Functional

Acceptance Method	Test
Acceptance Criteria	
Remark	<p>Testing tools are external components that can be connected to TDS and could host some scripts. Scripts may be time or event based e.g., one shot timer.</p> <p>Such tool and scripts shall not be used on operation.</p> <p>Requirement deleted :</p> <p>A connected device to ETP could emulate TDS, a display and driver interaction.</p> <p>In case of shadow testing, ETP would not be connected to the official TDS.</p> <p>Thus, TDS should not support such functionalities.</p>
Linked Work Items	has parent:  OCORA-10289 - General requirements

To illustrate the concepts of configuration, modularity and multiple display, the following pictures show the displays of four systems on four displays: CVR, CCD, TDD and an unidentified system (XYZ). The first figure shows the nominal configuration.

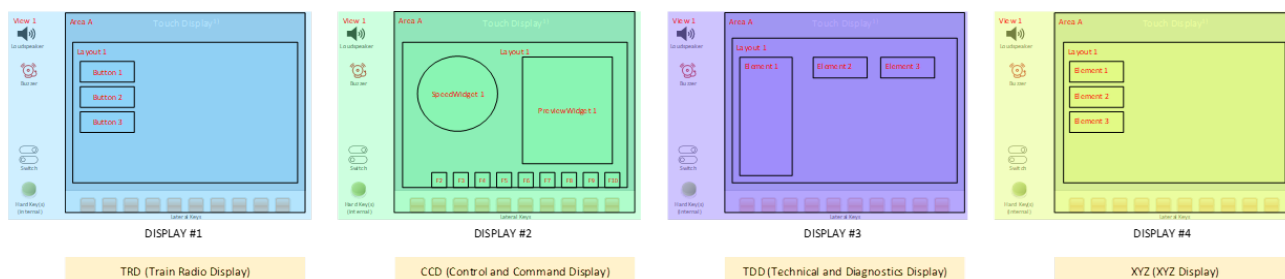


Figure 7 : Nominal configuration

If display 2 fails, a degraded configuration is automatically used. As the CCD display is mandatory for operation, this system is moved to display 3 in order to remain in a center position. As a result, the TDD display is moved to display 4. The XYZ display is now stacked in display 4 behind the TDD display.

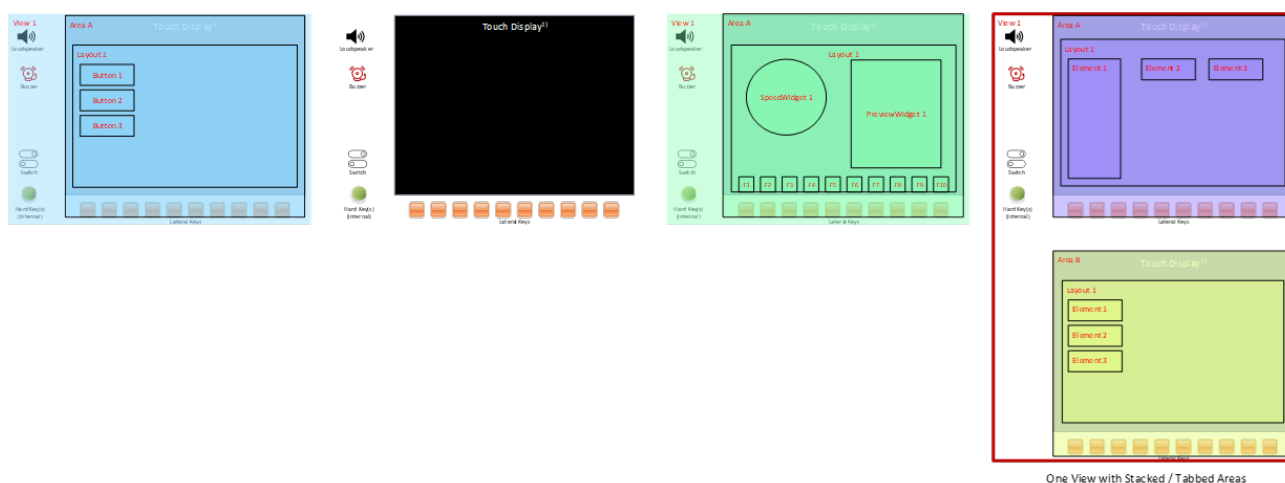


Figure 8 : Degraded configuration - display 2 failure

If display 4 fails, another degraded configuration is automatically used. The XYZ display is stacked in display 3 behind the TDD display without affecting the other displays.

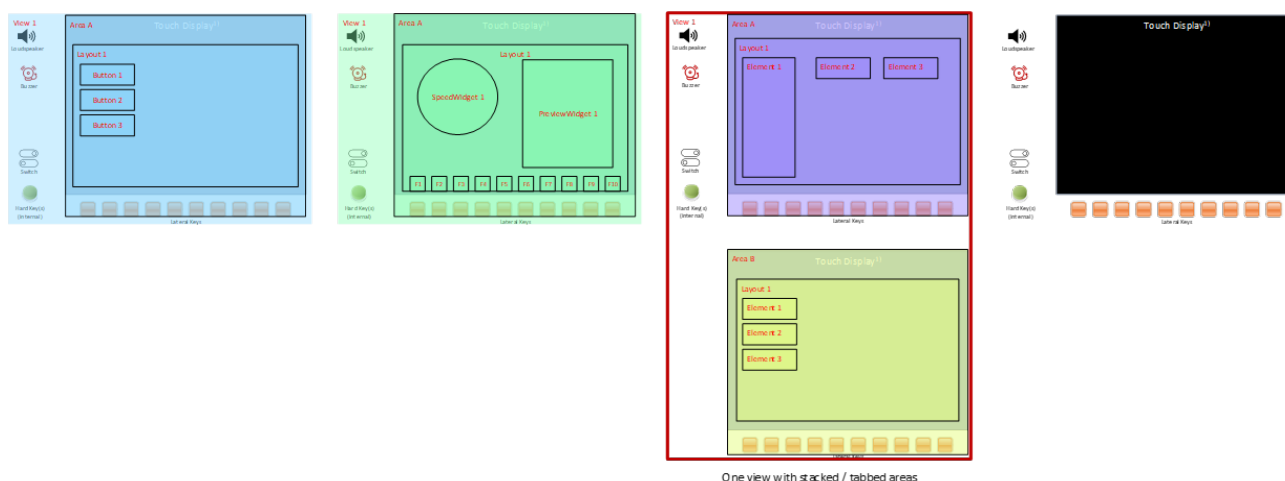


Figure 9 : Degraded configuration - display 4 failure

In the case of multiple display, the driver or hidden systems could request to have their areas displayed on the view. The figure below shows a view with TDD and XYZ display areas combined on display 3.

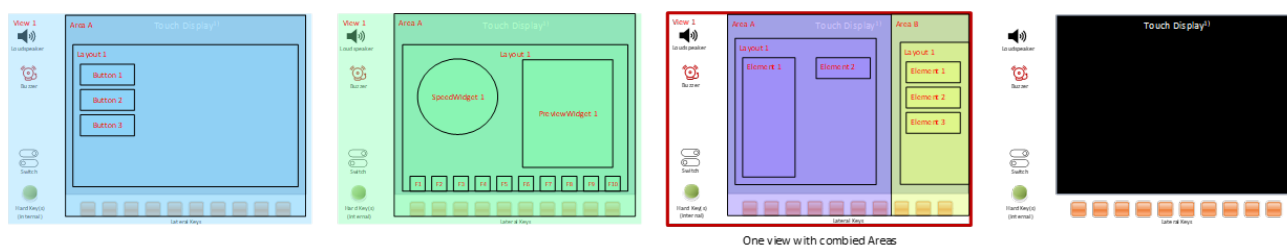





Figure 10 : Multiple display on display 3

4.2 External interfaces

4.2.1 Data exchange interfaces

OCORA-7675, D-Level - Compliance with a single data exchange standard (OSI layer 7)




The TDS shall exchange data on application level (OSI layer 7) with any other CCS-OB building block, and any CCS-OB external system, compliant with a single standard (to be defined).

Status	 In Review
Classification	Requirement
Rationale	<p>Rational for the interfaces:</p> <ul style="list-style-type: none"> To allow exchange of information between the TDS and any CCS-OB building block, and any CCS-OB external system. <p>Rational for standardisation of the interfaces:</p> <ul style="list-style-type: none"> To support the possibility to manage the life-cycles and the sourcing of the TDS independently of the original supplier(s) of the TDS, of any other interfacing CCS-OB building block, and of any interfacing CCS-OB external system. To allow the manufacturers of the TDS, of any other interfacing CCS-OB building block, and of any interfacing CCS-OB external system, developing their products according to a standard and therefore to reduce product variety and costs. To facilitate the integration, installation, testing, and maintenance of a TDS. To support the compatibility between different implementations of the TDS, of any other interfacing CCS-OB building block, and of any interfacing CCS-OB external system.
Category	Maintainability
Acceptance Method	Certification
Acceptance Criteria	
Remark	<ul style="list-style-type: none"> Subset 121 introduced by TSI-CCS 2023 for the interface between ETP and DMI could be a promising solution. However, this subset should be consolidated for TDS needs. Legacy application such as TCMS and CVR can continue using their proprietary solution. However, design products with direct compliance to this single standard or use an adaptor supporting it would ease the integration of TDS. New applications such as DAS, MDCM shall integrate this protocol.
Linked Work Items	<p>has parent:  OCORA-8002 - Data exchange interfaces ,</p> <p>defines:  OCORA-7587 - Train Display System (TDS)</p>

4.2.2 Communication interfaces

OCORA-7981, D-Level - Compliance with SUBSET-147



The TDS shall communicate (OSI layer 1 - 6) with any other CCS-OB building block and with any CCS-OB external system, compliant with SUBSET-147.

Status	 In Review
Classification	Requirement
Rationale	<ul style="list-style-type: none"> To be compliant with the TSI-CCS <p>Rational for the interfaces:</p> <ul style="list-style-type: none"> To allow exchange of information between the TDS and any CCS-OB building block, and any CCS-OB external system. <p>Rational for standardisation of the interfaces:</p> <ul style="list-style-type: none"> To support the possibility to manage the life-cycles and the sourcing of the TDS independently of the original supplier(s) of the TDS, of any other interfacing CCS-OB building block, and of any interfacing CCS-OB external system. To support the compatibility between different implementations of the TDS, of any other interfacing CCS-OB building block, and of any interfacing CCS-OB external system. To allow the manufacturers of the TDS, of any other interfacing CCS-OB building block, and of any interfacing CCS-OB external system, developing their products according to a standard and therefore to reduce product variety and costs. To facilitate the integration, installation, testing, and maintenance of a TDS.
Category	
Acceptance Method	Certification
Acceptance Criteria	
Remark	Currently, the subset 147 version 1 covers only OSI layer 1 and 2.
Linked Work Items	has parent:  OCORA-7998 - Communication interfaces , defines:  OCORA-7587 - Train Display System (TDS)

OCORA-7982, D-Level - Compliance with the OCORA addendum to SUBSET-147

The TDS shall communicate (OSI layer 1 - 6) with any other CCS-OB building block, and with any CCS-OB external systems, compliant with SUBSET-147.

Status	 In Review
Classification	Requirement


Rationale	<ul style="list-style-type: none"> To ensure unambiguous implementation of the communication. To consider currently not specified functionalities. <p>Rational for the interfaces:</p> <ul style="list-style-type: none"> To allow exchange of information between the TDS and any CCS-OB building block and any CCS-OB external system. <p>Rational for standardisation of the interfaces:</p> <ul style="list-style-type: none"> To support the possibility to manage the life-cycles and the sourcing of the TDS independently of the original supplier(s) of the TDS, of any other interfacing CCS-OB building block, and of any interfacing CCS-OB external system. To support the compatibility between different implementations of the TDS, of any other interfacing CCS-OB building block, and of any interfacing CCS-OB external system. To allow the manufacturers of the TDS, of any other interfacing CCS-OB building block, and of any interfacing CCS-OB external system, developing their products according to a standard and therefore to reduce product variety and costs. To facilitate the integration, installation, testing, and maintenance of a TDS.
Category	
Acceptance Method	Test
Acceptance Criteria	
Remark	<ul style="list-style-type: none"> The addendum to subset-147 covers OSI layers 1-6. The Contracting Entity must decide what requirements of the OCORA addendum shall be applicable to a specific tender. Current topics are: selection of the protocols, etc. EU-Rail and OCORA system architecture and design activities shall ensure that the points addressed in this requirement are considered for standardisation. Eventually, this requirement can disappear.
Linked Work Items	<p>has parent:  OCORA-7998 - Communication interfaces ,</p> <p>defines:  OCORA-7587 - Train Display System (TDS)</p>



4.3 PRAMSS requirements

4.3.1 Performance requirements

OCORA-10020, D-Level - Compatible performance according existing systems

The TDS shall be compatible with the performance requirements of each systems in interface with e.g., ETP, TCMS, CVR, etc.




Status	 In Review
Classification	Requirement
Rationale	keep compliance with subset 41 (chapters 5.2.1.X), TSI LOC & PASS (noise emission...).
Category	
Acceptance Method	Certification

Acceptance Criteria	
Remark	
Linked Work Items	has parent:  OCORA-8015 - Performance requirements , defines:  OCORA-7587 - Train Display System (TDS)

4.3.2 Reliability requirements

OCORA-10297, D-Level - Preservation of system's reliability





The TDS shall not decrease the reliability of existing systems (ETP, TCSM, CVR...).

Status	 In Review
Classification	Requirement
Rationale	The use of a generic display solution should not lead to different behaviour depending on the display solution used (latency, data exchanged, type of the key...).
Category	
Acceptance Method	Certification
Acceptance Criteria	
Remark	Reconfiguration should not be a source of disruption or misleading behaviour for systems and drivers.
Linked Work Items	has parent:  OCORA-8016 - Reliability requirements , defines:  OCORA-7587 - Train Display System (TDS)

4.3.3 Availability requirements




OCORA-10022, D-Level - Active configuration monitoring

The TDS shall monitor every system and HMI element involved on the active configuration. In case of failure, the TDS shall trigger an event.

Status	 In Review
Classification	Requirement
Rationale	The event shall be used by the TDS to reconsider its configuration ( OCORA-10015).
Category	Availability
Acceptance Method	Test
Acceptance Criteria	
Remark	<ul style="list-style-type: none"> For example, in the event of a display failure, TDS could change the configuration to provide a new display to the system using the failed display.
Linked Work Items	has parent:  OCORA-8017 - Availability requirements , defines:  OCORA-7587 - Train Display System (TDS)

OCORA-10329, D-Level - Preservation of system's availability




The TDS shall not decrease the availability of existing systems (ETP, TCMS, CVR...).

Status	 In Review
Classification	Requirement
Rationale	<ul style="list-style-type: none"> • The introduction of TDS as a configuration component should not affect the availability of systems. • A failure of a TDS component should not lead to a failure of all displays.
Category	Availability
Acceptance Method	Certification
Acceptance Criteria	
Remark	
Linked Work Items	has parent:  OCORA-8017 - Availability requirements , defines:  OCORA-7587 - Train Display System (TDS)

4.3.4 Maintainability requirements

OCORA-10113, D-Level - Reconfiguration data

The TDS shall inform systems (ETP, TCMS, etc.) and record maintenance data (root cause of reconfiguration, new configuration) in case of reconfiguration.



Status	 In Review
Classification	Requirement
Rationale	Provide configuration informations to systems and maintainer.
Category	Maintainability
Acceptance Method	Test
Acceptance Criteria	
Remark	
Linked Work Items	has parent:  OCORA-8012 - Maintainability requirements , defines:  OCORA-7587 - Train Display System (TDS)

4.3.5 Safety requirements

OCORA-10021, D-Level - Compatible safety requirements according to existing systems




The TDS shall be compatible with the safety requirements of each system it interfaces with (ETP, TCMS, CVR, etc.).

Status	 In Review
Classification	Requirement
Rationale	Keep compliance with subset 91 (DMI-XXx reported on ETCS_OB10).
Category	Safety

Acceptance Method	Certification
Acceptance Criteria	
Remark	The maximum current SIL level for train display depends on ETP's DMI. Nowadays, no system requires higher SIL Level.
Linked Work Items	has parent:  OCORA-8013 - Safety requirements , defines:  OCORA-7587 - Train Display System (TDS)

OCORA-10288, D-Level - Compatible SIL level configuration between systems and display panels




The TDS shall ensure a compatible configuration between the SIL level requirements of the systems and the SIL level functionality of display panels.

Status	 In Review
Classification	Requirement
Rationale	Ensure safety level needs of systems. E.g.: Keep compliance with subset 91 for ETP (DMI-XXx reported on ETCS_OB10)
Category	
Acceptance Method	Certification
Acceptance Criteria	
Remark	Display panels could be only compatible SIL0, SIL2. Some systems requires SIL2 functionality for display solution, for other system SIL0 display solution is enough. For all system, safety analysis should be performed to determine the suitable safety level supported by the display solution (e.g fault tree with regard to DMI-XXx reported in subset 91).
Linked Work Items	has parent:  OCORA-8013 - Safety requirements , defines:  OCORA-7587 - Train Display System (TDS)

4.3.6 Security requirements


OCORA-10298, D-Level - HMI elements allocation limited by configuration



The TDS shall allocate only HMI elements to systems which are registered in configuration.

Status	 In Review
Classification	Requirement
Rationale	Prevent access to system by a HMI elements that are not allowed by configuration.
Category	Security
Acceptance Method	Certification
Acceptance Criteria	
Remark	
Linked Work Items	has parent:  OCORA-8014 - Security requirements , defines:  OCORA-7587 - Train Display System (TDS)

OCORA-10299, D-Level - TDS and Configuration update

The TDS shall ensure an update of itself and its configuration only by a trusted person (e.g. maintenor).

Status	 In Review
Classification	Requirement
Rationale	Prevent access to TDS by a third party.

Category	Security
Acceptance Method	Certification
Acceptance Criteria	
Remark	
Linked Work Items	<p>has parent:  OCORA-8014 - Security requirements ,</p> <p>defines:  OCORA-7587 - Train Display System (TDS)</p>

5 Functional analysis

5.1 Logical component identification

With regard to TDS terminology, this section list all the logical components that should be involved with the TDS context. These components are linked to dedicated functions, defined in chapter 5.2, which refine the TDS requirements.

More precisely, the building block TDS consists of the following main components:

The *TDS Controller* interacts with system (CCS, TCMS,CVR) and manages the *Desk Display Area*.

The presentation logic controls the flow (dialogue sequence) and layout elements of the User interface using system specific layouts based on generic layout elements. The presentation logic may also include data validation.

The *View Controller* aggregates the *View*, the output devices and the controller of each input device.

The *Layout Engine* is a generic piece of software able to generate any *View* based on *Areas*, *Layouts* and *Layout Elements* as defined in a configuration.





5.2 Functional allocation

TDS requirements defined in chapter 4 are refined in this chapter as component requirements and allocated to logical elements presented above.

Concerning system (ETP, TCMS, CVR...), any requirement have been written because core functions are considered out of the scope of TDS (e.g. braking curves for ETP, setting calls for CVR, command doors for TCMS...).




OCORA-10280, D-Level - Control the flow and layout elements

Control the flow (dialogue sequence) and layout elements of the user interface using system specific layouts based on generic layout elements.

Status	 In Review
Classification	Requirement
Rationale	Guarantees interaction with the user interface in accordance with the expectations of the system application.
Category	
Acceptance Method	Certification
Acceptance Criteria	
Remark	
Linked Work Items	<p>has parent:  OCORA-10278 - Functional allocation ,</p> <p>refines:  OCORA-10017 - Modularity ,</p> <p>defines:  OCORA-10293 - System Presentation Logic</p>






OCORA-10281, D-Level - Data validation

Provide data validation.

Status	 In Review
Classification	Requirement
Rationale	Apply data validation rules expected by a system application
Category	
Acceptance Method	Certification
Acceptance Criteria	
Remark	e.g: resolution check, range check...
Linked Work Items	has parent:  OCORA-10278 - Functional allocation , defines:  OCORA-10293 - System Presentation Logic


OCORA-10282, D-Level - Generate View




Generate any *View* based on *Areas*, *Layouts* and *Layout Elements* as defined in a configuration.

Status	 In Review
Classification	Requirement
Rationale	Layout engine is a generic software that generate View based on Areas, Layouts and Layout Elements. These elements could be used by any system application.
Category	
Acceptance Method	Certification
Acceptance Criteria	
Remark	
Linked Work Items	has parent:  OCORA-10278 - Functional allocation , refines:  OCORA-10017 - Modularity , refines:  OCORA-10019 - Multiple systems on one display , defines:  OCORA-10294 - Layout Engine

OCORA-10283, D-Level - System application interactions






Interact with system applications (CCS, TCMS,CVR)

Status	 In Review
Classification	Requirement
Rationale	Enable data exchange between TDS and other system application (CCS, TCMS, CVR). This data exchange allows system application supervision (start up/configuration/failure/no power states).
Category	
Acceptance Method	Certification

Acceptance Criteria	
Remark	
Linked Work Items	has parent:  OCORA-10278 - Functional allocation , refines:  OCORA-10018 - Systems management , defines:  OCORA-10295 - TDS Controller








OCORA-10284, D-Level - Manage the Desk Display Area

Manage the Desk Display Area

Status	 In Review
Classification	Requirement
Rationale	Regarding the activation of cab, the TDS controller shall activate or deactivate input and output devices on a desk.
Category	
Acceptance Method	Certification
Acceptance Criteria	
Remark	
Linked Work Items	has parent:  OCORA-10278 - Functional allocation , refines:  OCORA-10012 - Managing desks , refines:  OCORA-10308 - One desk activation , defines:  OCORA-10295 - TDS Controller

OCORA-10285, D-Level - Manage configuration

Arrange system inputs/outputs to HMI elements with compliance to a pre-approved configuration.

Status	 In Review
Classification	Requirement
Rationale	Enable interaction with system applications in a cab.
Category	
Acceptance Method	Certification
Acceptance Criteria	
Remark	<ul style="list-style-type: none"> • Nominal configuration : At start up, a nominal configuration should be set up. • Failover configuration : In case of HMI element failures, rearrange the system output of the affected systems (failover) based on a pre-approved failover configurations (failover config1,...). • Other pre-approved configuration : In case of a system state change (e.g system wake up, system failure, request for displaying a view), rearrange the system outputs based on a pre-approved configurations (nominal config, failover config1,...).
Linked Work Items	<p>has parent:  OCORA-10278 - Functional allocation ,</p> <p>refines:  OCORA-10011 - Managing input and output devices ,</p> <p>refines:  OCORA-10013 - Allocating input/output devices to dedicated system ,</p> <p>refines:  OCORA-10014 - Allocations registered as configuration ,</p> <p>refines:  OCORA-10015 - Active configuration ,</p> <p>defines:  OCORA-10295 - TDS Controller</p>

6 TDS architecture

The consolidation of logical and physical views has led to a review of the architectural definitions and proposals listed in the OCORA release R3 of the System Architecture document. Some concepts have been added in OCORA release R4 and will be evaluated too.

Rather than presenting numerous views that would be abandoned in favor of a single view after evaluation, it has been decided to present and evaluate their key characteristics according to a list of criteria. This list has been built regarding the OCORA's objectives, TDS' stakeholder requirements and other criteria that are evaluated relevant in TDS context.

The list is :

- availability,
- integration effort for new system,
- Physical space for new system,
- Segregation among systems (splitting critical and non critical resources, risk that a system influences the output/input of another system),
- Avoid vendor lockin situation,
- Hardware costs,
- Implementation effort,
- Certification effort,
- Maintenance costs,
- Complexity,
- Latency,
- User experience,
- Cyber Security.

Currently, the evaluation is in progress and is purely qualitative. If needed, a scoring method will be added and criteria will be weighted. The result of this assessment will be aggregated to produce a final architectural view proposed by OCORA. More precisely, two topics remain open: §6.1 TDS integration and §6.5 Number of TDS controller. For the other topics, OCORA has provided an analysis.

6.1 TDS integration

Regarding the integration of TDS within CCS-OB, three options have been identified. Without considering a computing platform as solution, the two first options are only software based. The third option is hardware and software based.

1. The first option is hosting TDS software on a existing HMI element such as a displays.
2. The second option is hosting TDS software on a existing system (ETP, TCMS...).
3. Third option considered is a standalone building block using dedicated hardware and software.

Depending on the exact boundary of TDS and the allocation of logic elements to system, the final integration of TDS could be a mix of these three options.

Analysis :

The evaluation of the options is still in progress.

Architectural views considered are presented in chapter 6.6.

- The first option, hosting TDS software on a existing HMI element, is depicted by functional allocation 5.
- The second option, hosting TDS software on a existing system, is depicted by functional allocation 6.
- The third option, standalone building block using dedicated hardware and software, is depicted by functional allocation 3.
- Others functional allocations (1, 2 and 4) are mix of previous options.

6.2 HMI elements managed by TDS

With regards to HMI elements, such as the emergency brake button, two solutions can be considered. As they are considered to be used by the driver, these buttons should be directly in interface with the TDS. This building block would manage this information and transmit it to the train. Otherwise, it is debatable whether such buttons are part of the Physical Train Unit Operation System (PTU-OS), as proposed in the technical slide deck OCORA-BWS02-030_Technical-Slide-Deck.

Analysis:

As external buttons, biometrics reader, levers, RFID reader and switches are dedicated to systems and therefore not reconfigurable, OCORA proposes to leave these devices directly linked to the dedicated system or to the Physical Train Unit Operation System. This is an operator choice.

Note : the external HMI elements required for TDS functionality could be linked to any display for TDS purpose if TDS controller is hosted by a display computing unit. If not the case, they could be managed by Physical Train Unit Operation System. This is also an operator choice.

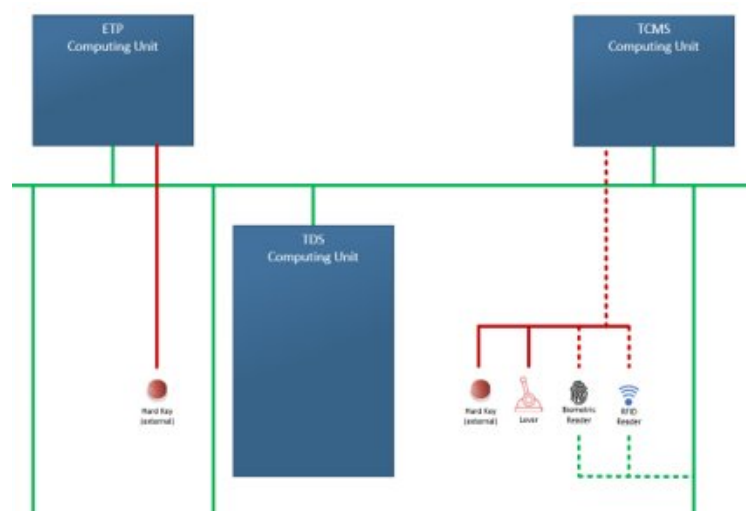


Figure 11 HMI elements in the scope of systems

The HMI elements that remain within the scope of the TDS are therefore: buzzer, internal hardkeys, lateral keys and loudspeaker.

These elements could be connected to a display computing unit or a display controller. Connecting these elements to the CCN does not provide any advantage and may even complicate the overall architecture. Only the displays would be connected via CCN to TDS or systems. More information is given in chapter "HMI elements connectivity".

With regards to loudspeakers OCORA considers that they support the ergonomic aspects of the HMI for a system but do not support intercom and voice communication functionalities. The possibility of sharing one loudspeaker for all system usage has been analysed. However, due to the noise level requirements (STI LOC and PASS) and the risk of noise distortion, this idea is not acceptable. Like the loudspeaker, the shared buzzer is no longer considered.

As for the internal hardkeys, the change of configuration may result in the loss of these internal hardkeys. To avoid such a loss, OCORA recommends to avoid or limit the number of these HMI elements. If only limited, the functions associated with these internal hardkeys shall be a shortcut to a dedicated functionality which can also be accessible by other means (laterals keys or touch keys). So a reconfiguration will not result in a loss of this functionality.

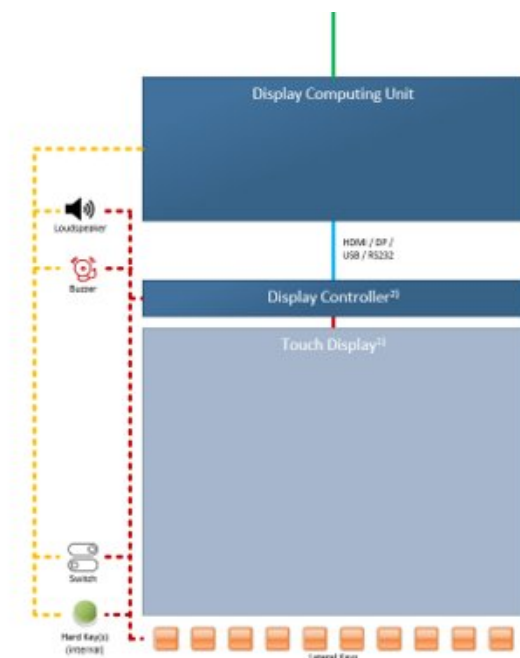


Figure 12 HMI elements in the scope of TDS

6.3 HMI elements management

HMI elements shall be managed by a controller unit and there are two possible implementations. The first option is to connect all the HMI elements to a central controller unit. The second option is a distributed management of HMI elements supported by multiple controllers.

Analysis :

OCORA considers too complex to have a single control unit for all display panels. Moreover, this might lead to a vendor lock-in situation which is in contradiction with the Operational Epics. So, any display panels should be connected to a dedicated computing unit.

As a consequence, OCORA considers the necessity to have a distributed management of HMI elements.

6.4 HMI elements connectivity

Another issue is related to the HMI elements that interface with the TDS. Two options are considered.

The first option is to use direct proprietary interfaces or standard from different industries such as DIN connector or Jack plug for buzzers or loudspeakers. Considering that TDS is compatible with many connectors, this option allows the use of HMI elements as they are designed today, thus allowing more suppliers to be involved, and minimises latencies to TDS. However, this may involve a lot of physical connectors.

The second option is to use the CCS consist network. This option requires HMI elements to be adapted to fit with subsets 146 and 147, may increase latencies to TDS but will limit the number of connector for TDS. With this option, the data exchanged shall be standardised to ensure modularity.

Analysis:

With regards to §6.2, HMI elements remaining in the scope of TDS are loudspeakers, buzzers, switch, internal keys and displays (controller unit and display panels). A list of connectors types allowed for this HMI elements is given below.

HMI elements	Connector types	Comments
Buzzer	-	Buzzers are essentially electrical dipoles that can be connected or soldered directly to an electronic circuit board. As a consequence, they could be considered as an integral part of the display.
Display (controller unit)	CCN connector	CCN connector should be used to ensure direct connection to TDS or systems.
Display panels	Display Port, DVI, HDMI, RS-232, USB type C, VGA	Currently, video and audio standards exist in industries and ensure the absence of vendor lock-in situation. The creation of a dedicated CCN connector for display panels doesn't seem relevant. As Display Ports, HDMI and USB type C are newer and widely used, these ports must be adopted in preference to DVI, RS-232 or VGA.
Internal keys	-	Internal keys are essentially electrical dipoles that can be connected or soldered directly to an electronic circuit board. As a consequence, they could be considered as an integral part of the display.
Loudspeakers	Din connector, Jack plug, RF connectors, SUB D9...	Standard connectors already used in other industry should be supported. In deed, the usage of CCN connector would not lead to a significant benefit.

6.5 Number of TDS controller

The first logical view presents TDS controller as a unique logical component. However, it is conceivable to design a solution based on multiple TDS controllers. A master would be required to control Desk Display area and invoke slaves TDS controller. The communication between all these controllers should lead to a better availability. However, this would imply a higher complexity, too.

Analysis :

The evaluation is still in progress.

Architectural views considered are presented in chapter 6.6.

Functional allocations 1, 3, 4 and 6 represent a single component called the "Display manager", which integrates the TDS controller.

Functional allocations 2 and 5 represent multiple "Display managers", thus multiple TDS controllers.

6.6 Physical and logical architectures

Currently, OCORA evaluates six TDS architectures called "Functional Allocation". These functional allocations address the main characteristics presented above.

For larger scale representations of the figures below refer to the appendix in [\[OCORA-TWS01-035\]](#).

Functional allocation 1: This allocation lets presentation logic in the scope of systems. A central "Display Manager", which includes TDS controller and View controller, manages displays and views.

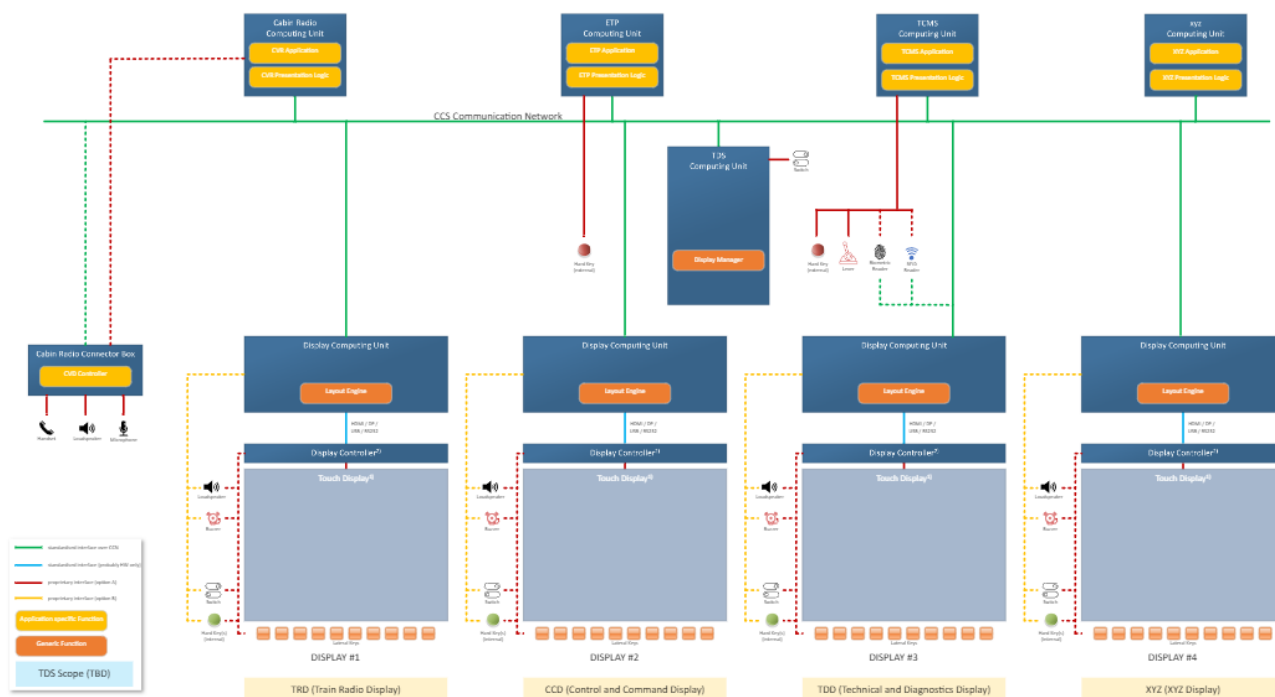


Figure 13: Functional allocation 1

Functional allocation 2: This allocation lets presentation logic in the scope of systems. Multiple "Display Managers", which includes TDS controller and View controller, manages a single display and a single view.

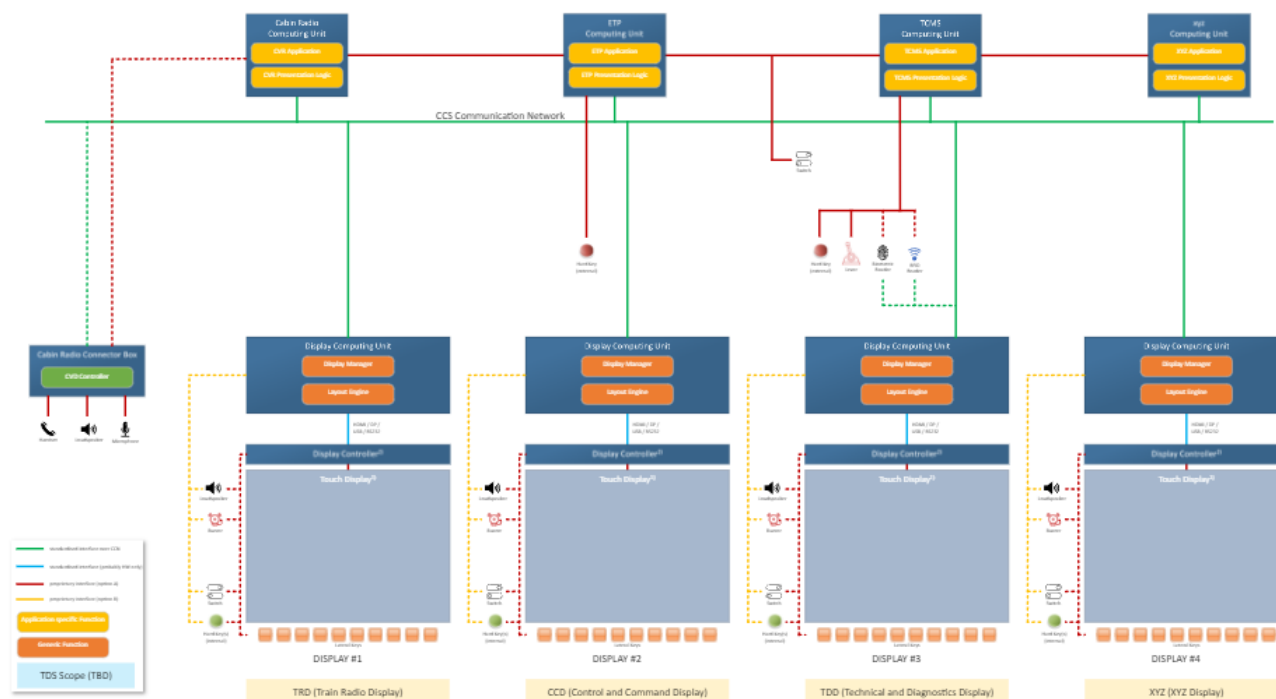


Figure 14: Functional allocation 2

Functional allocation 3: This allocation concentrates all presentation logics and a single "Display Manager", which includes the TDS controller and View controller(s) in a TDS computing unit. Display manager manages displays and views.

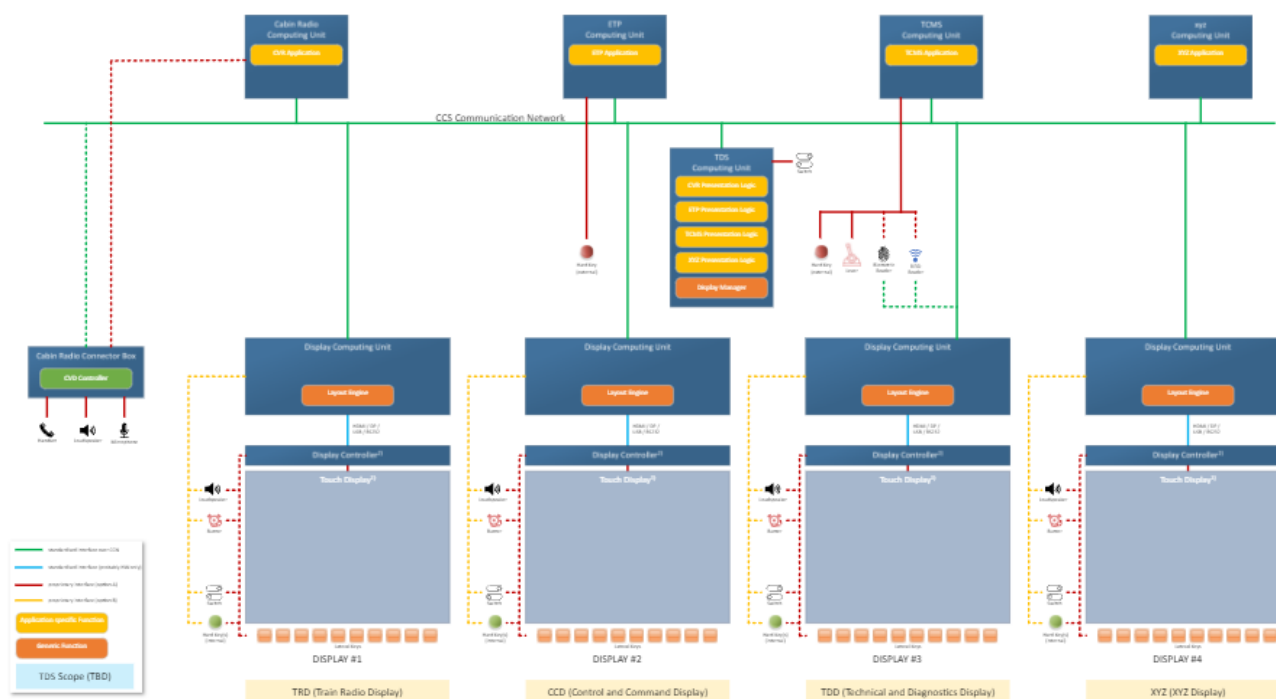


Figure 15 : Functional allocation 3

Functional allocation 4: This allocation concentrates all presentation logics in displays. A single "Display Manager", which includes the TDS controller and View controller(s) is hosted in a TDS computing unit. It manages displays and views.

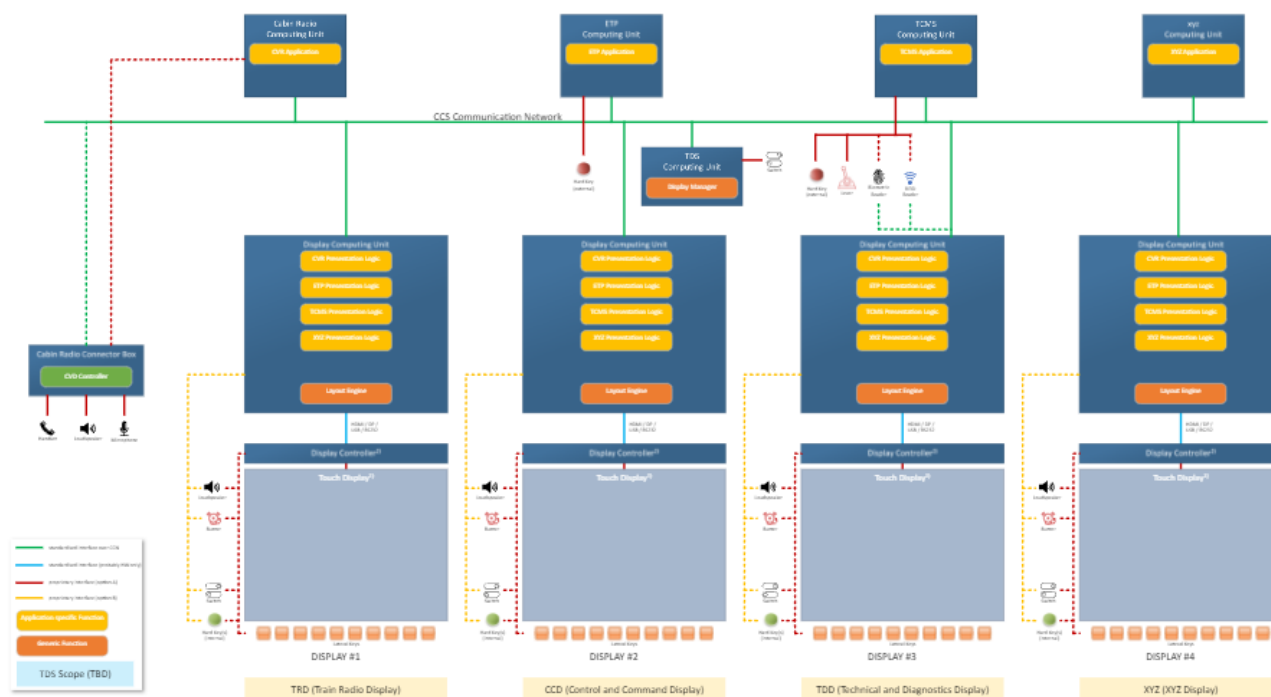


Figure 16 : Functional allocation 4

Functional allocation 5: This allocation concentrates all presentation logics and "Display Manager", which includes the TDS controller and View controller(s) on all display computing unit. Display manager manages a single display and a view.

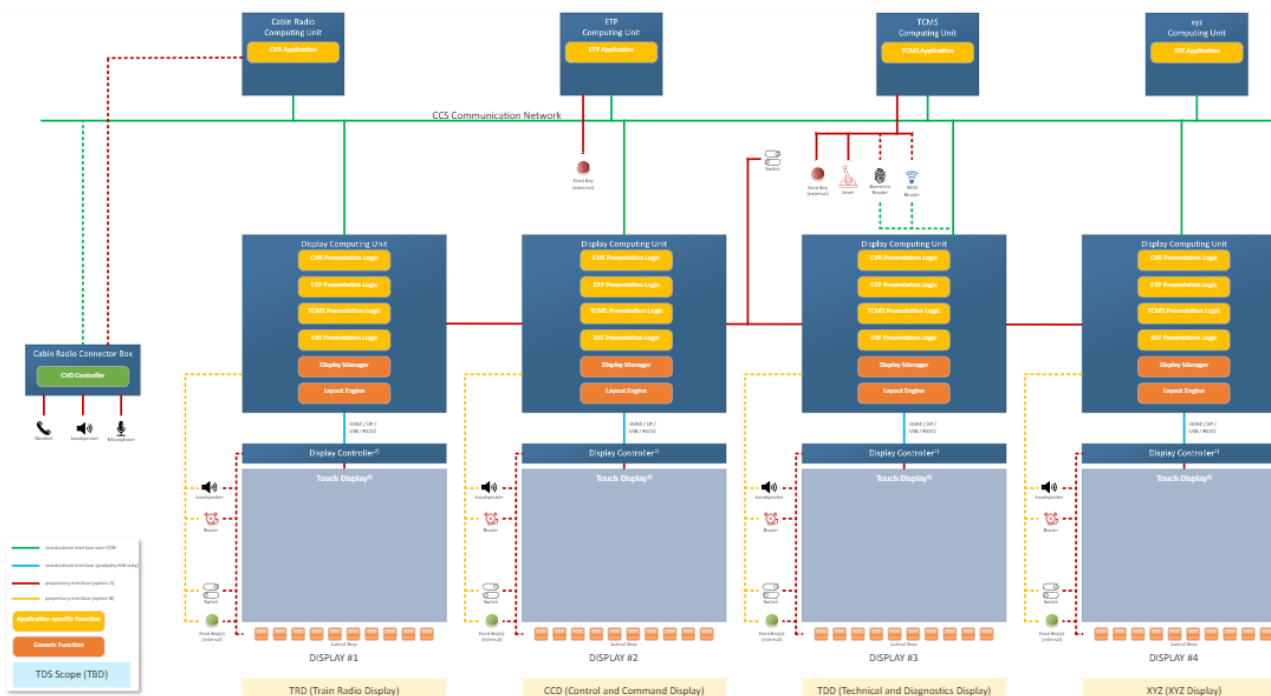


Figure 17 : Functional allocation 5

Functional allocation 6: This allocation lets presentation logic in the scope of systems. A central "Display Manager", which includes TDS controller and View controller, is hosted in an existing system and manages displays and views.

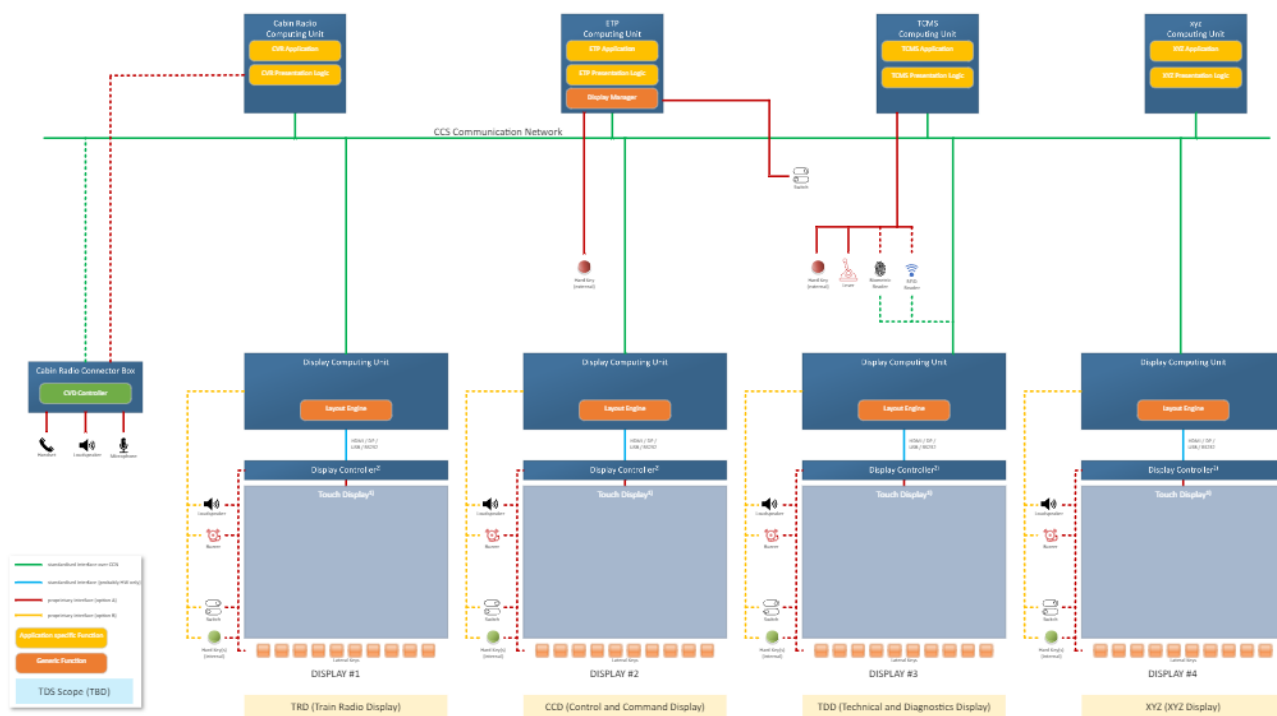


Figure 18 : Functional allocation 6

7 Annex : Cross-industry analysis of displays

This chapter gives an introduction of displays management among transport industries : railway, aeronautics, marine and cars.

OCORA will take under consideration all these inputs in the next version of TDS discussion paper.

Railway industry :

The railway industry has already published some norms to specify the Train Display System. The documents are:

- [CLC/TR 50542] Driver's cab train display controller, CENELEC, Mai 2018

This document introduces the concept of TDS. Chapter 9 supports a general description of TDS at a high level. Compared to other norms, the number of requirements for TDS is low. Chapter §9.2 presents how TDS should allow communication between systems and displays. Chapter §9.3 deals with a standard interface for TDS. Chapter §9.4 deals with compliance with EN50155 and EN50128. Chapter 9.5 presents safety and reliability requirements. Chapter 9.6 presents redundancy rules with extensive reference to UIC 612. Chapter 9.7 presents the architecture for the cab and the TDS. The architecture of the cab is limited to the management of 4 displays based on subset 121 and a local network. The physical architecture of the TDS requires a duplication of power supply, memory and CPU.

- [NF EN 1686] - Railway applications — Driver's cab — Part 1: Anthropometric data and visibility, AFNOR, February 2015

This document presents a set of rules for cab design in France. The main contributors are SNCF, RATP, EPSF and CERTIFER. Parts 2 and 3 contain interesting requirements for the OCORA analysis of TDS. It should be noted that rules are proposed for the existing configuration of the train : only ATP, TCMS, CVR are presented. In part 2, the characteristics of the display are presented. In particular, Table B1.1 describes the need to embed a system, if it has a mandatory location in the cab and the documents used as a reference. This could be useful for TDS configuration management. A deeper analysis should be done on part 3 where a concept close to TDS is specified. For instance, the management of multiple display and redundancy is described in §5.1.3. Chapters §5.1.4 and §5.1.5 present the need for simultaneous configuration of audible information and language between all systems...

- [UIC 612] - Driver Machine Interfaces for EMU/DMU, locomotives and driving coaches - Functional and system requirements associated with harmonised Driver Machine Interfaces, UIC, Mai 2011

The document UIC 612-01 is the document to be analysed in relation to TDS. It introduces the concept of a DDS (Driver Display system) which manages 4 displays for TRD, ETD, CCD and TDD. Although the configuration in the document is limited to a nominal configuration with one display for a system with only four systems, the concept of redundancy in chapter 5 is well described and should be taken as a reference for the OCORA analysis.

- Displays suppliers :

This section reports data collected from the websites of four display suppliers (Deuta, Centralp, Duagon and Eke-electronics).

The first observation is that no display supplier offers a display solution for the entire cab. They only sell individual displays. In other words, their customers may be CCS suppliers who select the appropriate display for their needs. Then the train integrators have to install all these displays in their cabs. A different paradigm where display suppliers offer a standard display solution for the cab to which CCS suppliers have to connect their system is not yet available.

The second point to note is the range of display sizes available, from 6,5" to 15,6". To ensure the configuration management of TDS, views need to be built with relative size or the variety of display size for system need to be reduced.

The third observation is that display suppliers offer SIL level capabilities up to SIL2. These solutions are optional and proprietary. Having standardised capabilities could improve interchangeability.

Fourth comment is that display suppliers offer touch key and soft key solutions but with a greater proportion of touch key solutions. The TDS approach could focus more on this type of display.

Fifth observation is the introduction of display solutions which increase availability. In fact, some redundant terminals are proposed with two adjacent portrait display panels. This solution implies two communication channels between this display and the system and the ability to compute a view spread in two screens.

The Last point concerns the connectivity supported by the displays. Most of them support ethernet interfaces (10BaseT, M12...), USB interfaces, RS 422, MVB, CAN, Profibus and have an audio output. Given the need for connectivity and modularity, a selection of mandatory interfaces should be made.

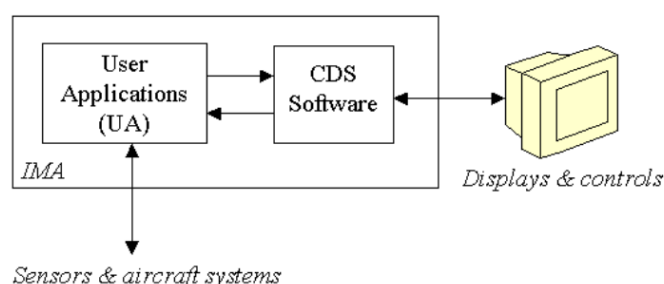
Sources:

- <https://www.deuta.com/en/deuta-multifunctional-terminals-dmi.aspx>
- <https://www.centralp.fr/k-vision-console-ihm-ferroviaire/>
- <https://www.duagon.com/products/#selectedCategory=122>
- <https://www.eke-electronics.com/products-and-solutions/eke-trainnet/human-machine-interfaces/>

Aeronautics industry:

The aeronautics industry has already developed a Cockpit Display System (CDS) that is close to the Train Display System concept. The following paragraphs present it and its current integration on aircraft.

In the mid-1970s, aircraft manufacturers were confronted with the problem of the number of instruments and controls in the cockpit (more than one hundred), in particular the lack of space in the cockpit and the limitation of the pilot's attention. To overcome these problems, the industry has developed a CDS software which, thanks to Integrated Modular Avionics (IMA), allows the interface between user applications linked to sensors or aircraft systems and the displays and controls. This CDS provides the visible and audible part of the HMI for the aircrew, managing the glass cockpit (displays) and the interactions with the systems. The CDS provides separation between user applications and the displays and controls. The displays are not dedicated to one application. It is therefore possible to have more applications than displays. If a display fails, an automatic reconfiguration is done with the other displays. The pilot can organise his displays according to the priority associated with his flight phase.



This concept is based on standards such as ARINC 661, which specify the integration of the CDS and its interactions with the aircraft systems applications. However, the interaction between sensors and aircraft systems is not specified : ARINC 429, Ethernet protocol such as ARINC 664 could be used, but are not mandatory. In addition, the ARINC 661 standard has a fully defined graphical user interface (GUI), which allows a homogeneous presentation of data. With regards to these standards and concept, aeronautics suppliers can now offer a complete cockpit display solution. These products are compatible with other aircraft systems thanks to the IMA concept.

The introduction of the CDS and the glass cockpit has brought many benefits. Several aircraft incidents are related to the loss of displays. This means that the loss of the CDS leads to the loss of all displays. Therefore, crews need to be trained to deal with these failures and avoid consecutive accidents. To limit the impact of such a loss, some manufacturers have proposed an additional system (Integrated Standby Instrument System) that provides the minimum information necessary to complete a mission. This system is electronically separate from the main instruments and can run for several hours on a back-up battery.

By the end of the 1990s, Liquid Cristal Display (LCD) panels were widely adopted for their efficiency, reliability and legibility. Today, glass cockpits are standard in commercial aircraft, business jets, military aircraft and spacecraft. In the

latest Airbus cockpits (A220, A350), the number of displays in the cockpit has been reduced. The aircrafts now have a maximum of 6 displays instead of 10 on the previous generation of aircraft (A380). This reduction is made possible by the use of very large screens that allow all informations to be displayed on fewer panels. These panels are also identical to ensure interchangeability and a significant reduction in maintenance costs. Most of the displays are touchscreens, resulting in a decrease in weight and Line Replaceable Units (LRUs).

Sources:

- https://en.wikipedia.org/wiki/Cockpit_display_system
- https://en.wikipedia.org/wiki/ARINC_661
- https://en.wikipedia.org/wiki/Glass_cockpit
- <https://www.airbus.com/en/products-services/commercial-aircraft/cockpits>
- <https://aerospace.honeywell.com/us/en/products-and-services/product/hardware-and-systems/cockpit-systems-and-displays#4>
- <https://www.thalesgroup.com/en/markets/aerospace/flight-deck-avionics-equipment-functions/flytx-tactile-large-display-flight-deck>
- <https://www.einfochips.com/blog/electronic-flight-deck-systems-in-modern-aircrafts/>
- <https://www.astronautics.com/products/displays/>

Marine industry:

Few informations have been found on marine industry. A deeper investigation could be done in a next release.

The first observation is that display suppliers can sell a single display dedicated to a system or a set of displays for the whole cab. For the latter, several configurations are possible: integration of a single unit with many displays (2 to 7 display panels) or integration of several units (units with 2 or 3 display panels). A more detailed analysis could be made on how these displays are managed and the type of connectivity used between systems and these displays.

Source:

- <https://seatronx.com/products/displays/marine-displays/>

Automotive industry:

As the automotive industry considers displays as one of the key differentiators of modern vehicle interiors, suppliers are proposing new interesting solutions for driver-vehicle interaction.

The first observation is that most suppliers are offering display solutions that cover the whole "cockpit" from one ultra-wide display to four wide displays. These displays have dedicated areas that supports functions: driver information (e.g. speed), control and information elements (e.g. cabin temperature), entertainment functions (e.g. radio)...

The second point to note is the quality of the displays. They are large, from 7" to 15" in a rectangular form, but the shape could be adapted to specific needs. They also have high resolution (OLED). Some of them have 3D capabilities to put focus on essential information. Other capabilities exist but seem less relevant in the context of train driving (privacy displays, providing images only visible to the passenger...).

All these displays could be managed by a single platform. This platform allows space savings compared to the integration of distributed control units and gives flexibility in configuring the view in the cab. This solution is based on a system on a chip, a hypervisor and compliance with Autosar, an automotive norm defining, among others things, interfaces and data exchanged, that allows different runtime environments and softwares to be embedded on a single platform.

The final observation is the ability to give control of parts of the cockpit or displays to non-native applications. In fact, applications such as Android Auto can run on the displays. This means that they are either pre-configured as authorised applications, or have cybersecurity features that enable authorisation and authentication on the displays.

Sources:

- <https://www.continental-automotive.com/en-gl/Passenger-Cars/User-Experience/Display-Solutions>
- <https://www.visteon.com/products/displays/>
- <https://www.bosch-mobility.com/en/solutions/infotainment/display-and-interaction-systems/>
- <https://www.faurecia.com/en/technologies/solutions-safe-advanced-personnalized-cockpit/display-technologies>
- https://www.android.com/intl/en_en/auto/