ERJU SYSTEM PILLAR

System_Concept_TrainCS_MultiDisplay_v0

System_Concept_TrainCS_MultiDisplay_v02

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Abstract	Description of the first concept which and how to integrate business applications on the new Multi Display approach, to enable switching between a generic and a degraded mode screen configuration
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1 Preamble

1.1 Management Summary

Scope and intended audience

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. Each 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 Driver Machine Interface (DMI) fails, the ETP will go into system failure and apply an emergency brake, if the ETP manufacturer is not providing a redundancy concept. 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 a new architecture, new building blocks and services (DAS, MDCM-OB, UID-Reader, etc.) 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, System Pillar Train CS and OCORA are 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 Multi Display System (MDS). Other needs are also expressed with the introduction of MDS such as management of multiple systems on one display. (In this document the geometry and view catalogue of the existing business applications is kept as it is. For the future the option of mixing different view catalogues on one single display can be elaborated).

This Train CS Systen Pillar document consolidates the operational and functional analysis made by OCORA and gives an architectural proposal developed in the Train CS System Pillar for the Multi Display System. With this in mind the Train CS System Pillar provides a proposal to realize a generic display system that offers redundant behaviour to multiple business applications. The architecture is based on virtualisation and the one common bus ethernet network for the onboard. To reduce the required space for screens in the drivers cab, it is possible to integrate multiple business applications on a defined number of screens.

These requirements are intended as input for:

- a standardised system architecture and design initiatives
- The development of future TSI standards, regulatory frameworks, and related specifications
- Contracting authorities, particularly in preparing tenders and conducting tests or certification for MDS

The document is directed at professionals in the CCS (Control Command and Signaling) field, as well as anyone interested in the Train CS approach to MDS.

1.2 Purpose

In today's architecture, there are at least three main screens in a cab supporting three systems: ETP, TCMS and CVR. Each screen is dedicated to one system. Every screen embeds only one business logic to enable data exchange with the appropriate system and elaborates the associated view. This paradigm leads to four 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, an update of the ergonomic part or the system itself leads to an update of both parts. This interdependency increases the cost of maintenance (update). This is more problematic for components with different SIL. For example, an ergonomic enhancement to the DMI of the ETP (SIL2 component) leads to an update of the ETP (SIL4 component).
- Thirdly, space in the cab is limited. By introducing new functionalities with the ERJU System Pillar Task 2 Train Control & Supervision Domain's (hereafter referred to as Train CS) 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.
- Fourthly, 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.

To solve these problems, Train CS is proposing the introduction of a new building block: the Multi Display System (MDS).

The first version of this document introduces the MDS concept (terminology and main characteristics of the architecture) and high level requirements. All the concepts are still under discussion.

Future versions will include the architecture chosen, after evaluation of the main characteristics, and the design requirements.

1.3 Glossary

Find here the Gloassary of the System Architecture Document (SAD) Glossary

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.

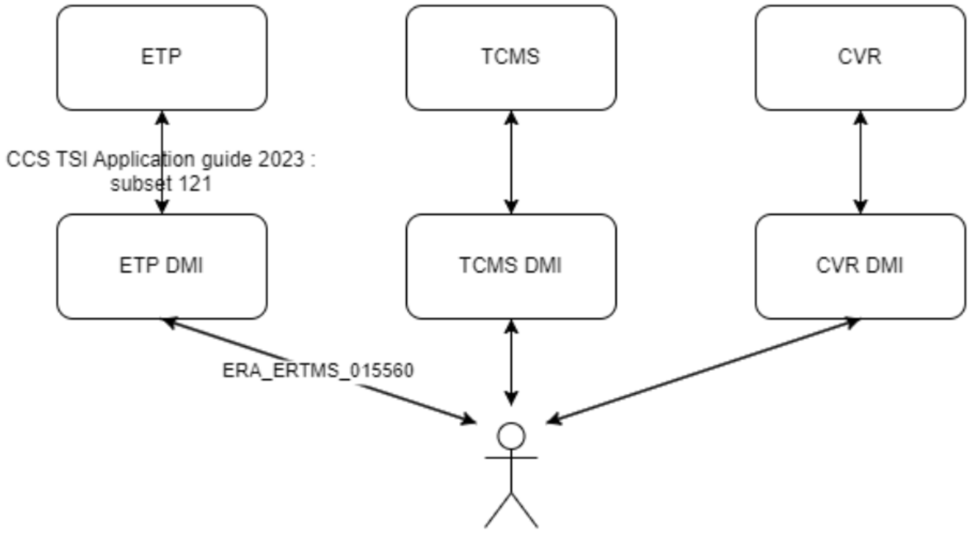

Figure 1 Problem Statement with three applications

If every additional application which is integrated into the cab is given its own screen, space will quickly become very tight.

As space in the cab of trains is limited, we want to limit the number of displays in the train. That causes the problem that there are at least four applications (ETP, TCMS, CVR and other Systems) and only three displays. As we will have at least one more application than screens on the locomotive in future, we need a solution to this problem.

Actual modern train cab designs are using up to six different screens for all required applications. More possible applications listed in the appendix.

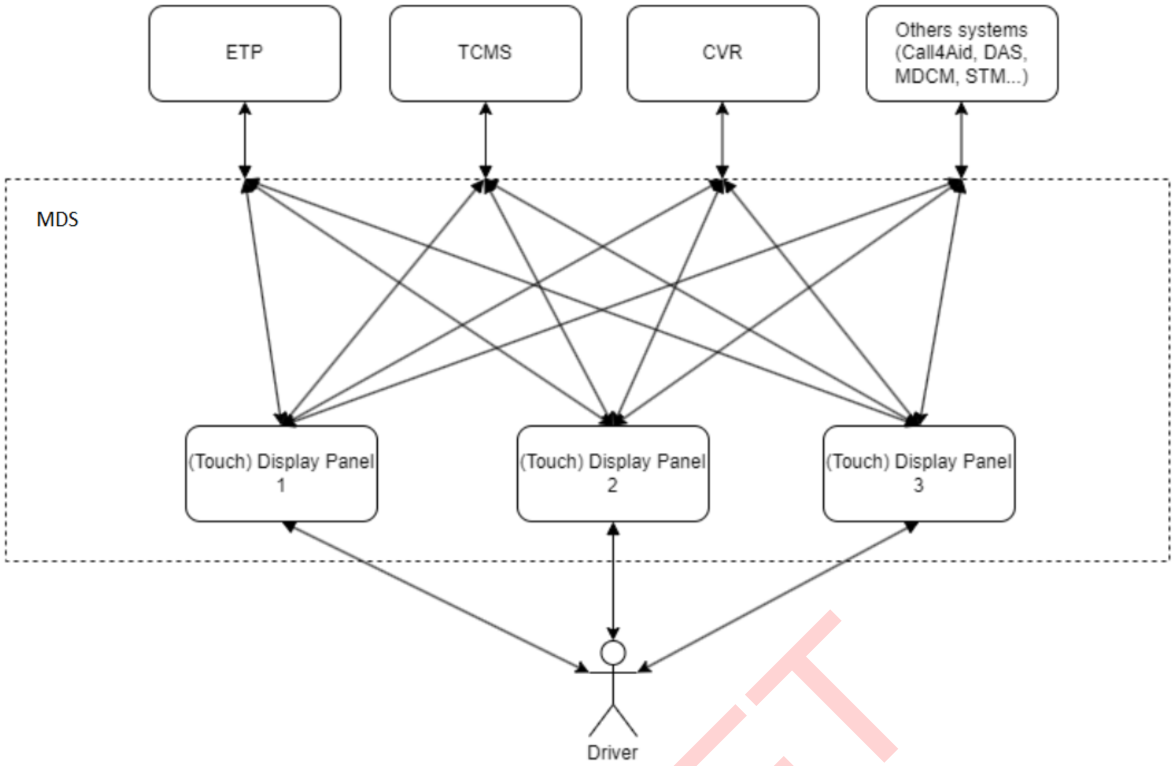

Figure 2 Problem Statement with four applications but only space for three displays

2.2 Key Design Drivers for the concept

As we continue to evolve our system architecture, we are deliberately placing a strong focus on modularity, exchangeability and redundancy. These principles are essential to ensure the maintainability, flexibility, and long-term sustainability of our display solution.

Modularity
Modularity allows us to break down complex systems into clearly defined, self-contained components. Each component serves a specific purpose and communicates with others through well-defined interfaces. This structure makes the overall system more manageable, easier to maintain, and simpler to test. Enhancements or changes can be made within individual modules without unintentionally affecting other parts of the system.

Exchangeability
Building on this modular foundation, we are also aiming for exchangeability. An exchangeable component can be replaced by an alternative implementation (for example, to integrate new technologies or to optimize performance) without requiring modifications to the rest of the system. This leads to greater technological flexibility, faster development cycles, and easier integration of external services or platforms.

Redundancy
In addition, we are embracing redundant system designs to increase overall reliability and fault tolerance. Redundancy ensures that critical functions remain available even in the event of partial system failures or outages. By duplicating essential components or services, we can minimize downtime, improve system resilience, and provide a seamless experience for end users. Redundant solutions are a key aspect of building robust, high-availability systems that can meet demanding operational requirements.

By combining modularity, exchangeability and redundancy we are laying a solid foundation for a scalable, extensible, and future-proof software architecture.

2.3 Scope limitation - not under consideration

The topics of remote driving, Human and Organizational Factors (HOF), and combining views are outside the scope of this document. While these aspects play an important role in the broader context of system design, user interaction, and operational safety, they are not addressed here in order to maintain a clear focus on the technical system architecture and overarching system-level functions.

- **Remote driving** introduces specific requirements and challenges—such as latency, network reliability, remote controllability, and safety-critical decision-making. A thorough analysis of this topic would exceed the scope of this document and will be considered separately.
- **Human and Organizational Factors (HOF)** refer to human, social, and organizational influences on system behavior. This includes user interaction, responsibilities, team dynamics, and error culture. Although these factors significantly impact the effectiveness and safety of a system, they are not the focus of the technical aspects discussed in this context.
- **Combining views**, in the sense of displaying multiple applications or system interfaces simultaneously on a single screen, raises important questions about usability, layout optimization, user attention, and workload. The design and evaluation of such multi-application views will be covered in a dedicated document or future phase of the project.

These exclusions are intended to provide a clear structure to the content and keep the discussion centered on the fundamental technical architecture and system interfaces.

2.4 Operational Epics

In the following section, identified key operational epics related to Multiple 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.

SPT2TRAIN-7709 - 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.

SPT2TRAIN-7710 - As a railway undertaking, I would like to add systems which require a display in the vehicle without
integrating dedicated display panels in the cabs, in order to better manage the available space and limit the integration
effort.

SPT2TRAIN-7711 - 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.

SPT2TRAIN-7712 - 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).

SPT2TRAIN-7713 - As a railway undertaking, I would like to manage the least possible number of display solutions in
order to reduce costs, efforts and downtime involved in maintenance (update).

SPT2TRAIN-7714 - 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.

3 Multi Display System overview

In order to better understand the environment associated with managing the Driver-Machine-Interface (DMI) in the driver's cab, physical and logical views need to be explained. Although these views do not offer an exhaustive list of possible integrations, they illustrate the key concepts.

3.1 Involved Entities and Actors

The figure below gives an overview of the entities/actors involved in the context of MDS. The entities/actors are the driver, the maintainer, the systems, the MDS and the train itself. For each of them, their main characteristics and tasks are given below.

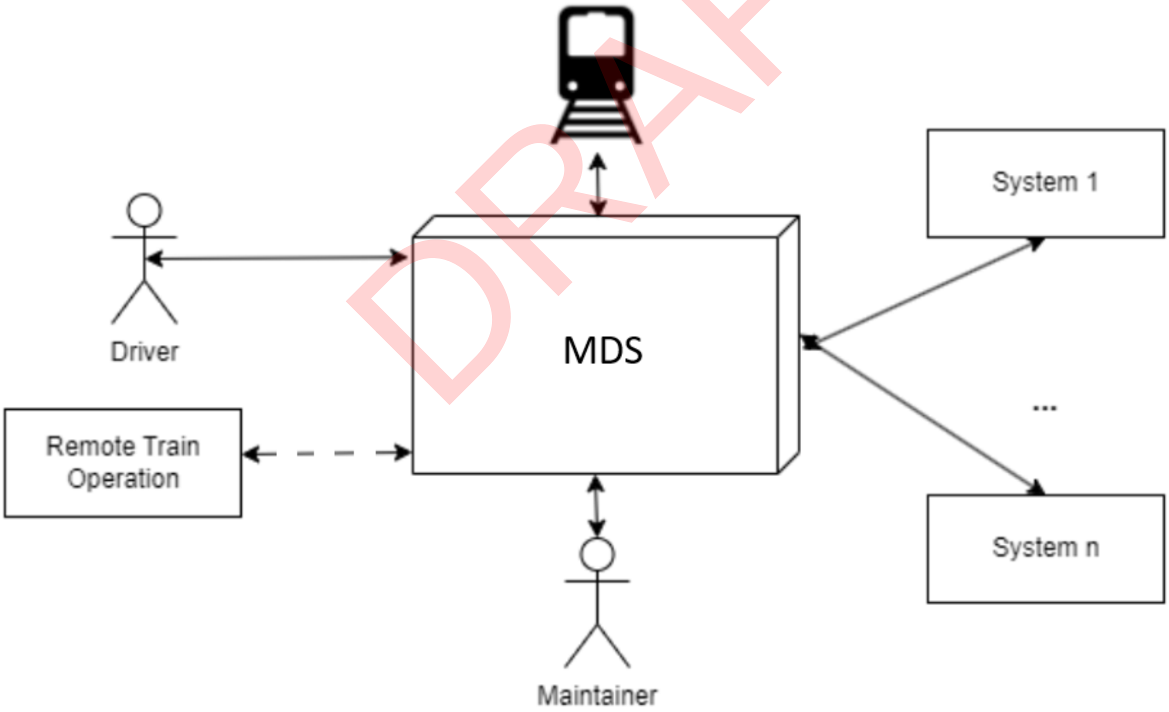

Figure 3 Entities and actors involved with MDS

The driver is an operational actor. He is in charge of (un)preparing and driving...
The driver is an operational actor. He is in charge of (un)preparing and driving trains. The main tasks of this actor are:
activate/deactivate the cab, activate/deactivate systems, configure displays on the cab and operate systems.

Remote Train Operation
The Remote Train Operation (RTO) system is an operational entity. It provides the status of the train in

terms of remote
driving: stand-alone, monitored, observed and controlled. Depending on this status, the MDS can change the active
configuration of the cab displays.
In addition to provide input to the MDS, the RTO may require a specific view on a display. If so, the interface between
the RTO and the MDS will be the same as for the other systems described below.

Maintainer
The Maintainer is an operational actor. He is in charge of maintaining a system in a operational state. To do so, he can
monitor, diagnose, repair, update and configure the system. The main tasks of this actor are: configure displays in the
cab, diagnose issues of a system, repair a system and update a system.

Systems
In the context of MDS, these are operational entities that require a human-machine interface. There are several systems in a cab. In this chapter, it is proposed to present the main systems considered in this paper in order to find the characteristic to be analysed from perspective of MDS. So descriptions of ETCS, TCMS, CVR and Rearview systems are given below and give an overview of their current situation. Other systems exist, such as Electronic Timetable Display, and should also be considered. However, it is assumed that the characteristics of the systems analysed would remain applicable to the other systems. An exhaustive analysis should be carried out to be sure of the relevance of this proposal. So far, the following characteristics have been considered: ergonomics, location in the cab, SIL requirements, when visibility is required, interface between the system and the driver's display.

ETCS (CCD display)
The display associated to this system is called CCD (Control Command Display) in UIC-612. The functionalities and the ergonomics of this system are standardised in the subset 026 and ERA DMI 15560.The CCD display is located in front of the driver according to UIC-612-0, EN 16186-2 (chapter 7.21). According to subset 091, some THR are related to the DMI and involve THR equivalent to SIL2. Information of ETCS are mandatory when train is in motion. It could be debatable if this is also the case at standstill. There is a proposal for standardisation communication between ETCS and MDS known as Subset-121.

TCMS (TDD display)
The display associated to this system is called TDD (Technical and Diagnostic Display) in UIC-612. The ergonomics of this system is also defined in UIC-612-3.The TDD is located on the right side of the cab according to UIC-612-0, EN 16186-2 (chapter 7.21). Depending of the configuration of the train, the SIL associated to TDD could be SIL2 (when safety related information are only displayed on TDD) or SIL0 / Basic Integrity (when safety related information is presented on TDD and also with safe lights in cab). According to EN 16186-3 (table B.2), if existing, some information is mandatory for high speed class 1 trains. Otherwise, other information is optional. Current communication between TCMS and TDD is supplier-specific. To facilitate the deployment of the MDS solution, a migration to a generic communication used also by other systems should be considered.

CVR (TRD Display)
The display associated to this system is called TRD (Train Radio Display) in UIC-612. The ergonomics of this system is also defined in UIC-612-4.The TRD is located on the left side of the cab according to UIC-612-0, EN 16186-2 (chapter 7.21).The SIL is SIL0 (Basic Integrity).Information is presented on demand when triggered by the driver or when external actors (passenger, traffic agent,etc.) call the driver. Current communication between CVR and TRD is supplier-specific? To facilitate the deployment of the MDS solution, a migration to a generic communication used also by other systems should be considered.

Rearview system
The Rearview system permits to see the states of the doors at standstill. The ergonomics of this system is supplier specific; no norm or standard specify it. Two displays are used for the rearview system. Two options exist for the position of the displays : one on the left side of the cab and the other on the right side of the cab (left doors vs. right doors), or the two displays side by side on the left or on the right side of the cab. The SIL associated to this system is SIL0 (Basic Integrity). Images from cameras are only displayed at standstill. Current communication between Rearview system and its displays is supplier specific. To facilitate the deployment of the MDS solution, a migration to a generic communication used also by other systems should be considered.

Overview:

System	Ergonomics	Localisation of the display*	SIL	when view is required	System <-> display interface
ETCS	ERA DMI 15560	mandatory in the front of the driver	SIL2	Mandatory when in motion, but debatable at standstill.	
TCMS	UIC-612-3	usually on the right of the ETCS	SIL2 or SIL0/BI	Some information of High speed class 1 train are mandatory. Otherwise, information are optional.	supplier specific**
CVR	UIC-612-4	usually on the left side of the cab	SIL0/BI	On driver demand or when external actors call the driver.	supplier specific**
Rearview system	not standardised	position of the two displays is related of the train integration: - One on the left (left doors) and the other on the right (doors on the right) or - both 2 displays side by side on the left or on the right.	SIL0/BI	Supplier-specific, mainly useful only at standstill.	supplier specific **

Table 1 overview table

*The localisation of displays is given according the recommendation of UIC-612. However, the chapter 3.3.2.4 of
UIC-612 document considers also that ability to change the location of any display in case of major constraints.

**To facilitate the deployment of the MDS solution, a migration to a generic communication used also by other systems
should be considered.

These systems are involved in the following tasks: activate/deactivate the cab, activate/deactivate system, configure
displays on the cab, diagnose errors of a system, interact with systems, monitor the state of a system, repair a system
and update a system.

The MDS is an operational entity that enables interactions between the driver and systems. This system is involved in the following tasks: activate/deactivate the cab, configure displays on the cab, diagnose errors of a system, interact with systems, monitor the state of a system, repair a system and update a system.

Train
The train is an operational entity that provides informations to MDS such as cab is active, train in motion or at standstill. The train is involved in the following tasks: activate/deactivate the cab and configure displays on the cab.

3.2 Physical structure

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

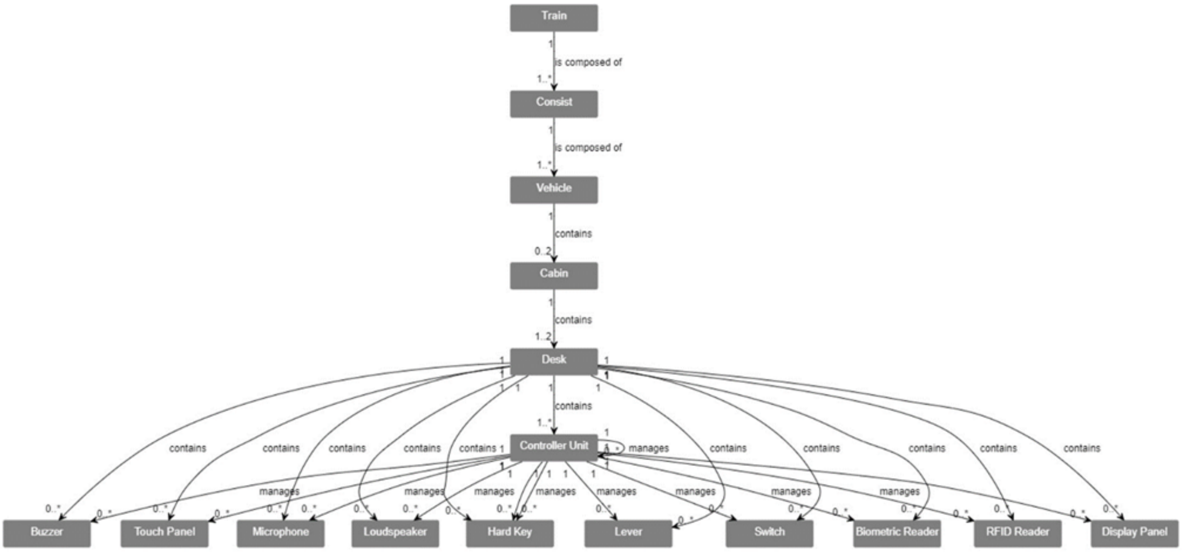

Figure 4 Physical terminology tree

SPT2TRAIN-7719 - Limit the perimeter of a MDS to the management of two desks:

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

3.3 Options to integrate the physical inputs/outputs

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

The communication between the Display Computing Units of the system are granted by the CCS Communication Network as Train CS consider mainly the integration of MDS for new trains. Switch, microphone, RFID Reader, Biometric Reader, Hard Key and Buzzer can be connected to a central Controller Unit. A distributed configuration is also possible. The picture in figure 5 shows two possible variants to connect the external elements. The discussion how to realize it is not finalized up to now. An automatic brightness and sound control in each display could help to avoid glare effects due to sunlight and enables minimum sound levels. Individual settings for brightness of each display must be possible although there is an automatic control. For the other elements no clear proposal was found.

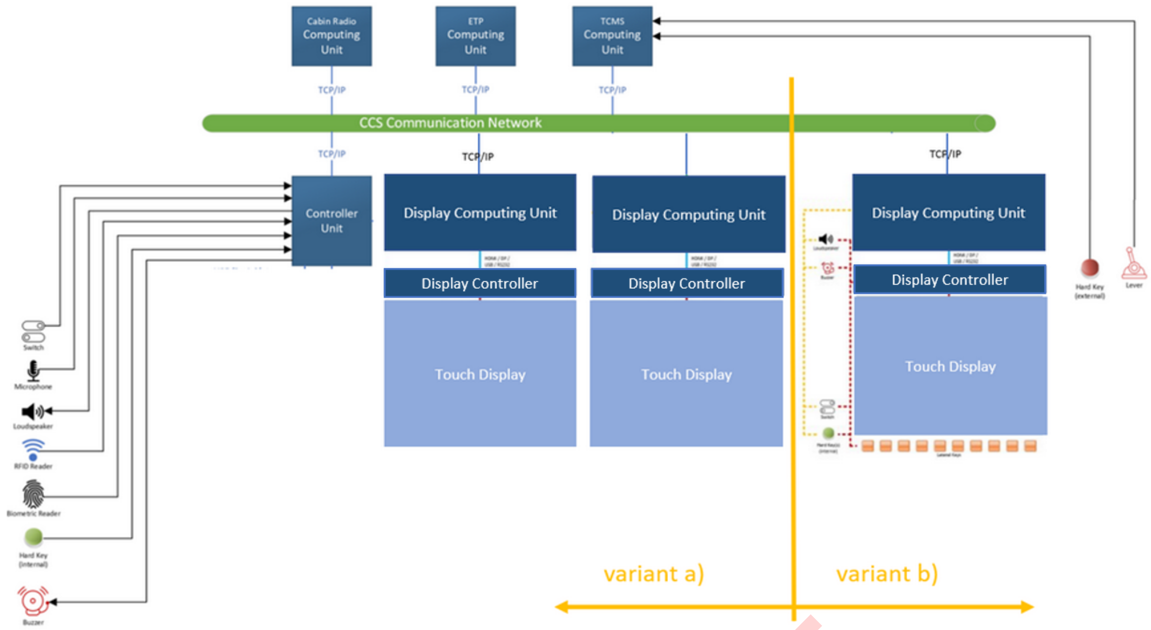

Figure 5: MDS context principle

3.4 Logical View

The figure below shows the logical elements of the Multi Display System and the elements that are involved for operating the MDS in the context of multiple systems (ETP, TCMS, Radio) to connect to all physical input and output devices.

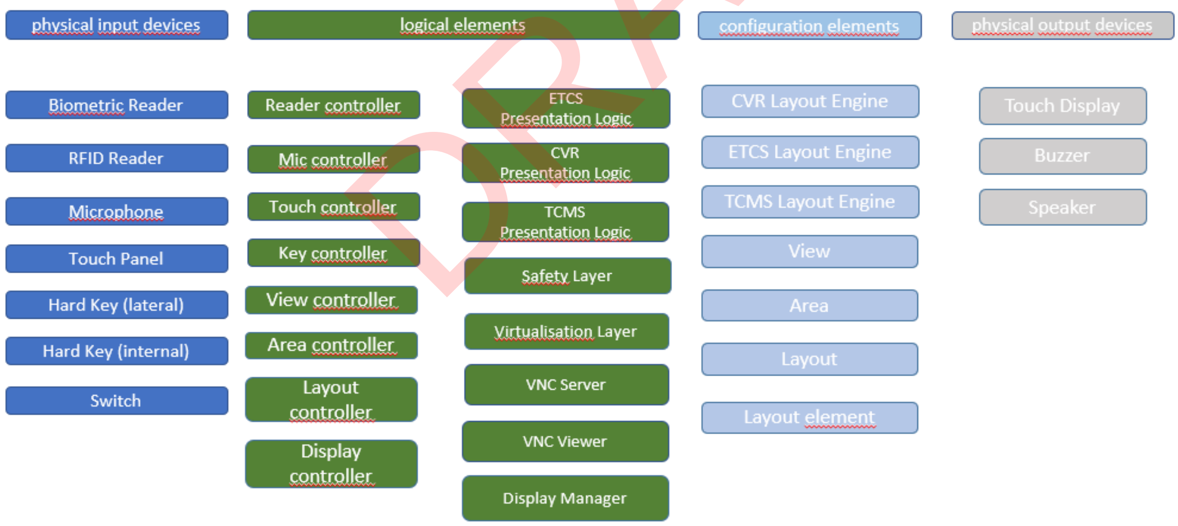

Figure 6: logical view of the MDS and the environment

3.5 Definitions

Area Controller

The *Area Controller* manages areas for the *View.*

Biometric Reader

Device that reads the identity of a person by comparing some attributes of their physiological being or behavioral traits against a sample database. This reader permits the authentication of the actor.

Button
A *Hard Key* allocated to a dedicated system on a cab. It's designed with a dedicated SIL. It allows a selection from two states and keeps one state as long as it is pressed.

Buzzer
Electrical device that makes a buzzing noise and is used to provide an audible warning.

Controller Unit
The *Controller Unit* is a hardware component which embeds logical controller(s). There may be only one Hardware or distributed to several HMI Elements.

Configuration
Refers to an allocation of systems with MDS units. This allocation could be selected and applied by the MDS (Display Manager). For each vehicle type there is a specific configuration of business applications that use the MDS. A generic configuration is only possible inside one vehicle type to describe the maximum number of involved applications.

Desk
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).
Exception: some single cab locomotives are fitted with one single desk, allowing normal movements in both directions.
*(set of operating controls: screens, buttons, traction/brake lever, direction controller, radio control, switches, …)

Desk Area
Desk Area is a location attribute (left, center…) associated to *HMI Element* for *Display Computing Unit* to allocate elements to a View.

Desk Display Area
The Desk Display Area identifies the desk controlled by MDS (in case of multiple cabins controlled only by one MDS such as locomotive or centralised integration).

Display Computing Unit
Computing Hardware that contains a real time operating system, virtualization software and virtual containers for the parallel applications. This hardware shall be generic to be interchangeable. (Software in DCU will be application specific).

Display Controller
The part of the display that is assuring the safe display of the requested information on the screen, related to time, place, duration and colour.

Display Manager
Is the interface to the Display Controller and synchronising all status and data informations of all business applications for the Display Units.

Display Panel
Glass (LCD) showing pixels without controller.

External Button
A button which is not directly managed by MDS.

Hard Key
Physical key not part of view. This key can also have a text label or symbol.

HMI Element
An HMI Element is a physical component that interacts with the driver: Buzzer, Display Panel, loudspeaker, Hard Key…

Internal Button
The *Internal Button* is a button which is managed directly by MDS.

Key Controller
Controller which manages states and failures of Hard Keys (internal and Lateral Key) and switches.

Lateral Key
Hard Key located close to a *Display Area* allowing soft key technology.

Layout
Layout is a list of *Layout Elements* which is displayed in an area.

Layout Controller
The *Layout Controller* manages the *Layout* for an *Area*.

Layout Element
Every element to be shown on the screen like button, speed gauge, video stream, symbol and text with
their characteristics (size, position, type, colour, associated icon, etc.)

Layout Element Controller
The *Layout Element Controller* manages *Layout Elements* of a *Layout*. It knows how to present itself and how to react on events.

Layout Engine
The *Layout Engine* is an application and supplier specific piece of software, able to generate any *View* based on application specific needs.

Loudspeaker
Device that converts an electrical audio signal into a corresponding sound.

LOC & PAS
Locomotives and Passenger TSI

Microphone
Device that translates sound vibrations from the air into electronic signals and scribes them to a recording medium or over a loudspeaker.

Microphone Controller
The *Microphone Controller* manages states and signals of *Microphone*.

Multiple Display System
The Multiple Display System is the train cab display system that comprises and manages one or more Multi Display System Units on the driver desk and a driver interface. It is composed of at least one Display System Unit with the associated input devices, at least one loudspeaker and at least one Display Manager. It offers a standardised communication interface to systems that need driver interaction.
The perimeter of a MDS is limited to the management of two desks:

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

Multi Display System Unit
The Multi Display System Unit consists of the generic Display Computing Unit, the Display Controller and the Touch Display (Touch Panel).

Presentation Logic
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
The *Reader Controller* manages states and failures of the *Biometric Reader* and/or the *RFID Reader*.

RFID Reader
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.

Soft Key
Context-dependent key which consists of a *Hard Key* with an associated label on the *Display Area*. When using a soft key technology, the driver action is done via the *Hard Key* adjacent to the label.

Switch
Physical component which allows a selection of 2 to N states and keeps the state until its position is changed.

System Computing Unit
This is the business application, ETCS, TCMS or Cabin Voice Radio that is sending the information to be viewed on a display.

Touch Controller
Controller which manages the states and failures of a *Touch Panel.*

Touch Panel
Hardware detecting where the finger touches the panel. Sometimes called Touch Display as well.

View
Aggregation of *Areas* required for systems (CCS, TCMS, CVR...). A *View* can represent *Areas* of different systems at the same time.

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

3.6 MDS proposals

The consolidation of logical and physical views has led to a review of the architectural definitions and proposals in Summary of the Discussions for a Preliminary Bottom-up On-board CCS Architecture

3.6.1 HMI elements management

SPT2TRAIN-7772 - HMI elements shall be managed by a *Controller Unit* and there are two possible implementations. The first option is to connect the *HMI Elements* to a central *Controller Unit*. The second option is a distributed management of *HMI Elements* supported by multiple controllers. The second option may provide a better availability for MDS.

3.6.2 Interface with HMI elements

SPT2TRAIN-7774 - Another issue is related to the *HMI Elements* that interface with the MDS. Two options are considered. The first option is to use direct proprietary interfaces. Considering that MDS 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 MDS. 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 MDS but will limit the number of connectors for MDS. With this option, the data exchanged shall be standardised to ensure modularity.

3.6.3 Interface with external buttons

SPT2TRAIN-7776 - With regards to *External Buttons*, such as the emergency brake button, two solutions can be considered. As they are considered to be used by the driver, these buttons should directly interface with the MDS. 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.

3.6.4 Number of Display Managers

SPT2TRAIN-7778 - The first logical view presents *Display Manager* as a unique logical component. However, it is conceivable to design a solution based on multiple *Display Mangers*. A master would be required to control *Display Area* and invoke slave *MDS Controllers*. The communication between all these controllers should lead to a better availability. However, this would bring higher complexity, too.

4 Multi Display System Logical Architecture

This document relates to the parallel and increasing usage of ETP-, TCMS-, CVR- and NTCs and new applications to describe the architectural options and specific topics, that arise if these specific applications have to use generic interfaces and protocols to operate as Multi Display System.

SPT2TRAIN-7780 - Legacy NTCs can have different operating rules in each country. As example a rule is requesting that a NTC has to operate in stand alone mode. In this case, ETCS and the STM are switched off, no information is transferred from STM to the display. In this case, there would be no presentation logic to provide speed data to the display, no operation would be possible. Special proposals for such NTC need to be considered if required.

SPT2TRAIN-7781 - Keep or increase the availability of existing systems using displays in a train in order to increase the overall availability of the train: i.e. not to stop the train and ensure a continuity of service.

SPT2TRAIN-7782 - It has to be able to add new system applications to an existing MDS without adding new physical screens. New applications shall reuse the existing MDS displays and have to be integrated in the generic- and reduncancy-view concept. Provided the timing requirements for the new applications must be in accordance of the MDS timing reserve, (computing power capacity).

SPT2TRAIN-7783 - A safe separation between the system applications running on a Display Computing Unit must be assured to avoid interaction or loss of functionalities.

SPT2TRAIN-7784 - It has to be possible to exchange the MDS, the Display Computing Unit hardware, without a vendor lock-in for operation and spare part provisioning in order to minimise OPerational EXpenditure (OPEX) and Mean Time to Repair (MTTR).

SPT2TRAIN-7785 - The MDS shall be organized with the least possible number of displays, to be able to show all operated applications, in order to reduce cost, effort and downtime involved in maintenance (update).

SPT2TRAIN-7786 - It must be possible to select the number and type of different system applications from a MDS specific configuration, for operating the MDS one a vehicle type, without causing additional effort for certification of each specific configuration. This specific configuration defines a set of applications and combinations of this applications that can be operated without additional certification effort.

SPT2TRAIN-7787 - List of all important criteria for applications that have to run on a MDS to define priority between them. Criteria depend on the actual operational status and the safety requirement of the needed functions.

Proposed priorities for applications that shall be displayed in parallel on the different screens of a MDS:

Property	Priority	Explanation	Application
train operation status	1	driving, standstill, shunting	all
• safety-requirement of used function,	2	(how much a displayed information contributes to the safety) driver needs, passenger safety, train safety, intrastructure safety,	all
• operational need	3	need for actual train operation, e.g. additional information about train or infrastructure status	all
position	4	HOF, ergonomics	all

Table 2 possible priorities for application properties

SPT2TRAIN-7789 - For each vehicle type, a MDS specific configuration shall be defined in which the possible applications are given and where a generic view is described with detailed description what has to be displayed and where in normal operation and in case of failure of any in the MDS contained Display.

SPT2TRAIN-7790 - The display information on the MDS shall be arranged in a generic order fulfilling all L&P-, HOF-, ergonomic- and normative- requirements. The impact of any ergonomic enhancement shall be minimized in order to lower OPerational EXpenditure (OPEX).

SPT2TRAIN-7791 - The configuration of the MDS shall allow changes in the ergonomic arrangement of the MDS to avoid effort for re-certification.

4.1 System Requirements

SPT2TRAIN-7793 - The MDS shall activate only one desk at a time.

SPT2TRAIN-7794 - The MDS shall manage all device allocations as configuration.

SPT2TRAIN-7795 - The MDS shall configure the generic view automatically as predefined per application and vehicle type out of a list of preapproved configurations. The generic view has to react automatically in case of failures and has to react on manually changes by the driver.

SPT2TRAIN-7796 - The MDS shall enable system applications to link all their input/output to any Display Computing Unit (touch-/softkey- display) panel based on a pre-approved configuration.

SPT2TRAIN-7797 - The MDS shall manage the Display Computing Units (HMIs) of multiple systems (e.g., ETP, TCMS, CVR, etc) in parallel.

SPT2TRAIN-7798 - The Multi Display System may display views from different system applications on the same display panel (Display Computing Unit) in case of a failure, but not at the same time.

SPT2TRAIN-7799 - The MDS shall adapt automatically or manually the brightness and volume level of all or part of the displays in the cab.

SPT2TRAIN-7800 - The MDS shall be compatible with the performance requirements of each system interfaced with e.g., ETP, TCMS, CVR, etc.

4.2 Functional requirements

Despite the absence of a final architecture selection, high-level requirements were defined for the single Multi Display System Unit or the generic Multi Display System consisting of multiple MDS Units. These requirements will continue to be relevant regardless of the solution adopted.

SPT2TRAIN-7803 - The MDS shall manage a defined set of input and output devices that are used for user interaction on a desk, required per system application of the MDS.

SPT2TRAIN-7804 - The MDS shall manage at most two desks.

SPT2TRAIN-7805 - The MDS shall be able to allocate input devices (e.g. switches, readers) and output devices (e.g. speaker, buzzer) to a dedicated system in a generic view. Allocated devices shall only be used by the configured systems.

SPT2TRAIN-7807 - The MDS shall allow automatically to set the active configuration (out of a list of preapproved configurations) according to events.
Events may be triggered by driver selection (driver can switch off a screen if not trusted any more), by failure detection of a system (e.g. ETCS system failure or isolation mode or any other system

displayed), input/output device failure (e.g. failure of a screen, MDS itself) or train (e.g. train status and moving status).

SPT2TRAIN-7952 - Depending on the selected applications for using the MDS in parallel, a configuration needs to be defined that is determining the allocation of application-content per screen and all reactions in case of degraded mode of applications or MDS parts.

SPT2TRAIN-7808 - The MDS shall allow by configuration the switch from the displayed view to another multiple display panel. The complete view of the application should be switched.
Options:

- Keep the screen in a central area for drivers
- Being resilient to a failure in order to continue a mission

The requirements of the applications regarding space and location on the touch display surface have to be respected.

SPT2TRAIN-7809 - The MDS shall be able to display any system output on any display.

SPT2TRAIN-7811 - The MDS shall offer two different display types:

1) Touch functionallity only

2) Softkey functionallity only

4.3 Non-functional requirements (PRAMSS)

4.3.1 Performance requirements

SPT2TRAIN-7814 - The MDS shall be compatible with the performance requirements of each system e.g., ETP, TCMS, CVR, etc., keep compliance with subset 41 (chapters 5.2.1.X), TSI LOC & PASS (noise emission...).

4.3.2 Reliability requirements

SPT2TRAIN-7816 - The reliability requirements of the MDS have to fulfill the requirements of the installed applications that are using the MDS. Reliability performance of the MDS has to be proven with a certificate for the hardware and application specific.

SPT2TRAIN-7817 - When a configuration is set, the MDS shall not decrease the reliability of existing systems (ETP, TCMS, CVR...).

SPT2TRAIN-7818 - 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...).

SPT2TRAIN-7819 - The MDS shall only apply a reconfiguration of the defined generic view, if a change in the context (inputs) justifies it.

SPT2TRAIN-7820 - Reconfiguration should not be a source of disruption or misleading behaviour for systems and drivers.

4.3.3 Availability requirements

SPT2TRAIN-7822 - The MDS shall monitor the health of every system involved on the active configuration and itself.

SPT2TRAIN-7823 - The MDS shall not decrease the availability figure of existing systems (ETP, TCMS, CVR...).

4.3.4 Maintainability requirements

SPT2TRAIN-7825 - The MDS shall record and send maintenance data to MDCM: root cause of reconfiguration (e.g failure, driver selection...), configuration applied... Required data needs to be defined per system application.

4.3.5 Safety requirements

SPT2TRAIN-7827 - The MDS shall be compatible with the safety requirements of each system it interfaces with (ETP, TCMS, CVR, etc.). It has to support the required SIL level to enable the safety-case of the used business functionallities.

SPT2TRAIN-7828 - The displays of a MDS need to prove their SIL with certificates according to the specified requirements. The SIL of the complete system applications running on one MDS have to be proven with dedicated safety analysis per application.

4.3.6 Security requirements

SPT2TRAIN-7830 - The MDS shall allocate Display Computing Units and HMI elements only to system applications that are registered in a predefined configuration. Business applications have to fulfill the latest Cyber Security Norms for the railway sector, defined by the ERJU System Pillar Cyber Security Specifications.

SPT2TRAIN-7831 - The MDS shall only allow updates (software and configuration) by a trusted person (e.g. maintainer). Procedures as described in the Secure Services Specification for Cyber Security Requirements apply.

4.4 External interfaces

4.4.1 Data exchange interfaces

SPT2TRAIN-7834 - The MDS shall exchange data on application level (OSI layer 7) with any other CCS-OB building block, and any CCS-OB external system, compliant with one single standard (for OSI layer 1-6) (to be defined).

4.4.2 Communication interfaces

SPT2TRAIN-7836 - The MDS shall communicate (OSI layer 1 - 6) with any other CCS-OB building block and with any CCS-OB external system, compliant with SPT2TRAIN-7017 - [Subset-147]

5 Functional Analysis

5.1 Logical component identification

With regard to MDS terminology, this section lists all the logical components that should be involved in the MDS context.
These components are linked to dedicated functions, which refine the MDS requirements.
More concretely, the MDS building block consists of the following main components:
The Presentation Logic is a logical component embedded within a system. It selects the view to be displayed (e.g. :
data entry view / main view, etc.) and sends it to the Layout Engine with the dynamic data from the system. It also
considers the driver interaction sent by the Layout Engine to update the view selection and data to be sent (to the
System or Layout Engine).

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

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 are refined in this chapter as component requirements and allocated to the logical components described above.
Concerning systems (ETP, TCMS, CVR, etc.), requirements have been written assuming that core system functions are
considered not in scope of MDS (e.g. braking curves for ETP, setting calls for CVR, command doors for TCMS, etc.).

The important Functional Allocations FA2 and FA5 are shown in the chapter 6.2 with explanations.

6 Multi Display System Physical Architecture

The Multi Display System will be connected to all existing Signalling, Train Management, Communication and other Services applications of different nationalities. We can not describe all possible Services but only relate to the known ones.

May be starting with FA2 and FA5 description from OCORA and then put the NTC IF-Box below the merge of FA2v2 and FA5v2.

Stopped here at 30.07.25, proceeding on 27.08.25, 03.09.25, 10.09.25.

- Add an overview of a normal display situation with explanations what is connected to a HMI, Kapitel 6.2

Each HMI element for the driver comes with different elements like Softkeys, Hardkeys, leavers, speaker, microphone or else. This is valid for each HMI of each Business Application. This is shown in the next figure 7. Each new application will bring more different elements to the drivers desk that have to be located somewhere. A list of possible input- and output-devices is already given in figure 6 above.

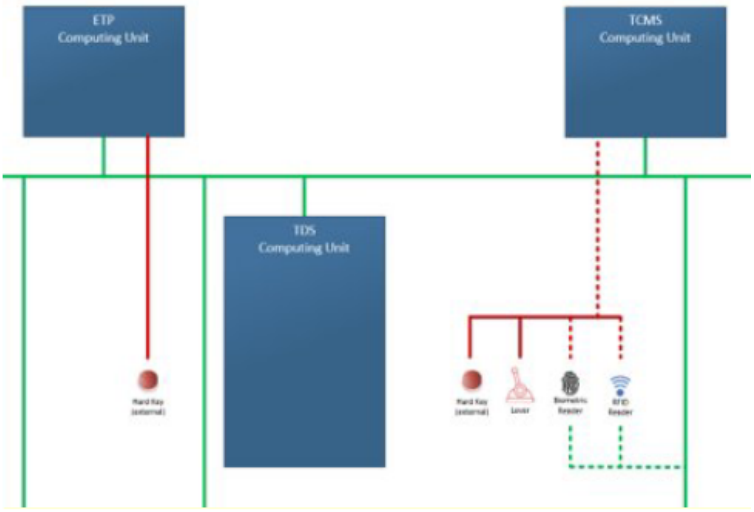

Figure 7 : example of three applications witht their HMIs and other needed elements

Even the allocation of these physical elements can vary in different ways how and where these elements are connected. Directly to the business application equipment like in figure 7 or to the Display Computing Unit or the Display Controller like in figure 8 below.

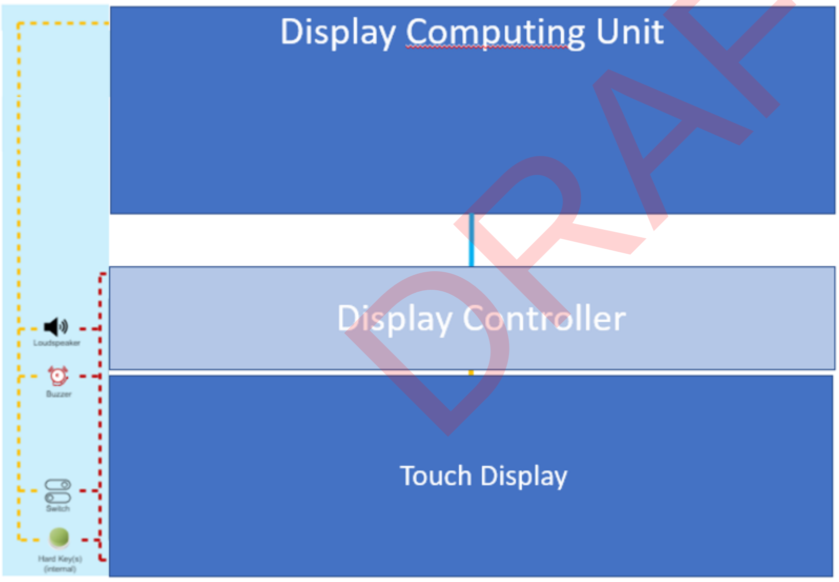

Figure 8: different variants to connect physical input- and output-elements (in addition to chapter 3.3)

In future there will be more business applications that need to be integrated on the drivers desk and that have information that has to be shown to the driver. This will be railway applications or other applications for supervision or management functions. If all applications need a display on the desk in parallel to the existing systems, space is very restricted, as there are applications that require maximum attention from the driver in special positions. This arrangements can lead to complete occupied drivers desks that will cause operational problems for the drivers. See next figure 9 with a complete "overcrowded" drivers desk.

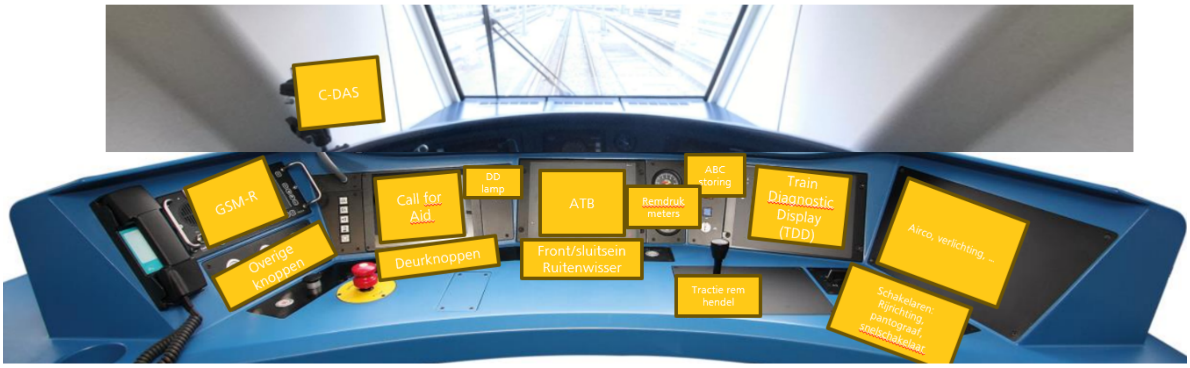

Figure 9 overcrowded drivers desk

To avoid this situation OCORA has already investigated different options how to define an architecture for a Multi Display System with a new structure that reuses defined logical elements to display the information of the different business applications in a more effective way.

These new architectures are mentioned in the OCORA document "Train Display System, OCORA-TWS01-201", V4.0 from 29.11.24. In this document are five different Functional Allocations (FA) described in chapter 6.6. that show different combinations of the logical and physical elements that we defined upfront.

From these 5 Functional Allocations we identified only Functional Allocation number two and five (FA2 and FA5) as feasible for the Multi Display System approach. At detailed analysis of these FAs it was found that some restructuring was needed because of old NTC systems, where the presentation logic is not implemented, because these systems never had a display.

As result of this restructuring we defined Functional Allocation FA2v2 and FA5v2 where the ETP presentation logic is now logical part of the Display Computing Unit but other presentation logic blocks stay in the business applications to avoid to change these systems.

6.1 Functional Allocations FA2 and AF5

Following here the introduction of FA2 and FA5 to understand the difference.

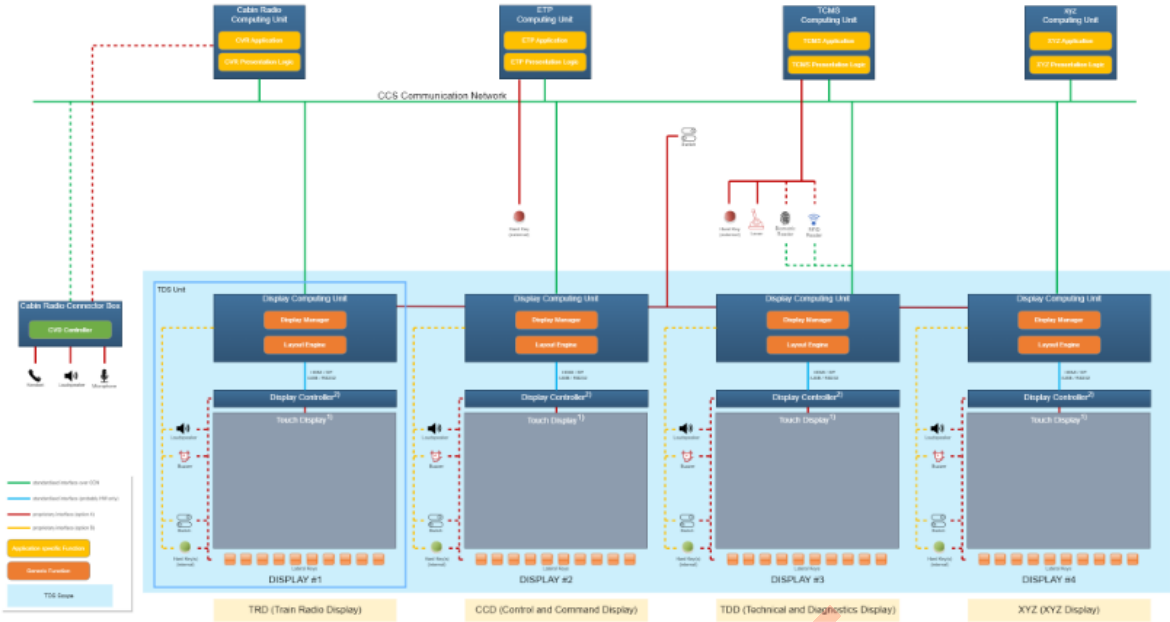

Figure 10 Functional Allocation 2 from OCORA

This allocation leaves the Presentation Logic in the scope of the single systems. Multiple "Display Managers" manage a single display and a single view. With the Presentation Logic remaining in the business applications it is not neccessary to change anything in the existing systems in the field.

In below figure 11 all Presentation Logics and "Display Managers" concentrate on all display computing units. This requires to change all existing business applications to fit to this architecture. This requires very high effort for adapting of all business applications as the Presentation Logic has to be implemented in the Display Computing Unit. Each Display Manager here manages a single display and a view.

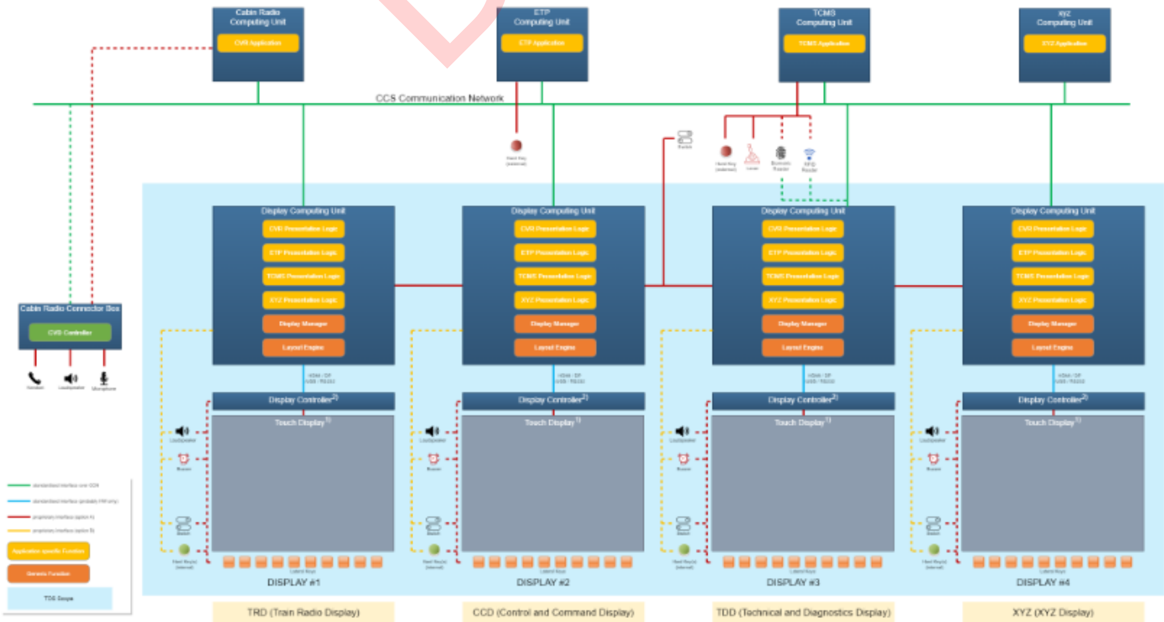

Figure 11: all Presentation Logics and "Display Managers" in all display computing units

Following figure 12 is the result of a working paper from OCORA TWS01 – WP04 – TDS Architecture Discussions and the SP TCS team for the Multi Display System. It is a combination of Functional Allocations 2 and 5 defined in OCORA with the additional option to have different locations for the Presentation Logic.

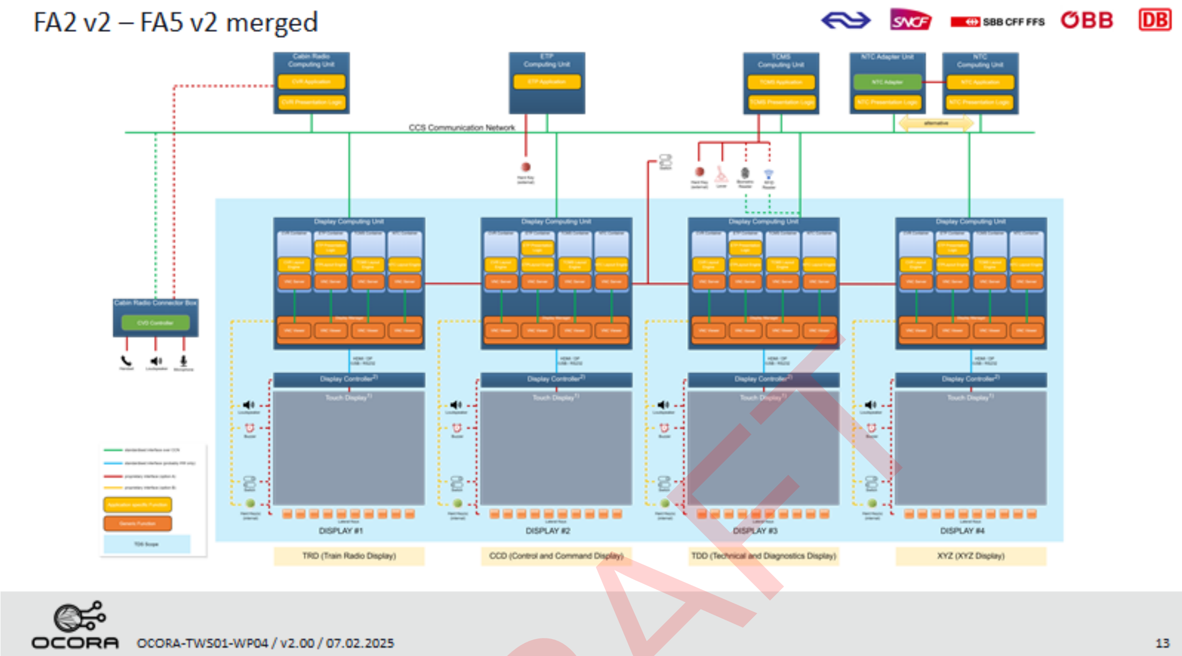

Figure 12: merged architecture of functional allocations 2 and 5

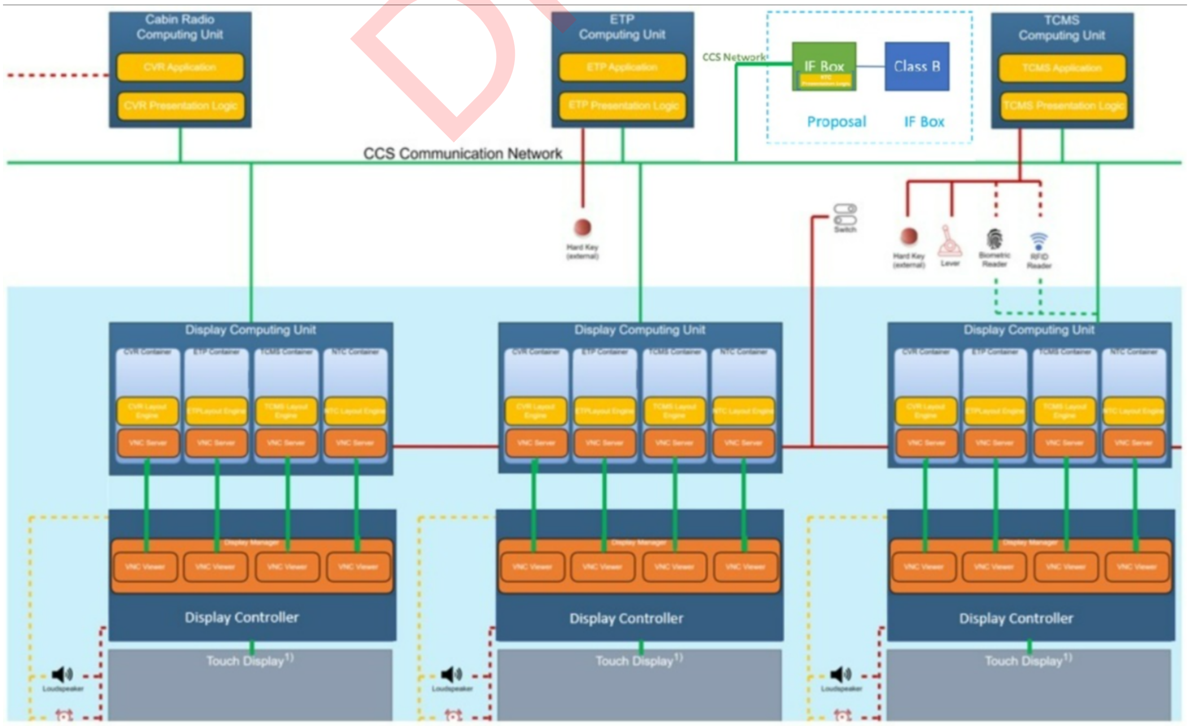

Figure 13: magnified part of figure 12 to better show the details of the logic parts in application and Display Computing Unit

Figure 13 above shows the business applications like TCMS and ETCS sending their data to the Display Computing Unit. This is a generic HW subsystem consisting of fast COTS computing boards and a fast operating system where a Hyperviser is running as a virtualisation tool to enable the specific business application SW as ETP presentation logic, layout engine and VNC server to run in a cluster, one business application per cluster, parallel with other clusters on dedicated HW (dedicated cores) of the processor boards. This is supervised by implementing standard safety protocols between VNC server and VNC viewer.

Figure 14 below shows two virtual clusters for SIL-4 applications with implemented safety protocols and a non safe application without this safety protocol. With this architecture safe and non safe applications can use the same hardware, but due to the virtualization they use dedicated parts of this hardware without influencing each other. This virtualisation concept is already proven in use for other safe applications. For the MDS concept a demonstrator would be needed to proof the concept and to explore how many applications can run in parallel on todays computing hardware.

In this proposal, the Presentation Logic can be placed in the System Computing Unit (business application part) **or** in the Display Computing Unit. Some restrictions apply if the Presentation Logic is placed in the System Computing Unit, in case of failure of the connected Display Computing Unit, the status of the Presentation Logic gets lost, (if the Presentation Logic is integrated in the Display Computing Unit). To avoid this the Display Manager of one display needs to synchronise all status informations with other Display Managers, a "Master" Display Manager is required. This problem needs further investigation.

Additionally, when moving the presentation logic from the existing application to the Display, it should be considered that this would result in significant software modifications to the existing applications that would not result in any functional improvements, but would lead to incompatibility with the existing systems in the field.

The idea of moving the presentation logic to the display should be reexamined. The existing ERA ERTMS 015560v4 specification for the ETCS display symbology would have to be modified for all countries if, for example, a color or symbol were to be changed in one country. The implementation effort should be determined in a cost-benefit analysis.

In this proposal we recommend to keep the Presentation Logic in the business applications to avoid any development efforts to existing systems.

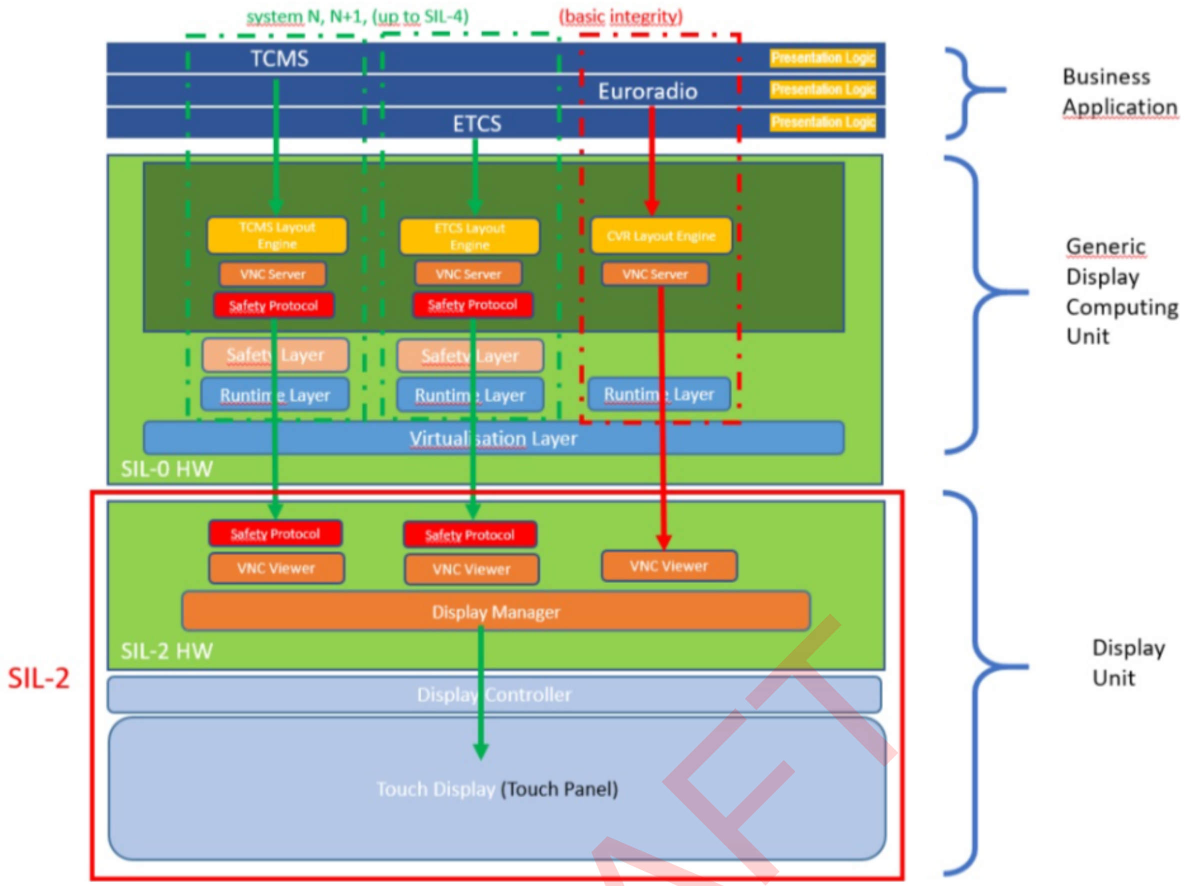

Figure 14: magnified part of figure 13 to show the safty layer in the logical description.

Figure 14 shows important new elements. The main invention is the virtualization layer. The virtualization is chosen here as new approach to substitute the existing separation of safe and non-safe HW and SW. The virtualization enables flexible and efficient allocation of physical processor resources to multiple virtual machines or applications. This improves utilization, enhances scalability, and ensures isolation between the business applications.

There is a VNC Server and VNC Viewer to send data for views (VNC Server) and to present the data (VNC Viewer). To assure a safe communication through the VNC components and more important to assure the safe communication through the virtualized use of dedicated parts of the processing hardware, an additional safety protocol is needed on the sending side, in the Generic Display Computing Unit and on the receiving part, the Display Unit. These two stages of the safety protocol will monitor and assure the safe communication of each business application. With the safety protocol an additional safety layer is implemented in the communication and with virtualization the runtime layer is added. As confirmed by the Computing environment group there are standardized protocol variants available to enable different solutions per supplier if needed.

As result two subsystems for the MDS hardware emerge, one generic SIL-0 computing system for the **Ge neric Display Computing Unit** and one SIL-2 computing system for the **Display Unit.**

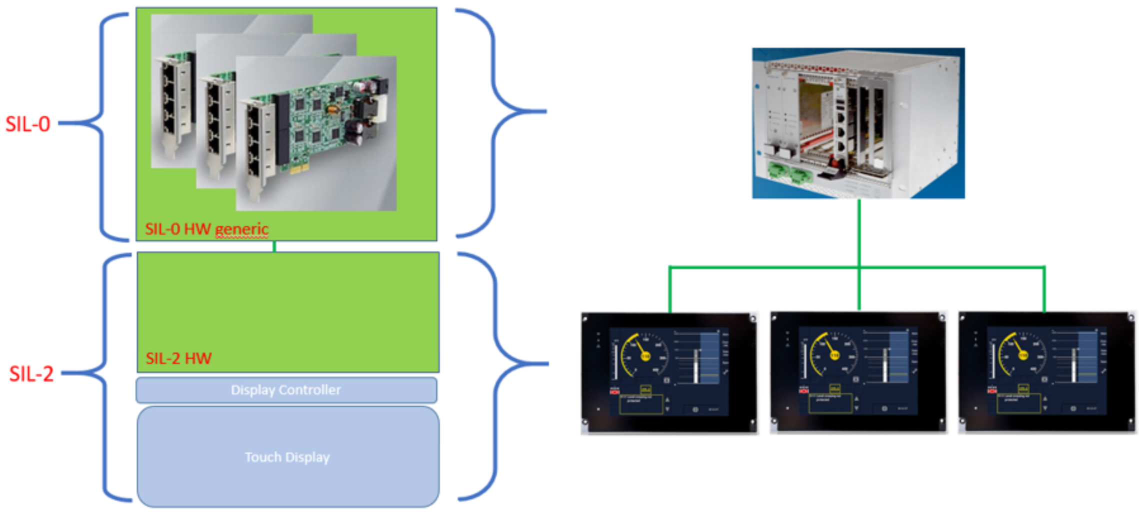

Figure 15: one Display Computing Unit can serve three Display Units as an example

Following figure shows the 2oo2 communication on seprated channels for SIL-4 information. In figure 16, the SIL-2 part is having a "SIL-2 HW", of course this is not possible for HW but it shall show the need for a certified SIL-2 Display here, combining HW and processes for safe read back of the display information on the real screen.

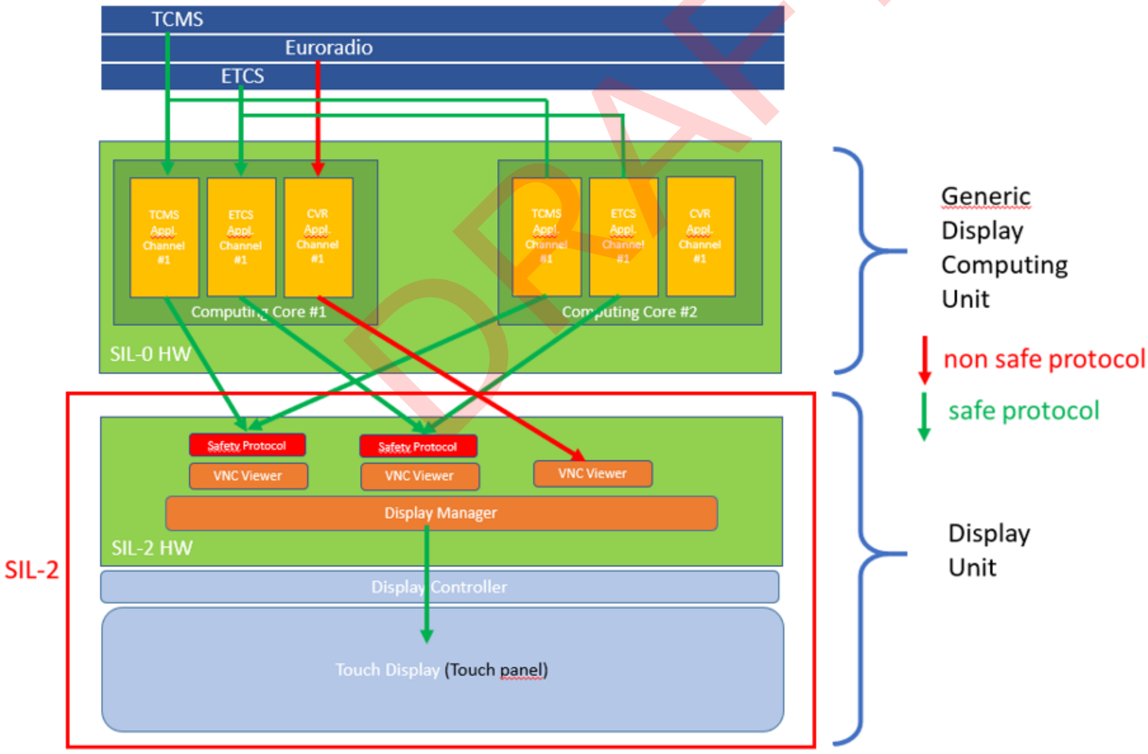

Figure 16: 2oo2 communication on separated channels for SIL-4 information

SPT2TRAIN-7840 - To avoid this information- and status-loss, the actual informations of all applications have to be synchronized with a central information base to have the latest informations available, if a single Display Computing Unit will fail.

SPT2TRAIN-7841 - Interface between System Computing Unit and Display Computing Unit shall be CCN layer 1-6 conform.

SPT2TRAIN-7842 - Interface between Display Manager and Layout Engine needs to be standardized. The VNC Server, VNC Viewer and the virtualisation application in between are transparent communication channels that will not be specified.

SPT2TRAIN-7843 - Interface between Display Managers shall be CCN layer1-6 conform.

SPT2TRAIN-7844 - To enable the safe operation up to SIL-2 of safe and non-safe applications on a common safe hardware, the specific applications in the Display Computing Unit shall be virtualized e.g. by using software in containers controlled by a hypervisor. This concept has to be proven with a safety analysis on the virtualization method. This topic needs further clarification with the Computing Environment domain.

SPT2TRAIN-7845 - Using a generic interface between Display Manager and the Specific Applications in the Display Computing Unit might cause negative latency effects on the display reactions, that might slow down the operating processes to the train driver and therefore lead to malfunctions. This effect needs further investigation.

SPT2TRAIN-8263 - Legacy NTCs can have different operating rules in each country. One rule is requesting that a NTC has to operate in stand alone mode. In this case, ETCS and the STM are switched off, no information is transferred from STM to the display. In this case, there would be no presentation logic to provide speed data to the display, no operation would be possible. To avoid this situation, an interface box has to be used to collect the needed data from the NTC and host a presentation logic to provide data with a generic interface to the display.

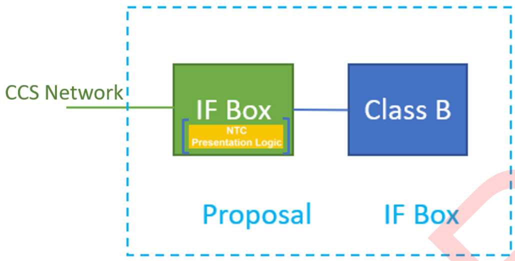

Figure 17 Proposal for Interface Box

7 Open points

This chapter presents potential errors that have already been identified during the current phase of development. Including these points helps to clarify the limitations and uncertainties of the proposed solution, offering a more realistic view of its current status. Recognizing such issues early on is important for a transparent and well-informed evaluation.

Known issues are:

The effort in calculation for the virtualization, for safety protocol and VNC-Server / -Viewer is assumed to cause latency problems between the input of the driver to the DMI touch surface and the reaction of the business application to the input. This has to be analysed in the planned MDS Demonstrator. In addition some tests can be performed to determine how many applications can virtually run in parallel on different processor types.

The virtualization of two safe applications (SIL-2) running in parallel on the intended Display Computing Unit has to be analysed and proven by the planned MDS Demonstrator.

Up to now no requirements for maintenance and diagnostic were included for the MDS concept. These requirements need to be added for the next rework of the MDS concept.

Some existing business applications have the LE included. For the MDS it would be neccessary to transfer the LE from the business applications to the MDS, because this is required to be able to switch display content between different business applications in one Display Computing Unit. Additionally a Master Display Controller is required to synchronise all data of the business applications on Display Unit level. As it will not be neccessary to include every possible business application in a MDS it is recommended to have a CBA to determine which and how many business applications shall be integrated in one MDS.

As there were no experts of the rolling stock partners in the MDS task, a review with rolling stock in the next working period should be done.

In chapter 3.3 there are two variants a) and b) mentioned to connect the external elements to the MDS. There was no final decision on which variant is the most economical or best technical choice. This has to be elaborated in a next step.

8 Standards and References

ID	Description	
SPT2TRAIN-5740 - [OCORA-BWS02-030]	Technical Slide Deck 4.0	
SPT2TRAIN-5928 - [OCORA-TWS01-WP04-TDS-Architecture Discussion-2025-02-04]	Technical Slide Deck v2.00	
SPT2TRAIN-5741 - [ERA ERTMS 015560]	ETCS Driver Machine Interface 4.0	
SPT2TRAIN-5742 - [CLC/TR 50542]	Driver's cab train display controller	
SPT2TRAIN-5743 - EN_16186-2_2017-12	Integration of displays	
SPT2TRAIN-5744 - EN_16186-3_2022-01	Annex C – functions using display	
SPT2TRAIN-5745 - [Preliminary on-board CCS architecture]	Summary of the Discussions for a Preliminary Bottom-up On-board CCS Architecture	
SPT2TRAIN-5746 - [Subset-147]	CCS consist network communication layer FFFIS V1.0.0	
SPT2TRAIN-5747 - [Subset-121]	TDS / ETCS On-board Interface FFFIS V1.1.0	
SPT2TRAIN-5748 - [Subset-091]	Safety Requirements for the Technical Interoperability of ETCS V4.0.0	

Table 3 References

9 Appendix

9.1 Possible applications that would need a display in the drivers cabin

The following table shows which applications must be shown in the display and what their requirements are. A distinction is made between the following categories:

SIL:	Safety Integrity Level
Availability:	Is the device already available on the market?
Position:	On which display should it be shown?
Visibility:	Permanently visible in the display or only on demand
Source:	Source of the requirement / Data
Sink:	Receiver of Data
Use in MDS:	Should it be included in the MDS?
Notes:	Additional information

Table 4 requirement of informations how to be displayed

Application	**SIL**	**availab.** (of the function today)	**position** (of the display)	**visibility** (during travel)	**source**	**sink**	**use in MDS**	**Notes:**
C-DAS (Connected-Driver Advisory System)	0	yes	open	on demand	ATO TS			
DAS (Driver Advisory System)	0	yes	open	on demand	ATO TS			
ETCS Tacho	2	yes	center	permane nt	EVC	EVC	yes	
ETCS / ATO Symbols	2	yes	center	permane nt	EVC	EVC	yes	
ATO (video for Remote Driving, remote location)	2	no	open	on demand	end device		no	not specified today, would handle it as future application that can be added to the generic view concept by using standardised interfaces for communication receiving data for status of remote operation, candidate to cut out because of unspecified function of RTO
TCMS Diagnostics	0	yes	left/right	on demand	TCMS	TCM S	yes	

Application	**SIL**	**availab.** (of the function today)	**position** (of the display)	**visibility** (during travel)	**source**	**sink**	**use in MDS**	**Notes:**
(TrainControl Management System)								
TCMS Status	2	yes	left/right	permanent	TCMS	TCMS	yes	
MDCM-OB (Monitoring, Diagnostic, Configuration, Maintenance - On Board)	0	no	left/right	on demand	all systems	all systems	yes	
UID-Reader, (User Identification-Reader)	0	yes	open	on demand	reader device	EVC, TCMS	yes	on demand means only during start of mission
CAB Radio, (Cabine Voice Radio)	0	yes	left/right	on demand	voice radio/ FRMCS	voice radio/ FRMCS	yes	handset and screen need to be separated
NTCs (National Train Control, Class B-Systems)	2	yes	center	permanent	NTCs	NTC	yes	In case of ETCS-OB isolation, the NTC shall still be able to display signaling information. In this case, the NTC have to be able to communicate directly with the MDS.
Rear View System	0	yes	left/right	on demand	end device		yes	will only be used in standstill
CCTV for passenger surveillance	0	yes	left/right	on demand	end device		yes	even during travel might be activated clarify what is the difference between CCTV and C4Aid Robert and Volker check if those systems exist.
	0	yes	left/right				yes	

Application	**SIL**	**availab.** (of the function today)	**position** (of the display)	**visibility** (during travel)	**source**	**sink**	**use in MDS**	**Notes:**
Manual Station Selector (NL)				on demand	end device			driver can change info if wrong
Call4Aid, (NL)	0	yes	left/right	on demand	C4D device		yes	for emergency only
DAC Information (Digital Automated Coupling)	2	not	open		DAC		to be determined if info available	

Table 5 possible business applications to be displayed on a DMI