Deliverable D3.1

First Lab Integration and Architecture Description

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5GRAIL

5G for future RAILway mobile communication system

First Lab Integration and Architecture Description (Work Package 3)

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Executive Summary

Within 5G Rail project, Work Package 3 (WP3) is mostly linked to WP1, WP2 and WP5:

- WP1 defines the test cases to be executed in WP3 and 5
- WP2 delivers the FRMCS Onboard and Trackside GW prototypes, with partner applications for Voice, Video , ETCS and TCMS to be used in WP3.
- Finally, WP3 lab configuration will be used to de-risk field tests in the scope of WP5, leaded by DBN in Germany and connect 5G core, MCX server and GSM-R infrastructure remotely for field test execution, where radio products are setup in Germany.

WP3 is indirectly linked to WP4, as the test activities planned for WP4 in France Lab are focusing on ATO and ETCS. Therefore with the complementary focus of test cases executed in Budapest and France a broad spectrum of use cases can be verified in 5GRail .

The purpose of this deliverable titled: “D3.1 - Lab Integration and Architecture Description” is to present the integration details of the lab architecture that is set-up in Hungary in Nokia Labs. The focus of the first 5G reference lab test is to combine FRMCS 5G infrastructure and On-board GW prototypes with the related application prototypes, namely Voice, Video/CCTV, ETCS and TCMS in a unique environment for testing. In the lab the following products delivered by the partner are integrated in the 5G lab provided by Nokia:

Application	Partner
Voice / CAB Radio	Siemens
TCMS/ETCS	CAF
Video	Teleste
OB/TS GW	Kontron

Table 1: Partner Products of WP3

This document provides a full description of environmental conditions for the achievement of tests, including integration considerations and technical architecture detailing all sub-systems, providing a description of the physical infrastructure, including, the laboratory Location, the list of equipment provided by the partners, followed by a list of the tools that are put in place supporting the test activities.

GSM-R infrastructure is available to cover 5G-GSM-R interworking scenarios as to be defined in WP1.

Note: There will be different test phases planned depending on the type of application (Voice, Data, Video) and combined application and availability. A timeline of these integration test phases is described in D3-2.

Abbreviations and Acronyms

Abbreviation	Description
3GPP	3rd Generation Partnership Project
5G SA	5G StandAlone
AS	Application Server
ATC	Automatic Train Control
ATO	Automatic Train Operation
BSC	Base Station Controller
BTS	Base Transceiver Station
CAM	Connected and Automated Mobility
CCS	Control Command and Signalling
CCTV	Closed Circuit TeleVision
CMU	Nokia Compact Mobility Unit (5G Core)
COTS	Commercial Off The Shelf
CP	Control Plane
CPU	Central Processing Unit
CSCF	Call/Session Control Functions
CSFB	Circuit Switched Fall Back
DC	Direct Current
DMI	Desktop Management Interface
DMZ	Demilitarized Zone
DN	Domain Name
DNS	Domain Name System
DRCS	Data Radio Communication System
DSD	Driver Safety Device
EDOR	ETCS Data Only Radio
ETCS	European Train Control System
ETSI	European Telecommunications Standards Institute

EU	European Union
EVC	European Vital Computer
FDD	Frequency Division Duplexing
FFFIS	Form Fit Functional Interface Specification
FIS	Functional Interface Specification
FRMCS	Future Railway Mobile Communication System
FRS	Functional Requirements Specification
FW	Firewall
GA	Grant Agreement
GC	Group Communication
GCG	Ground Communication Gateway
GNSS	Global Navigation Satellite System
GoA	Grade of Automation
GRE	Generic Routing Encapsulation (RFC8086) -> Tunnel GRE
GTW or GW	GaTeWay or GateWay
GBR	Guaranted Bit Rate
HDMI	High Definition Multimedia Interface
HLR	Home Location Register
H2020	Horizon 2020 framework program
HSS	Home Subscriber System
HW	Hardware
IMPI	IP Multimedia Private Identity
IMPU	IMS Public User Identity
IMS	IP Multimedia Subsystem
IP	Internet Protocol
IWF	Inter Working Function
JSON	JavaScript Object Notation
KPI	Key Performance Indicator

LAN	Local Area Network
LED	Light Emitting Diode
LTE	Long Term Evolution
MCG	Mobile Communication Gateway
(Open) MGW	Open Media Gateway
MCx	Mission Critical
MCC	Mobile Country Code
MIMO	Multiple Input Multiple Output
MNC	Mobile Network Code
MPTCP	MultiPath Transmission Control Protocol
MQTT	Message Queuing Telemetry Transport
MNO	Mobile Network Operator
MQTT	Message Queuing Telemetry Transport
(Open) MSS	Open Mobile Softswitch
N3IWF	Non-3GPP Inter Working Function
NR	New Radio
NSA	Non-Stand Alone (5G Core architecture)
NT HLR	(Nokia) Next Technology HLR/HSS
OAM	Operation Administration Maintenance
OB	On Board
OB_GTW	On-Board Gateway
OBA	On-Board Application (e.g. ETCS on-board, ATO on-board)
OBU	On-Board Unit
OM	Operation & Maintenance
OMC	Operation & Maintenance Center
One NDS	(Nokia) One Network Directory Server
OTA	Over The Air
OTT	Over The Top

PCB	Printed Circuit Board
PCRF	Policy and Charging Rules Function
PCU	Packet Control Unit
PIS	Passenger Information Service
PDN	Packet Data Network
PSS	Process Safety System
QoS	Quality Of Service
RAN	Radio Access Network
RAM	Random Access Memory
RAT	Radio Access Technology
RBC	Radio Block Centre
REST	REpresentational State Transfer
RPC	Remote Procedure Call
RF	Radio Frequency
SA	Stand Alone (5G Core architecture)
SDWAN	Software-Defined Wide Area Network
S-CSCF	Servicing-CSCF (Correspondence IMPU - @ IP)
SDF	Service Data Flow
SIM	Subscriber Identity Module
SIP	Session Initiation Protocol
SMA	Subminiatures version A, type of coaxial RF connectors
SRS	System Requirements Specification
TCMS	Train Control Management System
TCN	Train Communication Network
TCU	TransCoder Unit
TOBA	Telecom On-Board Architecture
TS	Track Side
TS_GTW	TrackSide Gateway

TSE	Track Side Entity (e.g. RBC, KMC, ATO trackside)
TSI	Technical Specification for Interoperability
UE	User Equipment
UIC	Union Internationale des Chemins de fer
UP	User Plane
URLLC	Ultra-Reliable Low-Latency Communications (5G)
URS	User Requirements Specification
VPN	Virtual Private Network
WP1	Work Package 1
WP2	Work Package 2
WP3	Work Package 3
WP4	Work Package 4
WP5	Work Package 5

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1 INTRODUCTION

The main objective of the 5GRAIL is to validate the first set of FRMCS specifications, known as FRMCS V1, by developing and testing prototypes of the FRMCS ecosystem, for both on-board and trackside infrastructure. The outcome of 5GRAIL will provide feedback to the FRMCS standardization based on 5G technology to demonstrate the capabilities for the deployment by railway sector in Europe.

WP3 as part of 5GRAIL provides the "first" 5G reference lab environment situated at Nokia's premises in Hungary/Budapest. It will be used to perform testing and validation of the main FRMCS functionalities, defined within WP1 and focused on voice, video and data applications related to ETCS and TCMS.

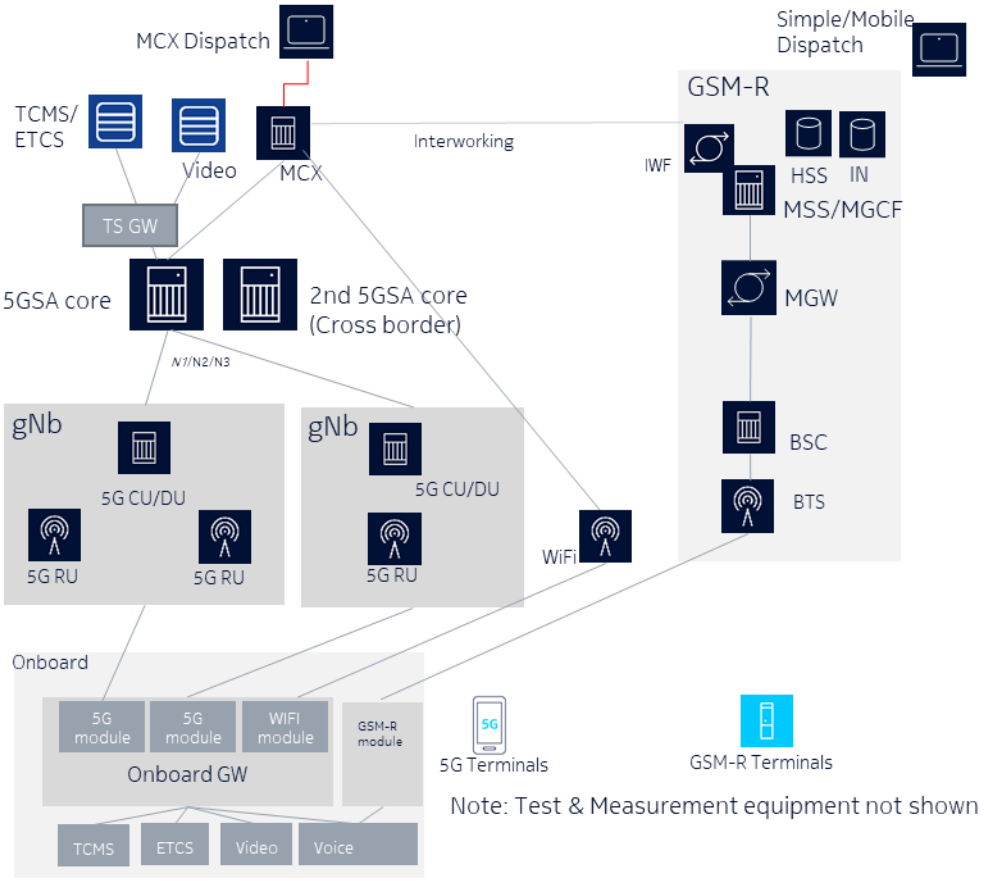

Figure 1: LAB Configuration

The objectives of this work package are to provide a first 5G reference lab environment to perform test and validation of the main FRMCS functionalities defined within WP1 related to specific applications prototypes including ETCS, Voice, TCMS and CCTV/Video pre-integrated within ONBOARD GW during WP2. It foresees the end-to-end integration of the application prototypes and the testing and integration of ONBOARD GW prototypes within a 5G reference lab, with the aim to validate the

concepts and demonstrate the capabilities of the ONBOARD GW and related applications for railway environments.

The 5G reference lab environment includes specific network functionalities, which are not fully standardised yet and therefore have not reached commercial maturity. This 5G reference lab for end-to-end FRMCS 5G system is setup in Budapest/Hungary. The tests defined in WP1 to be executed, are articulated around:

- Integration of all FRMCS ecosystem elements
- Functional & Performance tests in nominal and simulated conditions.

This will be achieved by following main tasks:

- Evaluation of 5G based FRMCS use cases in a laboratory environment with 5G radio, 5G core, FRMCS Mission Critical Services (e.g. MCX) application and FRMCS prototypes as provided by WP2
- Interworking scenarios between FRMCS and GSM-R by providing GSM-R laboratory environment
- Cross-border use cases (Cross-border cases are emulated)
- Evaluation of applicability related to QoS 5G capabilities and handover
- Preparation for field test by remote accessibility of the core networks.

Following environment will be setup to achieve the required tasks:

- The lab will provide a 5G telecommunication infrastructure based on 5G radio equipment, 5G core equipment and FRMCS MCX application server based on 3GPP Release 16 and Pre 3GPP Release 17 if applicable, including MCPTT functionality for end-to-end voice application evaluation and integrated SIP server functionality
- Dispatcher terminal to evaluate train – dispatcher communication
- The radio equipment allows for the evaluation of stationary and non-stationary use cases with the support of test equipment (e.g. attenuator for handover triggering)
- The lab is available to integrate on-board voice, data and other application (e.g. TCMS, CCTV/video) as provided in WP 2 with the Onboard Architecture
- The 5G radio will support commercially available and 3GPP defined spectrum. Spectrum used in the lab environment will be aligned with WP5 activities. The bands used are 5G n78 (20 MHz in 3.7-3.8 GHz TDD enterprise band) for lab and field, and band n8 (5MHz in 900MHz) for the lab test only as agreed in Technical Coordination Committee of 5GRail. Selection of bands for the planned use cases is to be defined in WP1 & WP3

• The 5G core will implement 3GPP Standalone (3GPP Option 2) with 5GC SA support composed of UPF, SMF, AMF, AUSF, SDM (PCF will not be available)

• FRMCS MCX application integration in 5G Standalone Core is not yet standardised in 3GPP Release 16 and will be realised by appropriate pre standard solutions or workarounds

• The lab provides GSM-R infrastructure as well to evaluate FRMCS and GSM-R interconnection and interworking scenarios as innovative action as not standardized today

• Cross border use cases can be evaluated by the emulation of different networks provide in the lab depending on WP1 test case definition

• Wi-Fi access is available to allow bearer flex use cases depending on WP1

• COTS phones for evaluating voice related services will be provided (5G, depending on available 3GPP band support), GSM-R terminals for interworking test scenarios

• Trackside servers for emulating ETCS, TCMS or CCTV/Video application will be deployed locally or remotely in the responsibility of the WP2 protype suppliers

• For field tests as defined for WP5 a remote connectivity to the 5G core and FRMCS MCX application server can be provided

Functional and performance tests will be done thanks to:

• Different applications with particular focus on Voice and CCTV/Video, as well as TCMS and ETCS

• Measurement tools e.g. for end-to-end latency & throughput, as defined by 3GPP TS 22.289, depending on use case.

2 PHYSICAL DESCRIPTION

This part defines the details of lab location (Budapest lab) and connections with external points (VPN) as well as the HW and SW listed for executing the tests.

As part of the lab test setup including 5G radio equipment, 5G core equipment, FRMCS MCX application server and test equipment, an initial radio interface test is performed using 5G radio modules that are planned to be integrated in ONBOARD GW WP2 prototypes and capable to support the WP3 selected Band n78 and Band n8.

The lab test setup will be designed to support the above use cases depending on standardization, module and network capabilities.

2.1 Laboratory information

2.1.1 Laboratory location

The laboratory is located in “Nokia Skypark” area in Budapest city center. The office hosting the test network facility has a central location 1083 Budapest, Bókay János utca 36-42, an ideal environment (has both dense urban and industrial areas) for research, prototyping, piloting and testing/validation for end-to-end mobile communication.

The 5GRail laboratory is located in a large working area, where the newest hardware for radio and core network elements are integrated and shared for several different testing environments.

Site Information - Nokia Skypark

Nokia Budapest Address

Bókay Janos utca 36-42

Bókay János utca 36, Budapest, Budapest 1083, Magyarország

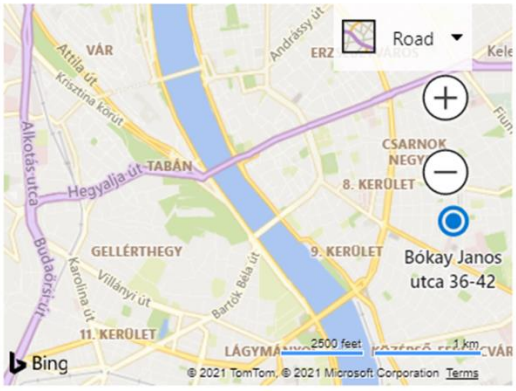

Figure 2: Budapest Lab location

In addition, partners will bring to this location some of their equipment.

2.1.2 Laboratory access

Whenever a partner's equipment is installed in Budapest, a remote access link might be needed to partner's technical team in order to manage the equipment remotely.

If personal attendance is needed, then the local Covid-19 regulation rules must be followed. The currently valid process requires that a list shall be sent to the laboratory contact person containing the names of external personnel who would like to enter the building including the time interval of the presence. Contact persons will be nominated when on site attendance will be planned.

Other access policies (e.g. separate Non-Disclosure Agreement) are under clarification.

2.2 Equipment provided by Kontron

Kontron will use the following equipment to provide the expected services:

- TOBA-K GW
- Trackside TS GW

2.2.1 TOBA-K GW and TS_GW

Kontron provides following prototypes: FRMCS OB_GTW-K and FRMCS TS_GW-K

2.2.1.1 Onboard equipment

FRMCS OB_GTW-K function is fully described in document D2.1 TOBA Architecture Report [S19].

The OB_GTW-K will be specific hardware box that will embed the software for the OB_GTW function.

2.2.1.2 Trackside equipment

FRMCS TS_GW-K function is fully described in document D2.1 TOBA Architecture Report [S19]

The TS_GTW-K will be a virtual machine to be hosted in any off the shelf X86 server with no specific hardware needs.

2.3 Equipment provided by Siemens

Siemens are planning for the provision of the required hardware platforms to enable functional testing activities as part of WP3, supplying 2 Cab Radio units which contain the Voice FRMCS component functionalities and are intending to connect these to display consoles (also supplied) for lab testing.

This cab radio setup with the display consoles require a 230V AC (domestic) power supply, and the appropriate antenna connections. Otherwise they are self-contained standalone units.

2.3.1 Architecture Overview

Siemens Voice Radio 400+ series (SVR400+) is a dual mode onboard solution that provides voice communication between a train driver and a train controller as well as a train driver and drivers of other trains over the existing GSM-R Network and the new FRMCS system.

Figure 3 illustrates the Dual Mode GSM-R/FRMCS voice application.

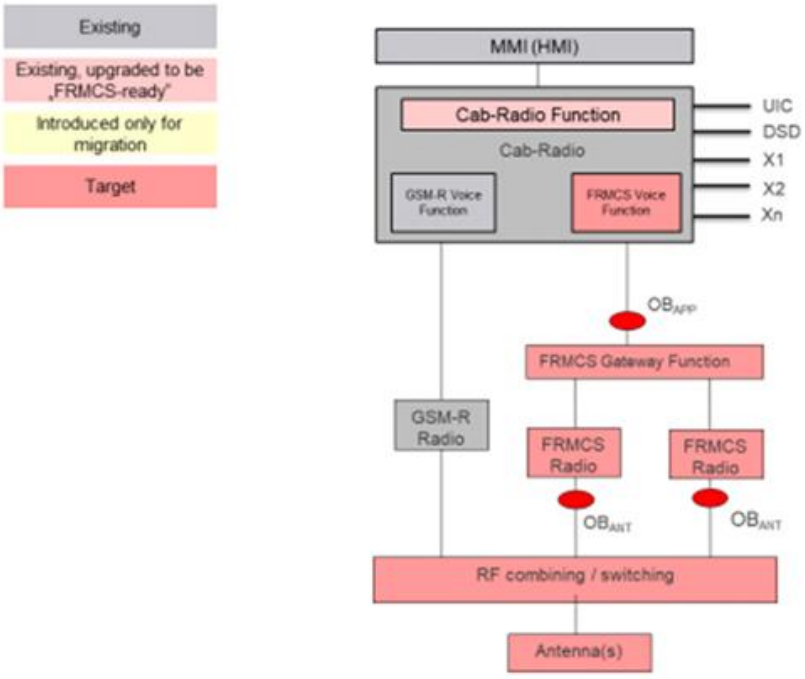

Figure 3: Dual Mode GSM-R/FRMCS Voice Application

2.3.2 Hardware Platform

The HW details of the equipment used in the lab environment are described in chapter 7.3.1.3

2.3.2.1 On-board

SVR400+ is an EIRENE compliant GSM-R voice cab radio solution that includes an additional i.MX microprocessor card which runs the FRMCS voice application. The Siemens' dual mode onboard solution comprises four units as illustrated in Figure 4 and further described in the following subsections.

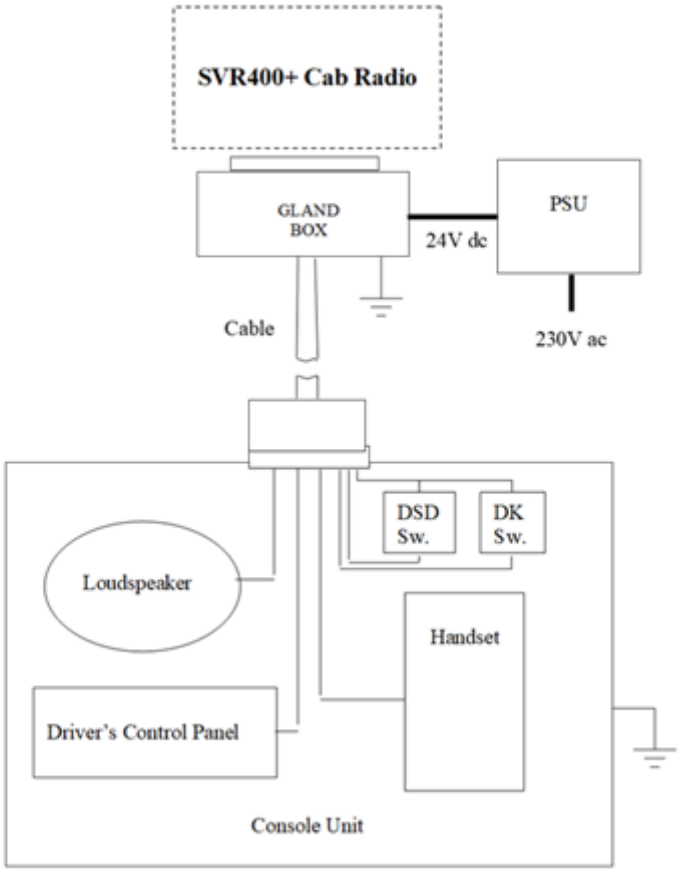

Figure 4: Siemens' hardware platform

2.3.2.2 Trackside

The SVR400+ Voice Cab Radio onboard solution communicates to MCX Server located between the FRMCS Onboard Gateway and the FRMCS Track Side Gateway which then communicates to the Dispatcher Server located on the trackside (which is directly connected to MCX in Nokia solution). The trackside solution is outside of Siemens' scope and will be provided by WP3, led by Nokia.

2.4 Equipment provided by CAF

The equipment provided by CAF, the architecture and its integration with the Lab environment could be seen in Figure 5.

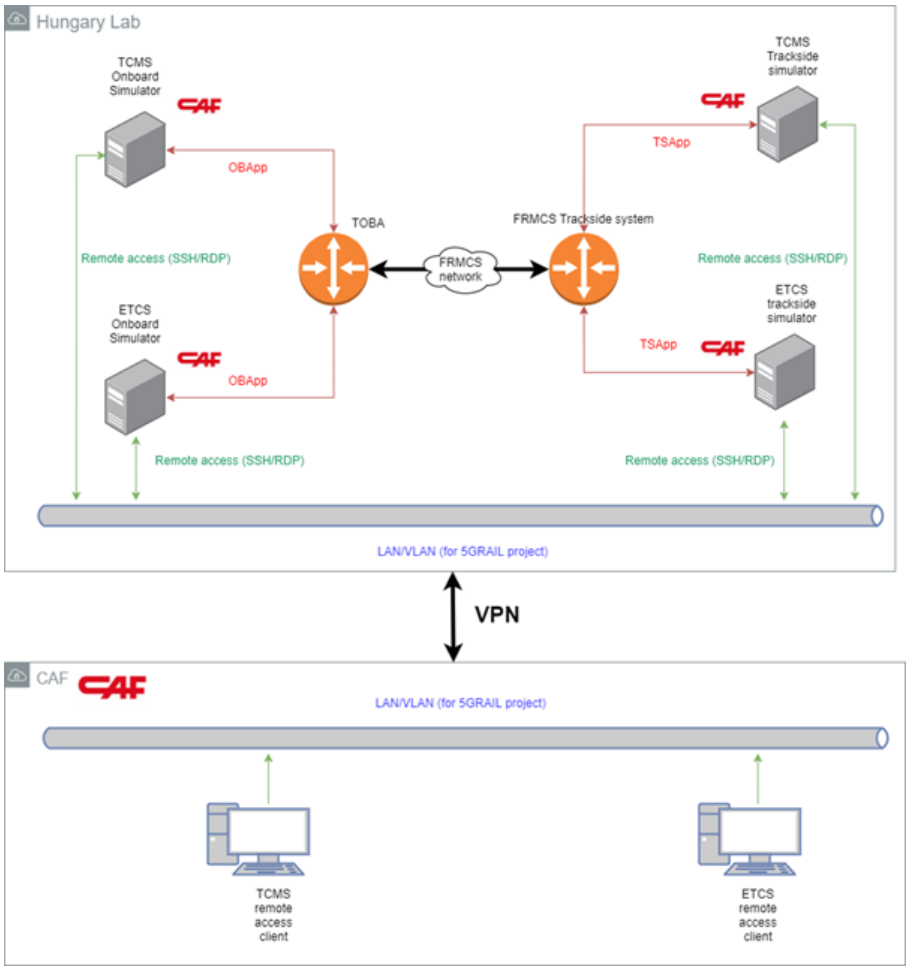

Figure 5: ETCS and TCMS use cases CAF's test environment architecture

As it can be seen, CAF will provide four equipment systems to the lab:

- ETCS onboard Simulator, which is connected using an Ethernet interface to the TOBA router to test the OBApp interface (both locally and E2E). Therefore, the related HTTP(s) ports shall be allowed between both.
- ETCS trackside simulator, which is connected using an Ethernet interface to the FRCMS trackside system to test the TSApp interface (both locally and E2E). Therefore, the related HTTP(s) ports shall be allowed between both.
- Same for TCMS.

The four systems will be connected to a local network via Ethernet interface, this interface shall allow remote access (via Secure Shell (SSH) and Remote Desktop Protocol (RDP) from CAF's installations (which will be provided by CAF). In order to secure the connection between CAF's network and Hungary lab, a Virtual Private Network (VPN) between them could be established.

This architecture will provide the following benefits:

- De-risk the current travelling limitations due to COVID-19.

- Issues found during the on-site testing could be solved remotely or anticipate to them before they occur.
- De-risk TOBA/FRMCS Gateway availability. If there are issues found during these implementations, the architecture provides flexibility to Kontron/Nokia to provide simulators, etc. before the prototype is done.
- As stated above, increases flexibility for overall testing (locally, on-site, E2E, etc.).

The HW details of the equipment used in the lab environment are described in chapter 7.3.1.4

2.5 Equipment provided by Teleste

Teleste will provide for the Onboard and Trackside following components. The HW details of the equipment used in the lab environment are described in chapter 7.3.1.5

2.5.1 Train Computer Equipment

TPC-40 series is a rugged CPU processing and mass storage product with two media trays for exchangeable 2.5" SATA3 drives. Typical rolling stock application is a standalone network video recorder operation.

2.5.2 CCTV cameras

Rugged network cameras for video surveillance in rolling stock

2.5.2.1 Trackside Video Management System

VMX Lite VIDEO MANAGEMENT SYSTEM: the complete surveillance suite delivering fully professional security application in a single unit

2.6 Equipment provided by Nokia

The following overview list of equipment depicts the main 5G equipment provided by Nokia for the lab:

Figure 6: LAB Overview

Additionally a GSM-R network including terminals are available for FRMCS – GSM-R Interworking Scenarios. The list of the GSM-R elements is provided in the following table:

Product	Units	Function
GSM-R system	1	The GSM-R system supporting the GSM-R Interworking voice use cases consist of Nokia's : • Open MSS for Railways, • Open Multimedia Gateway, • NT HLR+ONE NDS, • FlexiBSC, • Flexi Multiradio 10 BTS • GSM-R Terminals
Open MSS for Railways	1	Nokia Open MSS for railway based on ATCA
Open Multimedia Gateway	1	Nokia Open MGW based on ATCA
NT HLR/One NDS	1	Nokia HLR and Directorry Server, realized in LAB cloud environment
Flexi BSC	1	Nokia Flexi BSC, DX-200 HW
Flexi Multiradio BTS	1	Nokia GSM-R BTS
GSM-R Terminals	3	Triorail, Sagem,…
Dispatcher (lightweight)	1	Mobile phone as dispatcher

Table 2: List of Nokia GSM-R Equipment

Measurement and Monitoring Equipment is provided as

- Fading simulator is used for emulating degraded conditions as for higher speed scenarios,
- Attenuator system allows for emulating handover
- Monitoring tools like Wireshark and iPerf to trace messages and create load situations

The HW details of the equipment used in the lab environment are described in chapter 7.3.1

3 ENGINEERING VIEW OF THE LAB AND CONFIGURATION DETAILS

3.1 Platform Description

3.1.1 Hardware View

Hardware elements and physical links between them include tools is listed in chapter 2 and 7.3

3.1.2 Functional View

The following figure shows a functional overview of the Lab including VPN access.
Note: Measurement Tools are not shown but will be described in D3.2 documents. Different VPN connections to allow for remote support will be setup using Nokia LAB VPN capabilities.

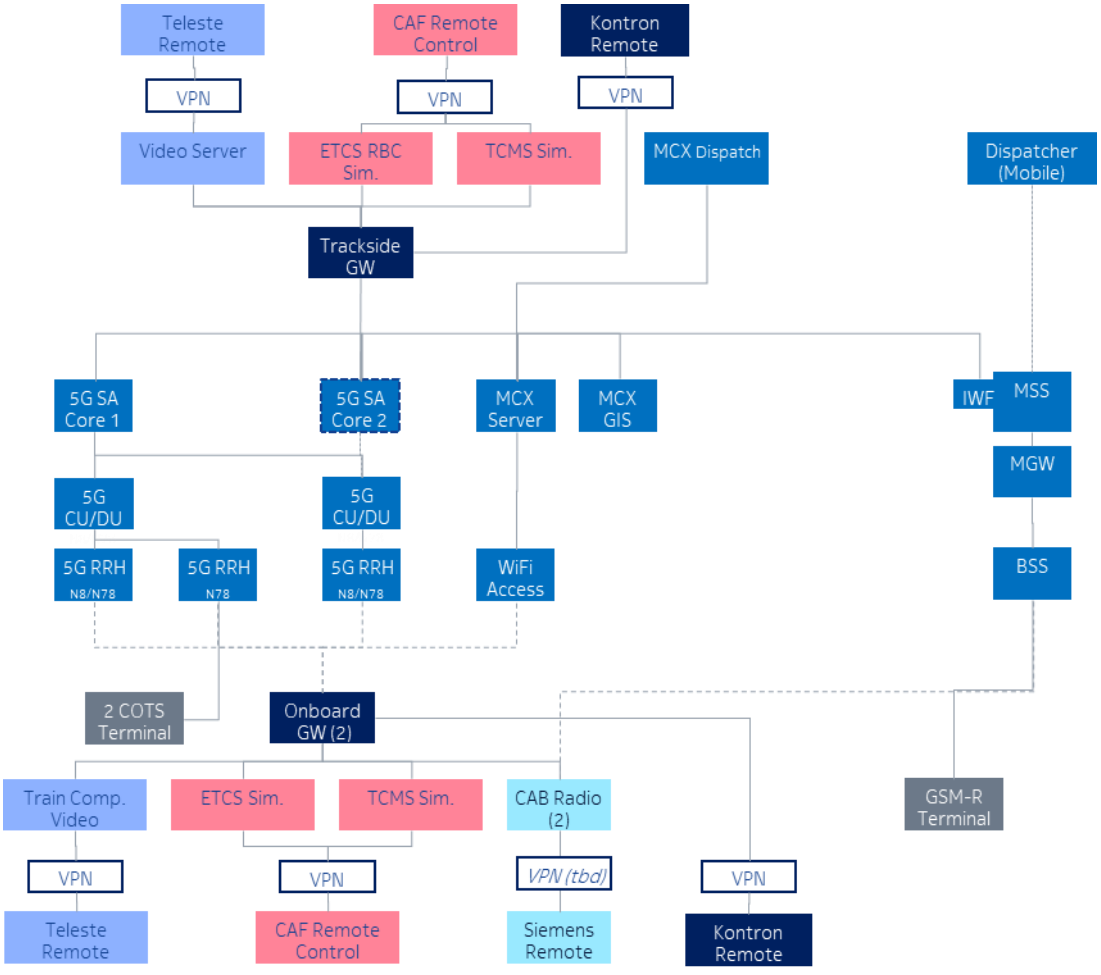

Figure 7: Functional View of the WP3 Lab

Note: The use the second Onboard GW and CAB Radio is for further study and depends on the final test cases defined by WP1.

The gNB configuration with respect to select RRH (Band n8, Band n78) is flexible to allow the use cases to be tested and to be defined in WP1

3.1.2.1 5G Core Functional View

The Nokia CMU (Compact Mobility Unit) provides a 3GPP compliant 5G SA Core network and is realised on a redundant server system with following functionality integrated:

Figure 8: Nokia 5G SA Core: Functional Units

Following functions according to 5G 3GPP standards are provided:

- UPF User Plane Function
- SMF Session Management Function
- AMF Access and Mobility Management Function
- AUSF Authentication server function
- UDM Unified Data Management

The following reference points are supported:

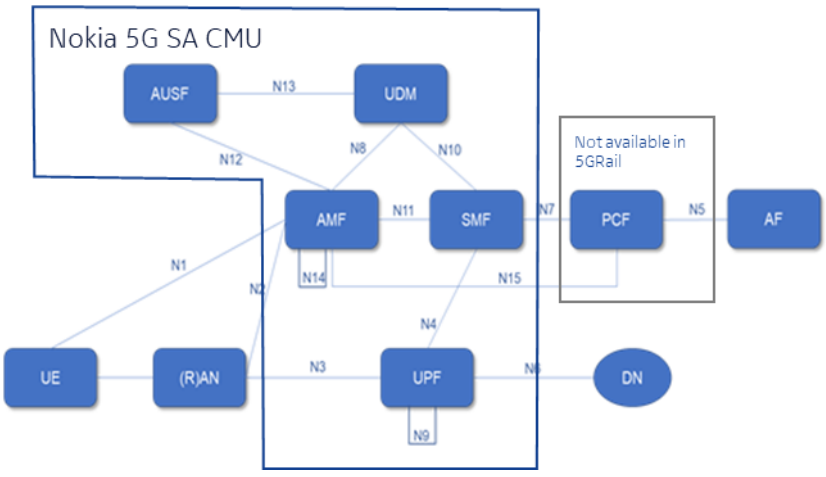

Figure 9: Nokia 5G SA core: Interfaces

Note: As the PCF is not included, static PCC configuration rules are supported.

Detailed configuration guideline for static policy configuration to be delivered in D3.2

3.1.2.2 5G Radio Functional View

The following picture shows the FRMCS 5G Radio configuration as well as the Wi-Fi access:

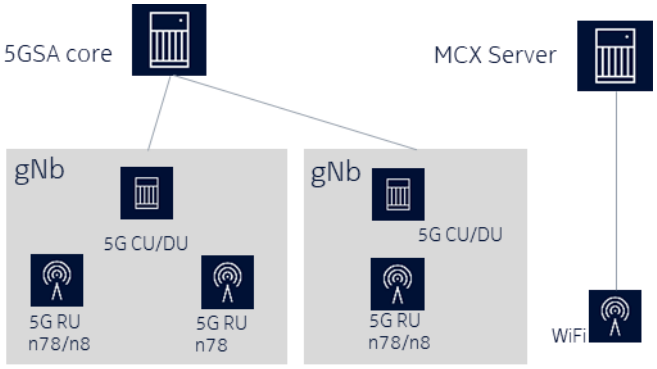

Figure 10: Radio Configuration

The Radio System consist of

- 2 gNB CU/DU: Nokia AirScale ASIK/ABIL
- 5G RU:
  - 3 Units AZQJ Band n78: 3480 -3800 MHz, 8T8R, 320 W (40W per TRX)
  - 2 Units AHDB Band n8: UL: 889 – 915 MHz/DL: 934 – 960, 2T4R, 2*80 W
- Wi-Fi: HW is to be detailed and will be described in D3.2

The concrete configuration with RRH supporting band n8 or n78 depend on the use cases defined in WP1. Band n8 is planned to be used for functional e2e tests only. Wi-Fi depends on the bearer flex use case.

3.1.2.3 MCX Functional View

The Nokia MCX System consist of

- MCX Server supporting Video, Voice and data
- Integrated SIP Server
- GIS Location Management Server
- GUI for Controller, Administration and GIS
- Android Clients to be installed on COTS terminals

The System is running on Nokia LAB cloud. It provides the following functionality:

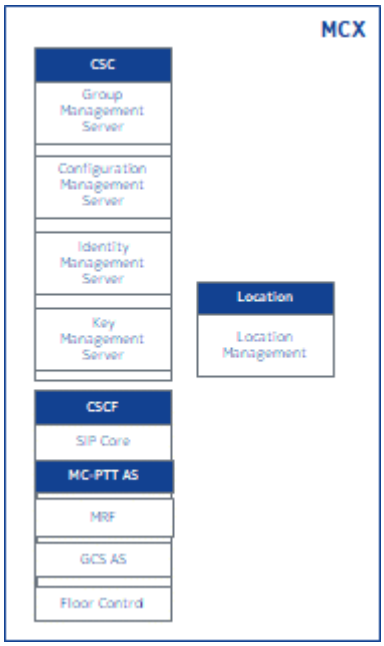

Figure 11: MCX Server Functional View

The MCX Dispatcher is running on standard PC and is connected to the MCX Server via IP connection

Additionally, a management console is available (running on standard PC) to visualize configuration and GIS information.

3.1.2.4 GSM-R Functional View

The following overview shows the GSM-R system to be used for GSM-R – FRMCS voice interworking test cases:

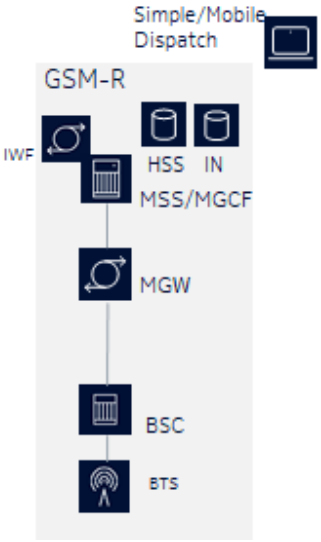

Figure 12: GSM-R configuration

GSM-R network provides GSM-R capable radio connectivity which requires the following functional entities:

MSS - Open Mobile Softswitch for Railways (MSS)

The Open Mobile Softswitch for Railways (MSS) is a mobile softswitch product offering a wide variety of services, including 3GPP defined teleservices, EIRENE compliant railway services, asynchronous and synchronous bearer and supplementary services.

MSS provides the Service Switching Function (SSF) logic for supporting Customised Applications for Mobile Network Enhanced Logic (CAMEL) and Core Intelligent Network Application Protocol (INAP) based Intelligent Network (IN) procedures. The MSS simultaneously supports different functions in the same physical network element.

MSS hosts the Group Call Register (GCR) functionality which is a database that stores group call attributes and serves group call control by providing group call attributes by request.

IWF : The Interworking Function between GSM-R and FRMCS will be implemented as integrated SW in the MSS. It connects to the MCX Server. IWF is described in chapter 3.1.2.5

MGW - Open Multimedia Gateway (MGW)

The Nokia Open Multimedia Gateway (MGW) is used for transmitting and converting user plane traffic in circuit-switched core networks. It is also a border element between different kinds of networks, the PSTN and the PLMN, and the CS core network.

NT-HLR/HSS + One-NDS

Provides Home Location Register (HLR) functionality in modern products

IN/Service Control Point (SCP)

IN/SCP provides the Intelligent Network (IN) service acting as Service Control Point (SCP) in the GSM-R network. The IN/SCP provides all the GSM-R IN SCP functions according to EIRENE specification.

Flexi BSC – Base Station Controller

The main function of the BSC is to control and manage the BSS and the radio channels. It transfers signalling information to and from the mobiles and manages handovers between the cells.

The BSC is connected to a BTS via the Abis (CS and PS traffic) interface. CS traffic goes to the core network through the A interface (CS traffic towards MSC/MGW). An integrated LAN switch in BSC3i and Flexi BSC provides access to the operator's IP network as the first level LAN switch.

BTS - Base Station

The Nokia **Flexi Multiradio 10** base station (BTS) is connected to the base station controller (BSC) via the Abis interface.

The BTS also connects the mobile subscriber's mobile station (MS) to the GSM network through the Radio interface and performs the radio functions of the BSS.

3.1.2.5 IWF – FRMCS – GSM-R Interworking

The Interworking Function between GSM-R and FRMCS will be implemented as integrated SW in the MSS. It connects to the MCX Server:

Figure 13: GSM-R and FRMCS Interworking

It provides the interworking for Group Call communication, where a group call established in the FRMCS system triggers a Group Call establishment in GSM-R (e.g. Railway Emergency Group Call).

It provides an integrated mapping of Addressing schemes.

Floor Control interworking mapping is not supported. IPSecurity is not supported on the interfaces.

3.1.2.6 Onboard and Trackside GW Functional View

FRMCS Onboard & Trackside GW function is fully described in document D2.1 TOBA Architecture Report [S19].

3.1.2.7 Bearer Flex Configuration

According to [S18] chapter 12.3.1.3-12.3.1.5 FRMCS Bearer flexibility encompasses two capabilities:

- FRMCS Multipath uses multiple transport domains on separate UEs for a given communication session.
- FRMCS Multi Access uses multiple radio access technologies on a single UE.

Open Topic: Demonstration of the Bearer Flexibility use case as to be defined by WP1.

3.2 Software & Hardware initial lineups

To be included in D3.2

3.3 Parameters

To be included in D3.2

3.4 IP Plan

To be included in D3.2

4 MATRIX TO CHECK THAT WHAT WAS EXPECTED IS PROVIDED BY THE LAB

The following chapter validates that all the necessary network elements are present in the lab setup to fulfil the use cases assigned to WP3 and prepare the field tests for WP5.

4.1 Matrix WP3 objectives / Lab setup resources needed

Whatever WP1 will decide to actually test, some expectations on WP3 lab setup are expressed in GA document. They are underlined in following table in order to show how these requirements have been fulfilled.

Expectations in terms of Lab infrastructure needs (from Proposal Submission Forms - Proposal number 951725 - 5GRAIL)	WP3 Lab means
The lab will provide a 5G telecommunication infrastructure based on 5G radio equipment, 5G core equipment and FRMCS MCX application server based on 3GPP Release 16 and Pre 3GPP Release 17 if applicable, including MCPTT functionality for end to end voice application evaluation and integrated SIP server functionality;	*Nokia 5G SA integrated core and RAN, MCX server & GIS server and integrated SIP core. Up to Rel. 16.*
Rudimentary Dispatcher terminal to evaluate train – dispatcher communication	*1 MCX Dispatcher on Standard PC connected to MCX Server. CAB Radio and OB GW*
The radio equipment allows for the evaluation of stationary and non-stationary use cases with the support of test equipment (e.g. fading emulator for handover)	*2 gNB CU/DU (Nokia Airscale), 3 RRH n78, 2 RRH n8. Attenuator / Fading Simulator*
The lab is available to integrate on-board voice, data and other application (e.g. TCMS, CCTV/video) as provided in WP 2 with the Onboard Architecture	*Onboard GW, TCMS & ETCS on standard PC simulated. Video server and CAB Radio*
The 5G radio will support commercially available and 3GPP defined spectrum. Spectrum used in the lab environment will be aligned with WP5 activities. Availability of radio equipment in the 900 Mhz and in the 1900 MHz bands depends on ongoing standardisation and regulation and mobile device availability;	*Agreed in TCC: 3 RRH Band n78, 2 RRH Band n8. allowing for mobility*
The 5G core will implement 3GPP Standalone (3GPP Option 2) with 5GC SA support composed of UPF, SMF, AMF, AUSF, SDM & PCF;	*5G Core : Nokia CMU on 2 HPE Server. Second core for cross border is tbd. PCF is not available*
FRMCS MCX application integration in 5G Standalone Core is not yet standardised in 3GPP Release 16 and will be realised by appropriate pre standard solutions or workarounds	*PCF is not available. Static configuration of QoS profile in CMU*
The lab provides GSM-R infrastructure as well to evaluate FRMCS and GSM-R interconnection and interworking scenarios as innovative action as not standardized today.	*Nokia MSS and MGW, BSC and GSM-R BTS, Funkwerk GSM-R phones. Lightweight GSM-R mobile dispatcher terminal. IWF for GSM-R - FRMCS implemented in MSS*
Cross border use cases can be evaluated by the emulation of different networks provide in the lab depending on WP1 test case definition	*Cross boarder use case is tbd. For FRMCS - FRMCS a second CMU and MCX server could be deployed. WiFi suports Multi Path use case*
Wi-Fi access is available	*WiFi Access Point (depends on Beaer Flex use case (tbd)*
COTS phones for evaluating voice related services will be provided (5G depended on available 3GPP band support), GSM-R terminals for interworking test scenarios	*2 COTS 5G QC SDX60 chipset, OnePlus 9. Funkwerk GSM-R*
Trackside servers for emulating ETCS, TCMS or CCTV/Video application will be deployed locally or remotely in the responsibility of the WP2 protype suppliers	*ETCS & TCMS simulation on standard PC. Video dedictated HW. Voice application: MCX Dispatcher by Nokia. TS GW by Kontron /to be described in D4.2). No remote deployment (only for remote maintenance)*
Measurement tools e.g. for end-to-end latency & throughput, as defined by 3GPP TS 22.289, depending on use case.	*Solution chosen will depend on WP1 needs.Attenuator and Fading simulator for mobility tests available as well as Wireshark for analysis, iPerf for traffic generation and e2e test. Further MCX related performance measurement is tbd. To be further described in D3-1*
Expectations in terms of Field infrastructure needs (from Proposal Submission Forms - Proposal number 951725 - 5GRAIL)	**WP3 Lab means**
Germany (DBN Test Site): Test line, 5G RAN to be deployed in 2-3 sites/sectors.	*3 CU/DU, 3 RRH N78. Remote VPN Connection from 5G Core Lab. No GSM-R at DBN site. Bearer Flex use case is tbd*

Table 3: WP3 lab means versus Grant Agreement Expectations

In addition to that, some expectations were also given in terms of use cases to be tested. Following table summarizes which parts of the lab are needed to test them (Note: Measurement tools for performance or analysis will be included in D3.2 delivery). For WP5 it is preliminary with respect to planned use cases and required configuration.

Expectations in terms of Use case needs	5G RAN	5G Core	MCx Server & GIS Server	2G BSS	2G NSS	2G NSS IWF	WIFI Router	GSM-R Handsets	Smartphones with MCx client	Multipath Fading Simulator	Matrix Attenuator	Trackside GW	Onboard GW	ETCS Trackside application	ETCS On-Board application	TCMS Trackside application	TCMS On-Board application	Voice Trackside MCX Dispatcher	Voice CAB Radio application	Video Trackside application	Video On-Board application
FRMCS 5G QoS																					
FRMCS 5G QoS: Applying 5G end-to-end QoS concepts for differentiation of critical and non-critical data over TOBA + FRMCS 5G infrastructure qualification while degrading radio transmission, emulating speed;	x	x							x	x	x	x	x								
Task 3.2 - TCMS, ETCS and CCTV/Video integration over 5G infrastructure																					
Verification and validation of the system behavior in reference to the user & system requirements as well as the FRMCS specification in nominal conditions	x	x	x									x	x	x	x	x	x			x	x
ETCS and TCMS over FRMCS 5G. Different radio conditions emulating different network conditions	x	x	x							x	x	x	x	x	x	x	x				
CCTV/Video over FRMCS 5G. Different radio conditions emulating different network conditions	x	x	x							x	x	x	x							x	x
Task 3.3 - Voice applications over 5G infrastructure																					
Voice over FRMCS 5G using MCX/MCPTT servers	x	x	x						x	x	x		x					x	x		
Railway Emergency Group calls involving TOBA voice application and COTS terminals;	x	x	x						x				x					x	x		
Point to Point calls involving TOBA Voice application and MCPTT dispatcher and COTS terminals;	x	x	x						x				x					x	x		
3GPP Release 16 and pre-Release 17 functionalities (e.g. location and functional alias); *)			x																		
Task 3.3 - GSM-R and FRMCS 5G interworking																					
Voice Group calls establishing in both FRMCS 5G network and GSM-R.	x	x	x	x	x	x		x					x					x	x		
Task 3.4 - Combined applications, cross-border scenarios over 5G infrastructure																					
Combined Application with data and video applications, critical data (ETCS) and non-critical data (TCMS). Qualification parallel use of TOBA applications to verify QoS separation capabilities of 5G FRMCS;	x	x	x									x	x	x	x	x	x			x	x
Cross-border scenario with TCMS application. Qualifying data continuity while TOBA moves between FRMCS 5G networks (2 isolated networks)	x	x	x									x	x			x	x				
Preparation of field tests in Germany (Preliminary view and to be aligned and confirmed with WP5)																					
Task 5.2 Requirements for FRMCS Functional and Performance Testing																					
5G/FRMCS – 5G/FRMCS border crossing scenario;	x	x	x																		
Selection of functional and performance test options with integration of applications / simulators: Germany (DBN Test Site): ETCS, MCPPT / Voice, Minimum set for Data & Video, TCMS.	x	x	x										x	x	x	x	x	x	x	x	x
Cross Border: Germany (DBN Test Site): MCPTT / Voice incl. 5G/FRMCS to 5G/FRMCS and 5G/FRMCS to 2G/GSM-R interworking via lab.Germany (DBN Test Site): 50-80 km/h.	x	x	x	x	x	x										x	x	x	x		
MCPTT voice call (incl. 3GPP Release 16 and Pre Release 17 *)	x	x	x					x	x									x	x		
Non-mission critical video	x	x	x										x							x	x
TCMS	x	x	x									x	x			x	x				
Bearer flexibility	TBD																				
Radio performance measurements (e.g. throughput, latency, data continuity at handover points);																					
*) 3GPP release 17 not supported																					

Table 4: WP3 needs in terms of use cases versus means to test them

4.2 Lab Setup resources needed for WP5

Field tests in Germany at DB site will be supported by remote connection of the Budapest core network with the radio sites along the field track. Note: As no GSM-R is available at DB site the GSM-R interworking test cases can only be executed in split mode between Lab and Field. The number of RRH depends on the concrete site plans.

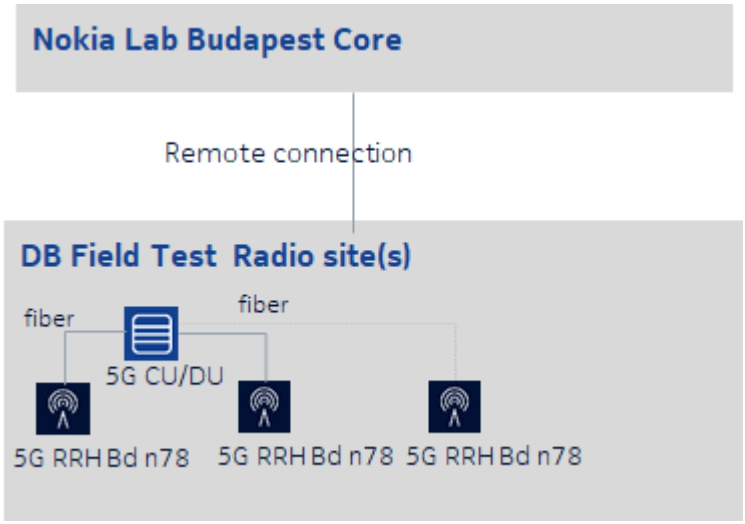

Figure 14: Remote connectivity of WP3 Lab with WP5 sites of DB- preliminary view

5 CONCLUSIONS

This document describes the different equipment provided by the WP3 5Grail partners in order to build the WP3 lab. It also gives information on the way this equipment is interconnected.

Grant Agreements needs on WP3 lab structure, regarding WP3 and WP5 objectives, have been checked and fulfilled according to the information given in chapter 4 and consequently, the lab setup appears to be in line to address the execution of the tests specified by WP1 – according to the current status.

Next WP3 delivery (D3.2 - First Lab Test Setup Report) will outline the lab setup, integration and verification of radio compatibility of 5G radio modules and other public band modules depending on spectrum. Based on WP1 definition, network functionality for GSM-R – FRMCS interworking will be simulated

Last WP3 delivery (D3.3 – First Lab Test Report) The lab testing reports outlines and details the different lab test phases for each application. It documents the work done and details the achieved results for the integration of prototypes into the 5G infrastructure and the validation of the communication capabilities in the lab environment in line with the lab test strategy document elaborated in WP1. It covers Voice, TCMS, ETCS, CCTV/Video test results, as well as cross-border testing, as well as details on the actual lab that was used, in particular which software versions were loaded.

6 REFERENCE DOCUMENTS

[S1] MC Services Security aspects (useful to understand MCx authentication and authorization)	3GPP TS33.180
[S2] Mission Critical Push to Talk (MCPTT); Stage 1	3GPP TS 22.179
[S3] Mission Critical Data (MCData) signalling control; Protocol specification	3GPP TS 24.282
[S4] Mission Critical Data (MCData) media plane control; Protocol specification	3GPP TS 24.582
[S5] UIC - FRMCS Use cases	UIC MG-7900, Version 2.0.0
[S6] 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Study on Future Railway Mobile Communication System	3GPP TR 22.889
[S7] UIC - FRMCS Principle Architecture	UIC MG-7904 Version 0.3.0 (Draft)
[S8] UIC – FRMCS – Telecom On-board system – Functional Requirement Specification	UIC ONBOARD GW FRS-7510 Version 0.2.0
[S9] Common functional architecture and information flows to support mission critical communication services	3GPP TS 23.280 Stage 2
[S10] 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Functional architecture and information flows to support Mission Critical Data (MCData)	3GPP TS 23.282 V17.6.0, Stage 2 (Release 17) - 04/2021

[S11]	Rail Telecommunications (RT); Future Rail Mobile Communication System (FRMCS); Study on system architecture	ETSI TR 103.459 V1.2.1, 08/2020
[S12]	UIC – FRMCS – User Requirements Specification	FU-7100 Version 5.0.0
[S13]	ETSI – Future Rail Mobile Communication System (FRMCS) – Study on system architecture	ETSI TR 103 459 Version 0.2.2
[S14]	UIC – FRMCS – Functional Requirements Specification	FU-7120 Version 0.3.0
[S15]	UIC FRMCS On-Board System Requirements Specification (TOBA SRS)	TOBA-7530
[S16]	UIC FRMCS Functional Interface Specification (FRMCS FIS)	
[S17]	UIC FRMCS Form-Fit Functional Interfaces (FRMCS FFFIS)	
[S18]	UIC FRMCS System Requirements Specification (FRMCS SRS)	AT-7800
[S19]	TOBA Architecture Report	D2.1

7 APPENDICES

7.1 WP1 test cases definitions

The following tables from WP1 reflect the current status of test cases to be executed in WP3:

							Relevant Communication Applications							Relevant Support Applications												
							5.9	5.10	5.19	5.20	5.27	6.19	6.20	6.23	8.1	8.2	8.3	8.4	8.5	8.7	8.8	8.9	8.10	8.11	8.12	10.1
		5GRAIL	LAB WP3	LAB WP4	FIELD DB WP5	FIELD SNCF WP5	Automatic Train Protection communication	Automatic Train Operation communication	Voice recording and access	Data recording and Access	Critical real time video	Messaging Services	Transfer of data	Real time video call	Assured voice communication	Multi user talker control	Role management and presence	Location services	Authorisation of communication	Authorisation of application	QoS class negotiation	Safety application key management communication	Assured data communication	Inviting-a-user messaging	Arbitration	Billing information
URS Ref.	Applications																									
5.1	On-train outgoing voice communication from the train driver towards the controller(s) of the train*	X	X	O	X	O										X	X	X	X	X	X			X	X	
5.2	On-train incoming voice communication from the controller towards a train driver*	X	X	O	X	O										X	X	X	X	X	X			X	X	
5.3	Multi-Train voice communication for drivers including ground user(s)	X	X	O	X	O										X	X	X	X	X	X			X	X	
5.9	Automatic Train Protection communication*	X	X	X	X	X		X					X				X	X	X	X	X				X	
5.15	Railway Emergency Communication*	X	X	O	X	O							X			X	X	X	X	X	X				X	
6.9	On-Train Telemetry communications (TCMS includes 6.9 + 6.11 + 6.20), including PIS	X	X	X	X	X							X				X	X	X	X	X				X	
6.11	On-train remote equipment control (TCMS includes 6.9 + 6.11 + 6.20)	X	X		X								X				X	X	X	X	X				X	
6.13	Non-critical real time video (see clause 5.27) - MCVideo, MCData related?	X	X	X	X	X							X				X	X	X	X	X				X	
6.20	Transfer of data (TCMS includes 6.9 + 6.11 + 6.20)	X	X		X												X		X	X	X				X	
6.22	Transfer of CCTV archives (Wi-Fi related?)	X	X	O	TBC												X		X	X	X				X	

Table 5: current status of test cases to be executed in WP3 (1/2)

							FRMCS System principles related use cases (source: TR 22.889)																											
							12.2	12.3	12.4	12.5	12.6	12.7	12.8	12.9	12.10	12.11	12.12	12.13	12.14	12.15	12.16	12.17	12.18	12.19	12.20	12.21	12.22	12.23						
		5GRAIL	LAB WP3	LAB WP4	FIELD DB WP5	FIELD SNCF WP5	Area Broadcast Group Communication interworking between GSM-R and FRMCS Users	Location Service interworking between GSM-R and FRMCS Users	Presence interworking between GSM-R and FRMCS Users	Point to Point communication between GSM-R and FRMCS Users	Interworking with legacy systems including LMR	Builds stable positioning framework for FRMCS services and devices including trainborne and handheld devices	Interworking between GSM-R and FRMCS	Bearer flexibility	QoS in a railway environment	Provide broadband and mission critical services with seamless connectivity	Offer railway services high-quality control functions with real-time train status monitoring	Provide call priority during interworking with LMR	FRMCS Positioning Accuracy	FRMCS System security framework	Interworking to external networks	FRMCS On-network/Off-network communication	Call restriction service	Allocation and isolation of FRMCS communication resources	FRMCS Equipment capabilities for multiple FRMCS Users	FRMCS System/FRMCS User roaming capabilities	Availability – increasing measures	Flexible use of available contiguous spectrum blocks(s) and related bandwidth(s)						
							Yes	Yes	N/A	TBC	N/A	Option	Yes	Yes	Yes	N/A	N/A	N/A	Yes	TBC	N/A	N/A	Option	Yes	Yes	Yes	Option	N/A						
URS Ref.	Applications																																
5.1	On-train outgoing voice communication from the train driver towards the controller(s) of the train*	X	X	O	X	O		O		X			X	X	X					O			O	O	X	X							
5.2	On-train incoming voice communication from the controller towards a train driver*	X	X	O	X	O		O		X		O	X	X	X					O			O	O	O	X							
5.3	Multi-Train voice communication for drivers including ground user(s)	X	X	O	X	O	X	X					X	X	X					X				O	O	X							
5.9	Automatic Train Protection communication*	X	X	X	X	X						O	X	X	X					X				X	X	X	O						
5.15	Railway Emergency Communication*	X	X	O	X	O	X	X				O	X	X	X				O	O				X	X	X							
6.9	On-Train Telemetry communications (TCMS includes 6.9 + 6.11 + 6.20), including PIS	X	X	X	X	X								O	X					X													
6.11	On-train remote equipment control (TCMS includes 6.9 + 6.11 + 6.20)	X	X		X									O	X					X													
6.13	Non-critical real time video (see clause 5.27) - MCVideo, MCData related?	X	X	X	X	X						O		X	X				O	X				X	X	O							
6.20	Transfer of data (TCMS includes 6.9 + 6.11 + 6.20)	X	X		X							O		O	X					O													
6.22	Transfer of CCTV archives (Wi-Fi related?)	X	X	O	TBC									X	X																		

Table 6: current status of test cases to be executed in WP3 (2/2)

Please note that the description of the functionality in each use cases - e.g. provided by a specific supporting functionality - could include several requirements not all applicable or selected for the test cases. More details will be defined in WP1.

7.2 WP3 Assumptions

The following table depicts the current assumptions and open points to be taken by WP3 for the execution of the planned test:

ID	Technical Architecture Open Items and Assumptions to support WP3 execution
1	5G public Band Modem (2.7 GHz TDD/ Band n78.) Band n8 for some dedicated use cases
2	Remote access to equipment for maintenance
3	No MCVIDEO, use MCData instead. Loose Coupling for Video as a data bearer
4	Separate dispatcher (GSM-R- FRMCS). Simple dispatcher (mobile dispatcher phone) for GSM-R
5	Numbering Plan: MC User ID : 11 digit. Functional Alias: 128 byte including domain name.
6	No MCX - MCX Interworking (3GPP Rel. 18)
7	Bearer Flex vs. Multiconnectivity use case : bearer Flex (multi access, one core) : No integration of WiFi in 5GCore (missing functionality e.g. no N3IWF in Rel. 15 Modem) -> no Multi Access/ bearer flex possible. Alternative for Multi Access: : two 3GPP bands / one modem (n78 sub bands, preferred by Field test / DB). Applications: no ETCS, no TCMS. Video offload archive. . Use Cae: CCTV offload: open how to trigger . No Multi Connectivity in WP3
8	Trackside GW provided by WP2 (OB App equivalent) -> TSApp for tight coupling/Voice not needed (direct connection to server). TS GW for Loose Coupling needed
9	Location: MCX support: Voice. GPS emulated available for LAB (eCGI emulation option not considered). No GMLC for 5G. Simulation in lab for Loose Coupled is tbd
10	GSM-R Interworking: Voice only. Group call only (REC)
11	Group Communication Interworking: FRMCS initiated group call only
12	Group Communication Interworking: no floor control / talker change (not specified yet for between system)
13	No PCF functionality, No MCX related 5GQI (66,67,..) supported. 5QI for MC Data -> non GBR (aligned with Rel. 17 MC Data 5QI 70 definition). Flexible assignment of 5QI/QFlowIdentifer in ToBa needed during test
14	Group Communication Interworking: no security/encryption for IWF (Note Two options. A) "Stop at IWF (as not in GSM-R)" B) no security for security in FRMCS)
15	Group Communication Interworking: no eMLPP mapping /interworking. Not defined in ETSI yet
16	MC Data / IP CONN : no functional alias required (3GPP Rel. 17)
17	Cross Border Use case: Re - registration needed (e.g. no inter plmn handover). Trigger by application tbd (no information on network registration info known on application layer)
18	Cross Border Use Case: Voice related: No FRMCS - FRMCS use case (WP5 open) . FRMCS - GSM-R Interworking scenario can be seen as roaming scenario
19	Cross Border Use Case: No ETCS use case. TCMS use case (home routed) Full functionality in Rel. 18 (automatic) . Proposal with one MCX Server
20	Emergency Alert: base on MCPTT , 3GPP Rel. 16 capabilities. Automatic Voice call setup
21	Multi Talker Control use case: only for Multi Train /Group call
22	MCData IPCon : Client to Client routing of user plane, MCX Server only in Control Plane
23	Private call for Train to Controller and controller to train
24	Floor request and GDCP for multi talker control: solved
25	MCData IPCon : Open: border crossing
26	Group Communication Interworking: no Functional Alias mapping. Not defined in ETSI yet
27	Location: MCX support for Loose: GPS emulated available for LAB
28	Dynamic QoS to be realized by static configuration in network, (DSCP/TOS) (as described in 3GPP 23.501.) Modem evaluation . Alignment with modem capabilities for voice:: 5QI-1 GBR supported by Nokia only for Voice (VoNR) capable devices. Proposed alterative is non-GBR for Voice

Table 7: WP3 Assumption and open topic list

Note: this table include the agreed assumptions (green) and open assumptions not yet finalized due to ongoing discussions.

7.3 Detailed HW Descriptions

7.3.1 Nokia HW Description

7.3.1.1 Nokia 5G Infrastructure

The detailed description is provided in the following table:

Product	Units	Function	Physical Size	Power Supply
Airscale Baseband 	2	5G Baseband (CU/DU) as indoor (IP20 rated) gNB proving plug-in units / Backplane for high bandwidth inter-connect between AirScale plug-in units Fans with changeable airflow direction are included The 5G L1 + L2 RT processing ingNB-DU will be realized	Dimensions: 19” rack / 3U / 8 447(w) x 128(h) x 400(d) mm Volume: ~23L, Weight: 10.1 kg min. / 23.5 kg max	76 to 288 VAC or -40.5 to -57 VDC
Airscale RRH **AZQJ (n78)** 	3	The AZQJ Airscale RRH is a Beamforming capable 8T8R solution providing with following characteristics: • Small Form Factor • High output power 320 W • Up to 4 MIMO spatial streams with CPRI • Band/Frequency Range • n78: 3480 - 3800 MHz • Carrier bandwidth: • 20, 40, 60, 80, 100 MHz	<26 liters, <23 kg IP65. -40°C to +55°C Natural convection cooling	DC -36 V ... -60 V
AirScale RRH **AHDB (N8)** 	2	The AHDB RRH is a Single band RRH solution for 900 MHz FDD with following characteristics: • Max RF Output Power* 80 W • 2T4R • Band/Frequency Range:band 8/n8 • UL(RX) 889 – 915 MHz	Physical & Environmental 11.9 liters, 12 kg IP65. -40°C to +55°C Natural convection cooling	-40.5 V DC to -57.0 V DC

		• DL(TX) 934 – 960 MHz • Instantaneous bandwidth (IBW): full band • Occupied bandwidth (OBW):full band • 5G NR Carrier bandwidth: 5, 10, 15, 20 MHz		
5GSA core 	1 (2) Pair	The 5G Enterprise Core (Nokia CMU) integrates UPF, SMF, AMF, AUSF and UDM functionality in a redundant server solution. Each HW consist of • 1 x AMD EPYC 7702P 64-core CPU • 512 GB DDR4 Memory (8 x 64 GB DDR4 DIMMs) • 1.92 TB storage (2 x 960GB SATA MU SSDs) • Four 25/10 Gbps I/O ports (2 x 2-port 10/25GbE SFP28 NICs) • Redundant AC or DC power and redundant fans Note: additional pair for cross border use cases is tbd.		
MCX, Dispatcher, GIS, MCX client App   	1 (2) 1 1 2	MCX solution consist of MCX Server (Nokia GC), Location Management GIS platfom and is realized for WP3 in a Lab cloud Environment using Nokia Airframe server Note: additional server for cross border use cases is tbd The Dispatcher and GIS GUI is running on Win10 laptop MCX Clients for the use in COTS terminals are running on Android		

		phone: COTS Terminals (2) (OnePlus 9 incl. SDX60 QC)		
WiFi Router		WiFi Router to be deployed depending on Bearer Flex use case decision. Will be updated later		
SIM Cards		Nokia will provide 4G and 5G Smartjack SIM cards for the tests. As regards 2G terminals, Nokia will provide Gemalto 2G SIM cards.		

Table 8: List of Nokia5G Infrastructure Equipment

7.3.1.2 Nokia Test and Monitoring Tools

The detailed description is provided in the following table:

Product	Units	Function	Physical Size	Power Supply
Fading simulator **Propsim F8** 	1	Versatile Channel Emulator for Advanced Performance Testing The industry standard MIMO channel emulator for WLAN 802.11ac chipset research and design verification, supporting up to 160 MHz signal bandwidth with MU-MIMO and 3D beamforming	link	
Matrix attenuator **Hytem FULL FAN OUT ATTENUATION MATRIX** **6x6 - 93/110 dB - 3 to 6 GHz** 	1	Matrix Attenuator is used for n78 band It allows for simulating cell change e.g. for handover or loss of signal	link	

Matrix attenuator **BUAW12 - 6X6 ATTENUATOR MATRIX** 	1	Matrix attenuator used for Band n8 (optional depending on test cases) It allows for simulating cell change e.g. for handover or loss of signal 6 inputs - 6 outputs matrix 700-2700MHz operation 60dB attenuator range Ethernet controllable	link	
iPerf	1	Open source speed test and reliability measurement tool for network connections, supporting both TCP and UDP.	link	
WireShark	1	Wireshark is the world's foremost and widely-used network protocol analyzer. It lets you see what's happening on your network at a microscopic level and is the de facto (and often de jure) standard across many commercial and non-profit enterprises, government agencies, and educational institutions.	link	

Table 9: List of Test and Monitoring Equipment

Note: additional tool support for MCX related KPI are under evaluation and will be included in D3-2.

7.3.1.3 Siemens HW Description (Voice)

7.3.1.3.1 VOICE CAB RADIO

The SVR400+ is sealed to IP54 and has a standard operating temperature range of -20ºC to +70ºC. This is achieved by the incorporation of an active cooling unit.

A photograph of the SVR400+ is shown in Figure 15.

Figure 15: SVR400+ front panel

Table 10: SVR400+ Specification provides specification of the SVR400+ Voice Cab Radio solution:

Physical Specification	
Dimensions of the SVR400+ Voice Cab Radio unit	**135.8mm (h), 299mm (w) and 241mm (d)**
Dimensions of the gland box unit (mounted on the rear face of the radio unit)	**120mm (h), 200mm (w) and 120mm (d)**
Dimensions of the fan unit (mounted on the front face of the radio unit)	**133mm (h), 299mm (w) and 65mm (d) (Plus, a minimum air gap of 20mm on the depth)**
Weight of the Voice Cab Radio	**9kg**
Weight of the gland box	**0.5kg**
Weight of the fan unit	**0.5kg**
Interfaces	
Voice Cab Radio Unit	**Interface to the Console Unit** **1 off ARINC type 404, triple male connector**
	Interface to the GSM-R Antenna **1 off N type female connector**
	Interface to the GPS antenna **TBC**
	Interface to the Portable Maintenance Unit (PMU) **15 way D type (gender?)**
Console Unit	**Interface to the Voice Cab Radio** **1 off N type male connector**
	Power (?)
Gland Box	**Interface to the Voice Cab Radio**

	1 off ARINC type 404, triple female connector
	Interface to the Console Unit Flying lead terminated with a D connector
	Interface to the PSU DIN connector
	OB_{APP} Interface connector 1 off M12 (gender?) Ethernet connector
	Interface to the PIS UIC 561 PA – we will need to make a cable with a connector
Power	
Train Input Power Supply	24 - 110VDC (nominal)
Output power to control panels	13V +/- 5%
Power Consumption	60W max, ~36W Nominal <1.5A (assuming dual DCP) at 24V DC

Table 10: SVR400+ Specification

7.3.1.3.2 CONSOLE UNIT

The Console Unit comprises a metal enclosure containing a Graphical Driver's Control Panel, Driver's Handset and Loudspeaker. Electrical connection to this unit is made via a D connector on the rear panel of the Console Unit.

Two switches are provided on the front panel of the Console Unit, which operate the Driver's Key and DSD Inputs on the Cab Radio for test purposes. Each of these switches provide 24V from the Power Supply Unit to the relevant digital inputs within the SVR400+ Voice Cab Radio.

Photographs of the Console Unit are shown in Figure 16 and Figure 17.

Figure 16: Console Unit front panel

Figure 17: Console Unit rear panel

7.3.1.3.3 GLAND BOX

The Gland Box contains an ARINC connector for connection to the SVR400+ Voice Cab Radio, a flying lead terminated with a D connector for connection to the Console Unit and a DIN connector for connection of the PSU, ethernet M12 connector for connection to FRMCS Onboard Gateway and UIC

A photograph of the Gland Box is shown in Figure 18.

Figure 18: Gland Box

7.3.1.3.4 POWER SUPPLY UNIT

The PSU is an AC/DC External Unit, which operates from a 230V, 50Hz mains supply and provides a 24V dc supply to the Gland Box assembly. This is used to provide power to the connected SVR400+ Voice Cab Radio.

A photograph of the Power Supply Unit is shown in Figure 19.

Figure 19: Power Supply Unit

7.3.1.4 CAF HW Description (ETCS/TCMS)

The HW details of the equipment used in the lab environment are the following:

Name of the product	Power Supply	Size	Network interfaces	Others
ETCS onboard simulator	TBD	TBD	2 Ethernet: TOBA LAN for VPN	TBD
ETCS trackside simulator	TBD	TBD	2 Ethernet: FRCMS trackside LAN for VPN	TBD
TCMS onboard simulator	TBD	TBD	2 Ethernet: TOBA LAN for VPN	TBD

TCMS trackside simulator	TBD	TBD	2 Ethernet: FRCMS trackside LAN for VPN	TBD

Table 11: CAF HW detail

The table describes the main HW which is going to be used in the lab for ETCS and TCMS simulators. Depending on the maturity of the project and time availability, optionally CAF could also provide real HW instead of generic one to run the tests against them.

7.3.1.5 Teleste HW Description (Video)

7.3.1.6 1 x TRAIN COMPUTER, Product code 98TPC40_01

TPC-40 series is a rugged CPU processing and mass storage product with two media trays for exchangeable 2.5" SATA3 drives. Typical rolling stock application is a standalone network video recorder operation.

Figure 20: Train Computer Teleste

Interfaces 10/100/1000 Mbps Ethernet (X-coded M12 Push-Pull), USB and DisplayPort for maintenance

Dimensions (WxHxD) 190 x 89 x 278 mm including ground stud

Weight 3.40 kg (without mass memories)

Housing, colour Aluminium / steel sheet

Protection class IP30

Temperature range Operational temperature -40 to +70 °C (EN 50155 class TX), Storage temperature -40 to +85 °C, (both ranges may be limited by the installed disk drives)

Operating voltage 24 VDC (16.8 to 34.0 VDC)

Power consumption 10 W (typical)

Standards EN 50155 (temperature range may be limited by selected disk drives), EN 50121-3-2, IEEE Std 1476, EN 45545-2, NFPA 130

Storage: 2x 960GB SSD (Product code UFLASH960G_02)

Power supply: 100-240VAC 24VDC/1A, with power cord EU CPS451 (Product code CPS451)
Harting connector for power input, PushPull Power connector Male (Product code XHARJU01)

Ethernet cable 1,5m. M12 X-Coded to RJ45 (Product code 98CAB0452)

7.3.1.7 1 x S-VMX LITE SFF, Product Code SL-09F04

S-VMX Lite VIDEO MANAGEMENT SYSTEM: the complete surveillance suite delivering fully professional security application in a single unit.

Figure 21: Video Management System Teleste

Video Encoding formats H.264, MPEG-4, MJPEG,

Storage 3.6TB (formatted)

Interfaces

- 1 x 10/100/1000Base-T
- USB (front) 2 x USB 2.0, 1 x USB 3.1, 1 x USB 3.1 Type-C
- USB (rear) 2 x USB 2.0, 4 x USB 3.1
- Monitor output 3 x Mini DisplayPort (female) 4K@60Hz

Software Application S-VMX

Power supply 230V AC 300W (90% efficiency)

Operating temp. range 0...+45°C / +32...+113°F

Storage temperature –40...+65°C / –40...+149°F

Relative humidity 20...80% (non-condensing)

Weight 5.26kg / 11.57lbs

Dimensions (WxHxD) 92,6 x 290 x 292 mm

7.3.1.8 2 x CCTV camera, Product Code 98VSC15

Rugged network cameras for video surveillance in rolling stock
H.264 with FHD video resolutions
WDR with forensic capturing and excellent light sensitivity with Light finder technology
(PoE) Power over Ethernet via M12 D-coded connector
Various lens options available

Figure 22. CCTV camera Teleste

98VSC15	
Usage	Rolling stock, indoor
Dimensions	Height 49 mm, diameter 109 mm, without network cable (cable length is 300 mm).
Weight	0.25 kg
Housing	IP66/67, IK08, aluminium / polycarbonate, light grey (NCS 1002-B)
Temperature range	Operational temperature -40 to +60 °C, maximum intermittent +70 °C (EN 50155:2017 class OT2/ST2) Storage temperature -40 to +65 °C
Power consumption	PoE class 2, max. 3.6 W
Maximum resolution	1920x1080 to 160x90, HDTV 1080p, max 25/30 fps
Streaming	Multiple individually configurable streams in H.264 (with Zipstream) and MJPEG
Angle of view	Angle of view 87° hor. & 47° ver. (on standard 3.6 mm F2.0 lens)
Interfaces (on cable)	M12 D-coded 10/100BASE-TX port
Standards	EN 50155:2017 (vibration, mechanical shock, bump, temperature), EN 45545-2, EN 50121-3-2 (more data available upon request)

Table 12: CCTV camera details

Grant agreement
No 951725