Ref. Ares(2023)692855 - 31/01/2023

Deliverable D4.1

Second Lab Integration and Architecture Report

Disclaimer:

The information in this document is provided "as is", and no guarantee or warranty is given that the information is fit for any particular purpose. The content of this document reflects only the author's view – the European Commission is not responsible for any use that may be made of the information it contains. The users use the information at their sole risk and liability.

No part of this document may be copied, reproduced, disclosed or distributed by any means whatsoever, including electronic without the express permission of the author(s). The same applies for translation, adaptation or transformation, arrangement or reproduction by any method or procedure whatsoever.

Grant agreement
No 951725

5GRAIL

5G for future RAILway mobile communication system

D4.1 Second Lab Integration and Architecture Report

Due date of deliverable: 29/08/2021

Actual submission date: 31/01/2023

Leader/Responsible of this Deliverable: KONTRON

Reviewed: Y

Document status		
Revision	**Date**	**Description**
0.1	28/07/2021	Draft Version
0.2	26/08/2021	Draft 4 Version
0.3	31/08/2021	Version 0.3 after Draft 4 review
1.0	14/09/2021	Final version after Appendices section update
1.1	10/03/2022	Revised version following EC comments
2.0	25/05/2022	Final version sent to consortium - version submitted
2.1	02/01/2023	Revised version following latest EC comments
3.0	24/01/2023	Final version after consortium review – version submitted

Project funded from the European Union's Horizon 2020 research and innovation programme		
Dissemination Level		
PU	Public	✓
CO	Confidential, restricted under conditions set out in Model Grant Agreement	
CI	Classified, information as referred to in Commission Decision 2001/844/EC	

Start date of project: 01/11/2020 Duration: 30 months

Executive Summary

Within 5G Rail project, Work Package 4 (WP4) is mostly linked to WP2 and WP5. Indeed, WP2 is providing FRMCS prototypes that must be installed, integrated and tested in WP4 lab : On-Board and Trackside Gateways, which are key components of the global FRMCS network, but also FRMCS applications and especially ATO, ETCS and PIS ones that are to be tested in WP4 lab, also known as “Second Laboratory” (First one being the one of WP3). Besides, WP4 is paving the way to WP5 French field tests and must then take into account a de-risking role for WP5 activities.

The purpose of this deliverable titled “D4.1 - Second Lab Integration and Architecture Report” is to present WP4 lab architecture which is set-up in France Kontron Labs. In order to do this, hardware devices, provided by consortium members Alstom, Kontron and Thales, will be introduced in detail. A listing of the tools that are put in place and made available to conduct the lab validation tests will also be provided. Then, the configuration details of the lab and its architecture will be reported to highlight the engineering view of the lab, including the platform description, in its hardware and functional views, in addition to software & hardware initial lineups, coupled with the diverse parameters and the global IP planning.

Furthermore, prior concluding this report, multiple matrices, checking that what was anticipated in 5G Rail WP4 and WP5 perspectives is actually provided by the lab facilities, will be given.

Abbreviations and Acronyms

Abbreviation	Description
3GPP	3rd Generation Partnership Project
5G NSA	5G Non StandAlone
5G SA	5G StandAlone
ANSSI	Agence Nationale de la Sécurité des Systèmes d'Information
API	Application Programmable Interface
AS	Application Server
ATC	Automatic Train Control
ATO	Automatic Train Operation
ATSSS	Access Traffic Steering, Switching and Splitting
BBU	Base Band Unit
BIOS	Basic Input Output System
BSC	Base Station Controller
BTS	Base Transceiver Station
CAM	Connected and Automated Mobility
CCS	Control Command and Signalling
CCTV	Closed Circuit TeleVision
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
GBR	Guaranteed Bit Rate
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
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
MCC	Mobile Country Code
MCG	Mobile Communication Gateway
MCPTT	Mission Critical Push To Talk
MCx	Mission Critical (x stands for voice, video and data services)
MGW	Media Gateway
MIMO	Multiple Input Multiple Output
MNC	Mobile Network Code
MNO	Mobile Network Operator
MPTCP	MultiPath Transmission Control Protocol
MQTT	Message Queuing Telemetry Transport
N3IWF	Non-3GPP Inter Working Function
NR	New Radio
NSA	Non-Stand Alone (5G Core architecture)
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 Centre
OTA	Over The Air
OTT	Over The Top
PCB	Printed Circuit Board
PCRF	Policy and Charging Rules Function
PCU	Packet Control Unit

PDN	Packet Data Network
PIS	Passenger Information Service
PSS	Process Safety System
QoS	Quality Of Service
RAM	Random Access Memory
RAN	Radio Access Network
RAT	Radio Access Technology
RBC	Remote 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)
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
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

CONTENTS

Table of figures

List of tables

1 INTRODUCTION

The main objective of the 5GRAIL project 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.

WP4 as part of the 5GRAIL, provides the second 5G reference lab environment situated at KONTRON's premises in France. It will be used to perform testing and validation of the main FRMCS functionalities, defined within WP1 and focused on data applications prototypes, knowing that some voice tests are optional as being part of main WP3 scope. These FRMCS applications, developed by WP2, are ETCS, ATO and PIS. The former PIS application is especially chosen to be a demonstrator of cybersecurity where the risk assessment and study are in the scope of WP1 and WP2.
Knowing that WP2, and more precisely Kontron and Alstom engineering teams, is also providing the essential FRMCS On-Board and Trackside Gateways, WP4 lab clearly appears as the place where many WP2 deliveries are tested:

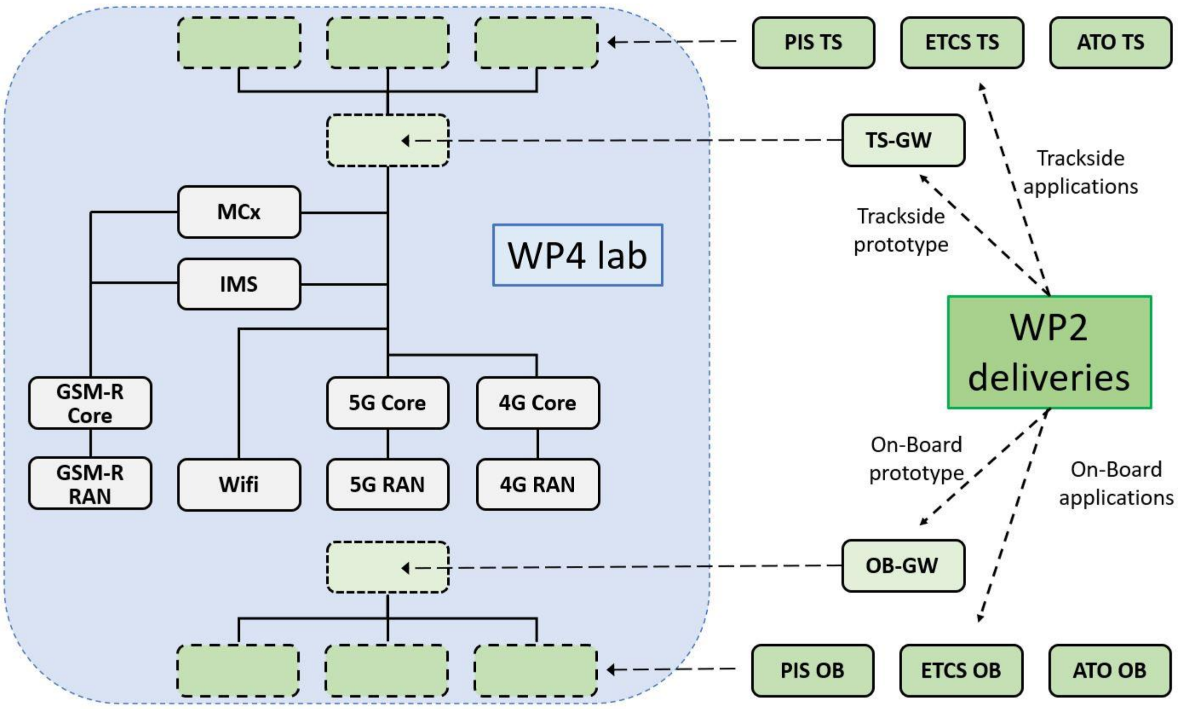

Figure 1: WP4 lab as a test place for some WP2 deliveries

It is worth mentioning also the other 5G reference lab environment, which is in the scope of WP3, situated in Nokia's premises in Hungary. The activities of this lab are focused on voice applications, ETCS, TCMS, CCTV and Video. Both lab activities are complementary for the whole 5GRail project and experiences are exchanged between them.
Furthermore, WP3 and WP4 constitute a valuable experience for the field activities of WP5 in Germany and France respectively, since almost all test cases will be prior realized in these labs. The de-risking of testing in-field activities is crucial, to raise potential issues. Particularly in France, the timeframe booked for the tests is very short and a commercial line will be used.

The objectives of WP4 will be fulfilled by accomplishing the following tasks in the lab environment:

- Evaluation of 5G based FRMCS selected use cases 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 lab configuration.
- Cross Border use cases.
- Evaluation of applicability related to QoS 5G capabilities, handover.

WP1 has defined the following use cases to be performed by WP4 in relation with the assigned tasks.

- Automatic train protection (ETCS)
- Automatic Train Operation communication (limited to GoA2 ATO)
- PIS
- P2P calls and voice group calls for 5G FRMCS and GSM-R interworking

The purpose of this document is to provide a full description of environmental conditions for the achievement of tests, including integration considerations and technical architecture detailing all sub-systems.

2 PHYSICAL DESCRIPTION

2.1 Lab Location and high-level description

2.1.1 Geographical situation

WP4 lab is located in Kontron's premises at Montigny-Le-Bretonneux, France. Montigny-Le-Bretonneux belongs to St Quentin-en-Yvelines area and is roughly 20 km South West of Paris.

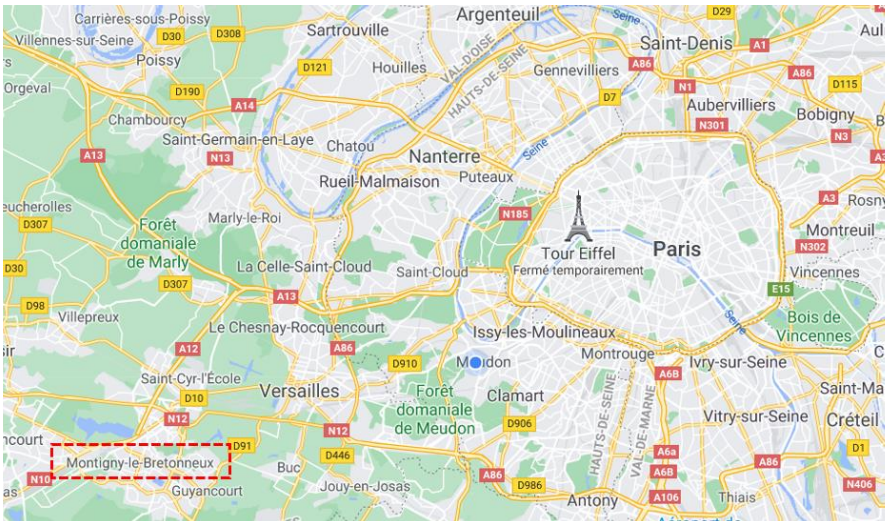

Figure 2: Montigny-le-Bretonneux location near Paris

Kontron's premises stands at 1 Rue Jean-Pierre Timbaud in the IMMONTIGNY block. Actually, Kontron uses few buildings on the right when entering the site and some of them host R&D labs.

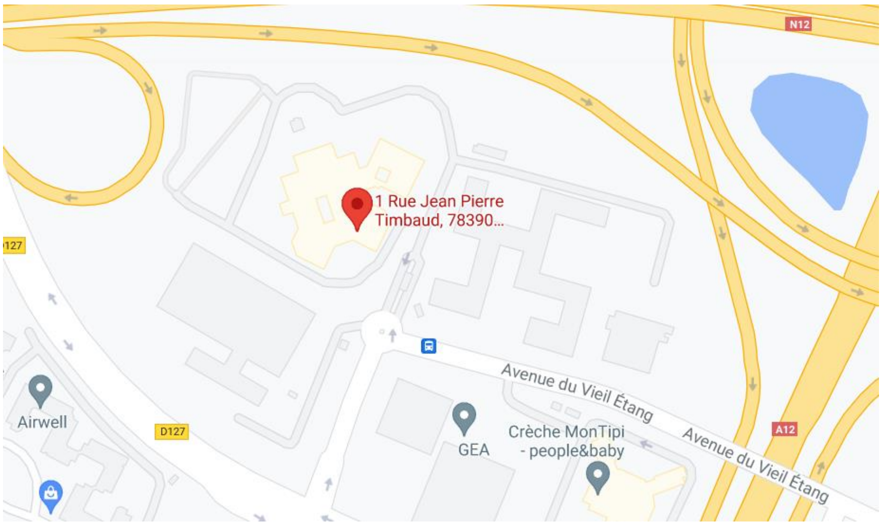

Figure 3: Kontron's premises in Montigny-le-Bretonneux

Two rooms have been chosen to set up 5G Rail WP4 lab: A working area room, where engineers can work, and a server room especially intended to host noisy or bulky equipment.

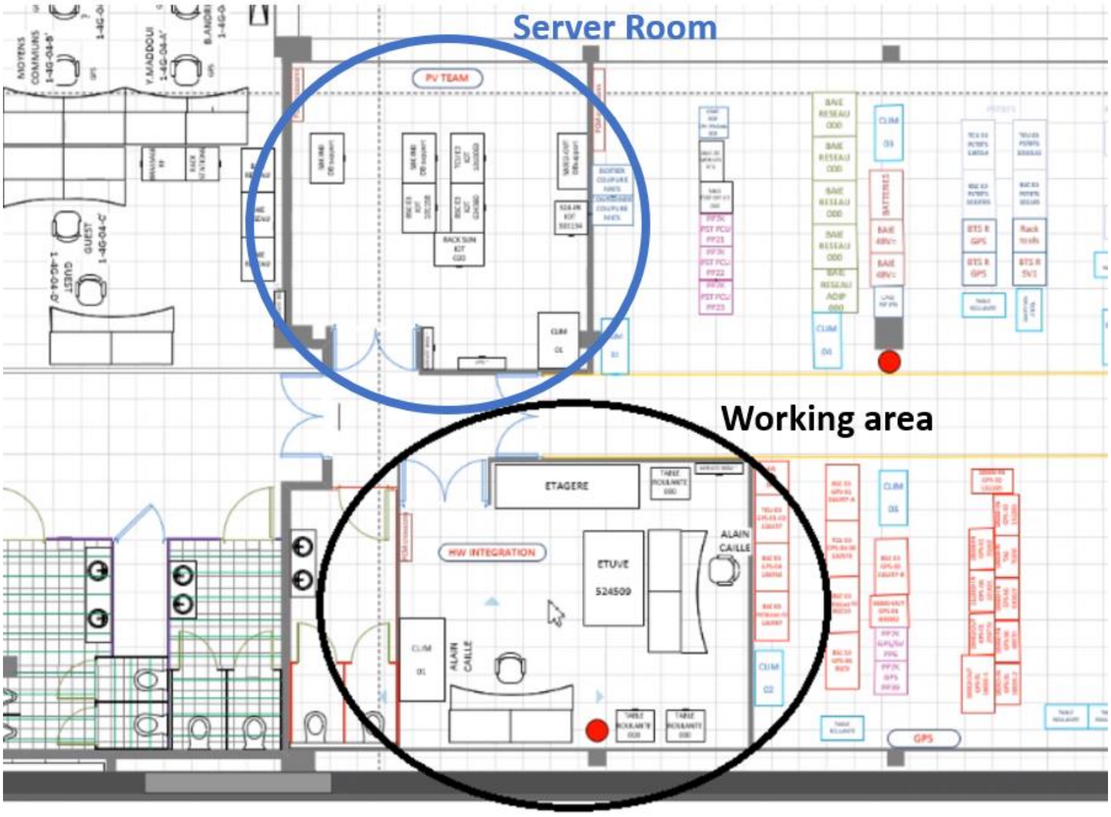

Figure 4: 5GRail WP4 server room and working area

In addition to this location, some partners will use some of their equipment in order to fulfil subtasks 4.2 and 4.3 linked with the installation and integration of ATO, ETCS and PIS applications. They will either send their equipment to Montigny lab or keep them in their own lab knowing that in that case a VPN connection must be considered in order to interconnect the equipment.

Moreover, whenever a partner's equipment is installed in Montigny, a remote access link must be available for partner's technical team to manage equipment remotely.

For subtask 4.2, Alstom has chosen to install the needed equipment in Kontron's Montigny lab.

For subtask 4.3, Thales has chosen to install the needed equipment in their Velizy lab, near Paris.

Consequently, a VPN connection was set-up between Kontron and Thales offices. This VPN carrying all traffic linked with subtask 4.3 activity. Besides, a VPN was also set up with Alstom office so that Alstom engineers could access remotely equipment sent to Kontron's lab.

Consequently, the high-level view of WP4 lab could be described like this:

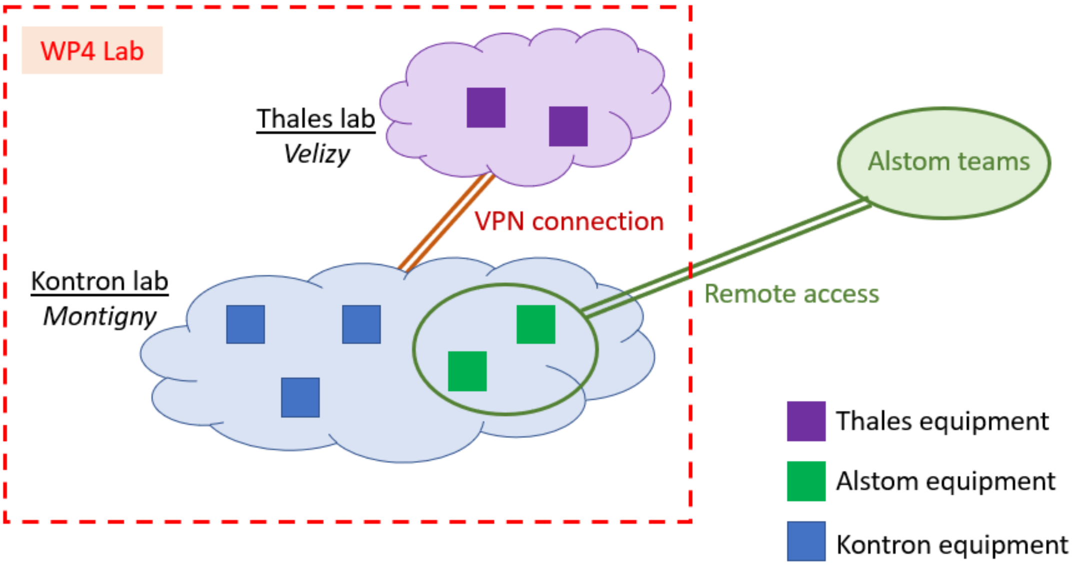

Figure 5: High-level view of WP4 lab

2.1.2 Lab overview

WP4 platform can be divided into several parts:

- 5G part (access and core)
- 4G part (access and core)
- IMS and MCx network part
- Wi-Fi part
- GSM-R part (access and core, including GPRS)
- MCx dispatcher and other MCx applications
- VPN and remote access part
- On-board side modems, on-board Gateways and on-board applications
- Trackside Gateways and railways applications

From high level perspective, the lab is composed of a telecommunication service (5G, 4G, Wifi and GSM-R parts) on top of which an IMS/MCx network is installed. This MCx service enables MCx clients from on-board side and trackside to establish FRMCS communications. On the train side, FRMCS on-board gateways are linked to on-board applications (ETCS, ATO, PIS onboard) and some handsets can also be used. On trackside, FRMCS trackside gateways connect to mate trackside applications and a Next Generation Dispatcher, based on MCx, can also be used for voice testing.

Globally, the platform can then be summarized like this:

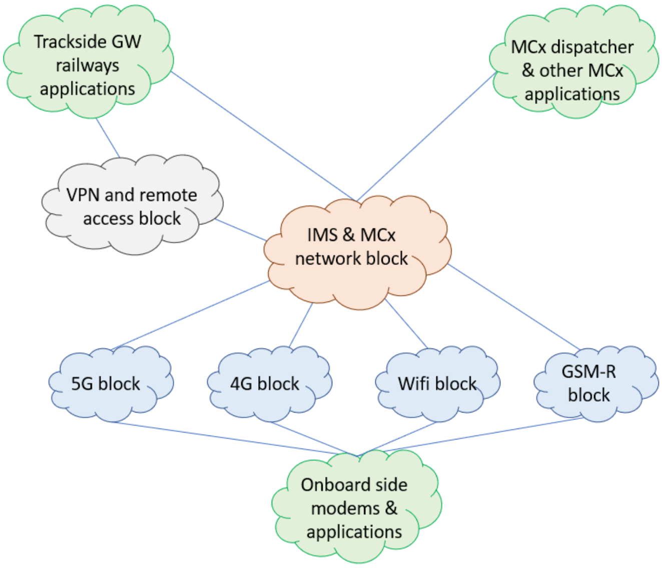

Figure 6: Logical view of the lab

Following sections 2.2, 2.3 and 2.4 will introduce the equipment respectively provided by Alstom, Kontron and Thales. More technical details about them can also be found in section 7.3.

2.2 Equipment provided by Alstom

2.2.1 Alstom FRMCS Gateways

2.2.1.1 Alstom On-Board Gateway

Alstom will provide an FRMCS On-Board Gateway, called “OB_GTW-A”. The Alstom name of this product is “Netbox”.

It consists in a “box”, called Netbox, compliant with main railways standards. It contains internal modems (a Wi-Fi modem and a 4G modem), and one or two 5G modem(s) (MV-31W) which can be external or internal. In a first version, the 5G modem(s) will be “out of the box”, connected to the front panel of the box (with USB3.0 connector).

Note: Border-crossing test cases will require two 5G modems. Then a version with two 5G modems will be used at least for border-crossing test cases.

Figure 7: Example of Alstom Netbox

2.2.1.2 Alstom Trackside Gateway

Alstom will provide an FRMCS Trackside Gateway, called “TS_GTW-A”.

It consists in a 1U rackable server, for a 19’’ rack. Model is a HPE Proliant DL20 GEN10 with 4 ethernet 1 G ports:

Figure 8: TS_GTW-A

2.2.2 Alstom ETCS Equipment

Here is a high-level view of ETCS on-board and trackside part grouping Alstom and Kontron equipment.

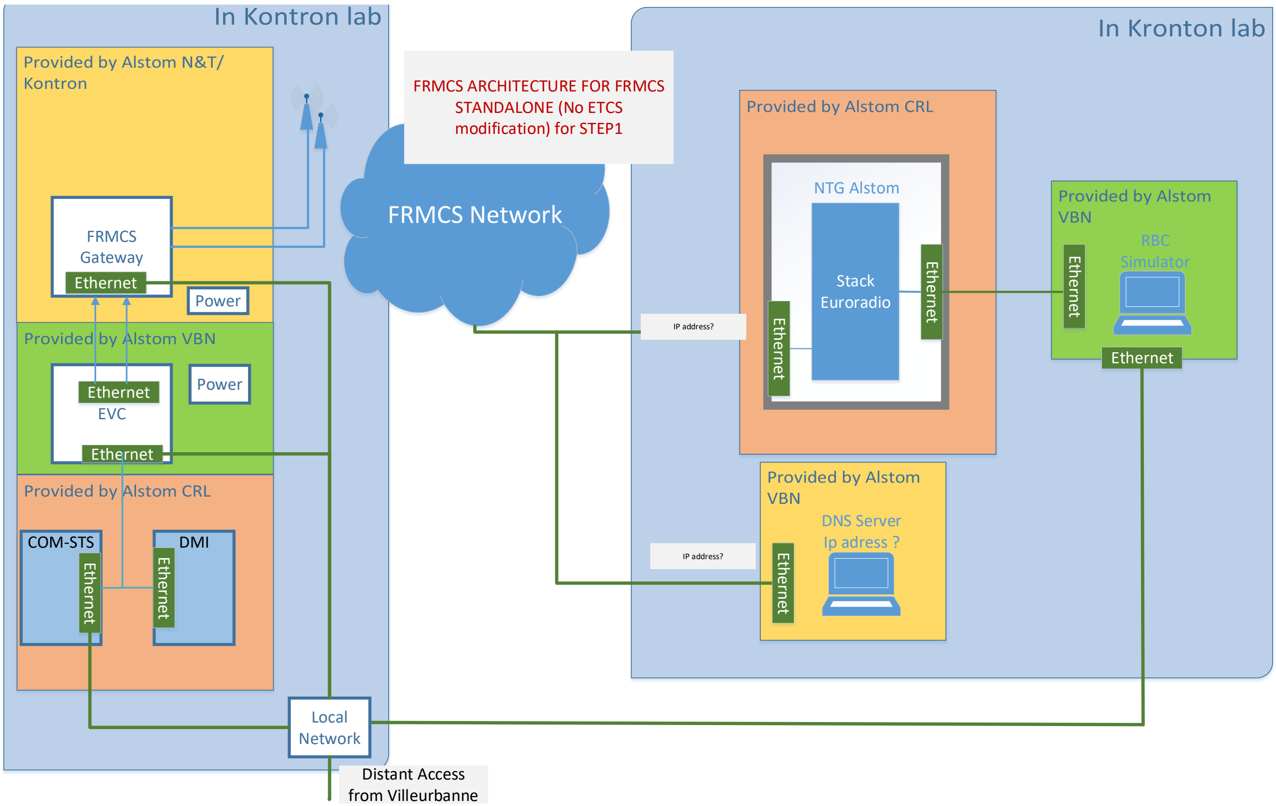

Figure 9: Laboratory equipment interface

2.2.2.1 ETCS On-board equipment

For Kontron laboratory tests, Alstom ETCS team will provide the following equipment for on-board part:

EQUIPMENT	DETAIL
Windows laptop for EVC Simulators (COM-STS)	This PC includes: • The com STS (3-channel EVC simulator) • Simulation tools (MSNG, BIOS …)
1 COMET and its COMET Tool (EVC)	EVC Board which host radio functions
1 DMI	DMI in order to perform operator actions.
Small equipment	1 or 2 switches for local network 1 IPX 800 equipment in order to reboot equipment in remote

Table 1: ETCS on board equipment

Figure 10: COMET and its COMET Tool

These ETCS On-board devices will be connected to TOBA-K Gateway (FRMCS Gateway rack + Antenna + cables, SIM cards etc…) that will be provided by Kontron, and also to TOBA-A Gateway (Netbox 5G) that is provided by Alstom Telecom team. As discussed before, ETCS On-board equipment will be managed remotely thanks to a Virtual Private Network (VPN) access between Kontron lab and Alstom Villeurbanne. Besides, some tools will be used for ETCS:

TOOL	DETAIL	Release
3 channel EVC simulator	EVC simulator in interface	7.3.B release
MSNG	Master Simulator New Generation. Simulation of train environment and scenario (odometry, balise scenario)	

Table 2: ETCS tools (on board)

2.2.2.2 ETCS Trackside equipment

For Kontron laboratory tests, Alstom will provide the following equipment for ETCS trackside part:

EQUIPMENT	DETAIL
Windows laptop for RBC Simulators	3 or 4 RBC simulator embedded with RBC Id: • 0x50 00 33 • 0x50 00 34 • 0x50 00 35 • 0x50 00 36
1 NTG Alstom	Trackside equipment.

Table 3: ETCS trackside equipment

Note that this equipment needs a DNS server that will be provided by Kontron.

Here is the list of the tools used for ETCS trackside application:

TOOL	DETAIL
RBC simulator	Radio Block Simulator for functional communication with EVC simulator

Table 4: ETCS tools (trackside)

2.2.3 Alstom ATO Equipment

The ATO architecture provides an overview of the proposed application architecture, including the sub-assemblies that will be used to pass data between ATO-OB and ATO-TS under the FRMCS communication session.

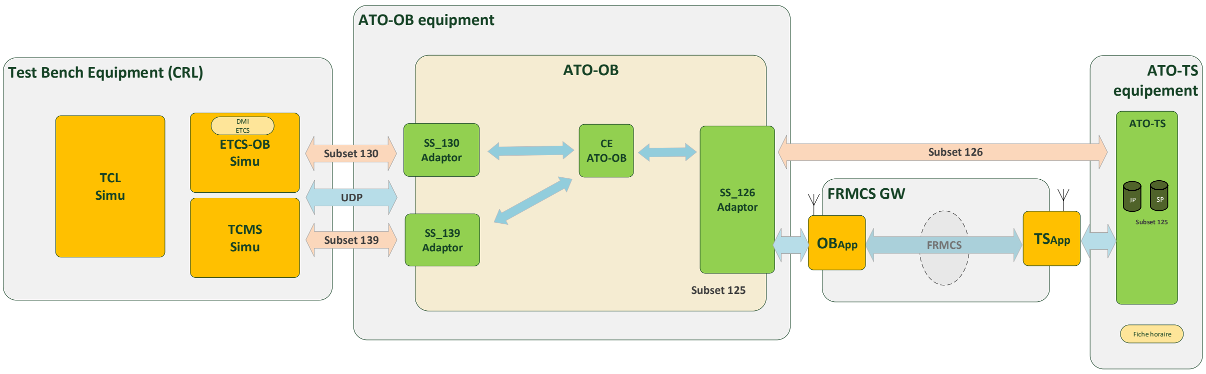

Figure 11: ATO over FRMCS

The figure above gives an overview of the different equipment to be put together during the test phase.

- TCL (Test control and Logging) simulator,

  The TCL shall be able to execute scripted test cases.

  The TCL shall be able to log and analyse all data exchanged via the adapter interfaces.

- ETCS simulator,

  ETCS simulator will allow to supervise the movement of the train on basis of trackside information as specified in [subset 026]

- TCMS simulator.

  TCMS simulator simulates the data communication to other train borne systems and also telecommunication to support systems operating remotely on the wayside

2.2.3.1 ATO On-board equipment

- SS 130 Adaptor

  The communication between ETCS-OB Simu and ATO-OB shall be realized as specified in Subset 130. IP addresses of both communication partners shall be static for lab purposes. The lower levels of communication are given in Subset-130-APP. For the purpose of the test bench activities the communication will be based on payload data only without any security layers.

- SS 126 Adaptor

  The SS 126 Adaptor allows the communication between the ATO-OB and the ATO-TS of mission data in the format SS126 format (Mission Profile, Journey Profile, Segment Profile).

- SS 139 Adaptor

  The SS 139 Adaptor will allow the ATO to communicate with the TCMS in order to control the train system in traction/braking.

The hardware platform to be used here is an ITA platform from Advantech, model ITA 5231

Figure 12: ITA Hardware platform

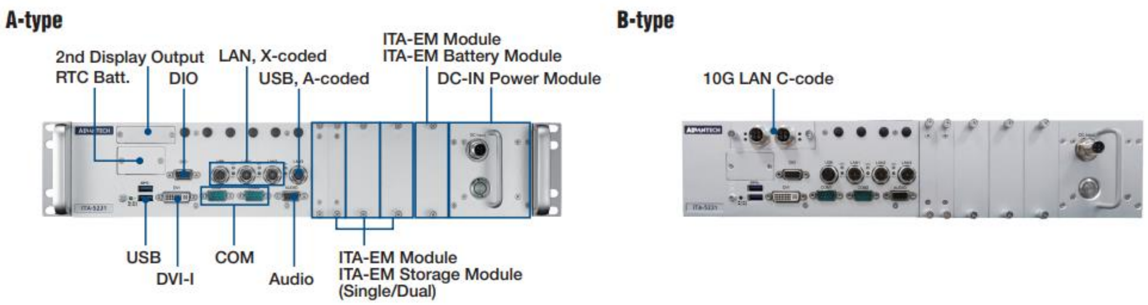

Figure 13: Front view of the ITA-5231

2.2.3.2 ATO Trackside equipment

- ATO -TS Server

The ATO-TS Server is the server on which the different trains will connect to retrieve their routes, route updates, and feedback of their positions on the track.

The ATO-TS Server will also connect to the MPE to receive route updates and timetables.

- MPE (Mission Profile Editor)

The MPE will interface the TMS and the ATO-TS, it will convert the timetables received from the TMS to modify the ATO-TS datastores and trigger the timetables and the route updates for the concerned trains.

2.3 Equipment provided by Kontron

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

- TOBA-K GW also known as On-Board and Trackside Gateways Kontron
- HP GEN-10 server: This server will host IMS network and MCx server
- Kontron ME1210: This server will host 5G Cores, gNB CU/DUs and also 4G Cores with eNodeB BBUs
- 5G RUs and 4G RRHs: AW2S Blackhawk 2x20W
- Cisco SG550: This router is used as a central connection point for the lab
- Dell uCPE: This equipment is used to bridge Kontron Montigny lab with external equipment
- GSM-R / GPRS Network
- Wi-Fi router
- Faraday Cage

2.3.1 Kontron FRMCS Gateways

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

2.3.1.1 On-board equipment

FRMCS OB_GTW-K function is fully described in document D2.1 TOBA Architecture Report [S20]. The OB_GTW-K will be specific hardware box that will embed the software for the OB_GTW function.

2.3.1.2 Trackside equipment

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

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

2.3.2 Radio Access Network

Radio Access Network is composed of elements that ensure the radio connectivity to the various core networks. As depicted before, we can distinguish:

- 5G RAN
- 4G RAN
- GSM-R / GPRS RAN
- Wi-Fi

2.3.2.1 5G RAN

5G RAN is composed of 2 CU/DUs and 5G RHs.

2.3.2.1.1 5G CU/DU

CU/DUs are hosted on Kontron ME-1210 product:

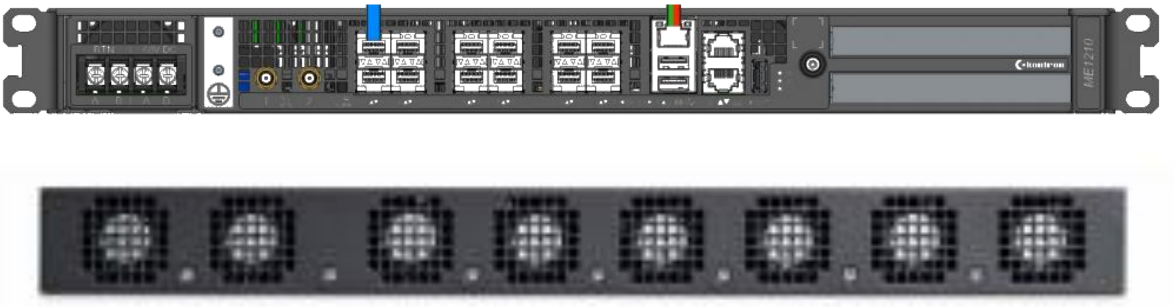

Figure 14: Front and rear views of the Kontron ME1210

Technical information on the ME 1210 stands hereafter. Note that an AC power supply will be used.

2.3.2.1.2 5G RU

5G RUs are manufactured by Advanced Wireless Solution & Services (AW2S).

It is a "Blackhawk" model, MIMO 2x2.

Figure 15: High Power MIMO 2x2 5G RU

RF Output of the RH can reach up to 2x40W. Interface with CU/DU is achieved thanks to CPRI interface.

Selected bands are:

- **N43/N78** TDD 3600-3800 MHz
- **N8** FDD 900 MHz
- **N39** TDD 1880-1920 MHz

2.3.2.2 4G RAN

Refer to 2.3.2.1 as 4G RAN uses the same kind of hardware than 5G RAN. B38, around 2.6 GHz, will be used

2.3.2.3 GSM-R / GPRS RAN

Kontron 2G RAN will provide GSM-R and GPRS radio access to 2G mobiles. It is composed of a BTS, a BSC, a TCU and a PCU-R function.

2.3.2.4 Wi-Fi radio access

Wi-Fi access is provided by a TP-Link device: a modem/router TD-W8961N

Figure 16: TP-Link TD W8961N WiFi router

2.3.3 Core Network

2.3.3.1 5G Core

5G Core is hosted on the same Kontron ME-1210 server that is used for 4G and 5G BBUs (see 2.3.2.1.1)

2.3.3.2 4G Core

5G Core is hosted on the same Kontron ME-1210 server that is used for 4G and 5G BBUs (see 2.3.2.1.1). Note that 4G and 5G cores can run at the same time on the ME1210 equipment.

2.3.3.3 GSM-R Core Network

<u>MSC Server and HLR:</u>

Based on the latest Advanced Telecommunications Computing Architecture (ATCA) technology and using a 13U high chassis with 14 slots, the platform for MSC-S and HLR has been designed to provide the superior reliability, serviceability and longevity required by GSM-R operators.

Figure 17: MCS-S and HLR 13U-14 slots ATCA platform

Media Gateway:

The Kontron MGW solution or MGW-R product is also based on ATCA technology and relies on a highly available, compact, lightweight and green 2-slot ATCA chassis. All MGW-R components (blades, I/O, Power, etc, ...) are replicated through various redundancy schemes to resist to any single failure.

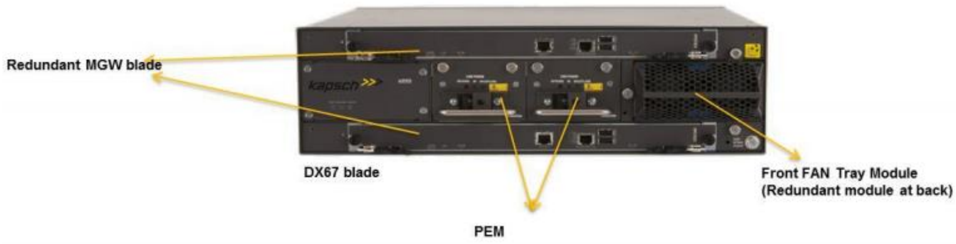

Figure 18: MGW-R 3U-2 slots ATCA shelf

SCP:

The Kontron GSM-R SCP product based on Service Delivery Platform (SDP) platform's high availability framework is deployed on Commercial Off-The Shelf (COTS) Information Technology (IT) platform: HPE ProLiant DL380 servers and always configured in (1+1) duplex configuration, providing local hot-standby redundancy.

Figure 19: SCP redundant platform HPE Proliant DL380

2.3.3.4 GPRS Core Network

GPRS or General Packet Radio Service extends the GSM Packet circuit switched data capabilities and brings a native IP bearer to the GSM-R network. Kontron will use its PCU-R and FPC-R solution to provide GPRS service (FPC-R hosts SGSN and GGSN functions).

2.3.4 IMS & MCx Network

IMS / MCx network is composed of several functions:

- Home Subscriber Server (HSS)
- Proxy Call Session Control Function (P-CSCF)
- Serving Call Session Control Function (S-CSCF)
- Application Server (AS)
- Media Resource Function (MRF)

Global picture of these network elements is shown on the following picture:

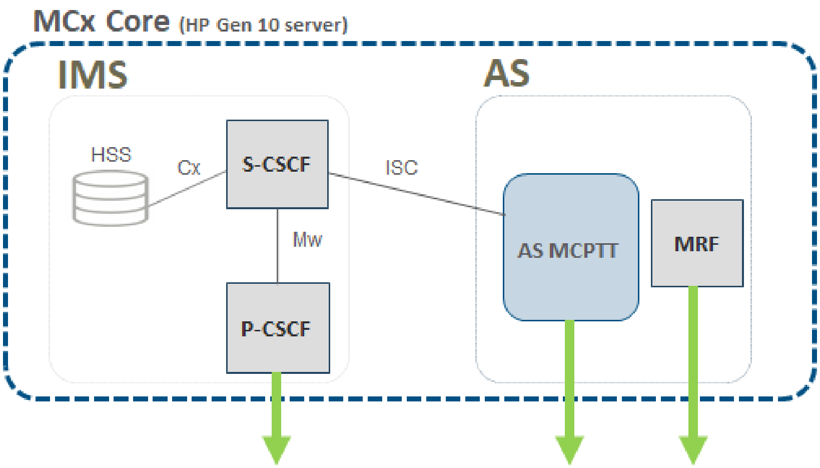

Figure 20: IMS and MCx network components

Each function is hosted on a virtual machine and, consequently, the whole IMS/MCx network can be installed on a server. HP GEN-10 Proliant server has been chosen for that purpose.

Figure 21: HPE Proliant DL380 Gen10 Server

This is a 2U sized and 230VAC powered server.

2.3.5 End user equipment

In addition to On-Board and Trackside end user equipment, some handset mobiles, MCx clients and dispatcher will be used. They are described in this section.

2.3.5.1 Next Generation Dispatcher

Kontron Transportation and Telematix jointly develop next-generation dispatcher solutions. The Kontron Next-Gen Dispatcher is an integrated, compact and flexible dispatcher terminal solution for voice, data and video communications. It combines point-to-point, group and broadcast call functions with message-based communication, such as chat with data transfer, SMS, SDS and emergency alarm. It has to be noted that the NG Dispatcher acts as a MCx client.

Figure 22: Telematix NextGen Dispatcher

2.3.5.2 SONIM XP8 and XP10 handsets

These rugged 4G/Wi-Fi smartphones can be used as MCx client with MCx app installed on the Android OS. XP8 version was used at the beginning of WP4 project.

Figure 23: Sonim XP8 Smartphone

XP10 version was received later and was able to connect to 5G SA network using band N78.

2.3.5.3 GSM-R handsets

2 Triorail x75 will be used for GSM-R tests.

Figure 24: Triorail x75 GSM-R handset

2.3.5.4 Linux MCx client

A Linux MCx client can be used to generate or receive MCx call. This software will be installed on the HP GEN-10 that hosts IMS/MCx network for debugging purpose. It can also be installed on a PC connected to a 5G/4G Modem in order to check MCx service over 5G/4G as well as over Wi-Fi.

2.3.5.5 SIM Cards

Kontron will provide 4G Smartjac SIM cards for the tests. These SIM cards can be inserted in 4G and 5G terminals.

5G SIM cards interest mainly deals with security (against IMSI catching for example) and consequently it is not needed in 5Grail perspective.

As regards 2G terminals, Kontron will provide Gemalto 2G SIM cards.

2.3.6 IP network components

2.3.6.1 uCPE and Velocloud box

In order to setup VPN connections with partners, a VPN endpoint is setup in Montigny lab: this is the so called uCPE platform.

In order to set-up a VPN with Kontron's lab:

- Alstom will use a common IPSec tunnel between its IT equipment and uCPE
- Thales will use a SDWAN connection, based on Velocloud/VMware solution. In order to achieve this, a Velocloud VCE520 box is installed in Thales Velizy lab.

Figure 25: VCE520 Velocloud box front and rear views

uCPE is hosted on DELL EMC Networking VEP1425 platform:

Figure 26: uCPE front and rear views

2.3.6.2 Cisco 3750 Catalyst Router

In order to interconnect the various IP equipment of the lab, a Cisco 3750 Catalyst router is used. This is a 1U rackable equipment with 48 gigabit ethernet ports and 4 SFP slots. It is powered by 230AC.

Figure 27: Cisco 3750 Catalyst

2.4 Equipment provided by Thales

2.4.1 PIS part

PIS Lab is located at Thales GTS France in Vélizy-le-Bois and is connected to Kontron's lab in Montigny-le-Bretonneux via a secured remote connection.

This lab is used to test FRMCS test cases related to PIS application identified in the WP 1 and validate the cyber secured counter measures identified in the risk assessment (performed in the Work package 1) to protect PIS application against threat scenarios (also defined in the risk assessment).

Figure 28 describes the PIS lab and illustrates the secured Internet remote connection configured between Thales and Kontron lab to ensure the confidentiality of PIS information.

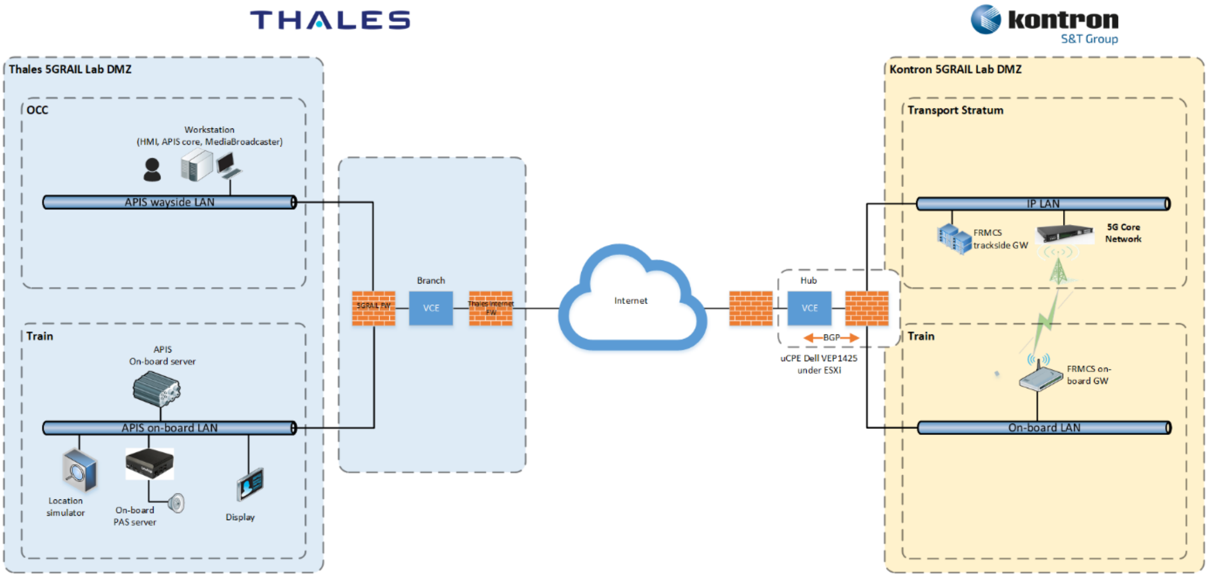

Figure 28: PIS LAB, interconnection between Thales' LAB and Kontron's LAB

<u>Note</u>: The secured remote connection is not part of the Work package 1 cyber risk assessment. Its role is to setup a secured communication link between the labs of Thales and Kontron.

PIS application is composed of two parts: on-board and trackside located in Thales' lab. Connections between the on-board and the trackside sides of the application go through two gateways, located on both side of the 5G infrastructure:

- The FRMCS on-board Gateway, connected to the applications through OBapp interface and to the 5G radio access networks, through a set of FRMCS modems;
- The FRMCS trackside Gateway, connected to the applications through TSapp interface and to the 5G core infrastructure.

FRMCS Gateways and the equipment of the 5G infrastructure are located in Kontron's lab.

2.4.1.1 On-Board PIS equipment

2.4.1.1.1 APIS ON-BOARD SERVER

On-board railway certified server (EN 50155, EN 61373, EN 50121-3-2, EN45545-2) which hosts APIS on-board application.

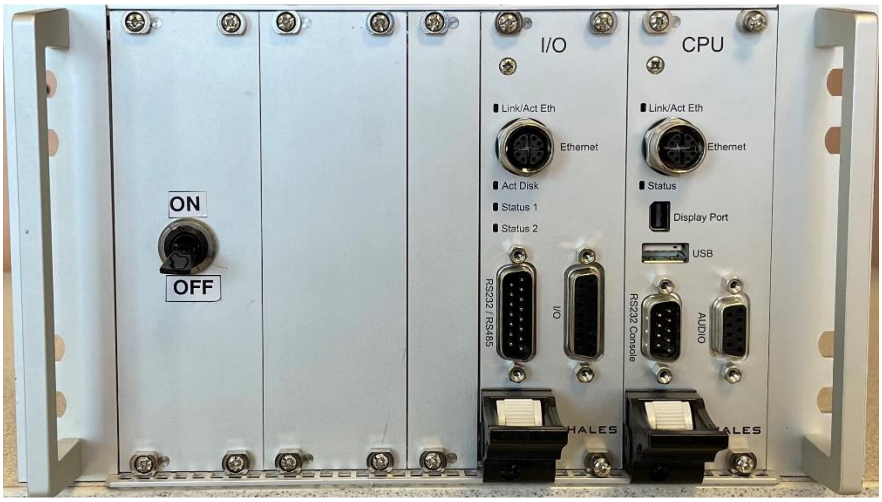

Figure 29: APIS on board server (Front panel)

The APIS on-board server is connected to the FRMCS on-board gateway. It hosts the APIS on-board application which will be compatible with OBapp. This application handles messages sent by APIS trackside application and dispatches them to loudspeaker or display device.

2.4.1.1.2 ON-BOARD PAS SERVER

The on-board PAS server is a fanless embedded system which controls the PA announcements.

Figure 30: On-board PAS server

Via its Ethernet port, the On-board PAS server is connected to the same LAN as the APIS on-board server and receives audio data from it. The audio data are sent to the loudspeaker which is connected to the on-board PAS server via an audio jack cable.

2.4.1.1.3 LOUDSPEAKER

The loudspeaker broadcasts audio information sent by the passenger information manager to the passengers in the train.

It is a standard PC speaker directly connected to the on-board PAS server via an audio Jack connector.

2.4.1.1.4 TFT DISPLAY DEVICE

The display device displays text information like train timetables sent by the passenger information manager to the passenger in the train.

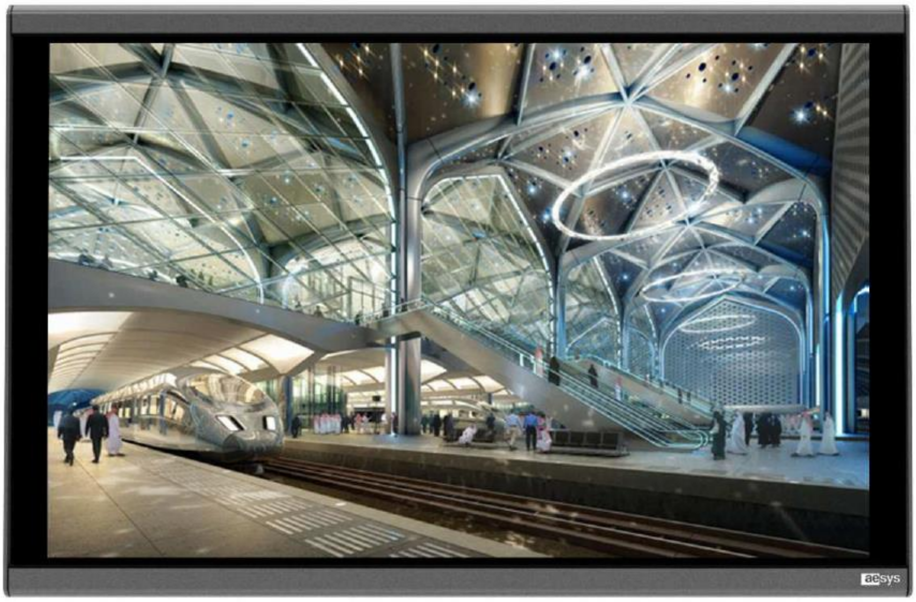

Figure 31: On-board TFT display device

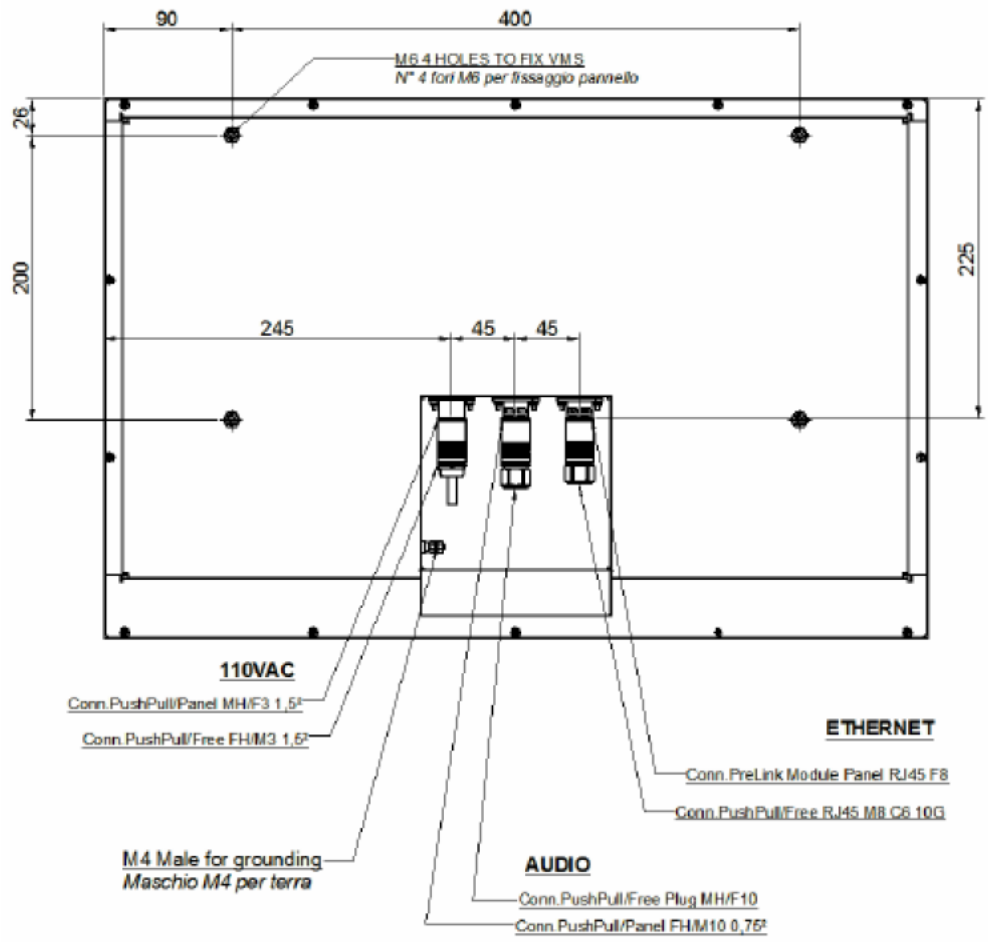

Figure 32: On-board TFT display device (rear view)

The display device embeds its own Operating System and via its Ethernet port is connected to the same LAN as the APIS on-board server and receives video data from it.

2.4.1.1.5 LOCATION SIMULATOR

PIS application needs to know train's location in order to provide information to the passengers such as real-time train schedules and other operator service information. At this stage of the FRMCS specifications, available for 5GRAIL project, no FRMCS equipment has been specified to be responsible to provide location information to the applications that need it.

In that context, Thales in charge to deliver PIS prototype will provide a location simulator for PIS needs.

That simulator will be installed on-board.

Following picture describes PIS simulator architecture:

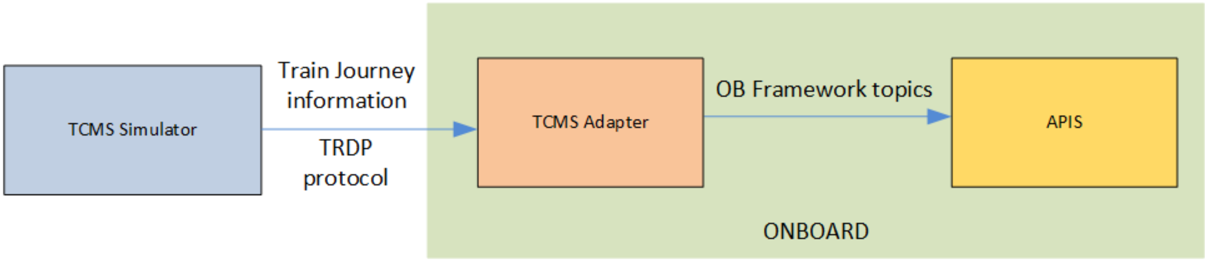

Figure 33: Location simulator for PIS

The TCMS Simulator simulates the trip of train. It sends Train Journey information such as:

- Speed of the train,
- Distance from the next station,
- Name of the next station,
- Name of the current station,
- Beacons number installed along the track.

This information is sent to the TCMS adapter using TRDP protocol. The TCMS adapter adapts the format of the information received and publishes them to the applications, especially APIS that need location information.

This simulator will be hosted on a Raspberry Pi3.

2.4.1.2 Trackside PIS equipment

2.4.1.2.1 APIS TRACKSIDE SERVER

From the APIS trackside server and a screen with a resolution of 1920 x 1080 pixels, the passenger information manager accesses to the APIS HMI via Chrome Web browser to dispatch information to passengers in the train.

Following table gives the hardware description of the APIS trackside server:

APIS trackside server hosts APIS trackside application. This application includes components responsible for interfacing with passenger information managers (HMI) and devices.

The APIS trackside server is connected to the FRMCS trackside gateway and the APIS trackside application will be compatible with TSapp. Cyber part PIS application is the demonstrator for cybersecurity test cases. The equipment to integrate in the LAB to secure PIS application will be provided by the Cyber Risk assessment in WP1. Today, that Risk Assessment has not been performed.

2.4.2 IP network equipment (routers, switch, VPN endpoints, FW)

2.4.2.1 Switch

A network switch from Cisco (Catalyst 2960) is used to connect all WP4 5GRAIL LAB equipment to the 5GRAIL firewall. 2 VLANs will be used:

- One VLAN for trackside equipment
- One VLAN for on-board equipment.

2.4.2.2 Firewalls

To secure the remote connection between the labs some firewall equipment are required.

2.4.2.2.1 THALES INTERNET FIREWALL

Thales Internet firewall is protecting Vélizy-le-Bois infrastructure against attacks coming from Internet.

2.4.2.2.2 THALES 5GRAIL FIREWALL

5GRAIL firewall is dedicated to 5GRAIL project. It creates a DMZ in order to isolate Thales' WP4 5GRAIL LAB from other Thales' LABs.

That firewall is a Stormshield 510.

Figure 34: Stormshield 510 used for Thales 5GRAIL DMZ

<u>Note:</u> Stormshield firewalls are recommended by the French National Agency for the Security of Information Systems: ANSSI.

2.5 WP4 Tools

WP4 lab will use many tools in order to:

- Create the conditions to run tests (Radio simulator tool, Load traffic generator tools…): *Test environment tools*
- Assess test status (protocol analyser, KPI measurement tools…): *Diagnostic tools*

2.5.1 Test environment tools

2.5.1.1 RF Signal Generator Keysight EXG

Keysight EXG Signal Generator provides RF signals for functional verification of receivers.

Figure 35: Keysight EXG Signal Generator

2.5.1.2 Spirent Vertex Multipath, Fading and Speed simulator

The Vertex® channel emulator is an advanced platform that replicates the comprehensive noise and spatial conditions of even the most complex wireless channels. Its cutting-edge capabilities enable users to emulate a real-world RF environment in the lab

Figure 36: Spirent Vertex Virtual Channel Emulator

2.5.1.3 MCx load simulator

A MCx load simulator based on the Linux MCx client can be used in the lab (see 2.3.5.4). This tool can be installed on a HP GEN-10 Proliant.

2.5.2 Diagnostic tools

2.5.2.1 RF Analyzer Keysight EXA

N9010B EXA signal analyser is a RF analyser that can check signals in the 10Hz – 44GHz range. It can perform power measurements quickly at discrete frequency points.

Figure 37: Keysight EXA Signal Analyzer

2.5.2.2 Wireshark Protocol Analyzer

Wireshark tool will be used to record and analyse traces on various IP interfaces. Version 3.2.7 or latest can be used, preferably with a MCPTT dissector Add-on (in order to decode RTCP floor control messages for example).

2.5.2.3 MCx Flow analyser & KPI measurement tool

In order to quicker assess tests results, a MCx flow analyser and KPI measurement tool will be installed by a Kontron partner on a specific HP GEN-10 Proliant hardware. This tool can capture all flow coming in and out of the IMS/MCx core, thus providing an analysis of the performances. It can also be used for troubleshooting.

3 ENGINEERING VIEW OF THE LAB AND CONFIGURATION DETAILS

3.1 Platform description

3.1.1 Hardware view

3.1.1.1 WP4 lab global view

The global view of WP4 lab is given in the following picture:

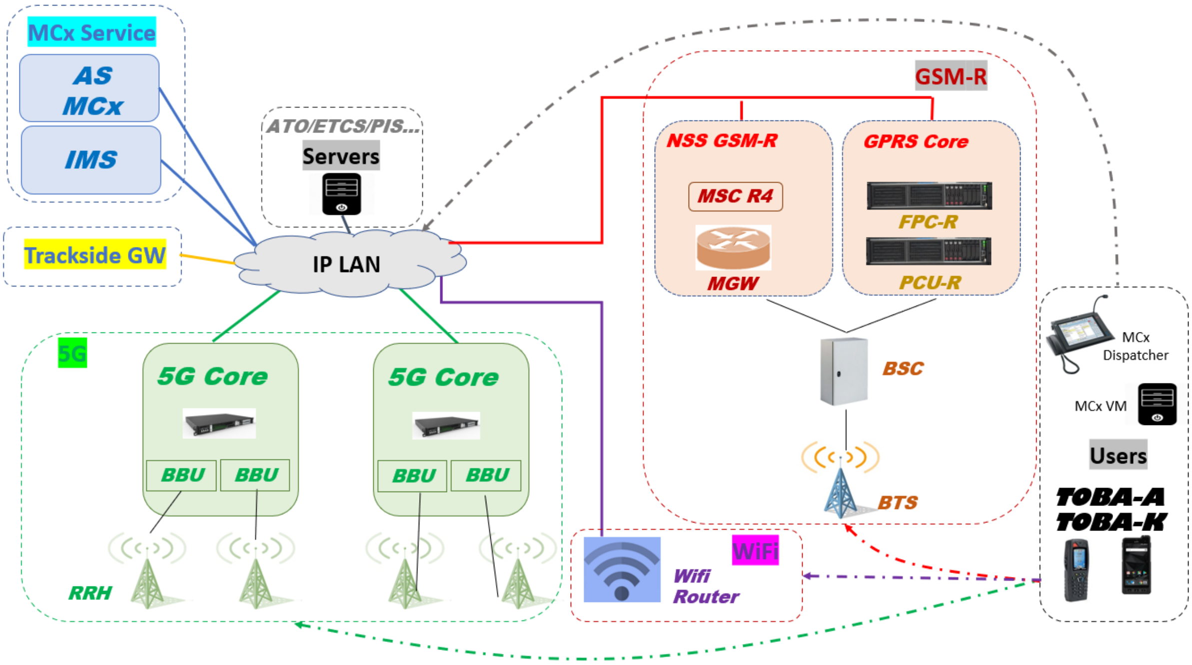

Figure 38: WP4 lab global view

- **<u>5G part:</u>**
  5G block is composed of the following hardware:

- 2 ME-1210 Kontron servers hosting each one 5G core and one gNB BBU
- RRHs: 10 RRHs are available :
  2 RRHs Band 78 (3600 MHz)
  4 RRHs Band 39 (1900 MHz)
  4 RRHs Band 8 (900 MHz)

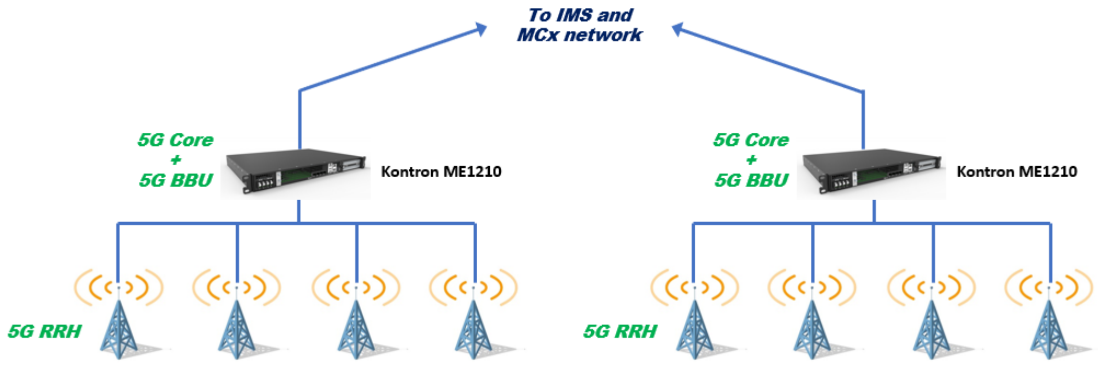

Figure 39: View of 5G block

- **4G part:**
  4G block is composed of the following hardware:
- 2 ME-1210 Kontron servers hosting each one 4G core and one eNB BBU
- RRHs: RRHs of 5G part may be reused for 4G

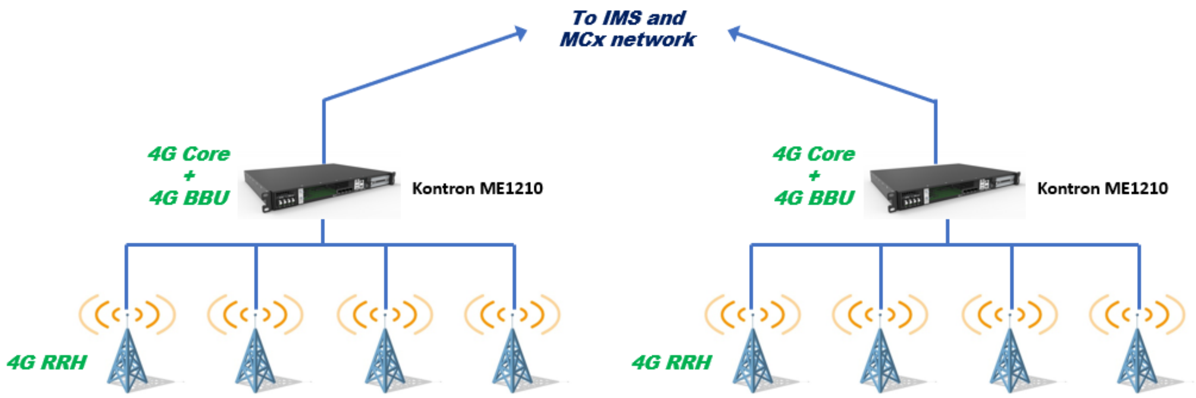

Figure 40: View of 4G block

Note that a Kontron ME1210 can host 4G Core and eNodeB BBU or 5G Core and gNodeB BBU. But not both at the same time. Swapping between 4G and 5G is easy and can be achieved in few minutes.

- **IMS and MCx part:**
  IMS and MCx block is composed of the HP Gen10 on which several VM are running to provide service.

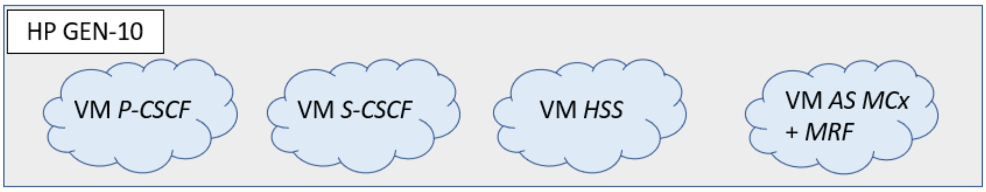

Figure 41: Virtual Machines configured on HP Gen-10

These IMS elements also stands on the following picture that describes global IMS structure (from 3GPP Technical Specification TS 23.228):

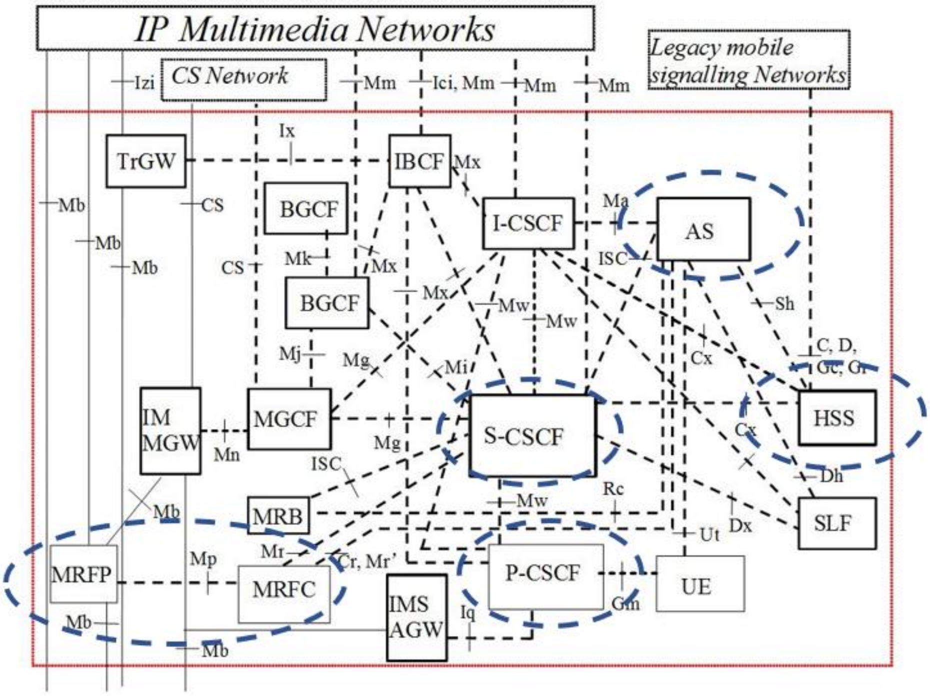

Figure 42: Available IMS components in the 5GRail WP4 lab

3.1.2 Functional view

The following picture gives information on the global functional setup of WP4 lab:

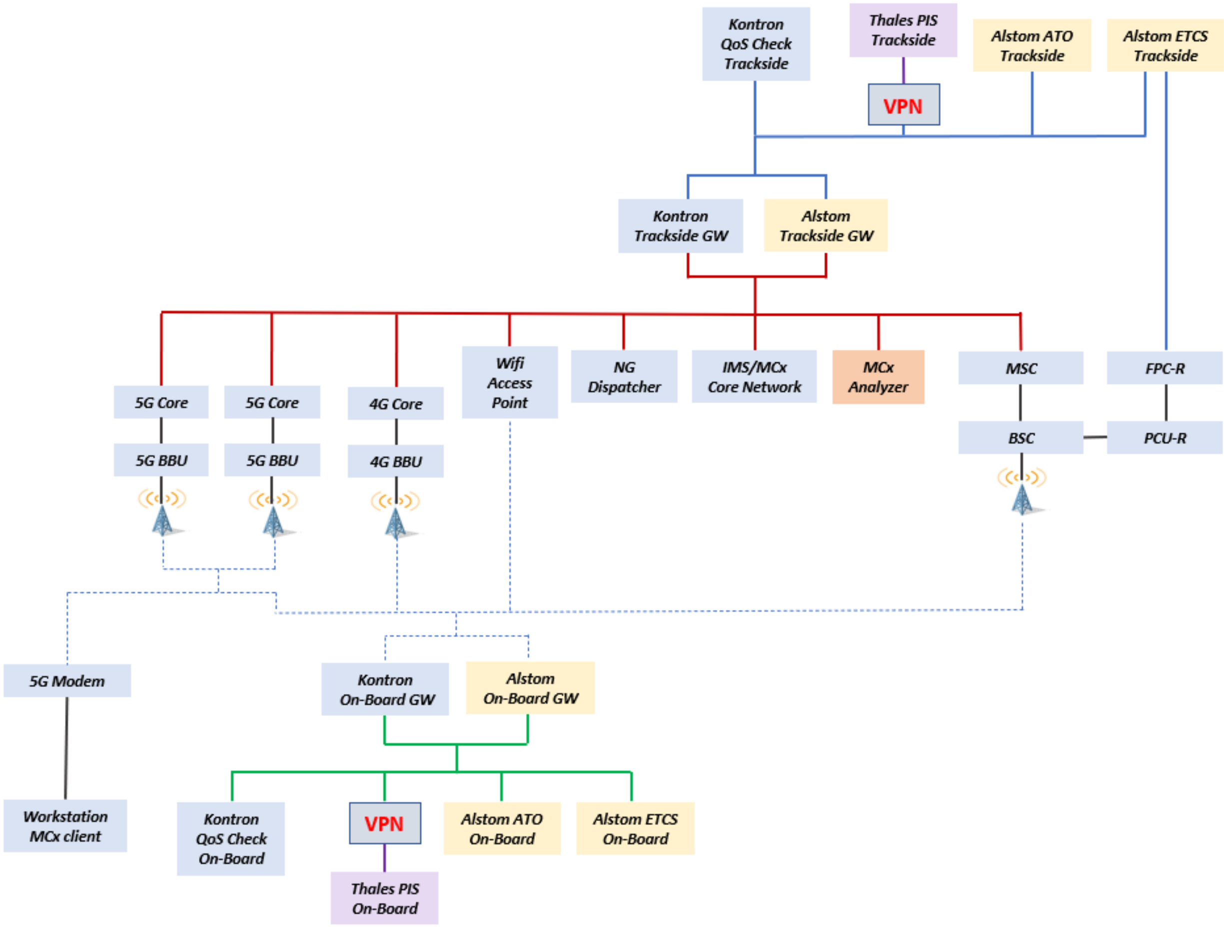

Figure 43: 5GRail WP4 functional view of the lab

It is also important to provide a functional view of OAM connections in WP4 lab as some remote connections are allowed onto some WP4 machines of WP4 lab.

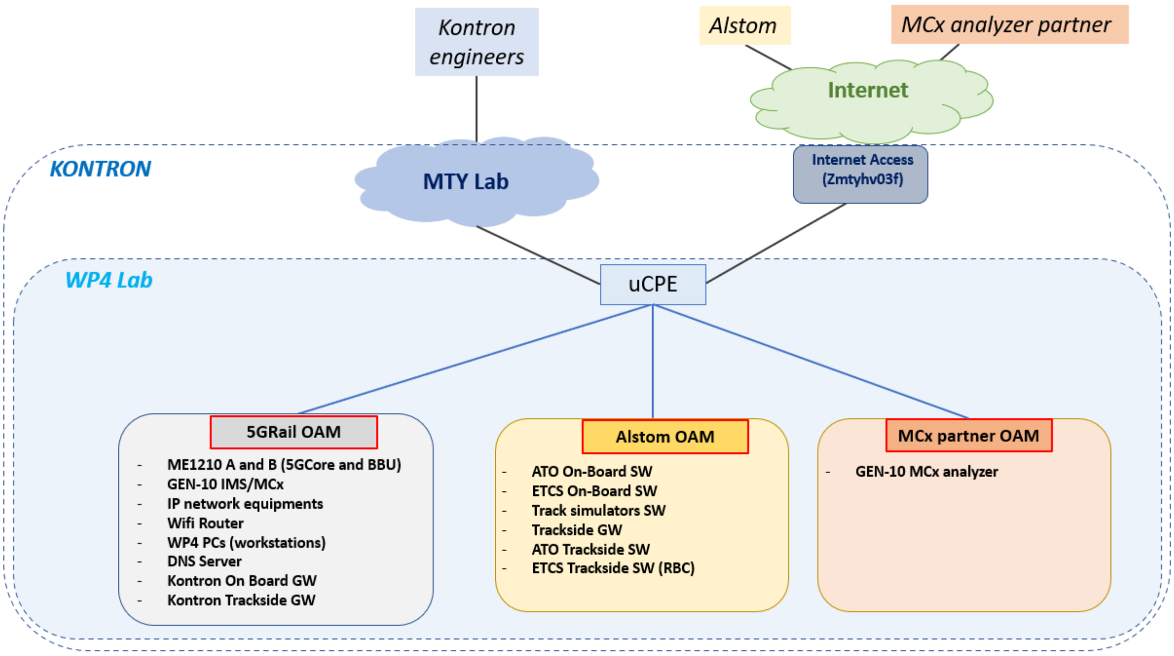

Figure 44: 5GRail WP4 functional view of the OAM connections in the lab

3.1.3 NTP and DNS services

DNS (Domain Name Server) and NTP (Network Time Protocol) are transversal services that have to be provided by WP4 lab to some components in order to provide IP addressing resolution and time synchronization. As shown in Figure 45, NTP is used on all LANs, it will be of great help for checking traces and logs. As regards DNS, only few trackside applications and some Core Network elements will need it, consequently DNS access will be enabled from Trackside and N6 subnets (See chapter 3.4 for IP plan details).

Both of these services will be hosted on PCs with ethernet connections to the needed subnets.

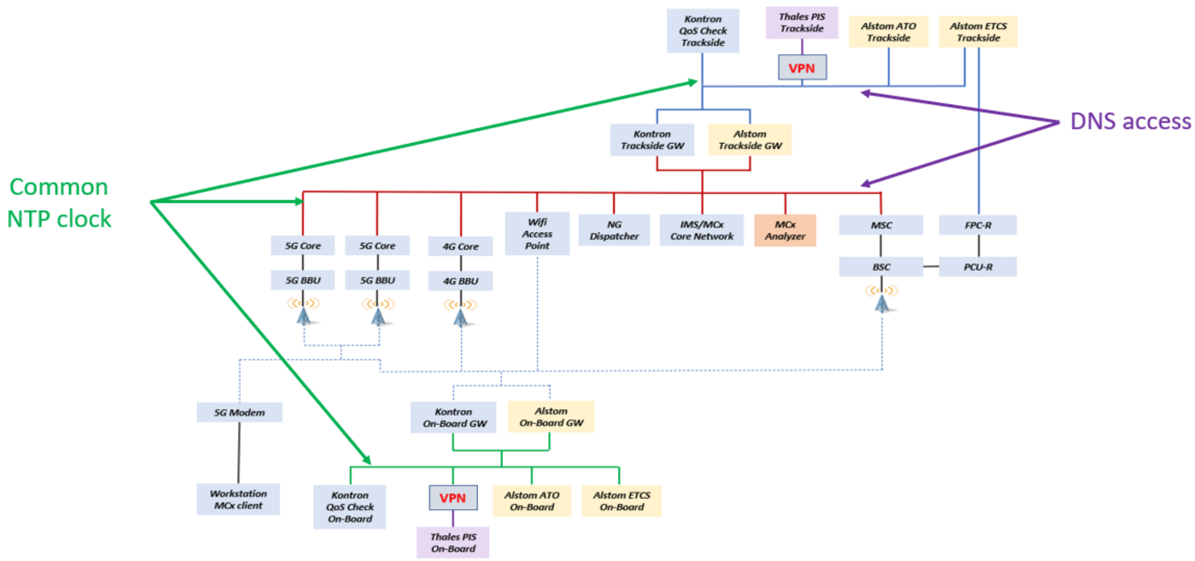

Figure 45: NTP and DNS access

3.2 Software and Hardware initial lineups

Following table 12 gives initial lineups of some WP4 lab components. Actual softwares that will be used during the tests will be extensively given in D4.3 document ("Second Lab Test Report").

Equipment	Software initial Lineup
BTS	V18a3e03
BSC	AIP01000081D
MGW	8.2.00
MSC-S	NSS23
OMC-R	18.07.15
PCU	18.07
ME1210	4.8.5
IMS core	1.1.7
MCx AS	6.1
SONIM XP8	8.1.0
MCx Application Client	1.2.57
Next Gen Dispatcher	6.3.0

Table 5: Lineups of WP4 lab main components

3.3 Parameters

WP4 lab configuration consists in many parameters that can be modified according to tests needs. These parameters can be divided in several groups:

- 5G Core parameters
- 5G RAN parameters
- 4G Core parameters
- 4G RAN parameters
- IMS parameters

- MCx clients and server parameters
- GSM-R parameters
- IP network parameters
- On-Board and Trackside Gateways parameters
- ETCS, ATO and PIS applications parameters

3.4 IP Plan

IP plan of the platform can be divided into two sections:

- IP plan regarding signalling and data connections
- IP plan regarding OAM connections

3.4.1 IP plan for signalling and data planes

Three main subnets can be considered for IP planning of signalling and data connections:

- Subnet Trackside (« **Lan TS** »): this subnet will connect Trackside applications (ATO, ETCS, Kontron QoS check application…) to FRMCS Trackside Gateways. Note that Thales PIS trackside application is able to connect to that subnet thanks to the SDWAN VPN.
- Subnet On-board (« **Lan OB** »): this subnet will connect On-board applications (ATO, ETCS, Kontron QoS check application…) to FRMCS On-board Gateways. Note that Thales PIS On-board application is able to connect to that subnet thanks to the SDWAN VPN.
- Subnet N6 (« **Lan N6** »): this subnet connects the 5G and 4G Cores to IMS/MCx network (P-CSCF, MRF, AS) so that mobile MCx clients can connect to MCx server.
  As NG dispatcher, Trackside Gateways and GSM-R MSC also needs to connect the IMS/MCx network, they will also have a leg in that LAN.

  The following picture gives of global view of these subnets:

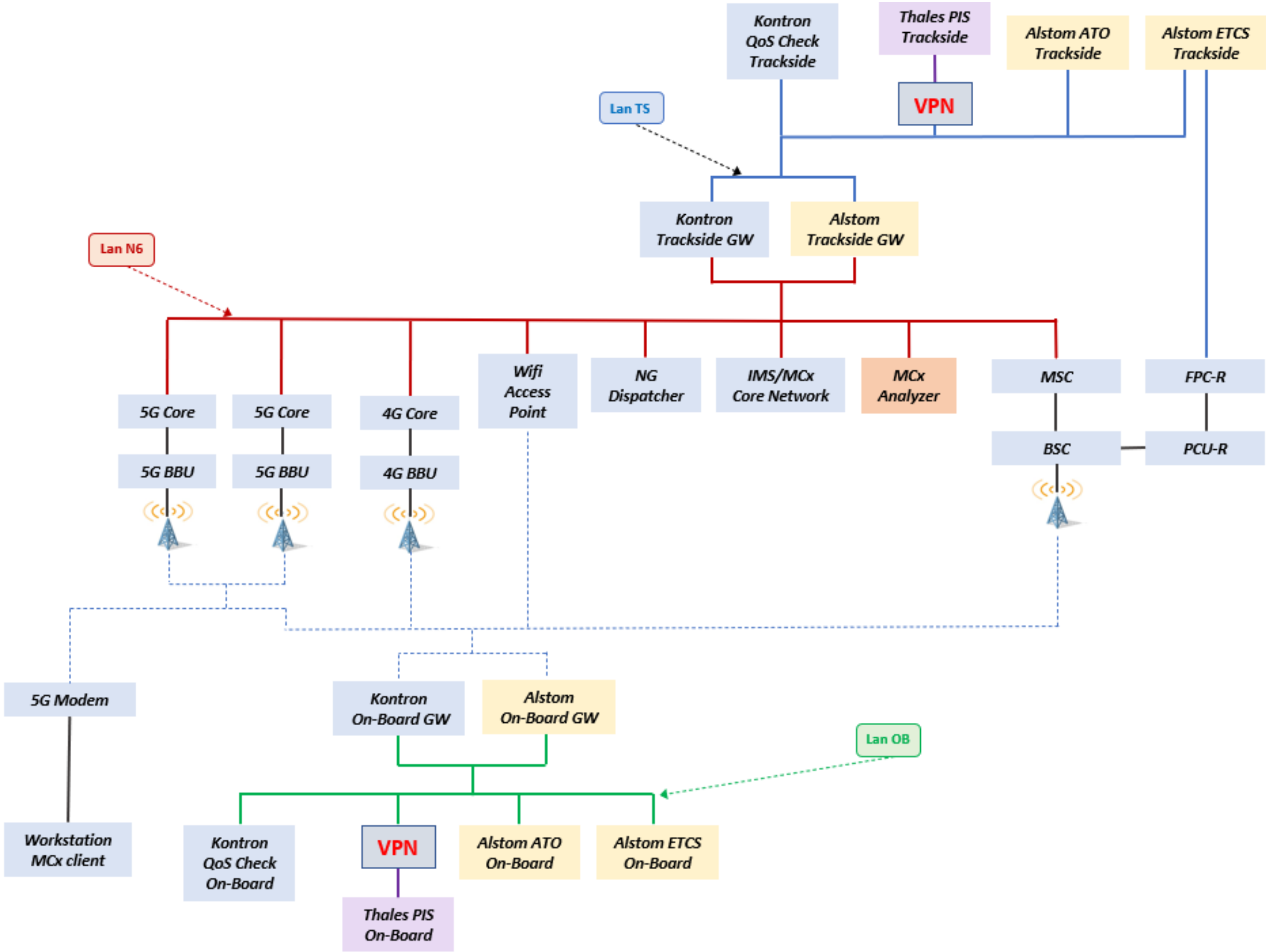

Figure 46: IP subnets for signalling and data connections in WP4 lab

3.4.2 IP plan for OAM

Three main subnets can be considered for IP planning of OAM connections:

- Subnet for Kontron devices (« **Lan 5GRAIL OAM** »): this subnet will connect all Kontron equipment of WP4 lab. For cybersecurity reasons, this LAN is separated from Kontron other labs thanks to uCPE and firewalls.
- Subnet for Alstom devices (« **Lan Alstom OAM** »): this subnet is used by all Alstom equipment that are installed in Montigny lab. This subnet is reachable by Alstom engineers thanks to a VPN.
- Subnet for MCx analyser partner (« **Lan MCx partner OAM** »): this subnet will connect to the HP GEN-10 Proliant that will be used by Kontron's partner in MCx analysing. It is reachable by partner's engineers thanks to a VPN.

3.4.3 IP addresses assignment

Subnets are defined as follow:

LAN	Subnet
N6	172.21.160.64/26
Trackside	172.21.160.128/27
Onboard	172.21.160.160/27
5GRAIL OAM	172.21.160.0/26
Alstom OAM	172.21.160.192/27
MCx partner OAM	172.21.160.224/28

Table 6: Main IP subnets for WP4 lab

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

The following table validates that all the necessary network elements are present in the lab setup to fulfil the use cases assigned to WP4 and prepare the field tests for WP5.

4.1 Matrix WP4 objectives / Lab setup resources needed

Whatever WP1 will decide to actually test, some expectations on WP4 lab setup are expressed in Grant Agreement document. They are underlined in following Table 14 in order to show how these requirements have been fulfilled.

Expectations in terms of Lab infrastructure needs (from Grant Agreement)	WP4 Lab means
5G RAN stand alone; x2 gNB with CU/DU units (Kontron platform) connected to RU working at 900MHz and their antennas	2 Kontron ME1210 servers and relevant RRHs → 2 gNB
5G CORE stand alone: x2 CORE virtualised and running on x86 servers	2 Kontron ME1210 servers and relevant RRHs → 2 5G CORE stand alone
5G Application server virtualised on x86 server	HP GEN-10 Proliant with Kontron MCx AS → 5G Application server
GSM-R Access: x1 BTS and its antenna, x1 BSC, x1 PCU, x1 OMC-R	1 RAN 2G composed of 1 BTS, 1 BSC, 1 PCU-R, 1 OMC-R
GSM-R Core and Application: x1 MGW, x1 MSC, x1 FPC, x1 HLR, x1 SCP	1 MGW-R, 1 MSC-S, 1 HLR, 1 FPC-R, 1 SCP
5G UE integrated within TOBA prototypes from WP2 including antenna	Provided by WP2
x2 GSM-R mobile for basic voice call	2 Triorail x75 mobiles
x2 android mobile to host MCX clients	2 Sonim XP8
x1 5G RF analyser	1 EXA Agilent
x1 5G RF generator	1 EXR Agilent
x1 5G RF MFE (Multipath Fading Emulator) with RF combiners, duplexers and splitters;	1 Spirent Vertex, RF cables and devices
5G Traffic load simulator: x1 5G UE traffic simulator;	*Solution chosen will depend on WP1 needs. Will be described in D4.2*
5G Performance monitoring tool: x1 ComTest with 5G capabilities;	*Solution chosen will depend on WP1 needs. Will be described in D4.2*
MCX Application for basic voice integration (and other application).	Kontron MCx client application for Android

Table 7: WP4 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 15 summarize which parts of the lab are needed to test them.

Expectations in terms of Use case needs	5G RAN	5G Core	IMS/MCx Core	2G BSS	2G NSS	GPRS	WIFI Router	GSM-R Handsets	Smartphones with MCx client	Next GEN Dispatcher	Multipath Fading Simulator	ATO Trackside application	ATO On-Board application	ETCS Trackside application	ETCS On-Board application	PIS Trackside application	PIS On-Board application
FRMCS 5G QoS																	
GBR flow combined with Non GBR flow over TOBA + FRMCS 5G infrastructure qualification while degrading radio transmission, emulating speed	x	x									x						
ETCS and ATO																	
ETCS and ATO over FRMCS 5G	x	x	x									x	x	x	x		
Basic voice over FRMCS 5G																	
Voice over TOBA + FRMCS 5G infrastructure in nominal and perfect lab conditions with no perturbations	x	x	x						x	x							
Voice over TOBA + FRMCS 5G infrastructure in real condition simulated with Radio link degradation, speed emulation and high traffic conditions.	x	x	x						x	x	x						
GSM-R and FRMCS 5G interworking																	
P2P calls from 5G FRMCS to GSM-R based in interworking between MCPTT server and GSM-R	x	x	x	x	x			x	x	x							
Voice Group calls establishing in both 5G FRMCS and GSM-R	x	x	x	x	x	x		x	x	x							
Cross border scenario																	
Qualifying data continuity while TOBA moves from GSM-R network to FRMCS 5G network and reverse;	x	x	x	x	x												
Qualifying data continuity while TOBA moves from FRMCS 5G network to another FRMCS 5G network (2 isolated networks)	x	x	x														
Bearer flex scenario																	
With as an additional FRMCS 5G bearer @1900MHz to interconnect with services such as MCX between 2 FRMCS 5G bearers	x	x	x														
With WIFI as alternative bearer for offloading best effort data flow when train arrive to station (simultaneously with FRMCS 5G)	x	x	x				x										
Coexistence																	
GSM-R and FRMCS 5G overlay within same frequency band and TOBA is handling both connectivity at the time	x	x	x	x	x												
Task 4.2 - ETCS and ATO application integration over 5G infrastructure																	
ETCS and ATO application over TOBA + FRMCS 5G infrastructure in nominal and perfect lab conditions with no perturbations	x	x	x									x	x	x	x		
ETCS and ATO application over TOBA + FRMCS 5G infrastructure in real condition simulated with Radio link degradation, speed emulation and high traffic conditions	x	x	x								x	x	x	x	x		
Task 4.3 - Cybersecurity end to end integration for safe applications over 5G infrastructure																	
Assessment of cybersecurity elements to be considered to secure both the 5G FRMCS infrastructure from an application prospective and the TOBA sub-system	x	x	x													x	x

Table 8: WP4 needs in terms of use cases versus means to test them

4.2 Lab Setup resources needed for WP5

WP5 tests in France will partly use WP4 lab as shown by Figure 47, extracted from the Grant Agreement.

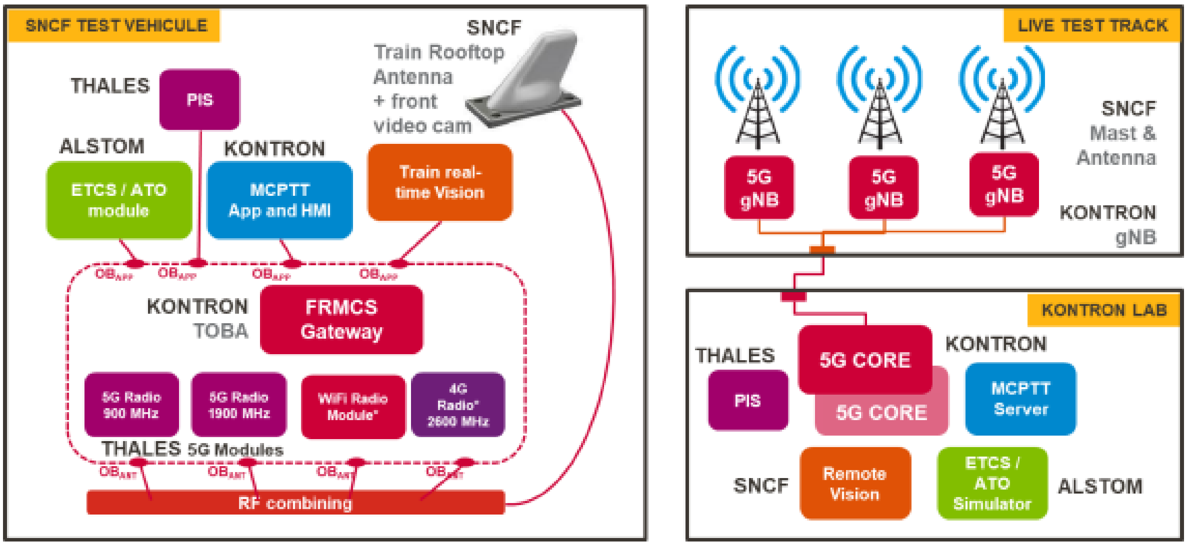

Figure 47: Field Test arrangements in France

Train Rooftop antenna and Mast Antenna will be provided by SNCF along the tracks. It will be connected to two 5G cores which are connected to the IMS/MCx server in WP4 Lab. Preferably, a VPN connection will be used for that purpose.

On trackside, PIS, ETCS/ATO and Train real-time vision applications will be used.

In principle, and according to what was presented in this document, all the necessary components needed for WP5 activities are in place as part of WP4 lab to ensure that field tests are pre-validated in the lab at first place.

5 CONCLUSIONS

This document describes the different equipment provided by the WP4 5Grail partners in order to build the WP4 lab. It also gives information on the way equipment is interconnected together.

Grant Agreements needs on WP4 lab structure, regarding WP4 and WP5 objectives, have been checked and fulfilled according to information given in chapter 4 and consequently, the foreseen lab setup appears to be in line to address the execution of the tests that will be specified by WP1 D1.1 delivery.

Next WP4 delivery (D4.2 - Second Lab Test Setup Report) will explain how the lab has been physically put in place and integrated. Integration report will also deal with components delivered by WP2 as they need to be validated before the actual WP4 test phase which will occur when WP2 will have delivered all the expected features.

Last WP4 delivery (D4.3 - Second Lab Test Report) will report results of test execution phase, as well as details on the actual lab that was used, in particular which software versions were loaded.

6 REFERENCES

Document Title	Reference, version
[S1] Radio-frequency connectors –Part 16: Sectional specification – RF coaxial connectors with inner diameter of outer conductor 7 mm (0,276 in) with screw coupling – Characteristics impedance 50 Ω (75 Ω) (type N)	IEC 61169-16
[S2] Management Information Base for Network Management of TCP/IP-based internet: MIB-II	RFC 1213
[S3] MC Services Security aspects (useful to understand MCx authentication and authorization)	3GPP TS33.180
[S4] Mission Critical Data (MCData) signalling control; Protocol specification	3GPP TS 24.282
[S5] Mission Critical Data (MCData) media plane control; Protocol specification	3GPP TS 24.582
[S6] UIC – FRMCS Use cases	UIC MG-7900, Version 2.0.0
[S7] 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Study on Future Railway Mobile Communication System	3GPP TR 22.889
[S8] UIC – FRMCS Principle Architecture	UIC MG-7904 Version 0.3.0 (Draft)
[S9] UIC – FRMCS – Telecom On-board system – Functional Requirement Specification	UIC TOBA FRS-7510 Version 0.2.0
[S10] Common functional architecture and information flows to support mission critical communication services	3GPP TS 23.280 Stage 2

[S11] 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
[S12] Rail Telecommunications (RT); Future Rail Mobile Communication System (FRMCS); Study on system architecture	ETSI TR 103.459 V1.2.1, 08/2020
[S13] UIC – FRMCS – User Requirements Specification	FU-7100 Version 5.0.0
[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
[S20] Second Lab Test Setup Report	D4.2
[S21] Second Lab Test Report	D4.3

7 APPENDICES

7.1 WP1 test cases definitions

The 2 following tables from WP1 reflects the current status of test cases to be executed in WP4.

							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
URS Ref.	Applications	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
5.9	Automatic Train Protection communication*	X	X	X	X	X		X					X				X	X	X	X	X				X	
5.10	Automatic Train Operation communication (limited to GoA2 ATO)*	X		X		X	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	
6.13	Non-critical real time video (see clause 5.27) - MCVideo, MCData related?	X	X	X	X	X							X				X	X	X	X	X				X	

Table 9: Current status of Test Cases to be executed in WP4 (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
							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)
URS Ref.	Applications	5GRAIL	LAB WP3	LAB WP4	FIELD DB WP5	FIELD SNCF WP5	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
5.9	Automatic Train Protection communication*	X	X	X	X	X						O	X	X	X					X				X	X	X	O	
5.10	Automatic Train Operation communication (limited to GoA2 ATO)*	X		X		X						O		X	X					X				X	O	O		
6.9	On-Train Telemetry communications (TCMS includes 6.9 + 6.11 + 6.20), including PIS	X	X	X	X	X								O	X					X								
6.13	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		

Table 10: Current status of Test Cases to be executed in WP4 (2/2)

All the supported applications and features to be tested per application (ETCS-ATP/ATO) are listed in the 2 tables above.

7.2 WP4 assumptions

For information, the following assumptions have been agreed by WP4 members:

ID	Owner	Technical Architecture Assumptions to support WP4 execution
1	Kontron	Multiconnectivity foreseen induces the need for Trackside GW to be planned in WP4 setup (WP2 deliverable)
2	Kontron	TOBA prototype integrates 1900MHz FRMCS 5G modem - (no info about 900MHz - best case out of box integration)
3	Kontron	Network setup should provide WIFI access and 5G access (frequencies = 1900MHz + TBC), no 4G
4	Kontron	QoS managed with low 5QI (1-9), no PCF on 5G SA Core
5	Kontron	WP4 cybersecurity assets -if any- to be provided by Thales (potential impact on architecture and schedule)
6	Kontron	For the moment WP4 does not plan any activity with N78 (3.7 GHz)
7	Kontron	Remote access to equipments for all partners
8	Kontron	Some partners equipments (Alstom so far) will be installed in Montigny WP4 lab
9	Kontron	No MCVIDEO, use MCData instead
10	Kontron	No MCX - MCX Interworking
11	Kontron	4G SIMs are suitable for 5G Rail test cases
12	Kontron	ETCS on GSM-R will be based on GPRS connection
13	Alstom	Trackside GW can communicate with both TOBA_K and TOBA_A
14	Alstom	Kontron will install a server to host DNS applications
15	Alstom	Track data not linked with real one used in WP5
16	Alstom	Train and Track simu separated ETCS/ATO
17	Alstom	Train and Track simu and radio link simu not correlated
18	Alstom	The ATO version will be the one tested in S2R and not necesseray the one currently udapted in the 2022TSI
19	Thales	O&M streams should be separated for some cyber tests
20	Thales	PIS will not use GSM-R
21	SNCF	RF combiner to be use in WP4 lab
22	SNCF	Remote vision app will be tested in WP4 if loose coupling chosen
23	Thales	PIS application trackside must be time synchronized by NTP (master clock trackside)
24	SNCF	Wifi test should be run in WP4 before WP5 if agreed to be done in WP5
25	SNCF	4G test should be run in WP4 before WP5 if agreed to be done in WP5
26	Thales	If 4G network is used, it will not be part of cyber risk assessment

7.3 Equipment details

7.3.1 On-Board Gateways equipment details

7.3.1.1 TOBA-A GW

- Hardware housing:
- Stainless aluminium « Box »
- Form Factor (CEI 60297-3-101): 3U x 21TE x 230mm
- IP 20
- Mass #2Kg

- Main standards:
- EN50155 (T3 Class for Base, TX Class for MPU/xPU, T1 Class for LTE DCS)
- Certificates (CE, RED, FCC*,…)
- Fire & Smoke (EN45545 HL3 Class)
- RoHS, Reach

- Power supply:
- Input power: 24-110V DC
- Nominal consumption: 15-30W
- Physical connector: M12 code A male 4pins

7.3.1.2 TOBA-K GW

TOBA-K GW is fully described in document D2.1 *TOBA Architecture Report* [S20].

7.3.2 Trackside Gateways equipment details

7.3.2.1 Trackside Gateway Alstom

- Dimension:
- 32 x 43.46 x 38.22 cm (H x l x p) Form Factor (CEI 60297-3-101): 3U x 21TE x 230mm

- Power Supply:
- Input power: 230Vac
- Redundant power supply (2 input connectors)
- Nominal consumption: 500W

7.3.2.2 Trackside Gateway Kontron

The Kontron Trackside Gateway is fully described in document D2.1 *TOBA Architecture Report* [S20].

7.3.3 ETCS application equipment details

7.3.3.1 ETCS application on-board

- Windows laptop for EVC:
- Size: L32cm x l23cm
- Weight: 1,5Kg
- Power supply : 230Vac

- COMET and its COMET tool:
- COMET Size: L122cm x l23cm
- COMET Weight: 0,747Kg
- COMET tool Size: L27cm x l17cm
- COMET tool Weight: 3Kg
- Power supply : 230Vac

- DMI:
- DMI Size: 10cm x 21cm x 31 cm
- Power supply : 12 Vdc

7.3.3.2 ETCS application trackside

- Windows laptop for RBC simulator:
- Size: L32cm x l23cm
- Weight: 1,5Kg
- Power supply : 230Vac

- NTG:
- NTG Size: 48cm x 5cm x 30cm
- COMET Weight: 3Kg
- Power supply : 230Vac

7.3.4 ATO application equipment details

7.3.4.1 ATO application on-board

- ITA 5231 platform from Advantech:
- Size: 427mm x 88mm x 195.8mm
- Power supply : 24Vdc
- Fanless computer for railway vehicle applications, fully compliant with EN 50155
- Satisfies temp. standard: EN 50155 TX (-40 ~ 70 °C) and IEC 61373 body mount class B
- Compliant with EN 50121-3-2/ EN 50121-4 EMC test standard
- Ruggedized connectors (M12) used for communication and power ports
- Supports easy-swap storage module and I/O module ƒ No RED Certification

7.3.4.2 ATO application trackside

- Windows PC laptop (Test Bench PC has the same characteristics):
- Power supply : 220Vac
- Minimum CPU 4 core last Generation
- 500 Gb Hard disc
- 16G RAM

7.3.5 PIS application equipment details

7.3.5.1 PIS On-Board Equipment

Thales on-board PIS application is using an APIS on-board server, an on-board PAS server and a TFT display device.

Following table gives technical information about APIS on-board server:

<table>
<tr><td colspan="2">Intel ATOM processor Quadcore

RAM memory 4GB DDR3L

Storage 500GB (SSD)</td></tr>
<tr><td rowspan="7">CPU board (front panel)

• height: 3U (128 mm)
• width: 8TE (40,64 mm)</td><td>Ethernet connector

• 8 pins female M12 X-Coded
• 10/100/1000Mbps interface</td></tr>
<tr><td>Display port connector

• 20 pins Mini Display port type</td></tr>
<tr><td>USB port connector

• USB Type A</td></tr>
<tr><td>RS232 Console connector

• 9 pins male D-Sub</td></tr>
<tr><td>Audio connector

• 9 pins female D-Sub</td></tr>
<tr><td>Link/Act Eth LED

• Green: 10/100Mbps Ethernet Link
• Red: 1000Mbps Ethernet Link
• Orange blinking: Ethernet activity</td></tr>
<tr><td>Status LED</td></tr>
</table>

	• Applicative Status
I/O board (front panel)	Ethernet connector • 8 pins female M12 X-Coded • 10/100/1000Mbps interface

	RS232 / RS485 connector
	• 15 pins male D-Sub
	• RS232
	  ○ Data rate: up to 1MBaud
	  ○ RTS, CTS signals
	• RS485
	  ○ Half duplex
	  ○ Data rate: up to 1Mbaud
	  ○ Optional Bus termination resistor (120 Ohms)

	I/O connector • 15 pins female D-Sub
	Link/Act Eth LED • Green: 10/100Mbps Ethernet Link • Red: 1000Mbps Ethernet Link • Orange blinking: Ethernet activity
	Act Disk LED • Green: Board powered • Green/Orange blinking: Disk activity • No colour: Board not powered
	Status 1 LED
	Status 2 LED

Table 11: Description of the front panel of the APIS on-board server

Following table gives technical information about on-board PAS server:

Processor	Intel® Celeron® J1900 4 cores
Memory	8 GB DDR3L
Audio	Codec Realtek ALC662 High Definition 2 x Phone Jack for MIC-in and Line-out
Ethernet	2 x RJ45 10/100/1000 Mbps
I/O	Serial Port 2 x RS-232/422/485, DB9 male USB 2.0 2 x Type A USB 3.0 1 x Type A
Power	Power Type ATX Power Supply Voltage +12 VDC Connector DC Jack with Lock Power Consumption (Idle) 7.36W Power Consumption (Full Load) 11.43W Power Adaptor AC to DC, AC 90 to 240 VAC Input, DC 12V/5A 60W
Dimension (WxHxD)	198 x 42 x 145 mm
Certification	EMC CE/FCC, Class A

Table 12: Hardware description of the on-board PAS server

Following table gives technical information about TFT display device:

Railway certifications	EN50155 – Railway applications – Electronic equipment used on rolling stock

	EN50121-3-2:2006 – Railway applications – Electromagnetic compatibility – Part 3-2: Rolling stock – Apparatus EN50122-1 – Railway applications – Fixed installations – Part 1: Protective provisions relating to electrical safety and earthing EN60529 – Degrees of protection provided by enclosures (IP Code) EN61373 – Railway applications – Rolling stock equipment – Shock and vibration tests EN60068-2-2-1998 – Dry heat test EN60068-2-1:2007 – Cold test EN60068-2-30:2005 – Damp heat, cyclic test EN45545-2:2010 – Railway applications — Fire protection on railway vehicles Part 2: Requirements for fire behaviour of materials and components
Processor	Intel Celeron J1900 QuadCore
Memory	2 GB DDR3L
Display connection	VGA, LVDS, HDMI
LAN	10/100/1000Mbps
Storage	1 x SSD 4GB
Input power supply voltage	Nominal voltage: 96Vdc According to EN50155 • Minimum voltage: (0,7 Un) 67,2 Vdc • Rated voltage: (1,15 Un) 110,4 Vdc • Maximum voltage: (1,25 Un) 120 Vdc • Between 0.6 ÷ 1.4 Un x 0.1S: no deviation of function • Between 1.25 ÷ 1.4 Un x 1S: no damage but equipment may not be fully functioning during these fluctuations
Dimensions Weight	580 (L) x 380 (H) x 55 (D) mm 11 Kg

Screen dimension	24” diagonal; format 16:10
Pixel format	1920 (H) x 1200 (V) px
USB	USB 3.0 USB 2.0 USB 2.0 on Internal I/O

Table 13: Hardware description of the on-board display device

7.3.5.2 PIS Trackside equipment

Following table gives the hardware description of the APIS trackside server:

Processor	Intel® Xeon® E5-1650 v2
Memory	8 GB
Storage	400 GB
Ethernet	1 x RJ45 10/100/1000 Mbps

Table 14: Hardware of the APIS trackside server

7.3.6 5G Network equipment details

7.3.6.1 ME1210 equipment

ME1210 is used to host 5G Core and 5G CU/DU functions. Following figure gives technical information about it:

PROCESSOR	Intel® Xeon® D-2100 Processor Skylake Architecture; Intel® QuickAssist Technology (Intel® QAT); Intel® Advanced Vector Extensions 512 (Intel® AVX-512); Built-In Intel® Virtualization Technology Available CPU options D-2187NT 16C/2.1Ghz 110W (QAT) D-2183IT 16C/2.2Ghz 100W	
MEMORY	8x DDR4 DIMM sockets, 4 channels @ 2667 MHz support up to 512GB	
STORAGE	2x M.2-2230/2280/22110, up to 960GB (SATA or NVMe); Support RAID 1	
NETWORKING (OPTIONS)	• Integrated Microchip switch (VSC7556) • Total 12 SFP28/SFP+ Ports (2x 25G + 6x 10G or 12x 10G firmware configurations) • 4 Internal 10GE connections to Xeon D-2100 integrated X722 controller	• Xeon D-2100 integrated X722 controller • 4X Direct SFP+ port connection
TIMING AND SYNCHRONIZATION	• SyncE & PTP with Telecom profile performance • Master and Boundary Clock modes • Optional advanced OCXO to support 4 hour Hold-Over requirement • Connector: 1x GNSS input (optional) and 1PPS output • Hosted in integrated Microchip switch and telecom PLL	• Xeon D-2100 integrated X722 controller PTP support
LOCAL DIAGNOSTIC PORTS	1xGE Copper Interface (shared Management port) (RJ-45) 1x Serial Console Port (RJ-45) 4x Dry contact alarm inputs (RJ-45) 2x USB 3.0 Interface to Xeon D-2100 1x USB 2.0 Interface to BMC	
PCIE EXPANSION	2x Full Height, ¾ Length PCIe slots with x16 Gen3 lanes 75W power per PCIe slots	
MANAGEMENT	Independent management network support Redfish API and IPMI v2.0 Secure Remote Management Capabilities (Encrypted firmware, boot, storage, Secure Boot, Failsafe Boot) Using TPM version 2.0 Remote access using KVM & Virtual Media In-service Firmware Upgrade capability	
ENVIRONMENTAL	Operating temperature: -40°C to 65°C 1U x 13.5in. (355mm) deep and designed to be mounted in a 19" standard rack Operating Input Voltage options: • -48V DC (-40VDC to -57VDC) • AC 115/230V 50/60Hz (-5C°C to 65°C)	

Table 15: Technical information on the Kontron ME1210 device

7.3.6.2 5G RU

- AW2S "Blackhawk model:
- Power supply : -48Vdc

7.3.7 Miscellaneous equipment

7.3.7.1 uCPE SDWAN box

- Dell EMC Networking VE1425 platform:
- Power supply : 220Vac
- RAM: 8 Go
- eMMC: 16 Go

- SSD drive: 120 Go

7.3.7.2 Wifi Router

Main characteristics of the Wifi router TP-Link TD W8961N are the following:

- High 35mm / Length 195mm / Depth 130mm
- Wi-Fi N 300 Mbps (IEEE 802.11n)
- 4 RJ45 ports
- Power: 230V AC

Grant agreement
No 951725