Deliverable D2.3

Functional & Technical Requirements Key Building Blocks

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Abstract

This document defines the key building blocks and provides the functional and technical requirements of the building blocks, including how they are interconnected, to implement Home, Museum, Train Station Tunnel, Supermarket use cases in IoRL project. Details of protocols and formats of interfaces will be provided in D3.1, D4.1 and D5.1 Furthermore, we describe an overall approach to address the use cases through parallel lines of development and demonstrations that include the RRLH, User Equipment, 5G Network, NFV/SDN, Services and key Hardware to integrate mmW and light.

Disclaimer

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Impressum

Internet of Radio Light

IoRL

WP2 Usage Scenarios, Requirement Specifics and System Design

Task 2.5 Functional & Technical Requirements Key Building Blocks

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[Estimation of man-months spent on the Deliverable 10.3MM]

Executive summary

This document describes the functional and technical requirements of key building blocks in IoRL project along with a detailed plan to integrate these blocks into Lab benchtop demonstrator that will be developed in six steps. We define and address key building blocks and protocols that should be developed and integrated in five parallel lines, of specifications, development and integration, namely:

19 key building blocks for RRLH (June 2018 – March 2019),

10 key building blocks for UE (June – 2018 – December 2019),

5 key building blocks for 5G Network (June 2018 – March 2019),

14 key building blocks for NFV/SDN in HIPGW (June 2018 – September 2019),

10 key building blocks in Service Layer (June 2018 – June 2019),

Key building blocks related to mechanical design of RRLH with integrated mmW into pendant rose and design trolley for portable UE (July 2018 – December 2019).

We provide benchtop demonstrators that are going to be built in:

- Home testbed – Cobham
- Museum – ISEP
- Tunnel – Brunel
- Supermarket - TH

The following subset will be built:

- Home testbed – Cobham

The results of this deliverable will guide the development the IoRL layered architecture consisting of four layers: Access, Software Defined Network (SDN), Network Function Virtualization (NFV) and Service; and as such our architecture is well aligned to the overall 5G architecture.

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Abbreviations

3D	Three Dimensional
5G	Fifth Generation (mobile/cellular networks)
5G PPP	5G Infrastructure Public Private Partnership
AF	Auto Focus
APP	Application
AR	Augmented Reality
BIM	Building Information Modeling
CAD	Computer Aided Design
CO	Carbon Monoxide
CO2	Carbon Dioxide
(D)DoS	Distributed Denial of Service
DVD	Digital Video Disc
EMF	Electro Magnetic Field
GTP	GPRS Tunneling Protocol
HDTV	High Definition Television
IHIPG	Intelligent Home IP Getaway
HiFi	High Fidelity
IPP	IoRL Positioning Protocol
ILBDA	Indoor location data base
IoRL	Internet of Radio Light (project)
IP	Internet Protocol
IPTV	Internet Protocol Television
KPI	Key Performance Indicator
LAN	Local Area Network
LED	Light Emitting Diode
LiFi	Light Fidelity
MAC	Medium Access Control
MME	Mobile Management Entity
MSS	Multiple Source Streaming
NAS	Non-Access Stratum (between UE and MME)
NFV	Network Function Virtualization
NFVO	Network Function Virtualization Orchestrator
NS	Network Service
PA	Power Amplifier
PaP	Picture and Picture
PC	Personal Computer
PDCP	Packet Data Convergence Protocol
PiP	Picture in Picture
PHY Layer	Physical Layer
PV	Photo Voltaic
QoS	Quality of Service
R&D	Research and Development
RAN	Radio Access Network
RLC	Radio Link Control
RRC	Radio Resource Control

RRLH	Remote Radio Light Head
SDN	Software Defined Networks
SFP cable	Small Form Factor Pluggable cable
SDAP	Service Data Adaptation Protocol
SoC	System on Chip
SSC	Smart Shopping Cart
TRL	Technology Reading Level
TV	Television
UC	Use Case
UDC	Up/Down Converter
UE	User Equipment
UHDTV	Ultra-High Definition TV
uMMTC	ultra-Massive Machine Type Communications
uRLLC	ultra-Reliable Low-Latency Communications
USRP	Universal Software Radio Peripheral
VCR	Video Cassette Recorder
VLC	Visible Light Communications
VR	Virtual Reality
WDM	Wavelength Division Multiplexing
xMBB	Extreme Massive BroadBand

Definitions

Building block, or module, refers to either hardware or software entity with defined input, output and specific processing to meet desired functional and technical requirements. A building block can perform one or more functions.

Interface - the connection between two building blocks

Subsystem is a collection of building blocks and the interfaces between them

System is a collection of subsystems

1 Introduction

1.1 Objective of this document

The main objectives of this document are to:

- Provide the detailed functional and technical requirements for the key building blocks identified for implementation in IoRL use cases architecture based on deliverable D2.2;
- Identify, define and detail the key building blocks identified for implementation in the IoRL use cases;
- Define and describe the interfaces between key building blocks;
- Define the integration steps and planned dates towards construction of the demonstrator

1.2 Structure of this document

The rest of the document is organized in the following Sections:

- Section 2: key building blocks of Access Layer;
- Section 3: key building blocks of User Equipment;
- Section 4: 5G Networks;
- Section 5: key building blocks of SDN/NFV layers;
- Section 6: key building blocks of the Service (Application) layer;
- Section 7: key building blocks for RRLH hardware and user equipment hardware;
- Section 8: the summary of the findings.

1.3 Overview of IoRL Layered approach

The IoRL architecture is a layered architecture consists of following layers, as shown in Figure 1-1, namely: Access, SDN, NFV and Service layers.

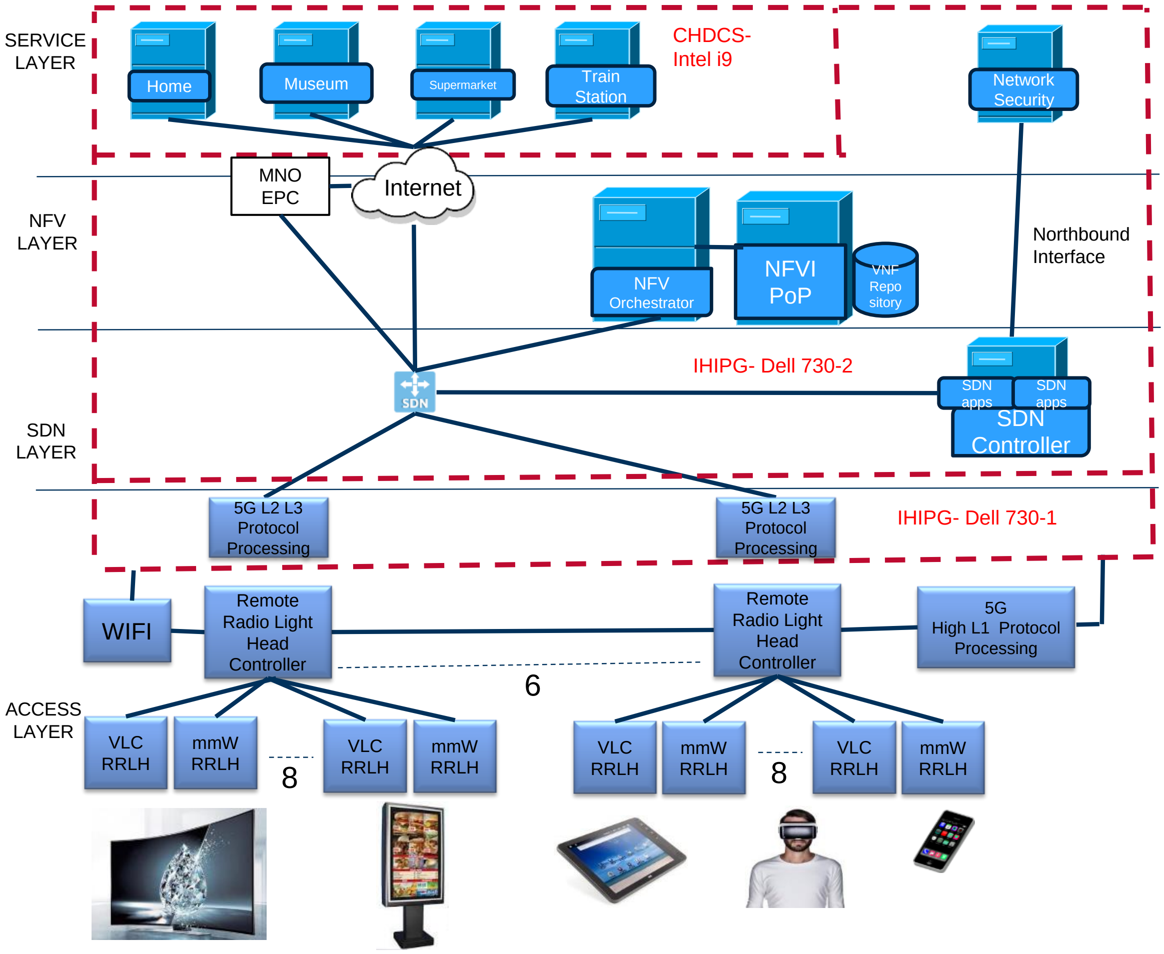

Figure 1-1: IoRL Access, SDN, NFV and Service Layered Architecture

Pert Chart of Construction Steps for the Lab Benchtop Demonstrator is shown below in Figure 1-2

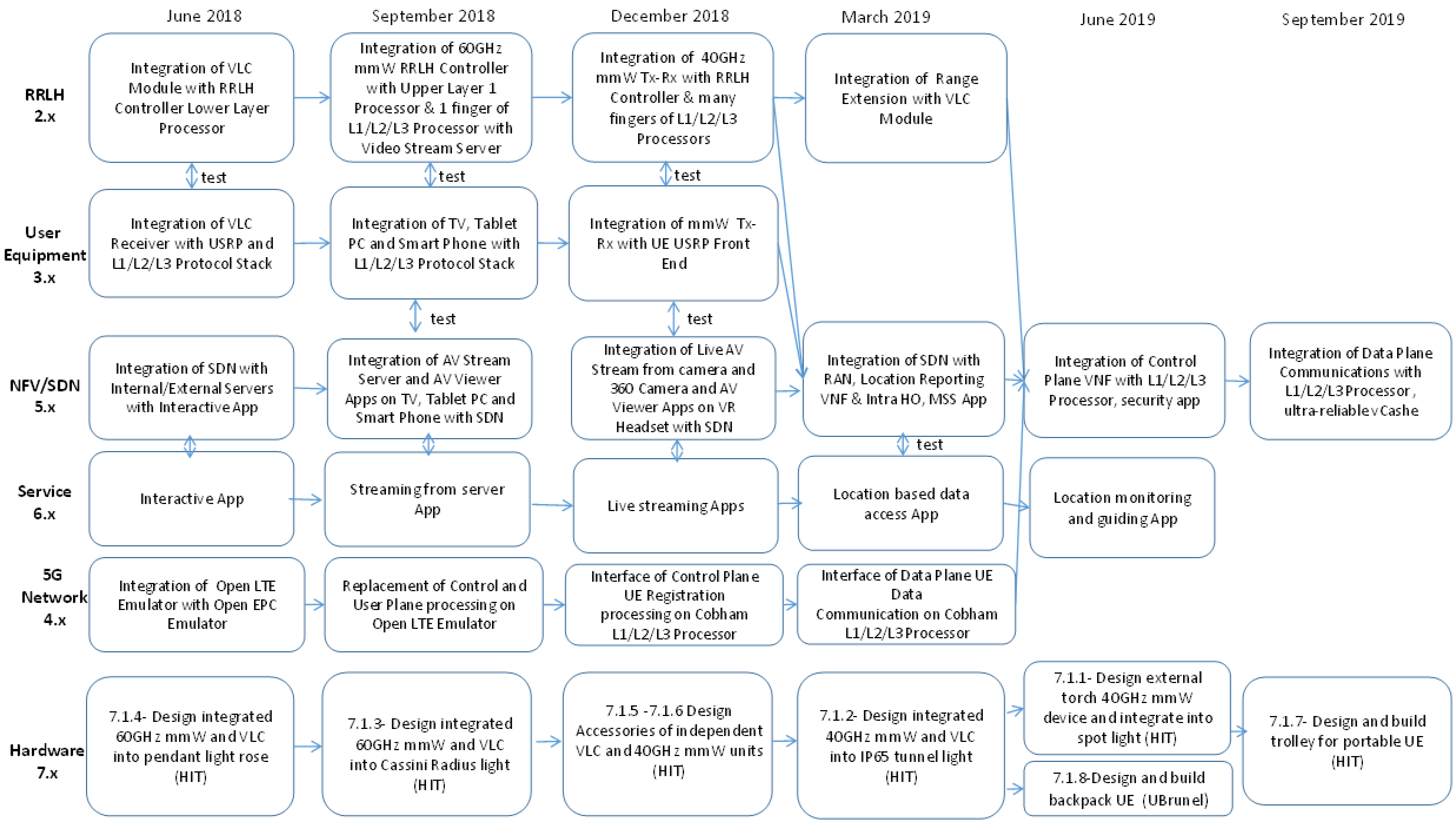

Figure 1-2 PERT Chart of Construction Steps or the Lab Benchtop Demonstrator

2 The Key Building Blocks of Radio-Light Access layer

The integration of the IoRL RAN will be performed in four steps, namely:

- **Step 1 (June 2018)** - Integration of VLC MISO RRLH module with RRLH Controller Lower Layer processor, as shown in Figure 2-1.

  Note this coincides with UE Step 1 (June 2018) - integration of VLC Receiver module in UE with USRP and L1/L2/L3 protocol stack, shown in Figure 3-1.

- **Step 2 (Sept 2018)** - Integration of 5G upper layer 1 Processor & 1 finger of L1/L2/L3 processors with single VLC MISO Module and RRLH Controller and 60GHz mmW, as shown in Figure 2-2.

  Note this coincides with UE Step 2 (Sept 2018) - Interface of UHDTV set to VLC module to UE, as shown in Figure 3-2.

- **Step 3 (Dec 2018)** - Integration of 40GHz mmW Tx-Rx with many fingers of 5G L1/L2/L3 processors with multiple VLC and 40 GHz mmW Modules and RRLH Controllers, as shown in Figure 2-3.

  Note this coincides with UE Step 3 (Dec 2018) - Interface of UHDTV, Table, and VR Headset to mmW and VLC modules of UE, as shown in Figure 3-3

- **Step 4 (Mar 2019)** - Integration of VLC range extensions, as shown in Figure 2-4

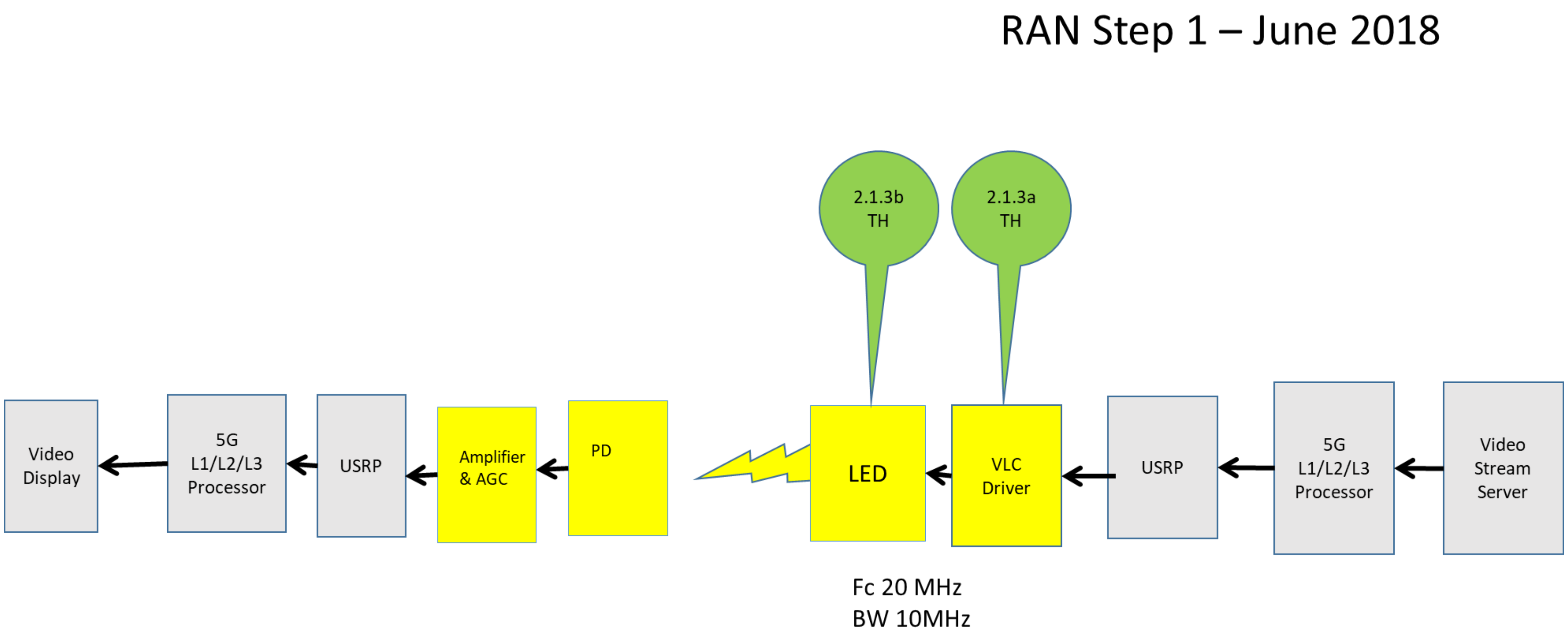

Figure 2-1: Step 1 (June 2018) - Integration of VLC module to RRLH Controller (onto existing COBHAM platform)

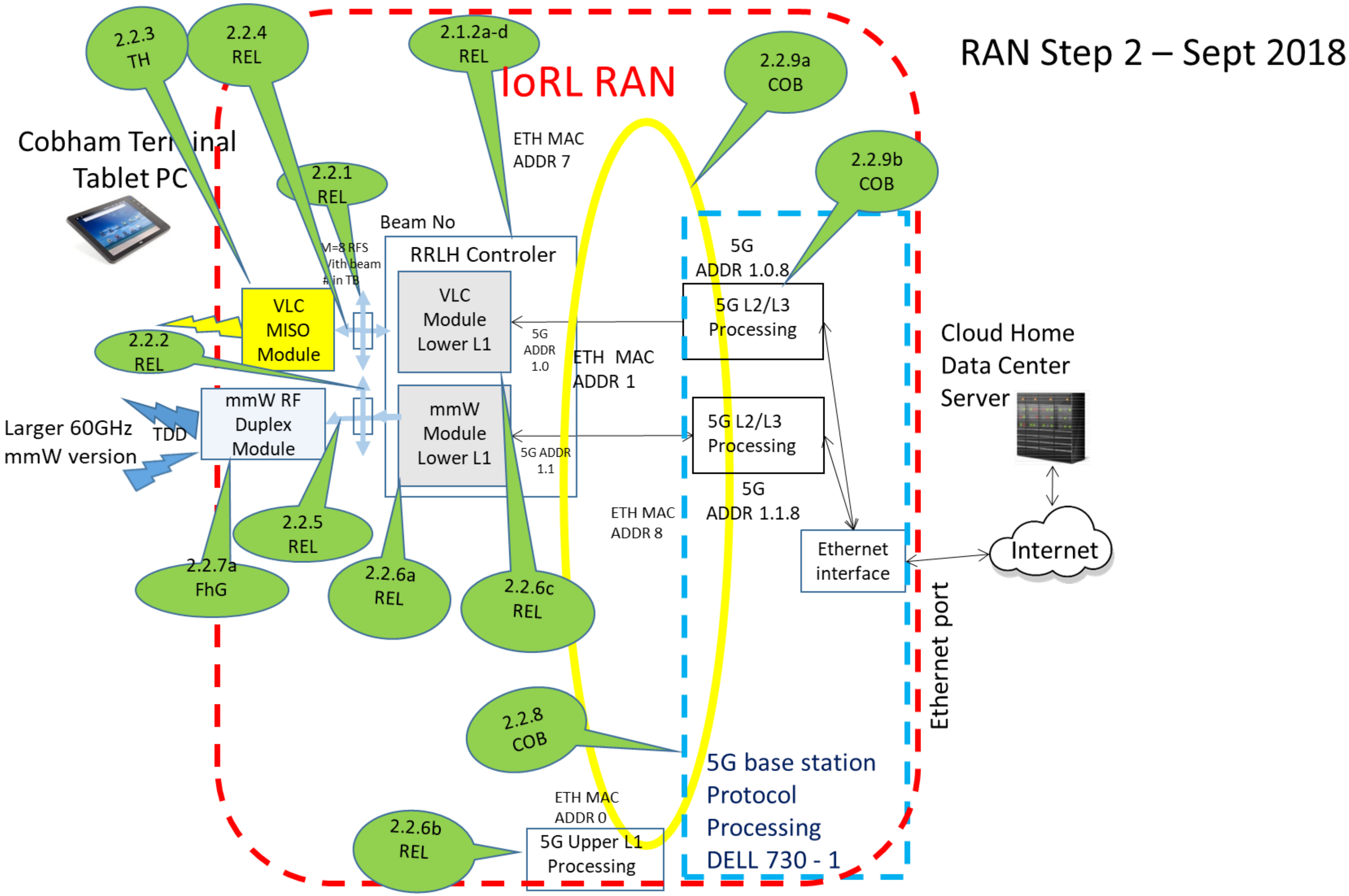

Figure 2-2: Step 2 (Sept 2018) - Integration of 5G L1/L2/L3 processors with single VLC Module, 60GHz mmW and RRLH Controller

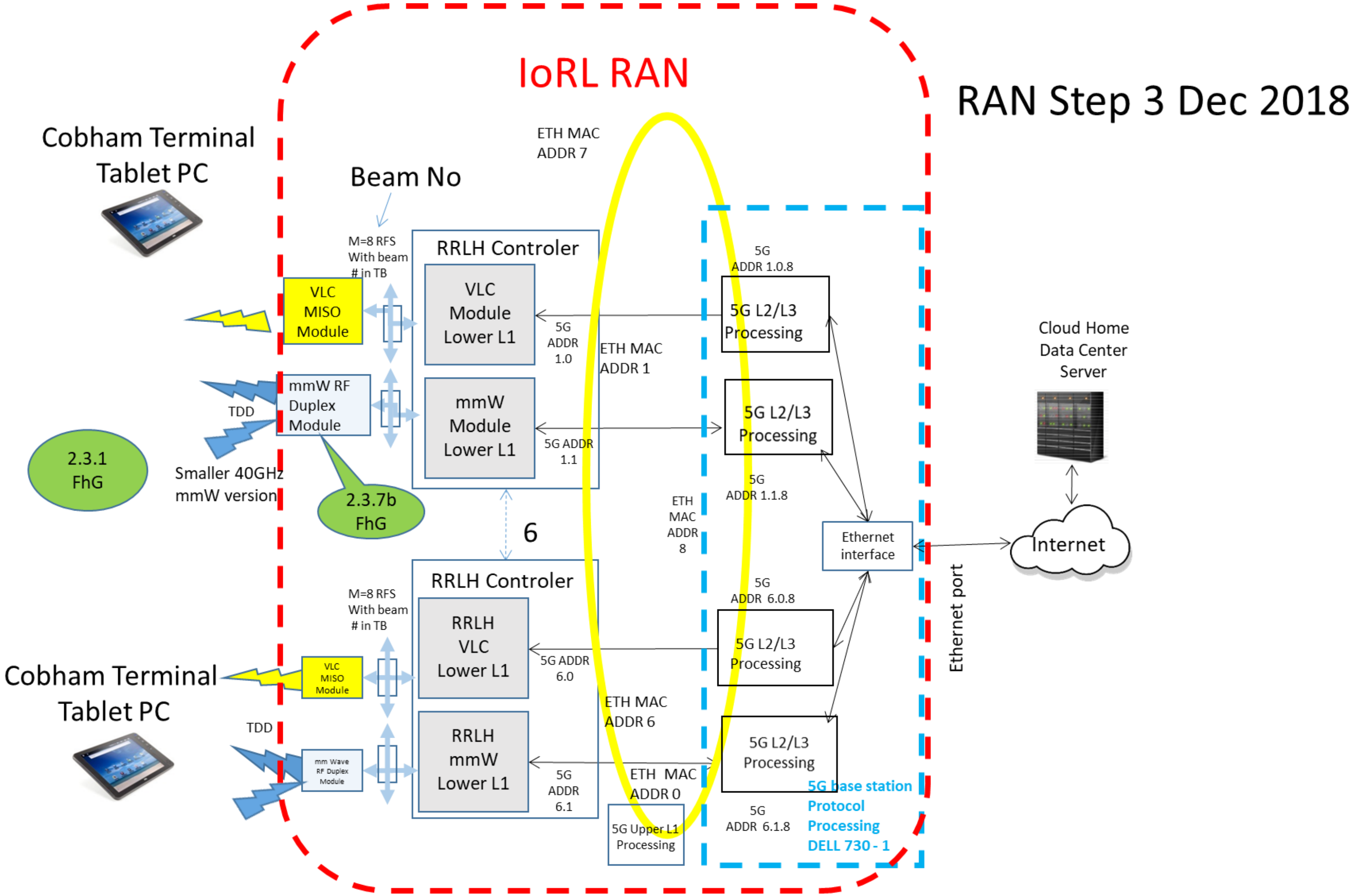

Figure 2-3: Step 3 (Dec 2018) - Integration of 5G L1/L2/L3 processors with multiple VLC and 40GHz/60GHz mmW Modules and RRLH Controllers

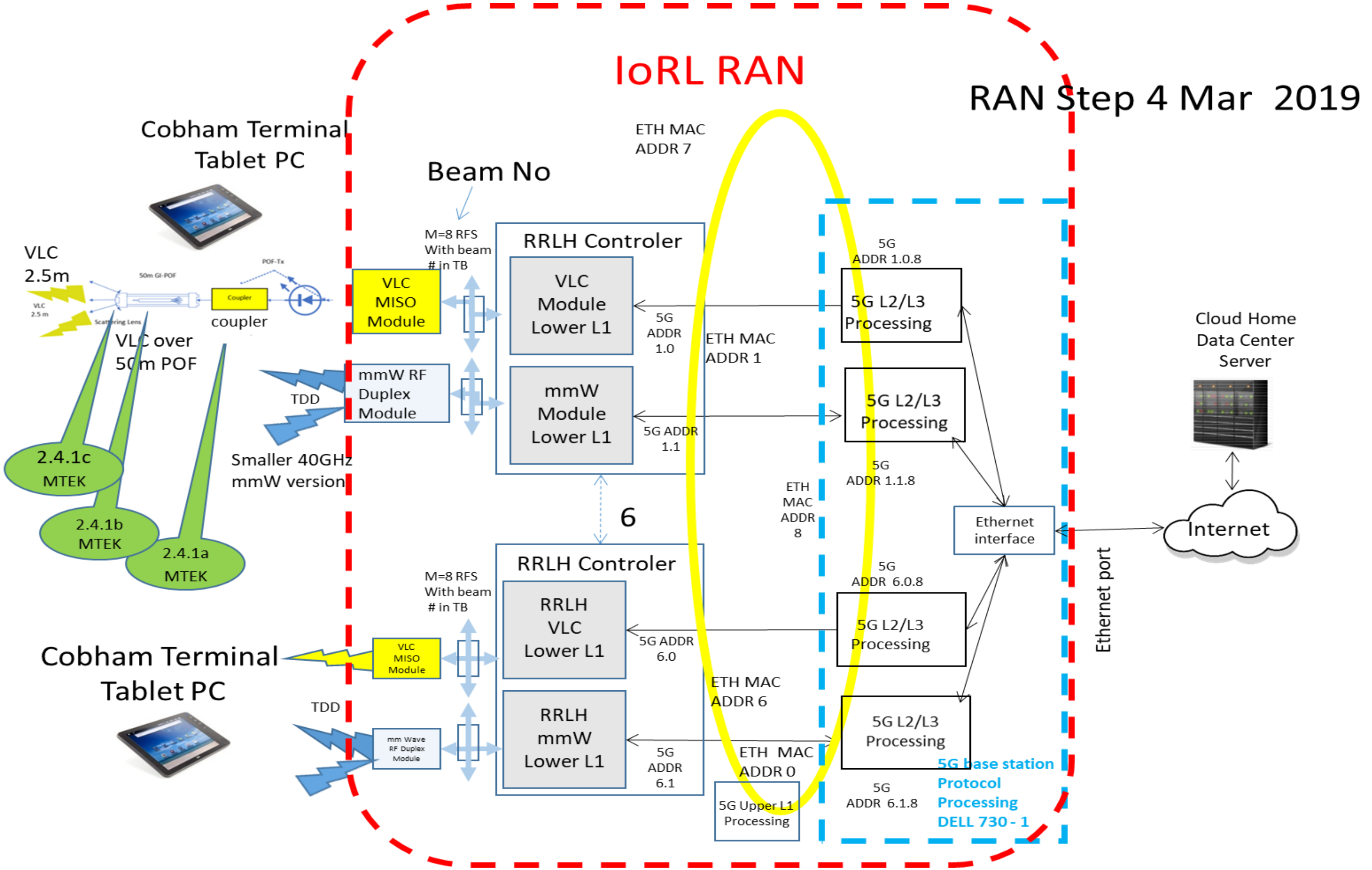

Figure 2-4: Step 4 (Mar 2019) - Integration of 5G L1/L2/L3 processors with multiple VLC with range extension over 50m GI-POF and 2.5m VLC over the air; mmW Modules and RRLH Controllers

2.1 System functional requirements and target dates for building blocks

Remote radio light head (RRLH) should serve as the base station for the access part of IoRL system for the key flavours of 5G services including: enhanced mobile broadband (eMBB), ultra-reliable low latency communications (uRLLC) and massive machine type communications (mMTC). Key protocols, components, functions to be addressed are described in TABLE 2-1 below:

Table 2—1: Key functional requirements and key building blocks for RRLH and target implementation dates

Sub-System	Protocols (L1/L2/L3/Application)	Block and responsible Task Leader	Functions Description	Cross reference with D2.2	Participants	Date
RRLH	application level	2.1.1 Audio/Motion/position sensor & light switch	This component is to provide the motion detection, position estimation by VLC and mmW	S2.1	Not going to provide this	
	application level	2.1.2 .a-d (REL) RRLH controller	The component is to provide the s/w interface from RRLH to SDN switch in SDN/NFV Layer as well as interface to the Lower L1 Processor (Sparq module 2.1.6a) 3.5GHz IF; interface to the Upper L1 Processor (Sparq DRAN module 2.1.6b) and Interface to the VLC 20MHz IF (2.1.6c)	S2.1, S2.5,	COB REL, FhG MTEK	a. June 2018 – Integration of single VLC RRLH with Controller b. Sep 2018 – Integration of one L2/L3 Processors for VLC Module and 60GHz mmW to RRLH c. Dec 2018 - Integration of multiple VLC & 40GHz mmW RRLHs with Controller d. March 2019-Integration with VLC range extension over GI-POF
	L1	2.1.3a, b (TH) VLC MISO RRLH module – Driver	VLC optical driver and LED	S1.3, S4.2	TH ISEP, TH, REL, OLED	June 2018 -detailed interface to USRP and to LED module.
	L1	2.2.1 (REL) VLC 1:8 splitter (REL, OLED) 2.2.2. RF 1:8 splitter (REL)	Interface to VLC Module Lower L1 Interface to mmW Lower L1 duplex	S1.3, S4.1	REL, OLED REL, COB	Sep 2018 Sep 2018

		2.2.3 (TH) VLC MISO RRLH module -LED	VLC LED spatial MISO array, VLC modulation. This component is to provide the VLC receiver improved quality from up to 8 LEDs	S1.3, S4.2	TH ISEP, TH, REL, OLED	Sep 2018
	L1	2.2.4, 2.2.5 (REL) RRLH switch	5G VLC and mmW IF interface to the 1-8 splitter switch to the VLC driver or the mmW module. Every N OFDM symbols of duration Nx16.7μs it will to only one light for a single OFDM symbol in a round robin to all 8 lights for duration 8Nx16.7μs for location estimation. If N = 140 then this whole process takes 1120x16.7μs = 18.704ms	S2.1	REL, FhG, COB	Sep 2018
	L1/L2	2.2.6a (REL) – 5G Lower L1 2.2.6b (REL) – 5G Upper L1 mmW TDD transceiver 2.2.6c – (TH) 5G VLC module lower L1 2.2.6d (FhG) polarization compensation	Sparq-2020 RDB 5G transceiver (NR 3GPP (Rel-15) sub-6GHz IF with BW up to 100MHz. Provides a system on chip solution for 5G uRLLC service. 5G VLC module with BW up to 20MHz Consider design for two pairs of uni- polarization at RRLH or Tx and Rx dual polarization at RRLH with a single Tx/Rx antenna pair in UE.	S2.5, S4.1 Table 1.1, S2.5	REL, FhG, COB Will be elaborated in deliverables D4.1 and D5.1	Sep 2018
	L1/L2	2.2.7a 60GHz mmW front end (FhG, REL) 2.3.7b 40GHz mmW RF (FhG, REL)	60GHz mmW, UDC, filtering, amplifier and 2 antennas (Tx and Rx). 40GHz mmW, UDC, filtering, amplifier and 2 antennas (Tx and Rx).	S2.1	COB	Sep2018 Dec 2018

	LI	2.2.8 (COB, FhG) 5G BS Protocol Processing Dell 730-1	(NR 3GPP Rel-15)	S4.4 S5.4	COB, REL, FhG,	Sep 2018
	L1	2.2.9a (COB) eCPRI fronthaul protocol	10G Ethernet to interconnect a High Layer 1 FPGA processor with up to six RRLH Controller	S1.3, S4.1, S4.5	REL, FhG, COB	Sep 2018
		2.2.9b (COB) 5G L2/L3 Processing	The interface between Cobham L2/L3 and Sparq2020 RunEL L1 is called L1 API, which will be development based on Functional Application Platform Interface (FAPI). As current FAPI protocol resides within the LTE base station, the detailed interface used in IoRL project will be modified based current FAPI specification version to meet 5G-NR requirements.	S4.4, S5.3, S5.4	COB, FhG, REL	Sep 2018
	Deployment Planning Level	2.3.1 (FhG) SW planning tool for enhanced mmW and VLC location estimation	SW tool to enable optimal distribution of RRLHs in rooms to enhance localization precision.	S1.3, S7.1, S7.2. S7.3	mmW by FhG VLC by OLED, ISEP, MTEK	Dec 2018
	LI	2.4.1a, b, c (MTEK) VLC through Plastic Optical Fiber (POF) range extension connection	The component is to enable larger coverage of IoRL systems. Consists of: a) coupler; b) 50m POF; c) lens	S2.6	MTEK	March 19

3 User Equipment

The integration of the IoRL UE will be performed in three steps, namely:

- Step 1 (June 2018) - Integration of VLC module with USRP and L1/L2/L3 protocol stack to UE, as shown in Figure 3-1.

  Note this coincides with RAN Step 1 (June 2018) - Integration of VLC module to RRLH Controller, as shown in Figure 2-1.

- Step 2 (Sept 2018) - Interface of UHDTV set, Tablet PC and Smart Phone, 60GHz mmW with L1/L2/L3 to VLC module to UE, as shown in Figure 3-2

  Note this coincides with RAN Step 2 (Sept 2018) - Integration of 5G L2/L3 processors with single VLC Module and RRLH Controller, as shown in Figure 2-2.

- Step 3 (Dec 2018) - Interface of UHDTV, Table, and VR Headset to 40GHzmmW and VLC modules of UE, as shown in Figure 3-3.

  Note this coincides with RAN Step 3 (Dec 2018) - Integration of 5G L2/L3 processors

Key requirements relevant to UE are detailed in Table 3—1.

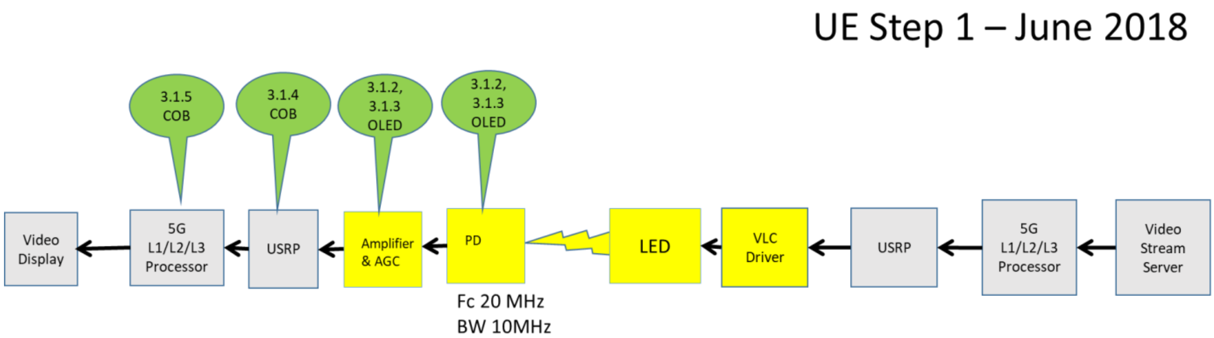

Figure 3-1: Step 1 (June 2018) - Integration of VLC module to UE (on existing Cobham platform)

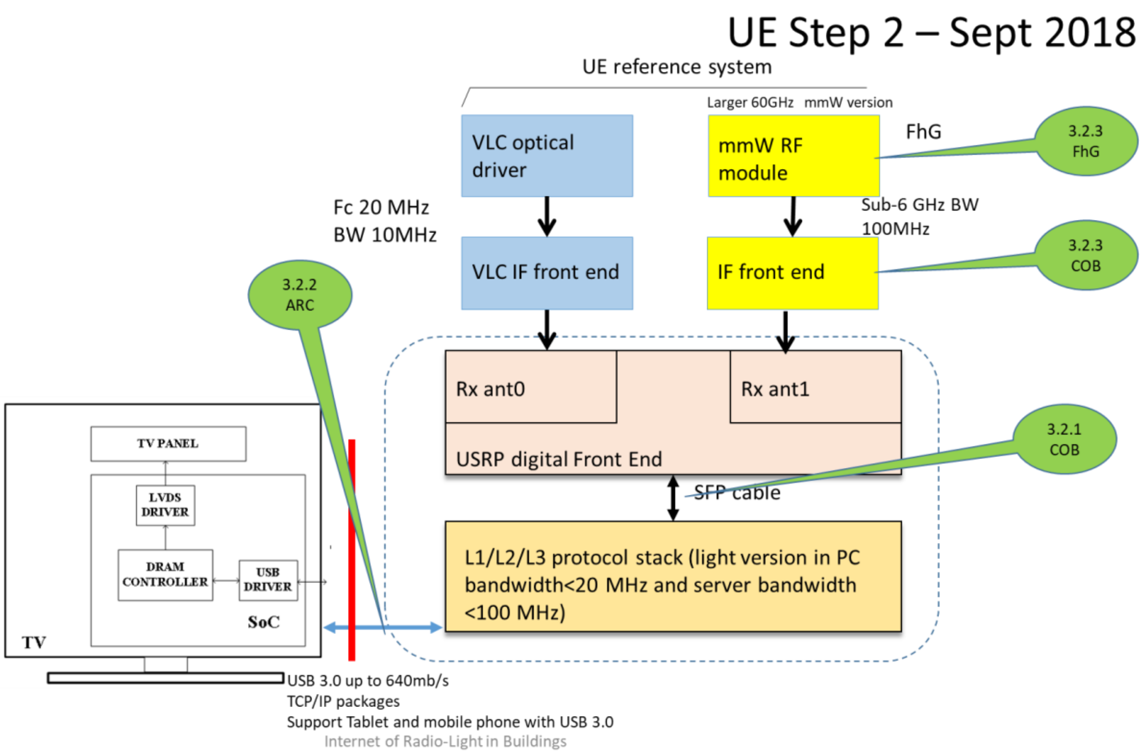

Figure 3-2: Step 2 (Sept 2018) - Integration of 60GHz mmW Tx-Rx and VLC IF Front End with UE USRP and support VR Headset Interface of UHDTV, Tablet PC and Smart Phone with L1/L2/L3 protocol stack

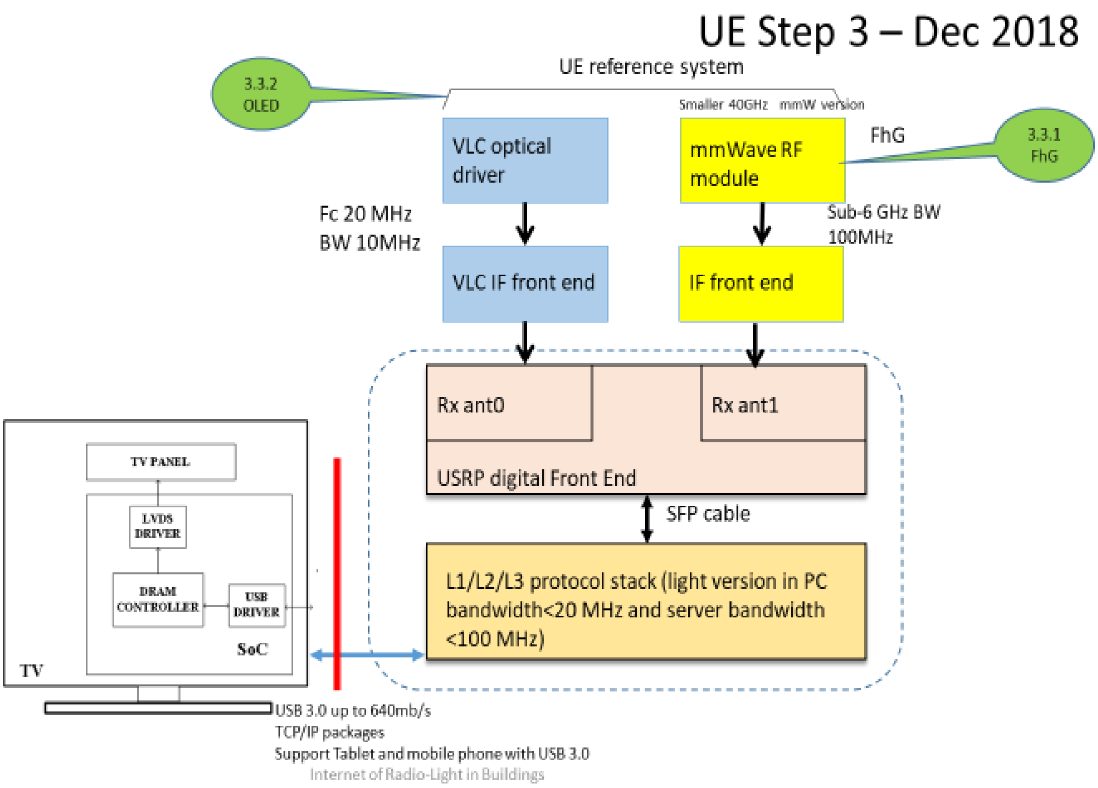

Figure 3-3 (Dec 2018) Integration of 40GHz mmW Tx-Rx with UE USRP Front End and support VR Headset

Table 3—1: Key functional requirements for UE and target implementation dates

Sub-System	Protocols (L1/L2/L3/Application)	Block and responsible Task Leader	Functions Description	Cross reference with D2.2	Participants	Date
		3.1.1 (OLED) VLC optical driver + LED	This part is Tx side at RRLH and tested with UE L1 modules	S2.1	OLED, ISEP, TH, MTEK	June 2018
	L1	3.1.2, 3.1.3 (OLED) VLC IF front end	PD + Amplifier + AGC	S3.1	OLED, ISEP, TH, MTEK	June 2018
	L1/L2/L3	3.1.4 (COB) Universal S/W Radio Peripheral (USRP) digital front end	This component can switch RF signal to baseband I/Q and transmit it into the 5G L1/L2/L3 protocol stack processing	S3.1	COB, OLED, REL	June 2018
	L1/L2/L3	3.1.5 (COB) 5G L1/L2/L3 processor	This component provides the L1/L2/L3 protocol stack processing for UE based on 5G COB equipment and OLED VLC front-end	S3.1	COB, OLED, REL	June 2018
	L1/L2/L3	3.2.1 (COB) SFP cable	small form-factor pluggable (SFP) cable testing	S2.5	COB	Sep 2018
UHDTV	L1/L2	3.2.2 (ARC)	USB 3.0 Connection TCP/IP of UE REF system UHDTV panel through SoC containing USB driver, DRAM controller, LVDS driver	S3.1	COB	Sep 2018

UE -REF		3.2.3 (COB, FhG) mmW transceiver 60GHz	mmW RF module consisting of USRP 5G transceiver, 60GHz UDC interfacing USRP over sub-6GHz IF with BW up to 100MHz and one transmitting and one receiving mmW antenna	S2.3, S3.0, S3.1	COB, FhG, REL	Sep 2018
		3.3.1 (FhG) mmW transceiver 40GHz 3.3.1a (FhG)	40GHz mmW UDC, filtering, amplifier and antenna. This component interfaces Sparq-2020 over sub-6GHz IF with BW up to 100MHz. Design polarization compensation between UE and RRLH at UE UDC + phase shifter	S2.3, S3.2, S4.4, S7.2 Not going to implement this	FhG, REL	Dec 2018
	L1/L2/L3	3.3.2 (OLED, COB)	Integration of VLC and mmW modules to UE	S3.1	OLED, FhG, ISEP,	Dec 2018

4 5G Network

The testing of the IoRL 5G radio Interface will be performed in four steps, namely:

- Step 1 (Jun 2018) – NAS Registration of a UE and User Plane Communication with Open LTE Emulator and Open MNO EPC emulators, as shown in Figure 4-1

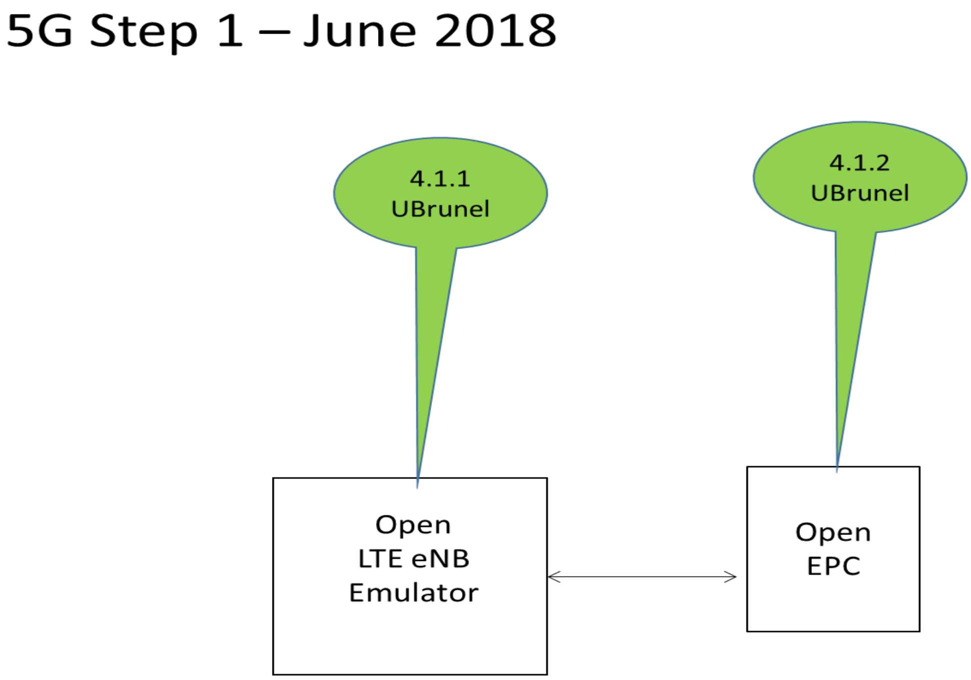

Figure 4-1: Step 1 NAS Registration of a UE and User Plane Communication with Open LTE and Open MNO EPC emulators

- Step 2 (Sept 2018) – Replacement of Control and User Plane processing on Open LTE Emulator

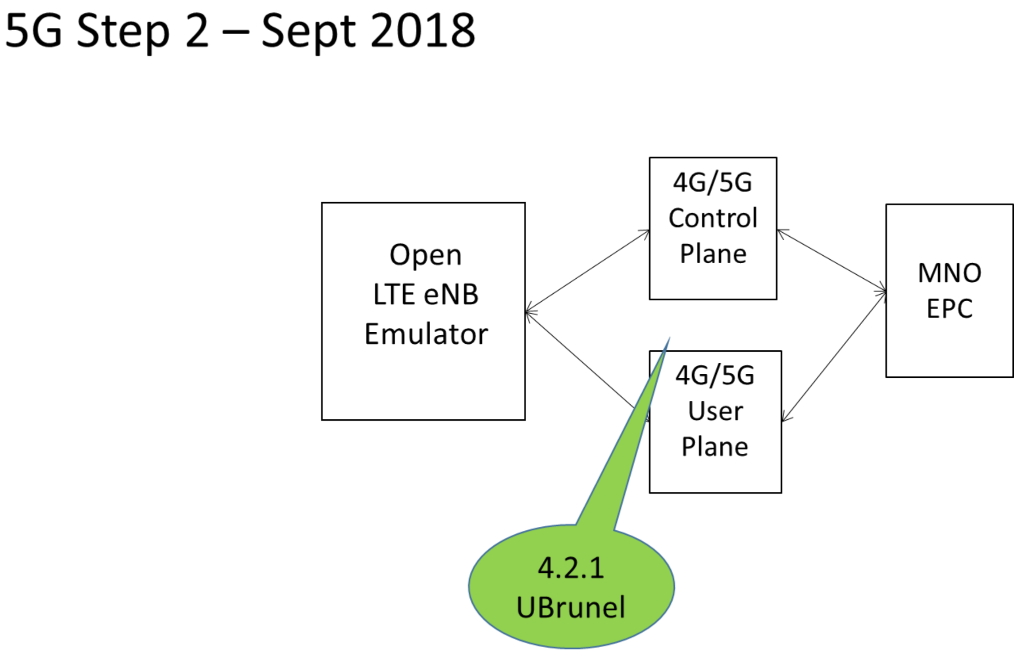

Figure 4-2: Step 2 NAS Registration of a UE and User Plane Communication with Open LTE and Open MNO EPC emulators and Open Source Control Plane and User Plane Protocols

- Step 3 (Dec 2018) - NAS Registration of a UE (on Cobham Wireless System 5G L1/L2/L3), as shown in Figure 4-3

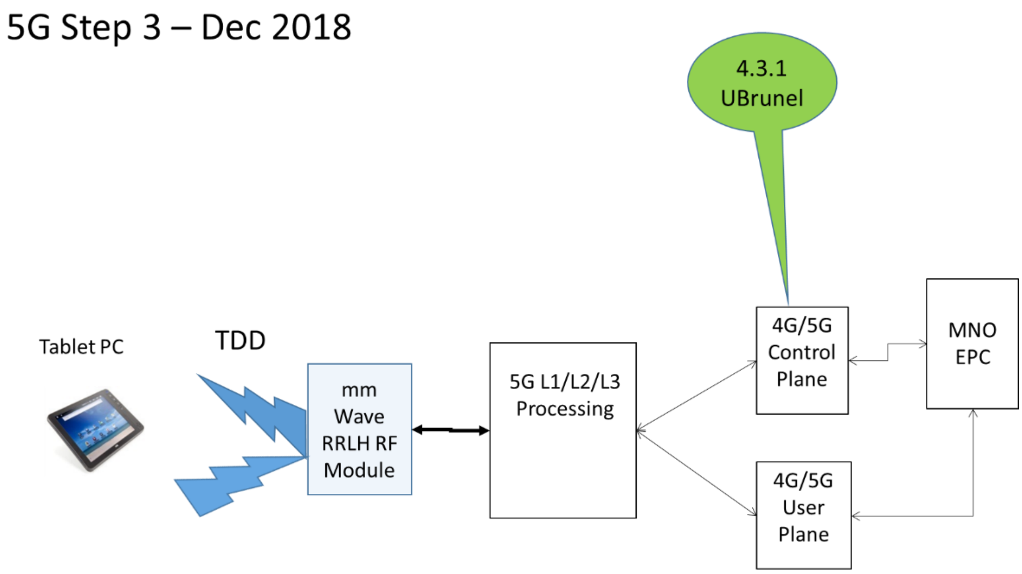

Figure 4-3: Step 3 (Dec 2018) - NAS Registration of a Control Plane UE (on Cobham 5G L1/L2/L3 processor)

- Step 4 (Mar 2019) – Target User Data Plane Communication on GTP for an application (on Cobham Wireless 5G L1/L2/L3 processor), as shown in Figure 4-4

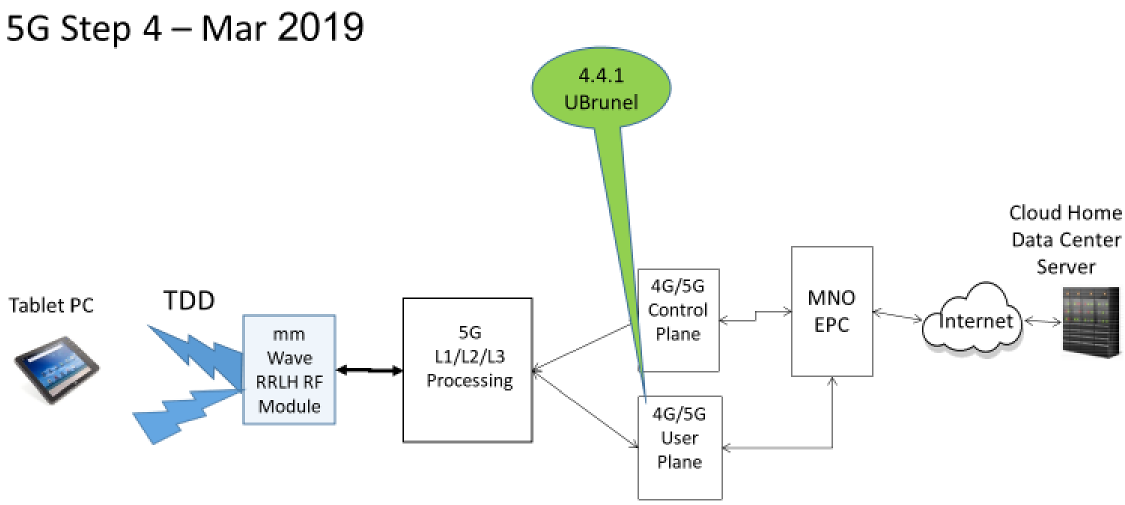

Figure 4-4: Step 4 (Mar 2019) – Interface of Data Plane of UE for an application (on Cobham Wireless System)

Table 4—1: Key functional requirements for 5G reference radio system and target implementation dates

Sub-System	Protocols (L1/L2/L3/Application)	Block and responsible Task Leader (COB)	Functions Description	Cross reference with D2.2	Participants	Date
SDN	L3	4.1.1 (TH, Brunel) Open LTE eNB Emulator	Emulates the eNB and UEs access to eNB	5.7 Example of Protocol Sequencing for 4G/5G Interface	TH, Brunel	Jun 2018
SDN	L3	4.1.2 (TH, Brunel) Open EPC Emulator	Emulates EPC	5.7 Example of Protocol Sequencing for 4G/5G Interface	TH, Brunel	Jun 2018
SDN	L3	4.2.1 (TH, Brunel) Open Source LTE Control Plane Protocols	Processes the LTE Control Plane and Data Plane Protocols Externally	5.7 Example of Protocol Sequencing for 4G/5G Interface	TH, Brunel, ULeic	Sept 2018 with eNB and EPC Emulators Dec 2018 with Cobham Wireless RAN and EPC Emulator
SDN	L3	4.3.1 (COB, TH, Brunel) 4.4.1 Open Source LTE Data Plane Protocols	Processes the LTE Control Plane and Data Plane Protocols with the Cobham Wireless System Communications on COB L1/L2/L3 Proc.	5.7 Example of Protocol Sequencing for 4G/5G Interface	TH, Brunel, ULeic	Dec 2018 Control Plane Mar 2019 Data Plane with Cobham Wireless RAN and EPC Emulator

5 The Key Building Blocks of the SDN/NFV Layer

Target SDN/NFV and its key functions is depicted in subsequent Figures 5.1 – 5.6.

The integration of the IoRL NFV/SDN will be performed in six steps, namely:

- Step 1 (June 2018) - Two interaction applications on two Tablet PCs accessing two server applications and databases - one real one virtual (act as database for location estimation), as shown in Figure 5-1
- Step 2 (Sept 2018) - Two Video viewer applications on two different UEs accessing video from stream server via transcoder VNF, as shown in Figure 5-2.

  Note this coincides with RAN Step 2 (Sept 2017) - Integration of 5G L2/L3 processors with single VLC Module;

  Note this coincides with RRLH Controller and UE Step 2 (Sept 2018) - Interface of UHDTV set to VLC module to UE.

- Step 3 (Dec 2018) - Two Video viewer applications on two different UEs accessing video from stream server via transcoder VNF through Ethernet and WLAN and live video viewing from theta-s on VR headset and AV Camera, as shown in Figure 5-3.
- Step 4 (Mar 2019) - Integration of SDN with RAN with Location VNF, Intra Handover and MSS, Location Based Data Access App, 5G Control Plane NAS registration of UE, as shown in Figure 5-4.

  Note 5G Control Plane NAS Registration of UE

- Step 5 (June 2019) - Security Monitoring, vlc/mmW Location Monitoring and Guiding App, User Plane Communication on GTP for an application, as shown in Figure 5-5.

  Note 5G User Plane Communication on GTP of UE

- Step 6 (Sept 2019) - Inter IoRL-NB to external eNB handover and Inter eNB to IoRL-NB external handover, as shown in Figure 5-6.

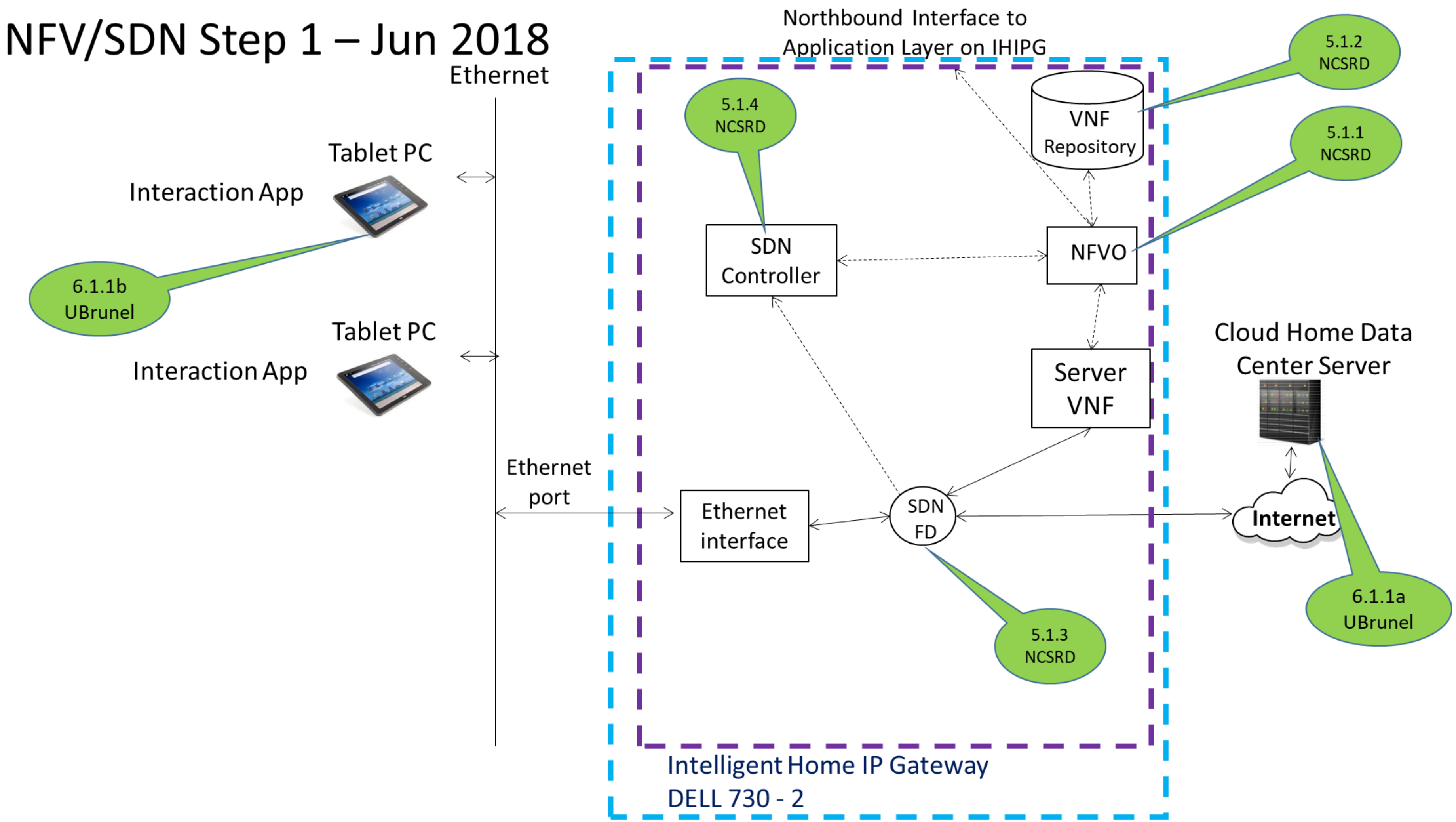

Figure 5-1: Step 1 (June 2018) - Two interaction applications on two Tablet PCs accessing two server applications and databases - one real one virtual (act as database for location estimation)

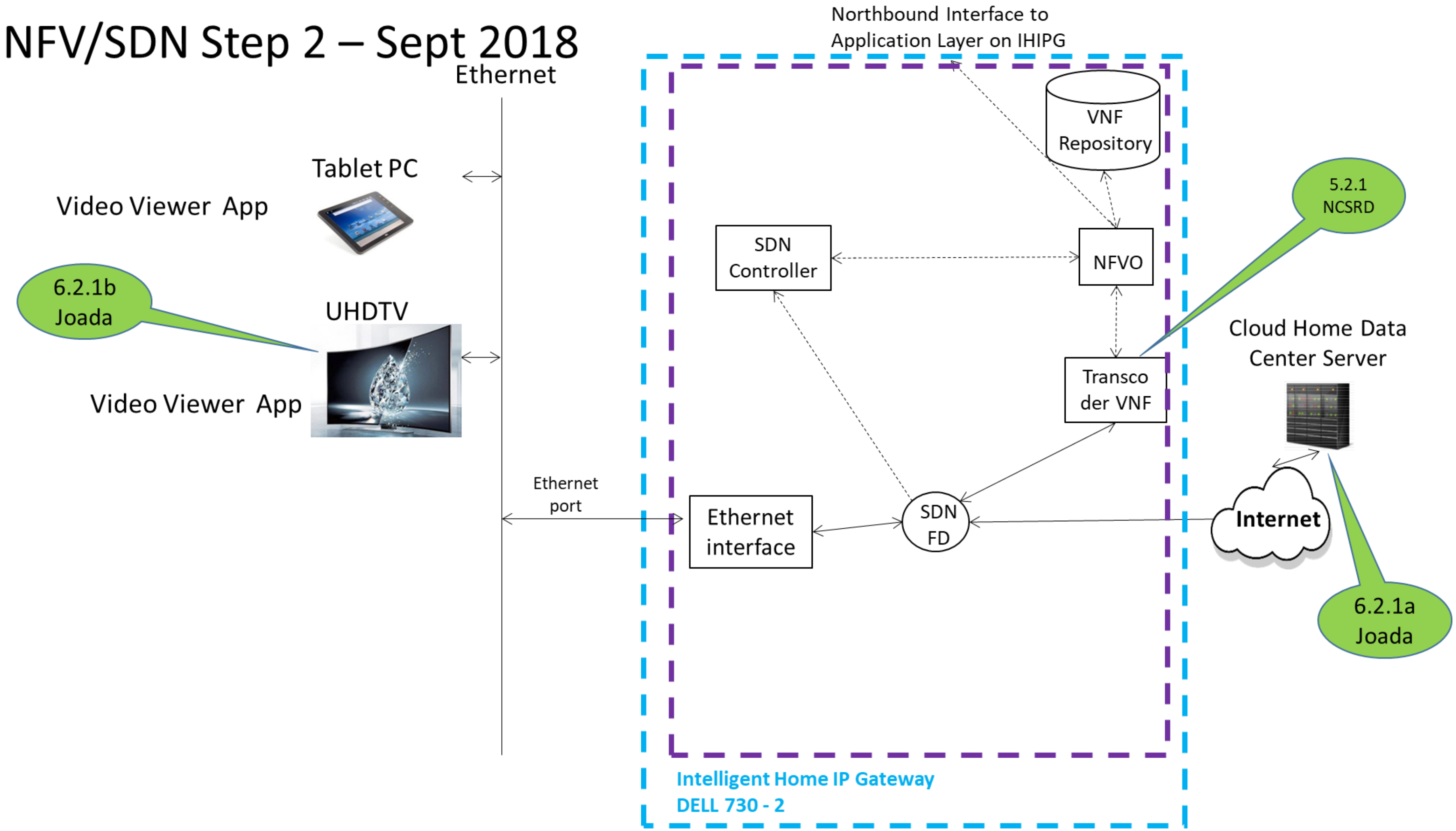

Figure 5-2: Step 2 (Sept 2018) - Two Video viewer applications on two different UEs accessing video from stream server via transcoder VNF

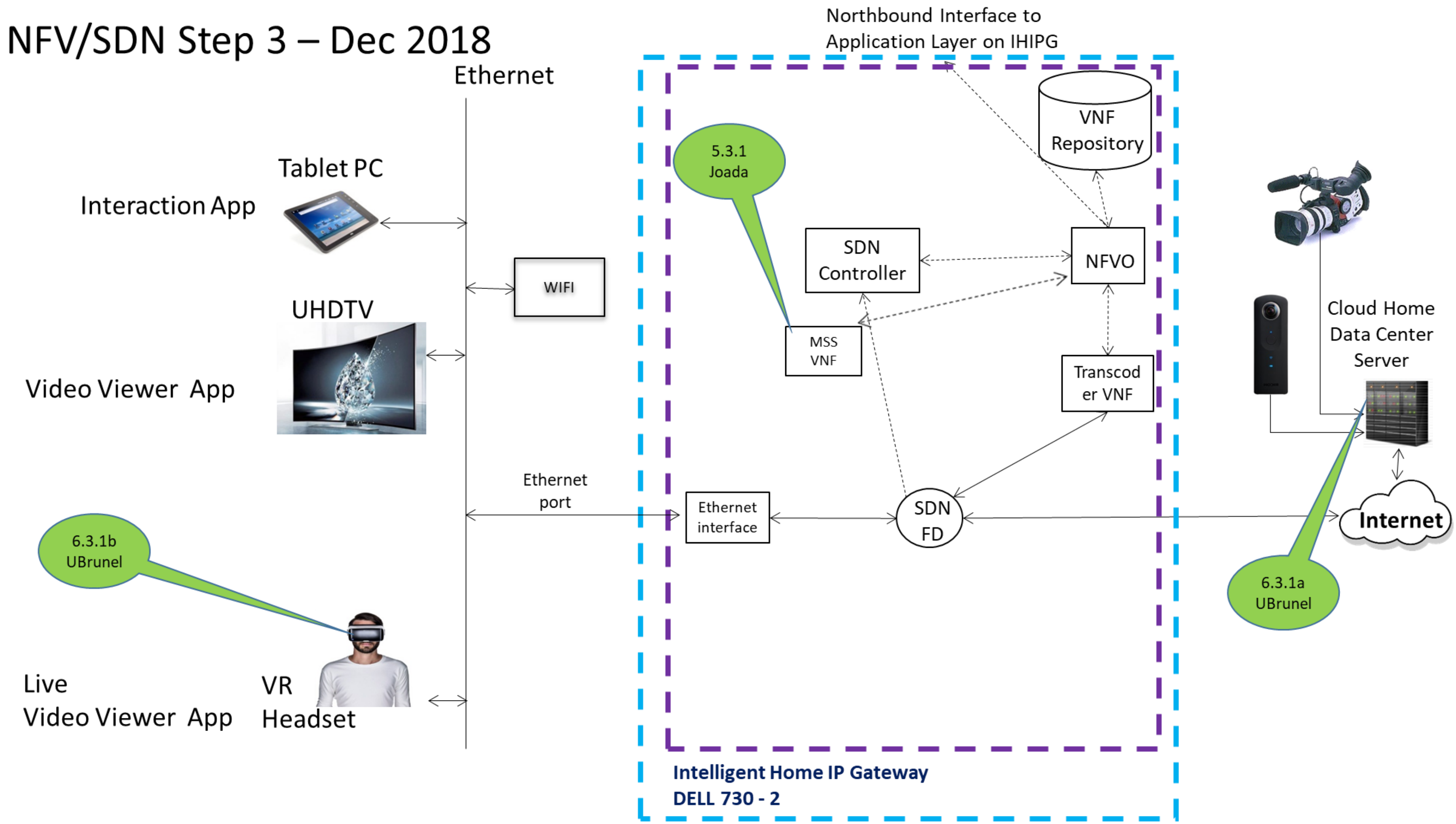

Figure 5-3: Step 3 (Dec 2018) - Two Video viewer applications on two different UEs accessing video from stream server via transcoder VNF through Ethernet and WLAN and live video viewing from theta-s on VR headset and AV camera

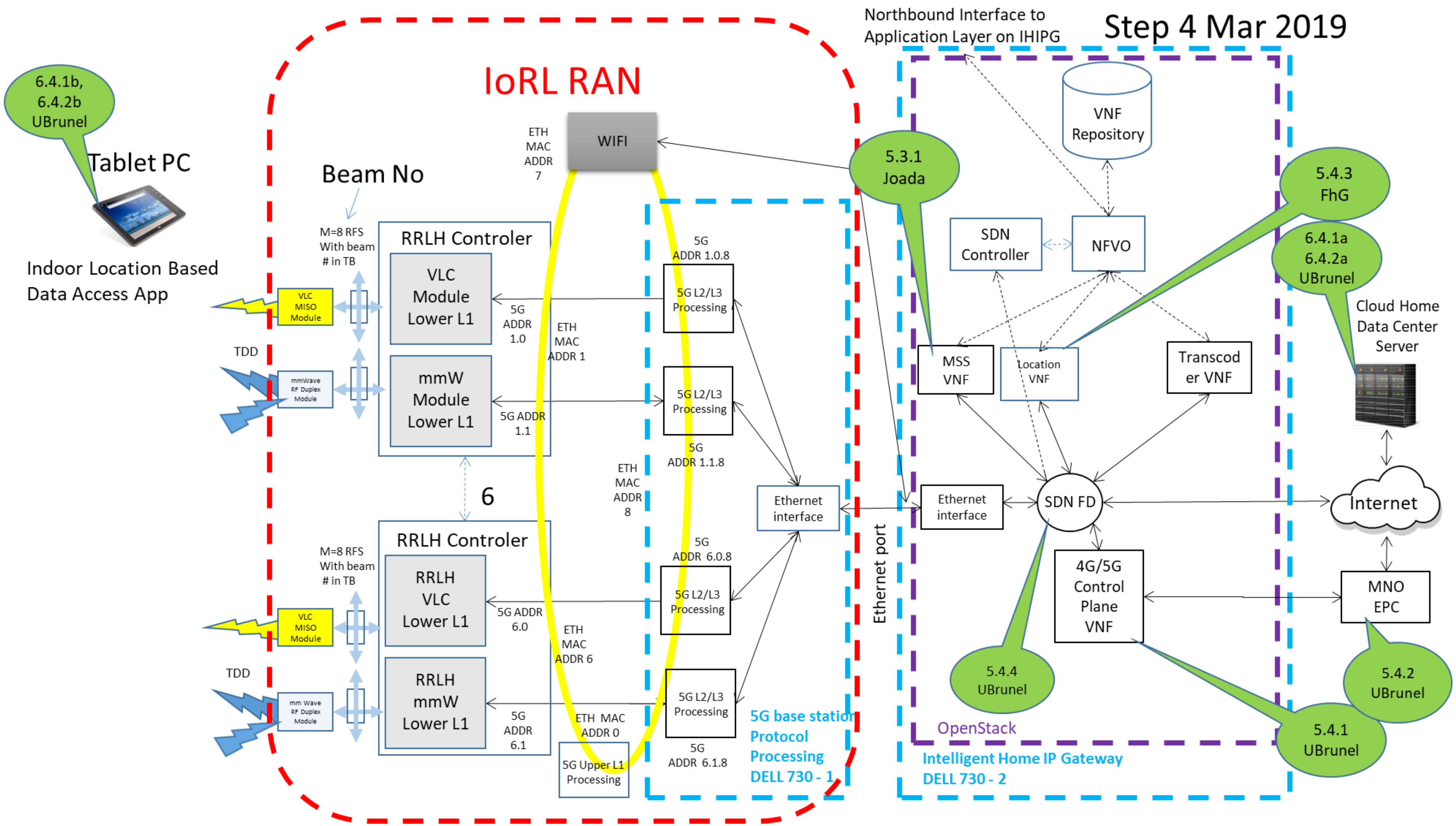

Figure 5-4: Step 4 (Mar 2019) - Integration of SDN with RAN with Location VNF, Intra Handover and MSS, Location Based Data Access App, NAS registration of UE

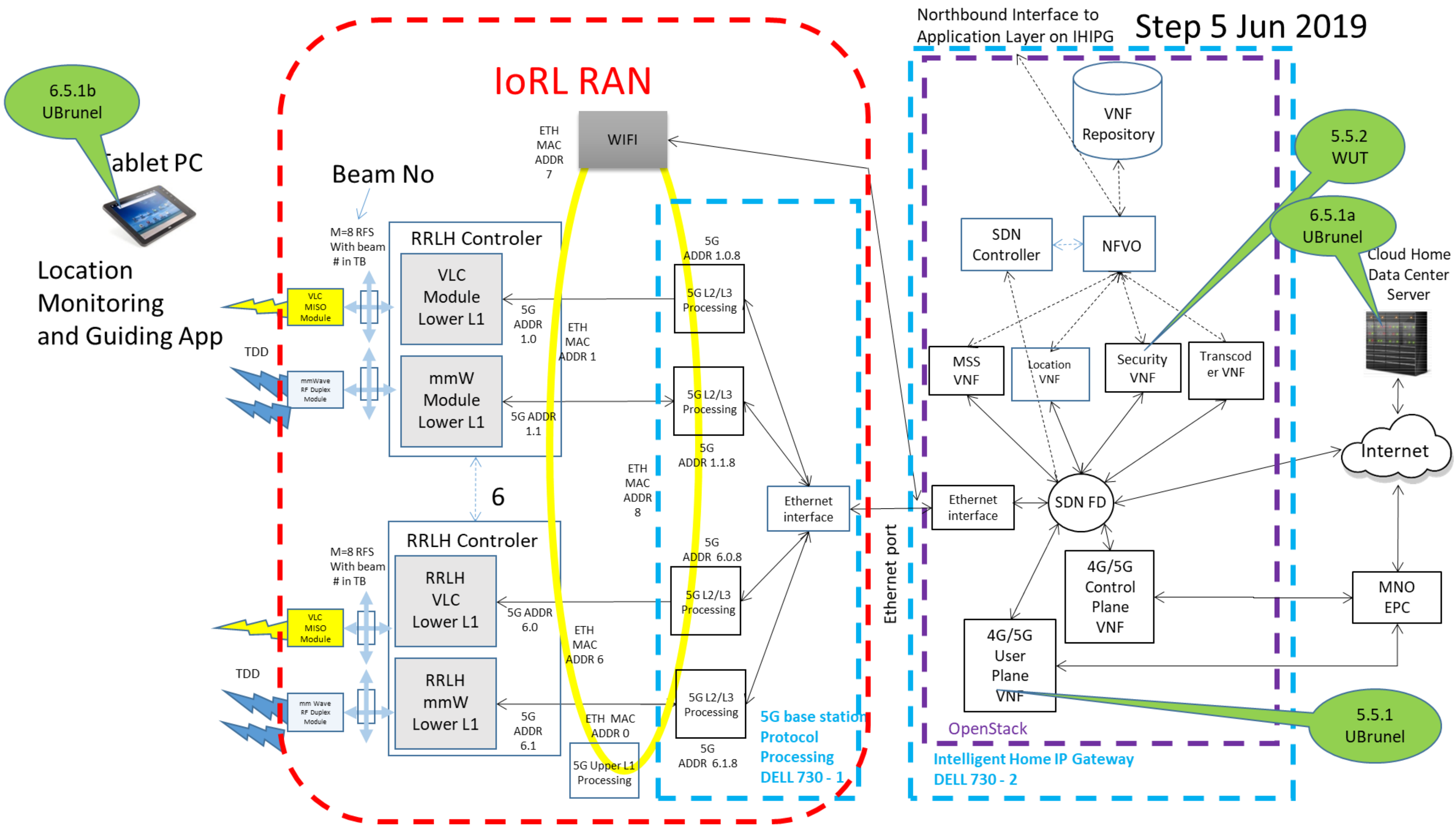

Figure 5-5: Step 5 (June 2019) - Security Monitoring, vlc/mmW Location Monitoring and Guiding App, User Plane Communication on GTP for an application

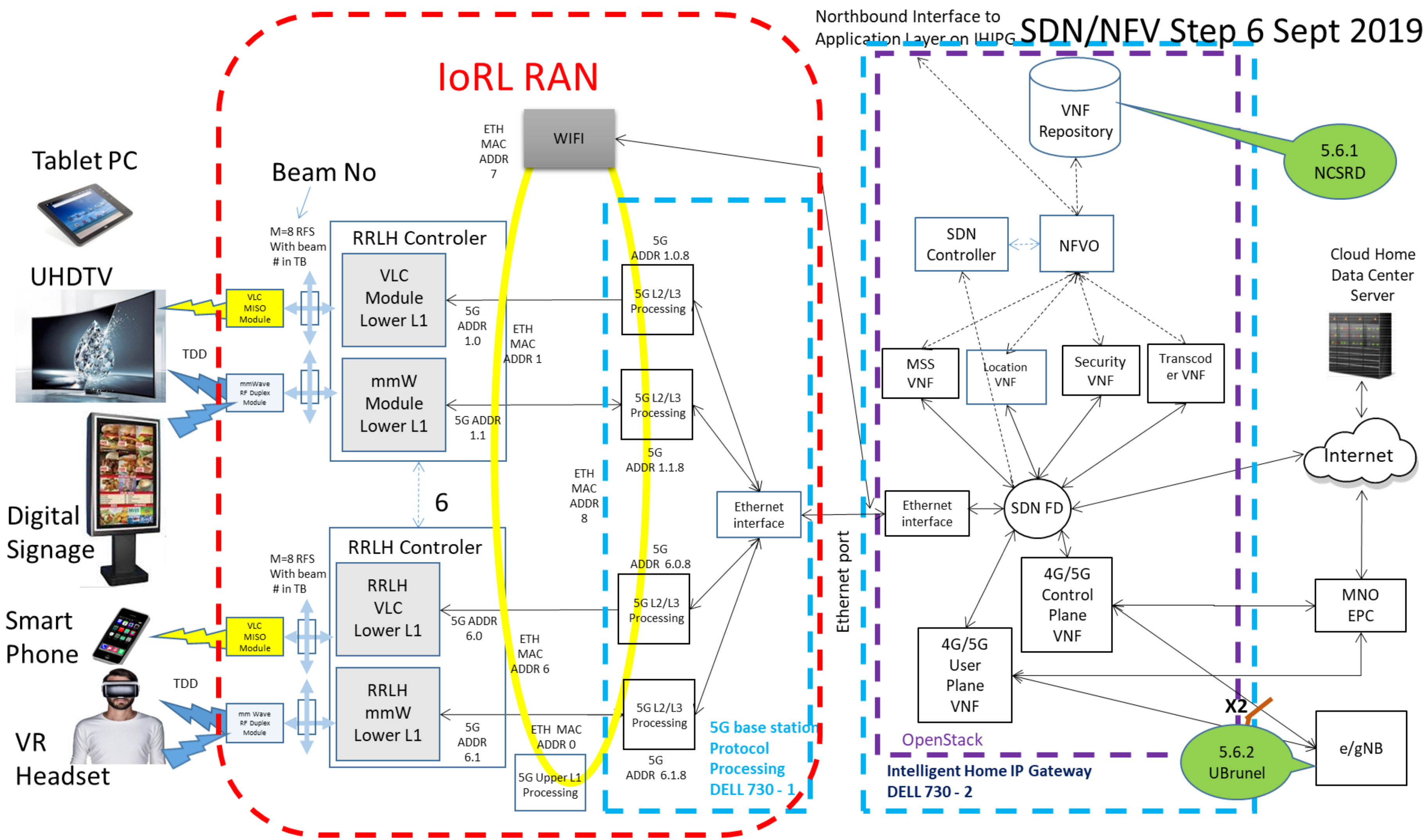

Figure 5-6: Step 6 (Sept 2019) - Inter IoRL-NB to external eNB handover and Inter eNB to IoRL-NB external handover

Table 5—1: Key functional requirements and key building blocks for SDN/NFV (Orchestration) in IHIPG and target implementation dates

Sub-System	Protocols (L1/L2/L3/Application)	Block (responsible)	Function	Cross reference with D2.2	Participants	Date
IHIPG DELL 730 - 2	L3	5.1.1 NFVO (NCSRD)	The NFVO is the NFV Orchestration entity, which is responsible for the management of the Network Service (NS) life cycle. Includes the NS instantiation, the dimensioning and the termination.	S5.2 NFV/SDN functions and structure	NCSRD, WUT, UBrunel, TH	Step 1: June 2018
IHIPG DELL 730 - 2	L3	5.1.2 VNF Repository (NCSRD)	This is the repository where images of the VNFs are stored and upon request they are deployed and instantiated.	Table 5.1 S5.1 S5.2 NFV/SDN functions and structure	NCSRD, WUT, UBrunel, TH	Step 1: June 2018 (vServer) Step 2: Sept 2018 (Transcoder) Step 3: Dec 2018 (MSS) Step 4: Mar 2019 (Location App, Intra HO, 5G CP) Step 5: June 2019 (Security Monitoring, 5G DP)
IHIPG DELL 730 – 2	L3	5.1.3 SDN FD (NCSRD)	This is a typical SDN-compatible virtual network device, such as Open Virtual Switch.	S5.2 NFV/SDN functions and structure	NCSRD, WUT, UBrunel, TH	Step 1: June 2018

IHIPG DELL 730 - 2	L3	5.1.4 SDN Controller (NCSRD)	For the scenarios that require location based forwarding information (Museum scenario), the SDN controller will require a separate and uniquely identified addressing scheme for each module in the RRLH controller, in order for the controller to enforce the rules on the forwarding devices to update their flow tables accordingly	S5.2 NFV/SDN functions and structure	NCSRD, WUT, UBrunel, TH	Step 1: June 2018 (Interactive Apps) Step 2: Sept 2018 (Stream Server Video, Transcoder) Step 3: Dec 2018 (Live Video, MSS) Step 4: Mar 2019 (Location App, Intra HO, 5G CP) Step 5: June 2019 (Security Monitoring, 5G DP) Step 6: Sept 2019 (5G Inter HO)
IHIPG DELL 730 – 2	Live Video Viewer App for Tablet PC, App UHDTV	5.2.1 Transcoder VNF (NCSRD)	This is the VNF responsible for receiving a video streaming service and applying new coding parameters on the fly (i.e. transcoding process).	S5.2 NFV/SDN functions and structure	NCSRD, UBrunel, TH	Step 2: Sept 2018
IHIPG DELL 730 – 2 Video Player over UE	Application on client and server	5.3.1 Multiple Sources streaming (MSS) VNF (Joada)	A client-oriented service over the IHIPGW. Module that can transcode input video data into MS-ready video data in one or several qualities. Consists of 2 sub-modules: - 5.3.1a the MSS Server, - 5.3.1b the MSS Player over the UE	S5.9 Multi-Source Streaming over remote radio light head	Joada	Step 3: Dec 2018 (On Ethernet) Step 4: March 2019 (On RAN)

		5.4.1 4G/5G Control Plane VNF (UBrunel)	OpenStack realization. The Control Plane that was separated from the e/gNB Emulator in 4.1.3 is integrated into the SDN and a VNF	S5.5-6, S5.8 Outdoor Inter HO protocol flow for 4G/5G in home	TH, UBrunel	Step 4: March 2019 (NAS Registration) Step 6: Sept 2019 (Intra HO)
	L3 /L4	5.4.2 MNO EPC (UBrunel)	The EPC in 4.1.1 is integrated with the SDN	S5.7, S5.5 Outdoor inter HO protocol flow for 4G/5G in home	TH, UBrunel	Step 4: March 2019
IHIPG DELL 730 – 2 UE		5.4.3. Location based VNF (FhG)	Location estimation service running at CHDS server. It estimates positions of UEs according to VLC and mmW measurements of location relevant signal parameters (RSS, TDoA, ToA, etc.) These parameters will be obtained from RRLHs or UEs using a protocol similar to LPP (LTE positioning protocol) which will be defined by COB, REL, ISEP, FhG. The location estimates or information required for location estimates will be forwarded to database in SDN or an external server by a location application from which other applications can retrieve their positions). Intra Handover will monitor UE location and reroute packets the related RRLH.	S5.2 NFV/SDN functions and structure, S5.8	FhG, ISEP, NCSRD, UBrunel, TH	Step 4: March 2019

		5.4.4 Intra Handover (Brunel)	Once more than RRLH has been integrated into the Home Network then intra Handover can be tested	S1.3 Fig1.14-1.15, S2.6 SDN network architecture	TH, Brunel	Step 4: March 2019 (Intra HO)
		5.5.1 4G/5G User Plane VNF (UBrunel)	Connecting 4G/5G User Plane VNF to MNO EPC and to 4G/5G SDN FD Server to support inter HO in step 6	S5.5 Outdoor Handover protocol flow for 4G/5G in home	TH, UBrunel	Step 5: June 2019 (User Plane Communication) Step 6: Sept 2019 (Intra HO)
	L3/Application	5.5.2 Security Application (WUT)	Detection of various network attacks and network devices reconfiguration for mitigation of detected attacks. two main parts: - SDN application which interacts with the SDN controller for data gathering and reconfiguration for attacks mitigation - virtual machine which hosts web user panel used for configuration and access to log of the detected issues.	S5.10 Security scheme for IoRL	WUT, MTEK	Step 5: June 2019
	Application	5.6.1 (NCSRD) vCache	vCache is a VNF responsible for caching the edge of the network, close to the end-user, the most recently requested data for faster response and bandwidth usage reduction.	S5.2	NCSRD	Step 6: Sept 2019

		5.6.2 4G/5G Inter e/gNB Handover (UBrunel)	Once the User and Control plane VNFs have been integrated with the SDN then Inter handover can be tested	S5.5 Outdoor Handover protocol flow for 4G/5G in home, S5.8	TH, UBrunel	Step 6: Sept 2019

6 The Key Building Blocks in the Service Layer

Table 6—1: Key functional requirements and key building blocks for CHDCS and target implementation dates

Sub-System	Protocols (L1/L2/L3/Application)	Block (responsible)	Function	Cross reference with D2.2	Participants	Date
CHDCS	Application level	6.1.1a. CHDCS (UBrunel)	Interaction Server stores and processes images and data.	S1.3, S6.5 Interaction,	NCSRD, UBrunel, VT, ARC	Step 1: June 2018
UE	Application level	6.1.1b. UE (UBrunel)	An Interaction application on the UE that access and retrieves images and data stored on virtual and physical interaction server	S6.5 Interaction	UBrunel	Step 1: June 2018
CHDCS UE	Application level	6.2.1a. CHDCS (Joada) 6.2.1b (Joada)	Stream Server that streams AV of different formats e.g. UHDTV, 360 video Stream Server that streams AV of different formats e.g. UHDTV, 360 video	S6.2 Streaming	Joada, UBrunel	Step 2: Sept 2018 (AV from stream server) Step 3: Dec 2018 (VR Headset, live camera)
UE	Application	6.3.1a. UE (Joada) 6.3.1b UE	Stream Server that streams AV of different formats e.g. UHDTV, 360 video	6.2 Streaming	Joada, UBrunel	Step2: Sep 2018 (AV from stream server)
CHDCS	Application level	6.4.1a CHDCS (UBrunel)	A server that provides data depending on location. Indoor Location Based Data Access Server.	S6.3 Indoor Location Based Data Access, S7.1, S7.2	UBrunel, FhG, COB, ISEP, WUT	Step 4: Mar 2019

UE	Application level	6.4.1b. UE (UBrunel)	An Indoor Location Based Data Access application on the UE that access data stored on virtual and physical interaction server based on its location	S6.3 Indoor Location Based Data Access	UBrunel	Step 4: Mar 2019
CHDCS	Application level	6.5.1a. CHDCS (UBrunel)	Indoor Location Monitoring **and Guiding** Server that provides maps and routes and guides UEs depending on location. It also records UE movements.	S6.4 Indoor Location Monitoring and Guiding	UBrunel	Step 5: June 2019
UE	Application level	6.5.1b. UE (UBrunel)	Indoor Location Monitoring **and Guiding** application that presents maps and routes and guides UEs depending on location. It also views records UE movements.	S6.4 Indoor Location Monitoring and Guiding, S7	UBrunel	Step 5: June 2019

7 Remote Relay Light Head Hardware (HIT) and user equipment hardware

Hardware – June 2019

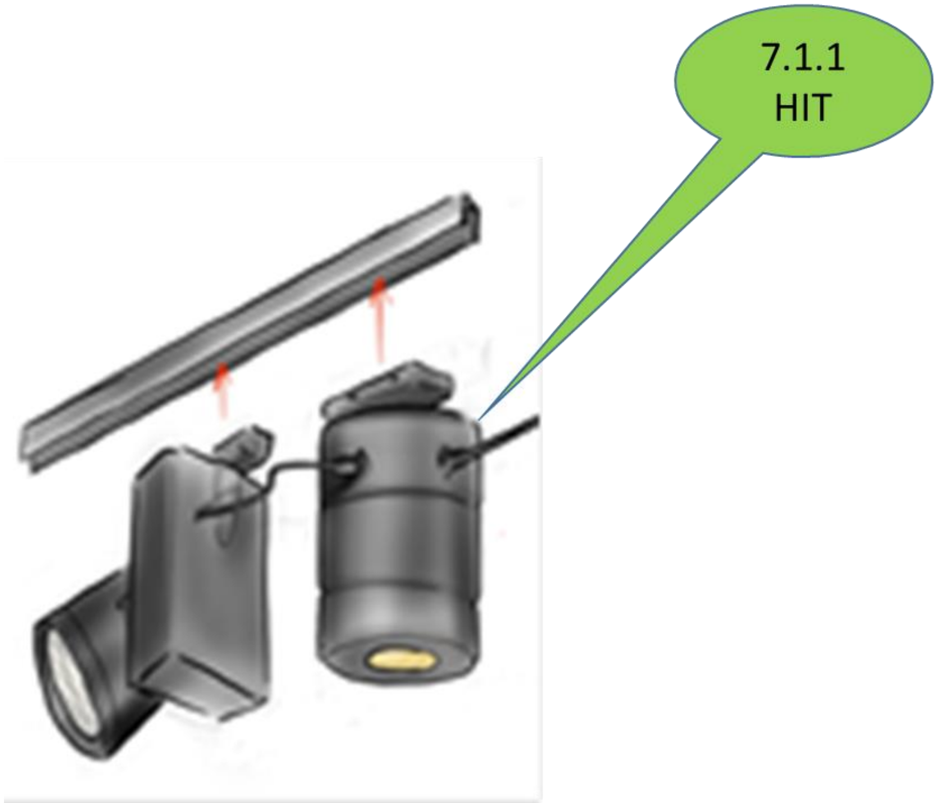

Figure 7-1: Design and build external torch 40GHz mmW device and integrate into spot light

Hardware – March 2019

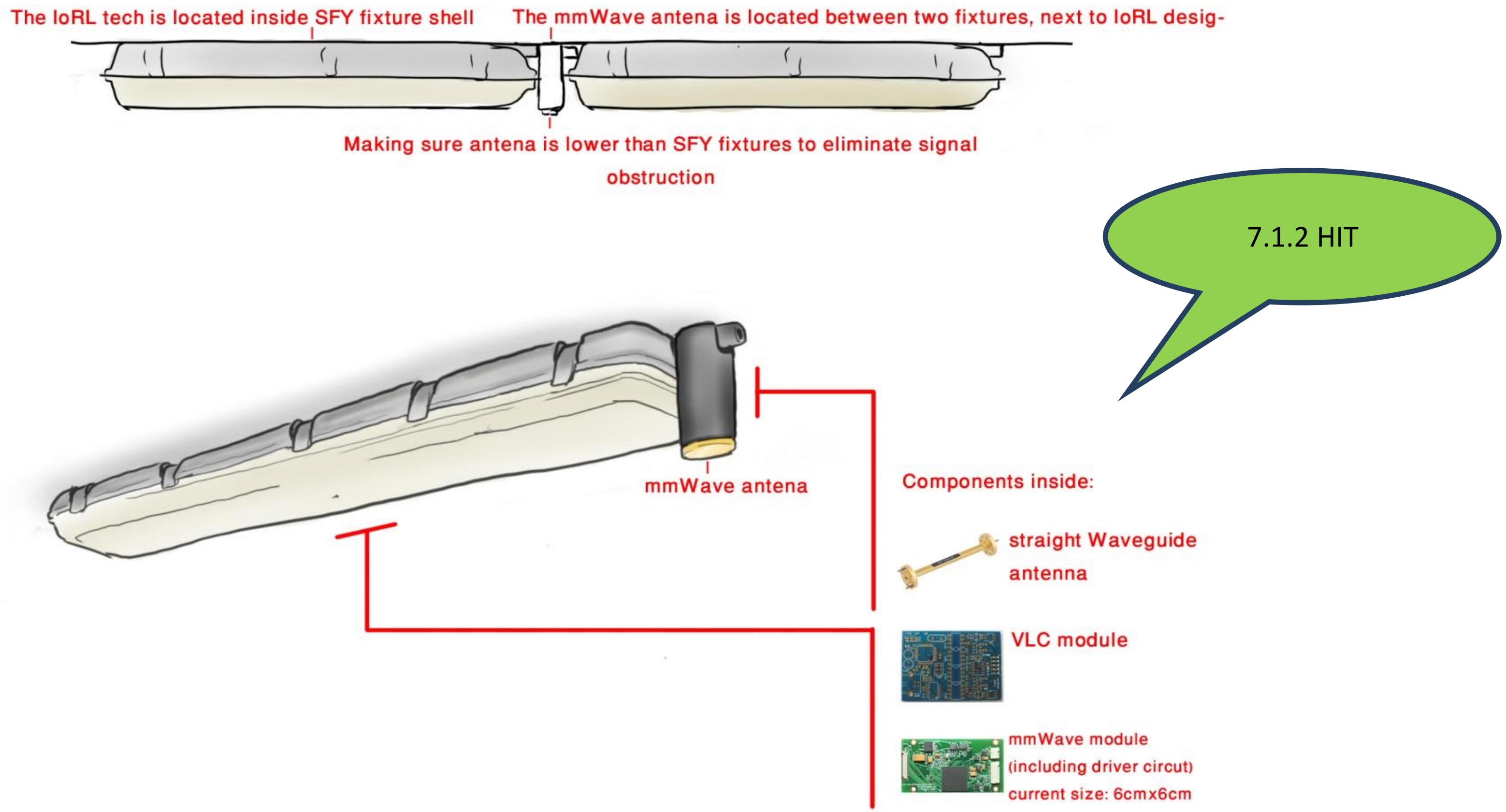

Figure 7-2: Design and build external torch 40GHz mmW device and integrate into strip light

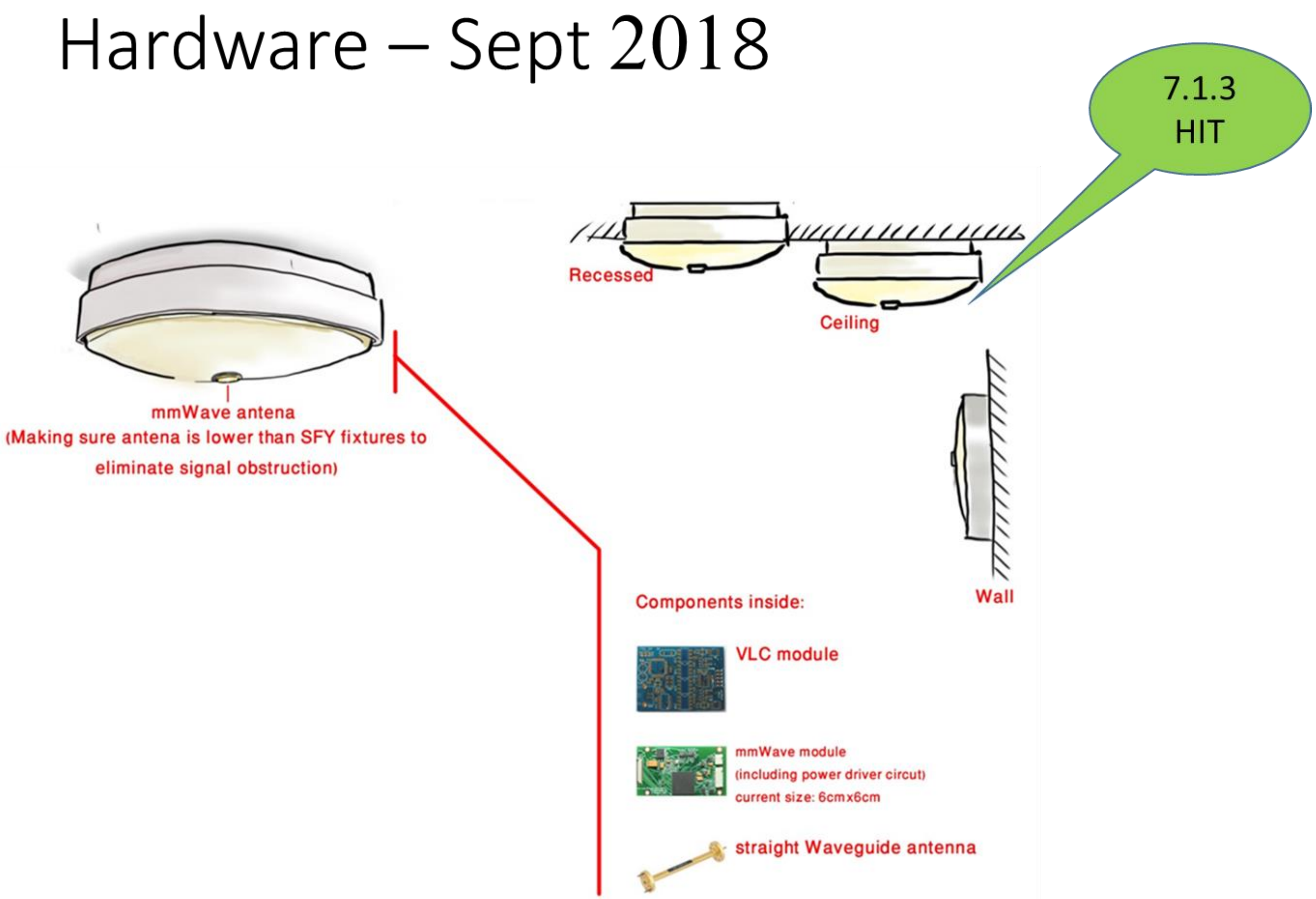

Figure 7-3: Design and build integrated 60GHz mmW into Cassini light

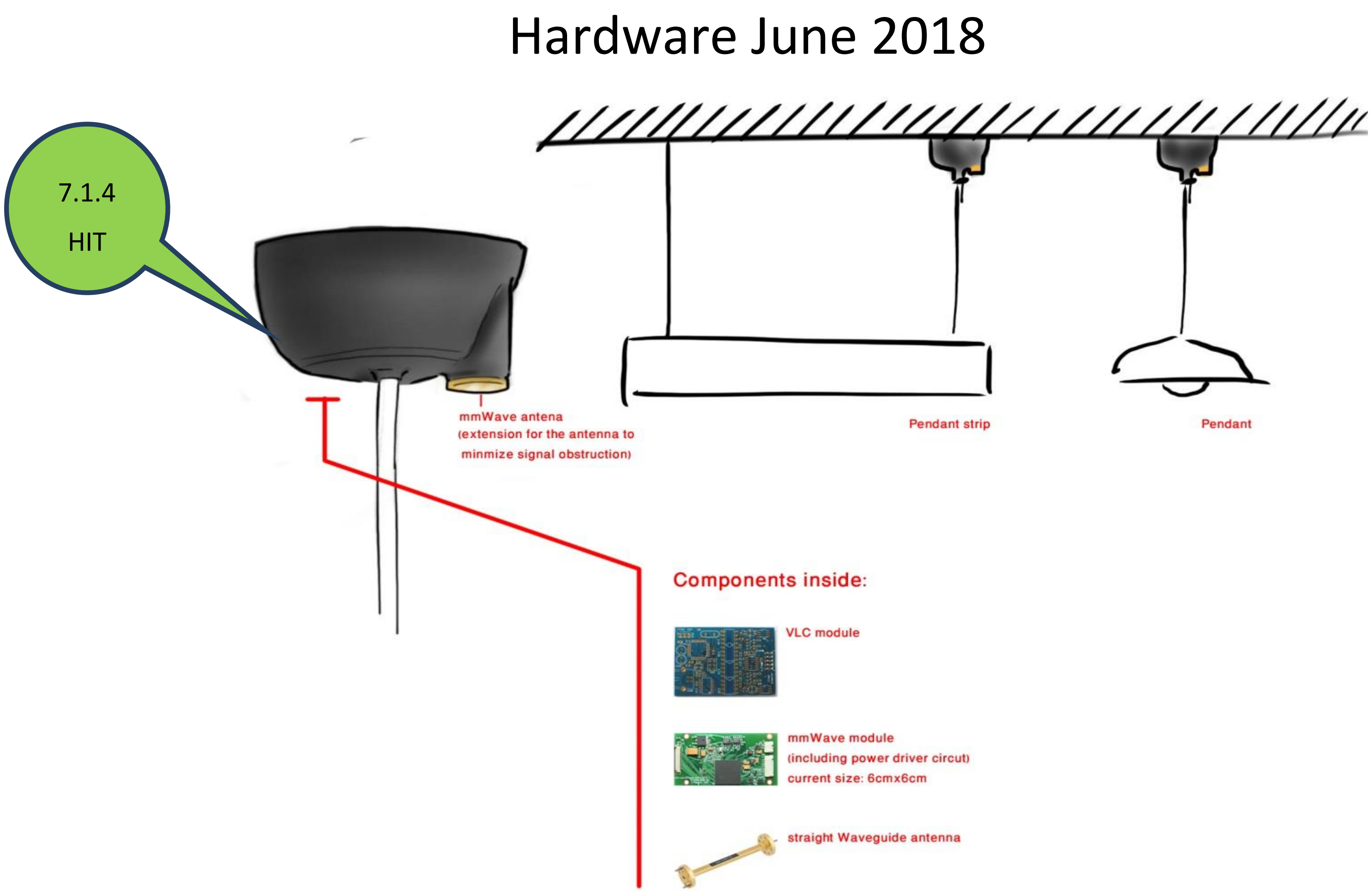

Figure 7-4: Design and build integrated 60 GHz mmW and VLC into pendant light rose

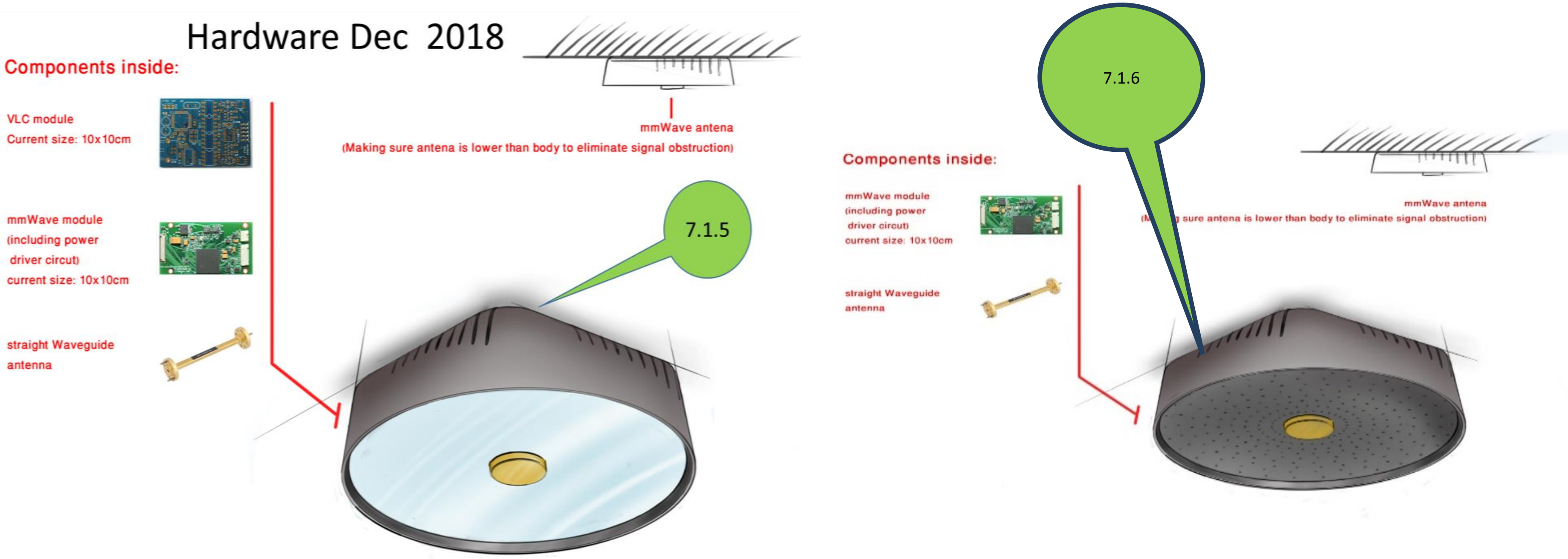

Figure 7-5: Design and build mmW and VLC independent transmitter unit (7.1.5 – VLC with 60GHz mmW, 7.1.6 , with 60GHz, to be modified to contain VLC)

Figure 7-6: Design and build trolley for portable UE

Table 7—1: Key blocks and system functional requirements for lighting system electro-mechanical architecture

	Scenario	Block and responsible Task Leader – HIT	Functions Description	Cross reference with D2.2	Participants	Date
7.1.1	RRLH 1 - Beacon LED MUSE II	HIT	Design external torch 40GHz mmW and integrate into	S8.4.1 Museums	HIT, UBrunel, SFY, FhG, TH	June 2018
7.1.2	RRLH 2 - MSF791	HIT	Continuous light (in tunnel) and 40GHz mmW	S8.4.2 Tunnel	HIT, UBrunel, SFY, FhG, TH	March 2019
7.1.3	RRLH 3 – Cassini Radius LED	HIT	Ceiling, wall and outdoor light, designed to support 60GHz mmW	S8.4.4 Home Recessed and ceiling	HIT, UBrunel, SFY, FhG, TH	Sept 2018
7.1.4	RRLH 4 - Light rose	HIT	Light roses for pendant lights designed to support 60GHz mmW	S8.4.3 Home light rose	HIT, UBrunel, SFY, FhG, TH	June 2018
7.1.5	Accessory 1	BRUNEL	60GHz mmW and VLC independent transmitter unit		HIT, UBrunel, SFY, FhG, TH	Dec 2018
7.1.6	Accessory 2	BRUNEL	60Ghz mmWave independent transmitter unit w/o VLC		HIT, UBrunel, FhG	Dec 2018
7.1.7	5G Trolley	HIT	40GHz mmW Kiosk for museum and mobile station	S9.3.1 Museum scenario kiosk station production	HIT, UBrunel, TH, FhG, OLED	Sept 2019
7.1.8	5G Backpack	BRUNEL	5G backpack for places you cannot use the trolley	S6.2	UBrunel, FhG, OLED	June 2019
	General remarks	It is preferred to develop light rose that can house the IoRL technology, so LED drivers are placed inside the light rose. However, mmW antenna should be outside the housing. Thus, special covering is required and will be designed.				

8 Summary of the Plans

The benchtop demonstrators are going to be built in:

- Home testbed – Cobham
- Museum – ISEP
- Tunnel – Brunel
- Supermarket - TH

The following subset will be built:

8.1 Home testbed – Cobham

Figure 8-1 illustrates the minimum implementation that should be built to estimate location, which uses three Surface Lights in one coverage area and three Pendant lights in a second coverage area and also perform Intra building handover between two RRLH coverage areas. This scenario tests the ability of Surface and Pendant Lights to estimate location given their different radiation patterns. It also tests the ability of the mmWave to estimate location as compared to estimating location from different types of visible light sources.

Additional Surface and Pendant Lights will be added for scaling to target demos depending on budget availability

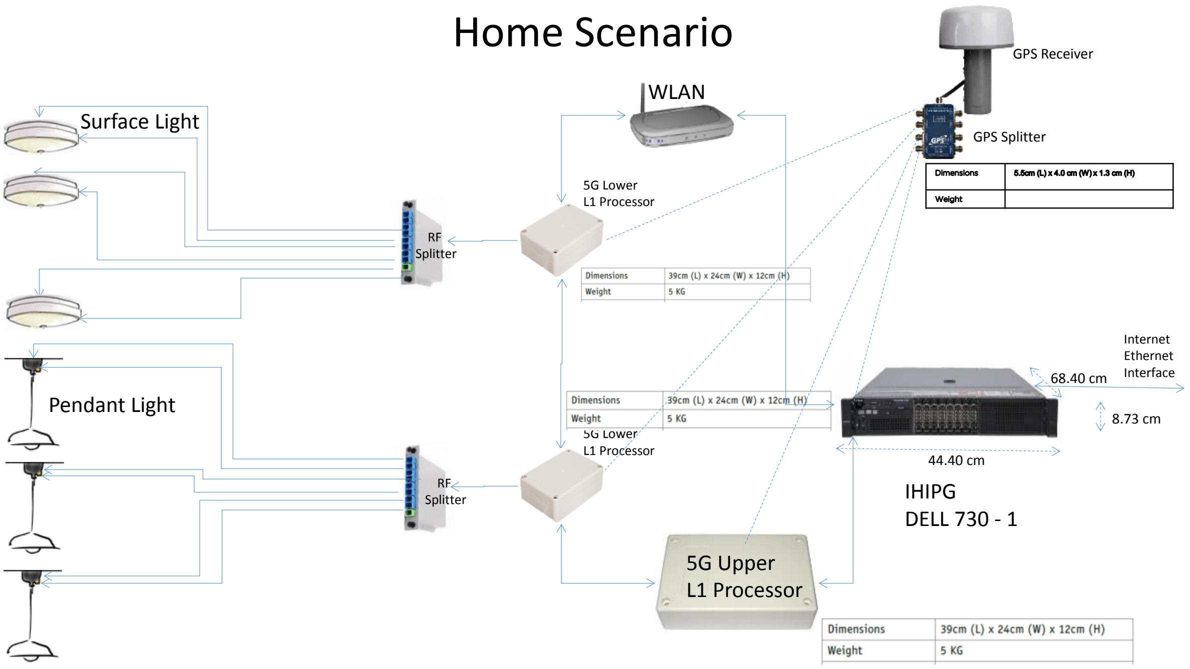

Figure 8-1: Minimum Home Scenario Implementation

8.2 Museum – ISEP

Figure 8-2 illustrates the minimum implementation that should be built to estimate location, which uses three Spot Lights in one coverage area and three Spot lights in a second coverage area and also perform Intra building handover between two RRLH coverage areas. This scenario tests the ability of Spot Lights to estimate location given the high directivity of the light radiation pattern. It also tests the ability of the mmWave to estimate location as compared to estimating location from different types of visible light sources.

Additional Spot Lights will be added for scaling to target demos depending on budget availability.

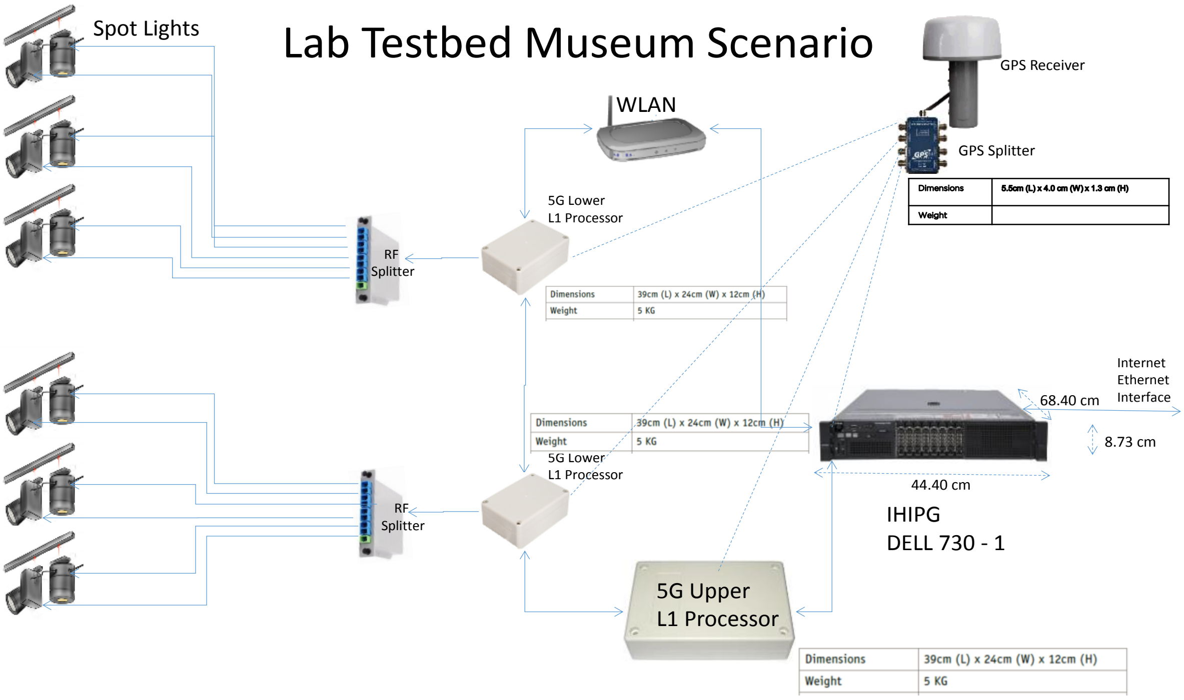

Figure 8-2: Minimum Museum Scenario Implementation

8.3 Tunnel – Brunel

Figure 8-3 illustrates the minimum implementation that should be built to estimate location, which uses three mmWave Torches in one coverage area and three Strip lights in a second coverage area and also perform Intra building handover between two RRLH coverage areas. This scenario tests the ability of Strip Lights to estimate location given the extended length of the light radiation points and pattern. It also tests the ability of the mmWave to estimate location as compared to estimating location from different types of visible light sources.

Additional Strip Lights will be added for scaling to target demos depending on budget availability.

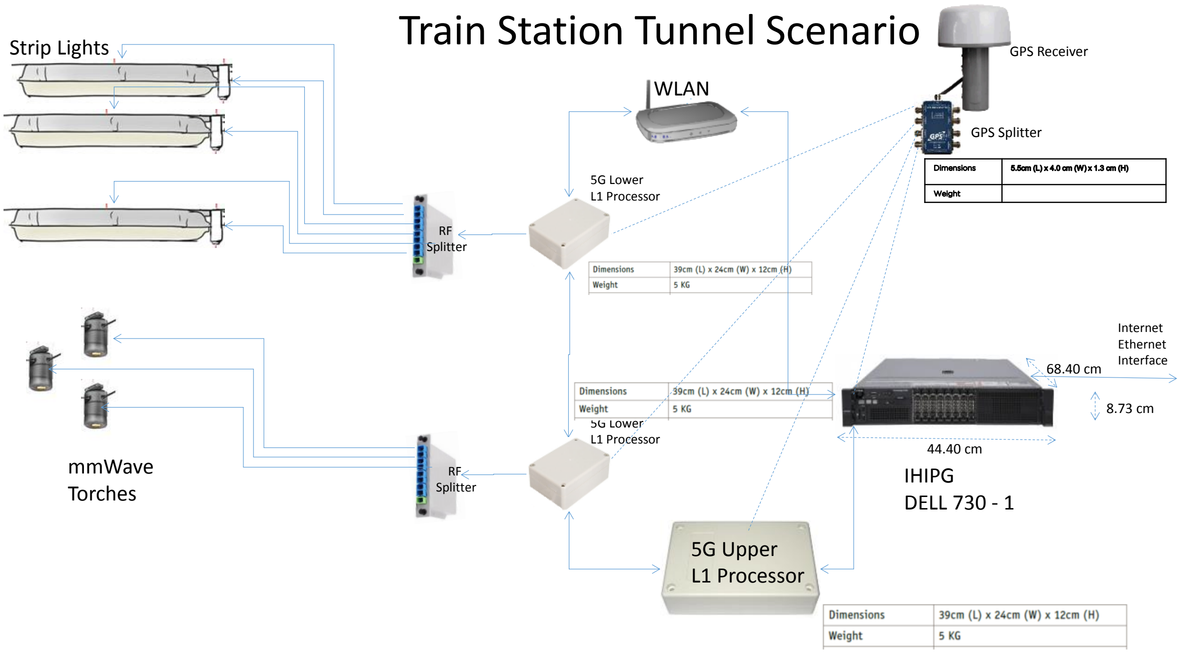

Figure 8-3: Minimum Train Station Implementation

8.4 Supermarket - TH

Figure 8-4 illustrates the minimum implementation that should be built to estimate location, which uses three Strip Lights in one coverage area and three Strip lights in a second coverage area and also perform Intra building handover between two RRLH coverage areas. This scenario tests the ability of Strip Lights to estimate location given the extended length of the light radiation points and pattern. It also tests the ability of the mmWave to estimate location as compared to estimating location from different types of visible light sources.

Additional Strip Lights will be added for scaling to target demos depending on budget availability.

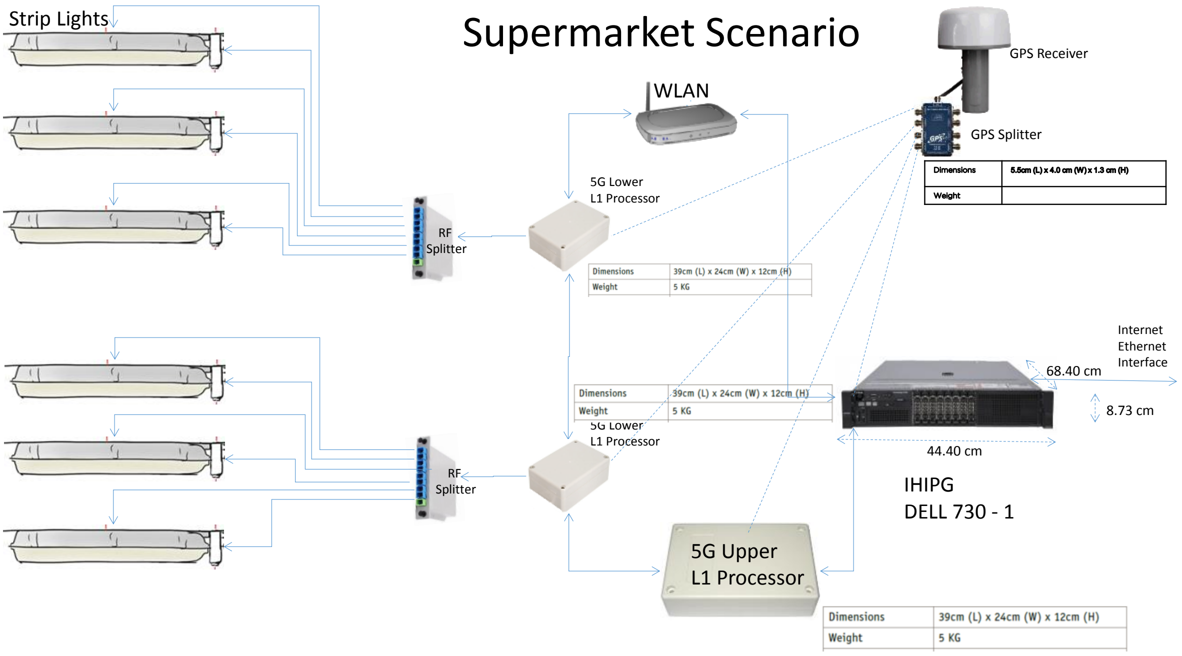

Figure 8-4: Minimum Supermarket Implementation

The resultant inventory list for benchtop demonstrators is provided in Table 8—1:

Table 8—1: Inventory list for benchtop demonstrators

	Home	Museum	Train Station Tunnel	Supermarket	Total
IHIPG – Dell 730 -1	1	1	1	1	4
5G Upper L1 Processor box	1	1	1	1	4
5G Lower L1 Processor box	2	2	2	2	8
RF Splitters	2	2	2	2	8
Spot Lights		6			6
Strip Lights			3	6	9
mmWave torches			3		3
Pendant Strip lights	0				0
Pendant lights	3				3
Surface Lights	3				3

