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# 5G EVE

**5G European Validation platform for Extensive trials**

**Deliverable D5.3**

**Testing environmental conditions document  
with first version of testing and validation  
suite**

### ***Project Details***

<b><i>Call</i></b>	H2020-ICT-17-2018
<b><i>Type of Action</i></b>	RIA
<b><i>Project start date</i></b>	01/07/2018
<b><i>Duration</i></b>	36 months
<b><i>GA No</i></b>	815074

### ***Deliverable Details***

<b><i>Deliverable WP:</i></b>	WP5
<b><i>Deliverable Task:</i></b>	Tasks T5.3/T5.4
<b><i>Deliverable Identifier:</i></b>	5GEVE_D5.3
<b><i>Deliverable Title:</i></b>	Testing environmental conditions document with first version of testing and validation suite
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<b><i>Contractual Date of Delivery:</i></b>	30/06/2020
<b><i>Submission Date:</i></b>	29/06/2020
<b><i>Dissemination Level:</i></b>	PU
<b><i>Status:</i></b>	Final
<b><i>Version:</i></b>	1.0
<b><i>File Name:</i></b>	5GEVE_D5.3_Final

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### *Deliverable History*

<b>Version</b>	<b>Date</b>	<b>Modification</b>	<b>Modified by</b>
<i>v0.1</i>	<i>03/04/2020</i>	<i>ToC proposal</i>	<i>Claudio Casetti</i>
<i>v0.1</i>	<i>01/06/2020</i>	<i>First draft Sec. 1-3</i>	<i>Claudio Casetti</i>
<i>v0.2</i>	<i>08/06/2020</i>	<i>First draft Sec. 4</i>	<i>Juan Rodrigues Martin</i>
<i>v0.5</i>	<i>09/06/2020</i>	<i>Full draft for review</i>	<i>Claudio Casetti</i>
<i>v0.7</i>	<i>16/06/2020</i>	<i>Internal Review</i>	<i>Giada Landi, Juan Rodriguez Martinez</i>
<i>v0.8</i>	<i>22/06/2020</i>	<i>External Review</i>	<i>Marco Molla, Emil Kowalczyk</i>
<i>v0.9</i>	<i>23/06/2020</i>	<i>Final Version Candidate</i>	<i>Claudio Casetti</i>
<i>v1.0</i>	<i>28/06/2020</i>	<i>QA review</i>	<i>Kostas Trichias</i>

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## List of Acronyms and Abbreviations

<b><i>Acronym</i></b>	<b><i>Meaning</i></b>
<b><i>AMQP</i></b>	Advanced Message Queuing Protocol
<b><i>API</i></b>	Application Programming Interface
<b><i>BBU</i></b>	Base Band Unit
<b><i>CP</i></b>	Cyclic Prefix
<b><i>CPE</i></b>	Customer Premise Equipment
<b><i>DB</i></b>	Database
<b><i>DHCP</i></b>	Dynamic Host Configuration Protocol
<b><i>DL</i></b>	Downlink
<b><i>E2E</i></b>	End-to-end
<b><i>eMBB</i></b>	Enhanced Mobile Broadband
<b><i>eNB</i></b>	Enhanced Node B
<b><i>EPC</i></b>	Evolved Packet Core
<b><i>FDD</i></b>	Frequency Division Duplex
<b><i>gNB</i></b>	Next Generation Node B
<b><i>GPS</i></b>	Global Positioning System
<b><i>GUI</i></b>	Graphical User Interface
<b><i>HTTP</i></b>	Hypertext Transfer Protocol
<b><i>ICMP</i></b>	Internet Control Message Protocol
<b><i>IP</i></b>	Internet Protocol
<b><i>IWL</i></b>	Interworking Layer
<b><i>KPI</i></b>	Key Performance Indicator
<b><i>LOS</i></b>	Line of Sight
<b><i>MAC</i></b>	Medium Access Control
<b><i>MIMO</i></b>	Multiple Input Multiple Output
<b><i>NFV</i></b>	Network Functions Virtualization
<b><i>NG-RAN</i></b>	Next Generation Radio Access Network
<b><i>NLOS</i></b>	Non Line of Sight
<b><i>NR</i></b>	New Radio
<b><i>QoE</i></b>	Quality of Experience
<b><i>QoS</i></b>	Quality of Service
<b><i>RAN</i></b>	Radio Access Network
<b><i>RRU</i></b>	Remote Radio Unit
<b><i>RTSP</i></b>	Real Time Streaming Protocol
<b><i>RTT</i></b>	Round Trip Time
<b><i>SDR</i></b>	Software Defined Radio
<b><i>SIM</i></b>	Subscriber Identity Module
<b><i>SSH</i></b>	Secure Shell
<b><i>TCP</i></b>	Transmission Control Protocol
<b><i>TDD</i></b>	Time Division Duplex
<b><i>TM</i></b>	Transmission Mode
<b><i>UE</i></b>	User Equipment
<b><i>UL</i></b>	Uplink
<b><i>UP</i></b>	User Plane
<b><i>URLLC</i></b>	Ultra-Reliable Low-Latency Communication
<b><i>USRP</i></b>	Universal Software Radio Peripheral
<b><i>UDP</i></b>	User Datagram Protocol
<b><i>vEPC</i></b>	Virtualized Evolved Packet Core
<b><i>VM</i></b>	Virtual Machine

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## Executive Summary

The main goal of this deliverable is to present results of an analytical survey of the necessary environmental conditions for testing and evaluation of the various 5G features and technologies of the site facilities, collected by polling the individual site managers. For each of the four 5G EVE sites, the document lists the tools used to generate traffic and to set up controllable, scalable, synthetic and near to realistic IP traffic needed for testing. Specifically, generators of test traffic or background traffic (types of higher-layer protocols that could be emulated or whose traffic can be synthetically generated) and whether they were to be used only in lab or in field testing as well. Next, the types of measurements are listed, which could be carried out within the facility as far as the propagation environment is concerned, addressing both indoors and outdoors cases. Finally, for each site, the document provides information regarding the configuration that is available at the site either for the network or for the test devices.

Additionally, this deliverable presents the first version of the testing, validation, and benchmarking tools, delivered as a suite for integration to the site facilities. Specifically, it includes some testing scripts that permit measuring 5G network KPIs such as speed, broadband connectivity and latency.

# 1 Introduction

One of the aims of the 5G EVE project is the delivery of a comprehensive testing and validation framework for Verticals, allowing them to plan, create and deploy their experiments and validate their services. Functional to this goal is the development of a set of testing and validation tools that are available at each of the four sites of the 5G EVE project. This deliverable summarizes the activities that were carried out in WP5 as relates to Task 5.2 and, at least until M24, to Task 5.3.

Recall that Task 5.2 aimed at identifying the necessary environmental conditions for testing and evaluation of the various 5G features and technologies of the site facilities, aiming to use the appropriate settings depending on the system under test and per 5G technology. In this spirit, the first part of this deliverable presents an analytical survey of the necessary environmental conditions for testing and evaluation of the various 5G features and technologies of the site facilities, collected by polling the individual site managers. The aim is to facilitate experiment isolation per experimenter and test, and guarantee the reproducibility and repeatability of the tests by selecting the appropriate 5G EVE site where the experiment should be conducted. The responses have allowed the accurate description of the testing capabilities of each site, highlighting, for indoor and outdoor components, the network configuration, the environmental configuration, such as the propagation conditions, and the device configuration. For each site, the availability of traffic generation tools and related protocols was also examined. Special attention was dedicated to the coherence of the environment of each testing location, allowing experimenters to match the test pre-conditions to the deployment scenario available at each site.

Task 5.3 has the goal of driving the implementation of the functional testing, validation and benchmarking methodologies and tools. Based on the high-level architecture of the monitoring & KPI collection framework described in Deliverable D1.4 and inputs from various standardization and technical bodies, testing procedures are being set up to enable the evaluation of the 5G technologies in various test cases. The methodology and tools designed and developed in this task will enable the functional testing of new features and technologies during site facility upgrades and the validation of 5G capabilities for real vertical industry applications. The developed methods and tools will also allow for the cross-comparison (benchmarking) of 5G technologies to each other, in specified test cases and potentially under various configurations, which will provide insights into the trade-offs of each technology/component and will progress the fine tuning of technologies per use case. The second part of this deliverable will thus present the first version of all the testing, validation, and benchmarking tools, delivered as a suite for integration to the site facilities. Specifically, it includes some testing scripts that permit measuring KPIs such as speed, broadband connectivity and latency.

## 2 Environment Conditions Settings

In order to collect the data for this deliverable, a survey was circulated among the managers of the four sites of 5G EVE. Site managers were asked to provide information regarding the available facilities at their sites, possibly splitting such information if more than one location at each site was available. Usually different locations have different equipment and they are devoted to the testing of different network segments such as access networks, core networks, or UE emulation.

### 2.1 Traffic and Scenario Generators

This part of the survey is intended to list the tools used to generate traffic and to set up controllable, scalable, synthetic and near to realistic IP traffic needed for testing. Traffic generators usually produce traffic loads in a controlled test-bed environment, or scenario, where some sources and destinations are present. The survey will discriminate between different types of scenarios.

As far as traffic generators are concerned, the survey asked site managers to report generators of test traffic or background traffic and specify whether they were to be used only in lab or in field testing as well. A choice between traffic that could be used for different use cases (eMBB, URLLC or MMTC) was presented, with the option of narrowing the choice down to specific Quality of Experience (QoE) service categories (here Virtual Reality, Augmented Reality, Gaming, non-live Streaming, Live Streaming, Social networking, High Speed Internet, Patient monitoring, Emergency services, Smart metering, Smart Grids or Connected vehicles). Site managers could also add information about the types of higher-layer protocols that could be emulated or whose traffic can be synthetically generated (e.g., TPC, UDP, HTTP, RTSP, AMQP etc.). Finally, it was asked whether the traffic generator only produced specific traffic or could also emulate traffic affected by particular radio-channel or operational conditions, with choices between traffic affected by fading/shadowing or by handover.

Regarding scenarios, the broad choices were taken between indoor and outdoor scenarios, and, more specifically among the different situations that presented themselves in these two categories. Namely, indoor coverage was articulated in office space, commercial mall, or other scenarios such as lab environments. Outdoors coverage was articulated in dense urban, urban macro, rural low speed and rural high speed. If Indoor scenarios were available at the site, site managers were asked to specify the number of cells as well as the number of test UEs. Further choice was among the type of cell mobility that could be tested: intra-cell, inter-cell, that is between gNB and gNB, or inter-RAT, that is between an eNB and a gNB.

### 2.2 Propagation environment

The survey then asked site managers to describe the type of measurements that could be carried out within the facility as far as the propagation environment was concerned. For example, whether an anechoic chamber was available if the measurements were done indoors or what was the propagation expected to be like if the test site was outdoors. In either case, it was asked to specify whether the propagation conditions allowed communication in Line Of Sight (LOS) or Not in Line Of Sight (NLOS). A further choice was given to specify whether the cell topologies were stand alone or it was expected to have a multi cell continuous coverage. Finally, just for the case of outdoor coverage, site managers could indicate weather tests could be run with a mix of outdoors to indoors coverage.

### 2.3 Network and device configuration

Finally, the survey asked site managers to provide information regarding the configuration that was available either for the network or for the test devices. The carrier frequency bands were one of the parameters for which site managers were to indicate different bands. In view of a better description of the equipment available at each site, site managers were asked to indicate the number of baseband and RF modules as well as the number of carriers that could be used. Further details could be provided, such as subcarrier spacing, slot length, Cyclic Prefix (CP) length, in case they were different than the default values. TDD/FDD mode and duplex mode were also options that could be indicated. The channel bandwidth could be specified as well as the range of output

power. Antenna parameters such as MIMO rank capabilities and beamforming capabilities, along with specific antenna patterns and antenna elements could be provided.

At the end of survey, the site managers were then asked to indicate the number of terminals available at each site with the associated capabilities, namely whether they had a screen or not, whether they had adjustable receiver sensitivity, and whether transmit power control was possible.

### 3 Mapping of environment conditions in 5G EVE sites

The results of the survey among site managers are reported below. For each 5G EVE site, the environmental condition settings available at given site are reported, mostly in a convenient, easily browsable tabular form.

#### 3.1 French Site

The 5G EVE French test site is structured in four locations: Paris Châtillon – Orange Gardens, Paris Saclay – Nokia, Rennes and Sophia Antipolis. It is to be pointed out that the Rennes and Sophia Antipolis locations capabilities are comprised under the Paris Châtillon description.

##### 3.1.1 Paris Châtillon – Orange Gardens – Rennes – Sophia Antipolis

Testing on these locations will generate traffic by real video 360° source for the eMBB service and also by test traffic for the URLLC service provided by EDF emulating the behavior of electricity routing. Further information on the traffic generators and user emulation tools are summarized below in Table 1.

**Table 1: French site 1 - Traffic generators and user emulation tools**

Traffic Generators and user emulation tools	
<b>Context</b>	Lab, Field Testing
<b>Use Categories</b>	eMBB, URLLC
<b>Service Categories</b>	Virtual Reality, Smart Grids
<b>Traffic Type</b>	TCP, UDP, RTCP, HTTP
<b>Traffic Conditions</b>	Ideal

Both indoor and outdoor scenarios can be tested. The indoor scenario emulates office space in a typical LOS propagation environment with a stand-alone cell, while the outdoor scenario is represented by one stand-alone cell of 500m cell radius in Orange premises environment with NLOS propagation.

Table 2 below summarizes the setting for the indoor scenario:

**Table 2: French site 1 - Indoor Scenario configuration**

Indoor Scenario configuration	
<b>Number of Cells</b>	1
<b>Number of Test UEs</b>	1 first for video 360° that can be extended to 4
<b>Cell Mobility</b>	Intra-cell
<b>Propagation Conditions</b>	LOS
<b>Cell Topologies</b>	Stand-alone

Table 3 summarizes the setting for the outdoor scenario:

**Table 3: French site 1 - Outdoor Scenario configuration**

Outdoor Scenario configuration	
<b>Number of Cells</b>	1
<b>Number of Test UEs</b>	1 first for video 360° that can be extended to 4
<b>Cell Mobility</b>	Intra-cell

<b>Propagation Conditions</b>	NLOS
<b>Cell Topologies</b>	Stand-alone

The parameters that can be configured in the gNB are summarized in Table 4.

**Table 4: French site 1 - gNB parameters**

<b>gNB parameters</b>	
<b>Carrier Frequency Bands</b>	B38 - B78 - B68 - B14 - B42
<b>Number of baseband and RF modules</b>	From 1 to 8
<b>Subcarrier spacing</b>	15 kHz (4G), 30 kHz (5G FR1 main BWP), 120 kHz (5G FR1 2 <sup>nd</sup> BWP)
<b>Slot length</b>	0.5 ms (4G and 5G main BWP), 0.125 ms (5G 2 <sup>nd</sup> BWP)
<b>CP length</b>	Normal for both
<b>TDD/FDD mode</b>	Both depending on the frequency band used
<b>Bandwidth</b>	From 3 MHz to 100 MHz
<b>Output power</b>	46 dBm (5G FR1), 46 dBm (4G B38), 43 dBm (4G B14/68)
<b>Frame structure</b>	TDD Config 1 (4G TDD), 6 DL, 3 UL, 1 Flexible (5G TDD)
<b>MIMO rank capability</b>	2 Layer 4G and 5G
<b>Beamforming capability</b>	TM 7/8 4G, 8 beams 5G
<b>Antenna patterns</b>	Single 65deg sector, 17 dBi gain, all bands
<b>Antenna elements</b>	4 4G, 16 5G

The site will use more than 10 UEs with 4G capabilities and at least 4 with 5G capabilities, all equipped with screen. 4 USRP N300 with high-end laptops will also be used.

### 3.1.2 Paris Saclay – Nokia

The Paris Saclay - Nokia site facility will have a similar test setup for traffic generation as the one specified for the Paris Châtillon site (video 360° source for the eMBB service). Further information on the traffic generators and user emulation tools are summarized below in Table 5.

**Table 5: French site 2 - Traffic Generators and user emulation tools**

<b>Traffic Generators and user emulation tools</b>	
<b>Context</b>	Lab, Field Testing
<b>Use Categories</b>	eMBB, URLLC
<b>Service Categories</b>	Virtual Reality, Augmented Reality, Smart Grids
<b>Traffic Type</b>	TCP, UDP, HTTP
<b>Traffic Conditions</b>	Ideal and Traffic affected by fading/shadowing

Both indoor and outdoor scenarios can be tested. The indoor scenario emulates office space in a typical LOS propagation environment with a stand-alone cell, while the outdoor scenario is represented by one stand-alone cell of 500m cell radius in Nokia premises environment with NLOS propagation.

Table 6 below summarizes the setting for the indoor scenario:

**Table 6: French site 2 - Indoor Scenario configuration**

Indoor Scenario configuration	
Number of Cells	1
Number of Test UEs	1 first for video 360° that can be extended to 4
Cell Mobility	Intra-cell
Propagation Conditions	LOS
Cell Topologies	Stand-alone

Table 7 summarizes the setting for the outdoor scenario:

**Table 7: French site 2 - Outdoor Scenario configuration**

Outdoor Scenario configuration	
Number of Cells	1
Number of Test UEs	1 first for video 360° that can be extended to 4
Cell Mobility	Intra-cell
Propagation Conditions	LOS/NLOS
Cell Topologies	Stand-alone

The parameters that can be configured in the gNB are summarized in Table 8.

**Table 8: French site 2 - gNB parameters**

gNB parameters	
Carrier Frequency Bands	n78 for 5G and B28 for 4G
Number of baseband and RF modules	5G : 4BB + 4 RU; 4G: 1 BBU + 3 RRH
Number of carriers	One 5G and one 4G
Subcarrier spacing	1 4G + 1 5G
Bandwidth	10 MHz for 4G and 100 MHz for 5G
Duplex mode	TDD
MIMO rank capability	4

## 3.2 Greek Site

The 5G EVE Greek test site is structured in two locations, both at the Athens - OTE Academy indoors facilities, where two different segments are under test, the one equipped by Nokia, the other equipped by Ericsson. They are both targeting indoor testing.

### 3.2.1 Athens OTE Academy – Nokia Segment

Information on the traffic generators and user emulation tools are summarized below in Table 9.

**Table 9: Greek site 1 - Traffic Generators and user emulation tools**

Traffic Generators and user emulation tools
---

<b>Context</b>	Lab
<b>Use Categories</b>	URLLC
<b>Service Categories</b>	Live Streaming, Patient monitoring, Emergency Services, Smart Monitoring
<b>Traffic Type</b>	TCP, UDP
<b>Traffic Conditions</b>	Ideal

Table 10 summarizes the setting for the indoor scenario, emulating office space:

**Table 10: Greek site 1 - Indoor Scenario configuration**

Indoor Scenario configuration	
<b>Number of Cells</b>	1
<b>Number of Test UEs</b>	8
<b>Cell Mobility</b>	Intra-Cell
<b>Propagation Conditions</b>	NLOS
<b>Cell Topologies</b>	Stand-alone

No gNB parameters are available. The site has 8 terminals (UEs) without screen that can be used for testing purposes.

### 3.2.2 Athens OTE Academy – Ericsson Segment

Information on the traffic generators and user emulation tools are summarized below in Table 11.

**Table 11: Greek site 2 - Traffic Generators and user emulation tools**

Traffic Generators and user emulation tools	
<b>Context</b>	Lab
<b>Use Categories</b>	URLLC
<b>Service Categories</b>	Connected Vehicles, industrial enterprise URLLC applications
<b>Traffic Type</b>	TCP, UDP
<b>Traffic Conditions</b>	Ideal

Table 12 summarizes the setting for the indoor scenario, emulating office space and a logistic use case in a warehouse facility:

**Table 12: Greek site 2 - Indoor Scenario configuration**

Indoor Scenario configuration	
<b>Number of Cells</b>	1
<b>Number of Test UEs</b>	1
<b>Cell Mobility</b>	Intra-Cell, Inter-RAT
<b>Propagation Conditions</b>	LOS
<b>Cell Topologies</b>	Stand-alone

The parameters that can be configured in the gNB are summarized in Table 13 below.

**Table 13: Greek site 2 - gNB parameters**

gNB parameters	
<b>Carrier Frequency Bands</b>	eNB B7(=2600MHz), gNB n78 (3400-3800MHz)
<b>Number of baseband and RF modules</b>	2x Baseband units and 2x RF modules (RDS)
<b>Number of carriers</b>	single LTE carrier and single NR carrier
<b>Subcarrier spacing</b>	15 KHz for LTE, 30 KHz for NR
<b>Slot length</b>	LTE=1 ms, NR=0.5 ms
<b>CP length</b>	LTE=4.69 $\mu$ sec, NR=2.34 $\mu$ sec
<b>TDD/FDD mode</b>	LTE in FDD, NR in TDD
<b>Bandwidth</b>	LTE=20 MHz, NR=100 MHz
<b>Output power</b>	LTE=2x50 mW, NR=4x250 mW
<b>Duplex mode</b>	LTE in FDD, NR in TDD
<b>Frame structure</b>	LTE 20+20 MHz (UL/DL), NR DDSU
<b>MIMO rank capability</b>	LTE MIMO 2x2, NR MIMO 4x4
<b>Beamforming capability</b>	LTE & NR SU-MIMO (no beamforming)
<b>Antenna elements</b>	LTE& NR active indoor antenna

### 3.3 Italian Site

The 5G EVE Italian test site is structured in three locations, all in the city of Torino, two of which are indoors (although they can emulate outdoor testing) and the other is outdoors.

#### 3.3.1 Torino Lab – RAN Segment

The first location, at TIM premises, focuses on the RAN segment. Further information on the traffic generators and user emulation tools are summarized below in Table 14.

**Table 14: Italian site 1 - Traffic Generators and user emulation tools**

Traffic Generators and user emulation tools	
<b>Context</b>	Lab
<b>Use Categories</b>	eMBB, URLLC, MMTC
<b>Service Categories</b>	Virtual Reality, Live Streaming, Robotics
<b>Traffic Type</b>	TCP, UDP, HTTP
<b>Traffic Conditions</b>	Ideal

Both indoor and outdoor scenarios can be tested. Table 15 summarizes the setting for the indoor scenario:

**Table 15: Italian site 1 - Indoor Scenario configuration**

Indoor Scenario configuration
-------------------------------

<b>Number of Cells</b>	2
<b>Number of Test UEs</b>	5
<b>Cell Mobility</b>	Intra-cell, Inter-cell
<b>Propagation Conditions</b>	LOS
<b>Cell Topologies</b>	Stand-alone

Table 16 below summarizes the setting for the outdoor scenario:

**Table 16: Italian site 1 - Outdoor Scenario configuration**

<b>Outdoor Scenario configuration</b>	
<b>Number of Cells</b>	1
<b>Number of Test Ues</b>	1 first for video 360° that can be extended to 4
<b>Cell Mobility</b>	Intra-cell
<b>Propagation Conditions</b>	LOS/NLOS
<b>Cell Topologies</b>	Stand-alone

The parameters that can be configured in the gNB are summarized in Table 17.

**Table 17: Italian site 1 - gNB parameters**

<b>gNB parameters</b>	
<b>Carrier Frequency Bands</b>	B43 e B7
<b>Number of baseband and RF modules</b>	2 radio and 2 baseband
<b>Number of carriers</b>	1
<b>TDD/FDD mode</b>	TDD
<b>Bandwidth</b>	80 MHz
<b>Output power</b>	up to 25
<b>Beamforming capability</b>	yes
<b>Antenna elements</b>	64T64R

### 3.3.2 Torino Lab – UE emulator

The second location, still at TIM premises but in a different lab, focuses on outdoor testing for UE emulation. Further information on the traffic generators and user emulation tools are summarized below in Table 18.

**Table 18: Italian site 2 - Traffic Generators and user emulation tools**

<b>Traffic Generators and user emulation tools</b>	
<b>Context</b>	Lab
<b>Use Categories</b>	eMBB, URLLC, MMTC
<b>Service Categories</b>	Live Streaming, Social networking, High-speed Internet, terminal emulation

<b>Traffic Type</b>	TCP, UDP, HTTP, RTSP, AMQP
<b>Traffic Conditions</b>	Ideal as well as traffic affected by fading/shadowing and handover

Table 19 summarizes the setting for the outdoor scenario:

**Table 19: Italian site 2 - Outdoor Scenario configuration**

Outdoor Scenario configuration	
<b>Number of Cells</b>	4
<b>Number of Test UEs</b>	400
<b>Cell Mobility</b>	Intra-cell, Inter-cell (gNB-gNB and eNB-eNB)
<b>Propagation Conditions</b>	LOS/NLOS
<b>Cell Topologies</b>	Stand-alone and multi-cell with continuous coverage

The parameters that can be configured in the gNB are summarized in Table 20.

**Table 20: Italian site 2 - gNB parameters**

gNB parameters	
<b>Carrier Frequency Bands</b>	up to 6 GHz
<b>Number of baseband and RF modules</b>	up to 4
<b>Number of carriers</b>	up to 4
<b>Subcarrier spacing</b>	
<b>TDD/FDD mode</b>	TDD/FDD
<b>Bandwidth</b>	up to 100 MHz
<b>MIMO rank capability</b>	4x4
<b>Beamforming capability</b>	yes
<b>Antenna elements</b>	4 coax connettors

### 3.3.3 Torino Field

The third testing location, at Politecnico di Torino premises and neighboring areas, can be used for both indoors and outdoors testing. Further information on the traffic generators and user emulation tools are summarized below in Table 21.

**Table 21: Italian site 3 - Traffic Generators and user emulation tools**

Traffic Generators and user emulation tools	
<b>Context</b>	Field Testing
<b>Use Categories</b>	eMBB
<b>Service Categories</b>	any
<b>Traffic Type</b>	TCP, UDP
<b>Traffic Conditions</b>	Ideal

Both indoor and outdoor scenarios can be tested. Table 22 below summarizes the setting for the indoor scenario:

**Table 22: Italian site 3 - Indoor Scenario configuration**

Indoor Scenario configuration	
Number of Cells	3
Number of Test UEs	5
Cell Mobility	Intra-cell, Inter-cell, Inter-RAT
Propagation Conditions	LOS/NLOS
Cell Topologies	Stand-alone

Table 23 summarizes the setting for the outdoor scenario:

**Table 23: Italian site 3 - Outdoor Scenario configuration**

Outdoor Scenario configuration	
Number of Cells	3
Number of Test UEs	5
Cell Mobility	Intra-cell, Inter-cell, Inter-RAT
Propagation Conditions	LOS/NLOS
Cell Topologies	Stand-alone, Outdoor-to-Indoor coverage

The parameters that can be configured in the gNB are summarized in Table 24 below.

**Table 24: Italian site 3 - gNB parameters**

gNB parameters	
Carrier Frequency Bands	B43 e B7
Number of baseband and RF modules	2 radio and 2 baseband
Number of carriers	1
TDD/FDD mode	TDD
Bandwidth	80 MHz
Output power	up to 25
Beamforming capability	yes
Antenna elements	64T64R

### 3.4 Spanish Site

The Spanish site offers only one location, at IMDEA Networks in Leganés, mainly oriented at indoors testing. Further information on the traffic generators and user emulation tools are summarized below in Table 25.

**Table 25: Spanish site - Traffic Generators and user emulation tools**

Traffic Generators and user emulation tools	
Context	Lab

<b>Use Categories</b>	eMBB, URLLC,
<b>Service Categories</b>	any
<b>Traffic Type</b>	TCP, UDP, QUIC
<b>Traffic Conditions</b>	Ideal

Table 26 summarizes the setting for the indoor scenario, emulating office space:

**Table 26: Spanish site - Indoor Scenario configuration**

<b>Indoor Scenario configuration</b>	
<b>Number of Cells</b>	1
<b>Number of Test Ues</b>	4 Smartphones, 2 CPE
<b>Cell Mobility</b>	Intra-Cell
<b>Propagation Conditions</b>	LOS
<b>Cell Topologies</b>	Stand-alone

Table 27 below summarizes the setting for the outdoor scenario:

**Table 27: Spanish site - Outdoor Scenario configuration**

<b>Outdoor Scenario configuration</b>	
<b>Number of Cells</b>	1
<b>Number of Test UEs</b>	4 Smartphones, 2 CPE
<b>Cell Mobility</b>	Intra-cell
<b>Propagation Conditions</b>	LOS/NLOS
<b>Cell Topologies</b>	Stand-alone

The parameters that can be configured in the gNB are summarized in Table 28 below.

**Table 28: Spanish site - gNB parameters**

<b>gNB parameters</b>	
<b>Carrier Frequency Bands</b>	B7 for LTE, N78L for NR
<b>Number of baseband and RF modules</b>	1 RF module + 1 BB module for LTE and 1 RF module + 1 BB module for
<b>Subcarrier spacing</b>	15 kHz (4G), 30 kHz (5G)
<b>Slot length</b>	0.5ms (4G and 5G)
<b>CP length</b>	Normal for both
<b>TDD/FDD mode</b>	FDD for 4G, TDD for 5G
<b>Bandwidth</b>	20 MHz for 4G, 50 MHz for 5G
<b>Output power</b>	40 dBm (4G), 42 dBm (5G N78L)
<b>Frame structure</b>	4G Frame Type 1, 5G Frame configuration flexible
<b>MIMO rank capability</b>	2 layers 4G and 4 layers 5G
<b>Beamforming capability</b>	8 beams 5G
<b>Antenna patterns</b>	22 dBi gain, Horizontal HPBW 22°, Vertical HPBW 10° (5G)

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<b>Antenna elements</b>	128 5G
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## 4 KPI-based overview of first release of testing suite

In Deliverable D5.2, “Model-based testing framework” [1], a detailed description of the procedure and steps for the validation of the 5G PPP network KPIs supported by 5G EVE was included. Also, adequate tools to provide initial KPI measurements in an automated way were identified for some of these KPIs. Very briefly, the list of KPIs is<sup>1</sup>:

- **Speed**: experienced user data rate, both in the uplink (UL) and in the downlink (DL), across time
- **Broadband Connectivity**: peak data rate, both in the uplink and in the downlink
- **Capacity, or Traffic Volume Density**: total user data volume transferred to/from end users during a predefined time span
- **Latency**: includes both the one-way delay and round-trip time (OWD/RTT) in the user and control planes
- **Device (or Connection) Density**: total number of simultaneous active connections per squared kilometre while maintaining a target QoS
- **Stationary and Pedestrian Mobility**: measurement of the system’s ability to provide seamless service experience to users that are moving

In this document, the idea is to include some testing scripts that permit measuring some of those above, normally by activation of the tools that were already mentioned in D5.2. The scripts are written for Robot Framework, a testing environment that can be easily integrated with Jenkins resulting in an automated testing framework. Both Robot Framework and Jenkins were described in Deliverable D5.1, “Disjoint testing and validation tools” [2].

As next steps, we will work in integrating these test scripts in the experimentation and validation framework developed in conjunction with WP3. In this environment, tests are executed by the Runtime Configurator (WP3 component), and use a different scripting tool (Ansible), as defined in Deliverable D5.3, “Second implementation of the interworking reference model” [3].

Beyond the capability to automatically launch scripts as required, integration can also benefit from the developed automated validation and visualization mechanisms. In particular, additional Ansible scripts may be created to, on the one hand, activate the monitoring of interesting infrastructure metrics and, on the other, automate the day-2 configuration of the involved testing components. This will permit that all the required metrics and KPIs are published in the Data Collection Manager component (implemented using a Kafka bus), from where they can be consumed by the validation and visualization components. With this, we will benefit from the appliance of validation conditions to the obtained KPIs (in case, for example, that we want to apply a success/failure threshold), and we will also be able to visualize KPIs along time using Kibana.

Of course, this integration will also mean that current Robot Framework scripts will have to be modified, producing the equivalent in Ansible. Although the scripting language is different, the look of the scripts should not differ greatly as we are using external tools like ping, iperf, tshark and wget, which we will need to invoke in any case.

Finally, it is worth noting that Deliverable D2.4, “Initial pilot test and validation” [4], already presents in its section 2.2 initial measurements carried out by the four sites (French, Greek, Italian and Spanish) for some of these KPIs. Several of them have been measured using different tools, even commercial ones, but when these scripts are fully integrated in the experimentation and validation platform, that will permit to verify the KPIs in a very easy automated way, and to keep track of them during the whole lifetime of the project (if needed).

### 4.1 Speed

The measurement of this KPI, as discussed in D5.2, requires the utilization of tools in the UE device (for the downlink) or the application server (for the uplink). One of the most interesting tools is Wireshark, which can

---

<sup>1</sup> Exact definitions of the extension of these KPIs can be found in D5.2, so they will not be included here.

make a capture in a specific interface, and measure the resulting bandwidth (in the appropriate direction) based on the captured packets. Using tshark, a terminal oriented version of Wireshark, we could automatically launch a capture in any UE<sup>2</sup> or application server, if we had SSH access to it. However, as of today we have not implemented a mechanism to automatically open the resulting wireshark/tshark captures (i.e., .pcap files), and read the bandwidth statistics that Wireshark provides. Therefore, this still needs to be done manually; it is expected to enhance this in the future, maybe using other tools like collectd.

The following script can be used to connect via SSH to an IP address (ideally, from a UE), and execute these operations:

- Trigger the downloading of a file using wget (in the background)
- Start a 5 seconds capture (the value is easily changeable; it should be adapted, according to the expected data rate, so that the storing buffer is not surpassed).
- Wait 120 seconds (again, changing this value in the script is very simple) to account for the end of the downloading process and the stabilization of the scenario
- Start again and loop 9 times with a different file (different name; different size), and a different capture file name.

The result is ten pcap files, corresponding to the ten planned captures, which can then be manually opened with Wireshark to find the downlink bandwidth measurements. The main initial requirement, apart from granting SSH access in the UE and having the different applications already installed, is that an HTTP server needs to be prepared, with ten different files having specific names (like file\_1 to file\_10 in the example script). Regarding the SSH access, the script is based on username and password, but public keys could also be used. In that case, another requirement would be to have a previous exchange of the key between the two components participating in the process.

After that we also include an equivalent script for the measurement of the UL. The only difference in this case is that the SSH connection is done to the server, which downloads files from the UE, and where the captures are executed.

## SCRIPT FOR DOWNLINK SPEED

```

*** Settings ***
Suite Teardown      Close All Connections
Library              SSHLibrary
Library              String
Library              Collections
Library              BuiltIn

*** Variables ***
${UE_IPADDRESS}     1.1.1.1
${UE_USERNAME}      admin
${UE_PASSWORD}      admin
${UE_CAPTURE_FILES_LOCATION}  /home/admin/captures/
${CAPTURE_DURATION}      5
${CAPTURE_ITF}          eth0
${SERVER_IPADDRESS}     2.2.2.2
${SERVER_FILES_URL}     https://${SERVER_IPADDRESS}/home/admin/test/files/
${TIME_BETWEEN_MEASUREMENTS}  120

*** Test Cases ***
Execute loop
    Open Connection to UE, Log In and Convert to Root
    FOR    ${i}    IN    0    1    2    3    4    5    6    7    8    9

```

<sup>2</sup> Wireshark/tshark is not clear to be compatible with all standard UEs, so other more sophisticated solutions might be needed

```

    Start Command    touch ${UE_CAPTURE_FILES_LOCATION}capture_${i}.pcap
    Log              Creating capture file: capture_${i}
    Start Command    chmod 777
${UE_CAPTURE_FILES_LOCATION}capture_${i}.pcap
    Log              Changing privileges to file: capture_${i}
    Start Command    wget -b ${SERVER_FILES_URL}
    Log              Downloading file with name: file_${i}
    Start Command    tshark -i ${CAPTURE_ITF} -a
duration:${CAPTURE_DURATION} -w ${UE_CAPTURE_FILES_LOCATION}capture_${i}
    Log              Capturing in file with name: capture_${i}
    Sleep            ${TIME_BETWEEN_MEASUREMENTS}
    Log              Sleeping ${TIME_BETWEEN_MEASUREMENTS} seconds after capture
END
Log                Outside FOR loop

```

\*\*\* Keywords \*\*\*

Open Connection to UE, Log In and Convert to Root

```

Open Connection    ${UE_IPADDRESS}
Login              ${UE_USERNAME}    ${UE_PASSWORD}
Write              sudo su
Write              ${UE_PASSWORD}

```

## SCRIPT FOR UPLINK SPEED

\*\*\* Settings \*\*\*

```

Suite Teardown    Close All Connections
Library            SSHLibrary
Library            String
Library            Collections
Library            BuiltIn

```

\*\*\* Variables \*\*\*

```

${SERVER_IPADDRESS}    1.1.1.1
${SERVER_USERNAME}    admin
${SERVER_PASSWORD}    admin
${SERVER_CAPTURE_FILES_LOCATION}    /home/admin/captures/
${CAPTURE_DURATION}    5
${CAPTURE_ITF}        eth0
${UE_IPADDRESS}        2.2.2.2
${UE_FILES_URL}        https://${UE_IPADDRESS}/home/admin/test/files/
${TIME_BETWEEN_MEASUREMENTS}    120

```

\*\*\* Test Cases \*\*\*

Execute loop

Open Connection to UE, Log In and Convert to Root

```
FOR    ${i}    IN    0    1    2    3    4    5    6    7    8    9
```

```
    Start Command    touch
```

```
${SERVER_CAPTURE_FILES_LOCATION}capture_${i}.pcap
```

```
    Log              Creating capture file: capture_${i}
```

```
    Start Command    chmod 777
```

```
${SERVER_CAPTURE_FILES_LOCATION}capture_${i}.pcap
```

```
    Log              Changing privileges to file: capture_${i}
```

```
    Start Command    wget -b ${UE_FILES_URL}
```

```
    Log              Downloading file with name: file_${i}
```

```
    Start Command    tshark -i ${CAPTURE_ITF} -a
```

```
duration:${CAPTURE_DURATION} -w ${SERVER_CAPTURE_FILES_LOCATION}capture_${i}
```

```
    Log              Capturing in file with name: capture_${i}
```

```
    Sleep            ${TIME_BETWEEN_MEASUREMENTS}
```

```

    Log    Sleeping ${TIME_BETWEEN_MEASUREMENTS} seconds after capture
END
Log    Outside FOR loop

```

\*\*\* Keywords \*\*\*

```

Open Connection to UE, Log In and Convert to Root
Open Connection    ${SERVER_IPADDRESS}
Login    ${SERVER_USERNAME}    ${SERVER_PASSWORD}
Write    sudo su
Write    ${SERVER_PASSWORD}

```

## 4.2 Broadband Connectivity

In this case where the objective is to measure the peak data rate, IPERF is a very adequate tool, since it tries to download at maximum speed, and provides later on the measurement directly.

The following script can be used to measure this KPI. It must be noted that it is valid both for the uplink and the downlink, understanding correctly which entity (UE or application server) plays the role of IPERF client or IPERF server.

Requirements in this case are that there is no other background traffic running in the experiment, and that both the IPERF client and server have the appropriate IPERF software installed. Of course, running the below script only once would not suffice to provide a precise measurement. A series of tests under different conditions (range, angle, different devices...) should be executed, and then the maximum bandwidth from all the measurements would be a more precise value for the peak data rate.

### SCRIPT FOR ONE-WAY BROADBAND CONNECTIVITY

\*\*\* Settings \*\*\*

```

Suite Teardown    Close All Connections
Library           SSHLibrary
Library           String
Library           Collections
Library           BuiltIn

```

\*\*\* Variables \*\*\*

```

${CLIENT_IPADDRESS}    1.1.1.1
${CLIENT_USERNAME}    admin
${CLIENT_PASSWORD}    admin
${SERVER_IPADDRESS}    2.2.2.2
${SERVER_USERNAME}    admin
${SERVER_PASSWORD}    admin
${SERVER_START}    iperf3 -s
${CLIENT_TCP_START}    iperf3 -c ${SERVER_IPADDRESS} -f g

```

\*\*\* Test Cases \*\*\*

```

Execute test
    Open Connection to Server And Log In
    Start Command    ${SERVER_START}
    Open Connection to Client And Log In
    ${output}    ${rc}    Execute Command    ${CLIENT_TCP_START}
return_stdout=true    return_rc=true
Should Be Equal As Integers    ${rc}    0
${receiver}=    Get Line    ${output}    -3
@{rcv_list}=    Split String    ${receiver}
Log    Bandwidth is ${rcv_list[6]}GBps

```

```

*** Keywords ***
Open Connection to Server And Log In
  Open Connection    ${SERVER_IPADDRESS}
  Login    ${SERVER_USERNAME}    ${SERVER_PASSWORD}

Open Connection to Client And Log In
  Open Connection    ${CLIENT_IPADDRESS}
  Login    ${CLIENT_USERNAME}    ${CLIENT_PASSWORD}

```

## 4.3 Latency

The following script can be used to measure the round-trip time (RTT) in the data plane between two nodes, using PING.

### SCRIPT FOR RTT IN THE DATA PLANE

```

*** Settings ***
Suite Teardown    Close All Connections
Library           SSHLibrary
Library           String
Library           Collections
Library           BuiltIn
Library           Process

*** Variables ***
${MGMT_ADDRESS}    1.1.1.1
${DATA_SOURCE_ADDRESS}    10.0.0.1
${DATA_DESTINATION_ADDRESS}    10.0.0.2
${USERNAME}        admin
${PASSWORD}        admin
${REPETITIONS}     4
${WORKSPACEDIR}    /home/admin
${PATH}            Join Path    ${WORKSPACEDIR}    stdout.txt

*** Test Cases ***
RTT in data plane measurement
  Open Connection to Device and Log In
  ${result} = Run Process    ping -c ${REPETITIONS} -S
  ${DATA_SOURCE_ADDRESS} ${DATA_DESTINATION_ADDRESS}    shell=True
  stdout=${PATH}
  Log    all output: ${result.stdout}
  Should Contain    ${result.stdout}    rtt min/avg/max/mdev

*** Keywords ***
Open Connection to Device and Log In
  Open Connection    ${MGMT_ADDRESS}
  Login    ${USERNAME}    ${PASSWORD}

```

## 5 Conclusions and Future Work

This deliverable has presented the activities that WP5 has conducted in Tasks 5.2 and 5.3. It represents the final report of all activities of T5.2, while it concerns the activities of T5.3 until M24.

Specifically, Task 5.2 aimed at identifying the necessary environmental conditions for testing and evaluation of the various 5G features and technologies of the site facilities, in order to allow experimenters to use the appropriate settings depending on the system under test and per 5G technology applied. Since Task 5.3 focuses on driving the implementation of the functional testing, validation and benchmarking methodologies and tools, this deliverable is aimed at setting up testing procedures and enable the evaluation of the 5G technologies in various test cases, based on the high-level architecture of the monitoring & KPI collection framework.

The future work in T5.3 will address the integration of the test scripts reported here in the experimentation and validation framework developed in conjunction with WP3 where tests are executed by the Runtime Configurator (WP3 component), and use a different scripting tool (Ansible), as defined in Deliverable D5.3, for which additional scripts will be created to, on the one hand, activate the monitoring of interesting infrastructure metrics and, on the other, automate the day-2 configuration of the involved testing components. This will allow all the required metrics and KPIs to be published in the Data Collection Manager component (implemented using a Kafka bus), from where they can be consumed by the validation and visualization components.

## References

- [1] 5G EVE Deliverable D5.2 “Model-based testing framework” – ICT-17-2018 5G EVE Project – 20/12/2019
- [2] 5G EVE Deliverable D5.1 “Disjoint testing and validation tools” – ICT-17-2018 5G EVE Project – 03/05/2019
- [3] 5G EVE Deliverable D3.4 “Second implementation of the interworking reference model” – ICT-17-2018 5G EVE Project – To be published in June 2020.
- [4] 5G EVE Deliverable D2.4 “Initial pilot test and validation” – ICT-17-2018 5G EVE Project – To be published in June 2020

## Appendix A.1

This Appendix includes the original questionnaire that was circulated among site managers.

### Overview of the Facilities

TO BE FILLED BY THE SITE MANAGER: please, fill in the table to list the available facilities on the 5G EVE site. Add as many rows as necessary.

**5G EVE Site:** (Italian site/French site etc.)

Facility code	Location	Network segment(s) under test

#### Legend

**Facility Code:** Unique facility reference code to be used in this document. Formatted as: (country)-F(number of facility). For example, the first testing facility listed by the Greek site would be **GRE-F01**.

**Location:** geographical location and indoor/outdoor info. For example, **ITA-F01** could be “Torino indoor”

**Network segment(s) under test:** what parts of the 5G architecture can be tested here.

In the following, copy and paste as many sections as are the facilities, following the template provided below.

## Facility XXX-FYY Description

Please answer the questionnaire below related to the environment setting capabilities of the facility.

### Traffic and scenario generators

List and describe any testing tools used to generate load and to populate specific scenarios.

What type of scenario can be tested (check all that apply)?  Indoor  Outdoor

- If indoor coverage can be tested, specify which scenario(s) can be tested:  
 office space     commercial mall     Other (please specify):
- If outdoor coverage can be tested, specify which scenario(s) that can be tested:  
 Dense Urban     Urban Macro     Rural low speed     Rural high speed  
 Other (please specify):

### Traffic generators and user emulation

Provide information on the type of *synthetic* traffic that can be generated (either as test traffic or background traffic). You can either specify a broader usage scenario category:

- eMBB  
 URLLC  
 MMTC  
 not applicable

or be more specific and indicate traffic generators based on QoE service categories:

- Virtual Reality     Augmented Reality     Gaming     non-live Streaming  
 Live Streaming     Social networking     High Speed Internet     Patient monitoring  
 Emergency services     Smart metering     Smart Grids     Connected vehicles  
 other:     not applicable

Provide additional information on the types of protocols that can be emulated or whose traffic can be synthetically generated (e.g., TPC, UDP, HTTP, RTSP etc.):

Briefly describe the tools to collect QoS metrics (e.g., throughput/latency estimator, Human Perception-based Quality Evaluators...):

### Indoor scenarios

Provide information on scenario generation for indoor coverage (if available at the facility)

Number of cells

(Approximate) number of test UEs:

Type of Cell Mobility that can be tested:  Intra-Cell     Inter-Cell (gNB-gNB)     Inter-RAT (eNG-gNB)

### Outdoor scenarios

Provide information on scenario generation for outdoor coverage (if available at the facility)

Number of cells

(Approximate) number of test UEs:

Type of Cell Mobility that can be tested:  Intra-Cell     Inter-Cell (gNB-gNB)     Inter-Cell (eNG-gNB)

## Propagation Environment

Describe the types of measurements that can be carried out within the facility (e.g., in an anechoic chamber or in an outdoor test site).

## Indoor coverage

Provide information (check all that apply)

Propagation conditions:  LOS  NLOS

Cell topologies:  Stand-alone cell  Multi-Cell continuous coverage

## Outdoor coverage

Provide information (check all that apply)

Propagation conditions:  LOS  NLOS

Cell topologies:  Stand-alone cell  Multi-Cell continuous coverage  Outdoor-to-Indoor coverage

## Network and device configuration

List and describe the parameters that can be configured either in the gNB or in eNB

Parameter	Value Ranges, details (if applicable)
<input type="checkbox"/> Carrier Frequency Bands	
<input type="checkbox"/> Number of baseband and radio (RF modules, active antennas)	
<input type="checkbox"/> Number of carriers	
<input type="checkbox"/> Subcarrier spacing	
<input type="checkbox"/> Slot length	
<input type="checkbox"/> CP length	
<input type="checkbox"/> TDD/FDD mode	
<input type="checkbox"/> Bandwidth	
<input type="checkbox"/> Output power	
<input type="checkbox"/> Duplex mode	
<input type="checkbox"/> Frame structure	
<input type="checkbox"/> MIMO rank capability	
<input type="checkbox"/> Beamforming capability	
<input type="checkbox"/> Antenna patterns	
<input type="checkbox"/> Other (please specify):	

Indicate the number of the terminals (UEs) available with the associated capabilities listed below:

- n. with screen
- n. without screen
- n. with adjustable receiver sensitivity
- n. with transmit power control