5G European Validation platform for Extensive trials

Deliverable D7.5
Report on Training activities after Year 1

Deliverable History

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List of Acronyms and Abbreviations

3GPP	Third Generation Partnership Project
5G	Fifth Generation
ACM	Association for compuing machinery
CI/CD	Continuous Integration/Continuous Deployment
CN	Core Network
CNF	Containerized Network Function
ETSI	European Telecommunication Standards Institute
HW	Hardware
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet-of-Things
MANO	NFV management and network orchestration
NFV	Network Function Virtualization
NFVI	NFV Infrastructure
NGMN	Next Generation Mobile Networks
NR	New Radio
NSF	National Science Foundation
NR	New Radio
OAI	Open Air Interface
ONAP	Open Network Automation Platform
ONF	Open Networking Foundation
OPNFV	Open Platform for NFV
ORAN	Open Radio Access Network
OSM	Open-source MANO

PAWR	Platforms for Advanced Wireless Research
QoS	Quality-of-Service
RAN	Radio-Access Network
SW	Software
VCO	Virtual Central Office
VNF	Virtual Network Function

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Executive Summary

This deliverable provides an overview of the initial plans for training in 5G-EVE in preparation for the deployment phase of the project. We first summarize the basic technologies and methodologies that will be covered by various training initiatives and pedagogical material developed in the context of 5G-EVE. We then specifically review the phases for training in preparation for and to support partners representing vertical industries, beginning those which are already part of 5G-EVE and subsequently those from associated ICT-19 and ICT-22 projects. The latter are conceived in order to smoothly integrate the vertical use-cases proposed by the partner projects. Finally, we list specific training actions and provide an initial example of a one-day training session using a 5G-EVE facility which targets technology conferences in communication systems or computer science.

1 Introduction

1.1 Purpose of this deliverable

To avoid confusion resulting from the title of this deliverable in the description of work of 5G-EVE, we state here the basic purpose of the deliverable. The document is intended to provide an overview of the initial plans for training in the 5G-EVE facility prior to the actual start of training-related activities.

1.2 Objectives

The training activity in 5G-EVE is part of the Training task (T7.3) in the Community Building work package (WP7) whose main objective is to provide end-users guided hands-on experience for using the facilities, especially those from partners representing vertical industries within 5G-EVE and afterwards from associated projects in the context of ICT-19 and ICT-22. The activity will furthermore facilitate the collection of measurements and guide the analysis and dissemination of results derived from them. It will also provide several means to train *within* the 5G-EVE community, in particular to allow for interoperability between the facilities in different geographic locations and joint experimentation across sites. The actual means for training will vary from facility to facility but will include a combination of workshops, tutorials, webinars, online collaborative documentation, community mailing lists and online real-time interactions using tools such as *slack*[1]. The most important aspect of real-time tools is that they allow direct interaction with maintainers of the facilities. In order to be effective, the content provided by these methods should be useful and easily-accessible. Moreover, the methods should contribute to the sustainability of the facilities beyond the timeframe of the 5G-EVE project, in order to foster both academic and international collaboration in industry-driven initiatives such as OPNFV, ORAN and ONAP.

Task 7.3 takes its input from the following work packages:

- Implementation, pilot execution and validation work package (WP2)
- Design and implementation of interworking, multi-x slicing, and orchestration (WP3)
- Development of specific tools and components to support vertical trials (WP4)
- Design and implementation of testing and validation methodologies and tools (WP5)
- Exploitation, dissemination, standardisation, and sustainability (WP6)

and provides output to the Site Facility Implementation task (Task 2.2), the Pilot execution, validation, and support task (T2.3), the reporting in deliverables D7.5/7.6/7.7, and the general 5G experimentation community (e.g. OPNFV). This is depicted in Figure 1. WP2 provides the descriptions of the facilities as well as the operational methods that are provided to end-users. T7.3 will act as an intermediary with the facilities to assist the end-users. As a result, it will also provide feedback to the site managers regarding the impressions of the end-users during the course of the 5G-EVE project. It will rely on WP3 to provide information about service orchestration, in particular when it comes to the on-boarding of service frameworks by end-users. This could potentially be both at the level of the 5G-EVE portal or within particular sites that require low-level interactions with the individual sites. An example of the latter would be on-boarding of third-party core network or RAN functions in the open component of the French and Spanish facilities. WP4 will mostly be involved with providing tools related to the 5G-EVE portal and the research component in the Implementation and benchmarking of innovative data planes and radio access features task (T4.5) which can be the subject of tutorials at major conferences. WP5 will provide the test and measurement methodology as well as benchmarking which is crucial for end-users of the facility during the experimentation phase. Through the

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[1] Slack (www.slack.com) Is an interactive tool for managing teamwork. It is organised in channels providing a single place for messaging, tools and files. It is suited for technical interaction.

Dissemination, Communication, and Outreach task (T6.1), the Exploitation, WP6 assists in the promotion of training activities towards target audiences and reports about the results, e.g. in a web news item. It is important to highlight the need for a good relationship between T7.3 coordinators and actual providers of content from WP2/3/4/5, and in particular the site managers from WP2.
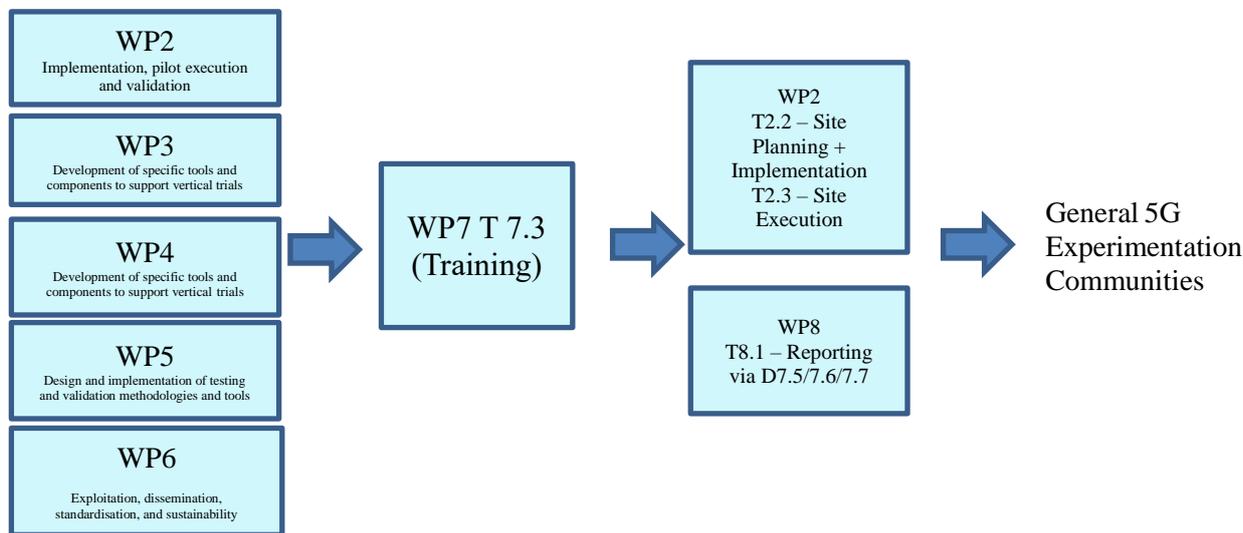
Figure 1: Position of T7.3 in 5G-EVE

We list the main objectives and their performance indicators in Table 1

Table 1: Main Objectives and Performance Indicators

Training Objective	Performance indicators
VNF/CNF on-boarding	Per-site documentation (wiki, slack), number of on-boarded VNFs/CNFs for network functions or service framework
Basic technology training	Number of tutorials, catalogues/manuals, availability of online training resources (webpages, contributions to high-profile technology sites)
Integration of vertical end-user devices	Number of different vertical end-user devices
Running experiments on particular vertical use-case	Number of different experiment configurations

1.3 Overview of subsequent sections

The remainder of this deliverable aims to lay out the initial plans for training in 5G-EVE in preparation for the deployment phase of the project starting in M12. Section 2 provides an overview of the basic technologies and methodologies that will be covered by various training initiatives and material developed in the context of 5G-EVE. Section 3 addresses the phases for training in preparation for and to support partner ICT-19 and ICT-22 projects. This specifically focuses on the integration of the vertical use-cases that they propose. Finally in Section 4 we list specific training actions and provide an initial example of a one-day training session using a 5G-EVE facility which targets technology conferences in communication systems or computer science.

2 Training Areas for Underlying 5G-EVE Technologies

5G comprises very complex technological building blocks used in all layers of the 3GPP protocol stack and the over-arching service architecture. A solid understanding of the 5G standard and the implementation technologies pertinent to deploying services and network functions as well as 5G KPI measurement methodology is clearly beneficial to all end-users and the greater 5G experimentation communities. The following subsections provide a brief overview of the 5G-related themes that will be made available to end-users as well as the primary means through which they will be exposed.

2.1 Basic Technologies

Here we describe the basic 5G technologies which we believe are most pertinent for training activities. They cover the RAN and Core Network components, open-source orchestration by ONAP and open interface descriptions which foster collaboration with industry-driven specification groups.

2.1.1 5G New Radio and 5G Core Network

5G-EVE will provide basic training on 3GPP specifications related to the RAN (5G New Radio) and Core Network components. These components represent the central 3GPP network functions for building an end-to-end 5G network. The associated training material is primarily useful for experimental VNFs provided in 5G-EVE alongside solutions provide by the network vendors. The training material will be in the form of *ex cathedra* lectures with freely-available slide sets in addition to links and contributions to useful web resources like SharedTechNote, LTE University, etc. ECOM provides regular training on these subjects and will make the material available to the greater 5G community through the 5G-EVE portal. In particular, information covering the evolutions towards Rel-16 and 17 extensions for 5G NR will be extremely useful for the greater community.

2.1.2 ONAP

ONAP is the main open-source solution for 5G service orchestration and is poised to become a dominant force in commercial deployments. It is thus a key technology to be considered by training activities in 5G-EVE. In the context of the French node integration, hands-on training provided by ORA-FR is made available in the form of **sandboxes for VNF onboarding** in the Plug'In platform. During the course of the second year of 5G-EVE we will aim to open these sandboxes to the general 5G community in order to experiment with ONAP-based network deployments.

2.1.3 New Interface descriptions and their implementation

Several industry-driven initiatives such as OPNFV, ORAN and the Small-Cell Forum are in search of facilities such as those in 5G-EVE in order to perform experiments for testing innovative interfaces for interconnecting different implementations of the 3GPP network entities and those at its periphery. Examples include the VCO 3.0 project () within OPNFV for which the French node in Sophia Antipolis site is being used to test emerging 5G VNFs from several vendors, in addition to its own VNFs. ECOM is maintaining portions of the VCO 3.0 training material in order to facilitate on-boarding of third-party VNFs which can be used by the greater 5G-EVE community.

Similarly, ECOM will maintain training material for integration of ORAN compatible elements such as the RAN Intelligent Controller (RIC) via ORAN E2 within the French node of the 5G-EVE network. Similarly, training material for using the 5G NR FAPI interfaces specified by the small-cell forum will also be provided.

2.1.4 Data-center and Radio Network architectures in 5G-EVE

Finally, 5G-EVE will provide basic training on data-center and radio-network architectures. In particular, this will emanate from basic descriptions of the sites and their components. The sites which provide open-architecture should aim to describe the deployment as faithfully as possible. This is underway in the Sophia Antipolis component of the French node via the VCO 3.0 project initiative described in Section 2.1.3 where the complete OpenShift deployment information will be provided on the VCO 3.0 *github* during the course of 2019. This should allow full or partial replication by other labs in the greater community. More generally, any innovations in data-center technologies resulting from the deployment of 5G-EVE facilities should be the subject of tutorials at IEEE/ACM conferences and Linux Foundation events.

Other more technical subjects emanating from research content in T4.5 will also be the subject of tutorials at major conferences. Areas already identified include user-plane transport technologies and slicing and scheduling paradigms making use of the innovative features of 5G radio-access in support of new vertical industries such as industrial IoT.

2.2 Testing and Continuous Integration (for open-source components)

Another key aspect that can be exploited for training is the area of testing and particularly continuous-integration/continuous-deployment (CI/CD). This is a fundamental collaborative development and testing methodology used by open-source communities. In the context of 5G-EVE experimental facilities, the open-source components could be tested continuously on live networks. This involves defining tests for updated or new software components which are deployed either on a test network or live deployed network. It can also include updating end-user network elements (i.e. deployment of end-user physical devices) to test new network configurations or services. The latter will require integration proper testing methods to control remote devices. Clearly, innovation in such testing methodologies in an open-architecture framework will have to be supported by appropriate training for contributors whether they are vertical end-users or VNF-providers.

2.3 Software Deployment

Here we consider the means to assist users of the 5G-EVE facilities when it comes to deploying software elements. This includes basic training on the NFV infrastructure (e.g. OpenStack or OpenShift) and the associated means to describe the software service or higher-level entry-points such as the 5G-EVE portal. Training material such as wikipages, webpages can be complemented by real-time interactive methods such as *slack channels*. This is typically the means that are used for training in platform-oriented community-developed initiatives such as ONAP or OPNFV and should be provided for 5G-EVE facilities as well.

2.4 Catalogues and Manuals

Finally, 5G-EVE should provide catalogues of network functions and service frameworks that can be used to build experiments. These should include sufficient description for the end-user to be able to make judicious choices regarding the configurations that best suit the use-case that is under experimentation. This will incur minimal effort on the part of the platform maintainers. This activity will be carried out in collaboration with the ICT-21 EMPOWER project[2].

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[2] https://www.advancedwireless.eu/

3 Phases for Training in preparation of and to support integration of vertical industries

Integration of new vertical industries both within 5G-EVE and subsequently from identified ICT-19 and ICT-22 projects is a primary requirement for the 5G-EVE sites, Several such projects have been identified at the time of this writing and will be accommodated starting in the second half of 2019. Training audiences are primarily

- Suppliers of VNFs/CNFs for network functions
- Suppliers of VNFs/CNFs for service frameworks
- End-user KPI measurement on 5G infrastructure
- physical integration of end-user devices specific to the vertical use-case under study

We envisage three phases for integration of these vertical industries using the 5G-EVE facilities infrastructures. These are described in the following three subsections.

3.1 Phase 1 – Documentation and Per-site Preparation of Training Activities (M12-M16)

At M12, all sites should have a certain amount of basic documentation from WP2/3/4/5 deliverables available to describe the deployment of software (both services and VNFs/CNFs) and execution of experiments. This will be used primary to train suppliers of VNFs/CNFs and organized in the form of wiki pages. During this phase, the documentation will be refined for the purpose of training and pedagogical exposure to the internal and external partners. As such, the documentation should be reviewed by the initial partners that will on-board software to the 5G-EVE facilities. This step is crucial to proceed to actual onboarding of software in phase 2 and each site should perform several dry-runs with partners within or outside 5G-EVE during phase 1

In order to guarantee the proper preparation of each national facility, the documentation phase will be coordinated by the associated academic partners (i.e. ECOM for France, UC3M for Spain and CNIT for Italy) with support of their respective site managers. Training preparation for the Greek facility will be under the responsibility of OTE. All initial documentation for on-boarding must be ready by M16.

3.2 Phase 2 – Testing of On-boarding Procedures (M16-M18)

Early testing by the 5G-EVE operators or site managers and with the vertical partners within 5G-EVE will start at M12. This will refine the on-boarding procedure and provide necessary information for training in order to be able to present a tested framework for ICT-19 projects towards M18. The basic documentation and other pedagogical material initiated in Phase 1 will be enhanced based on initial testing within the project and then afterwards. This activity requires a strong interaction between the site managers and the three academic training coordinators mentioned in Section 3.1.

It is important to provide sufficient training on tools to allow on-boarding among partners within 5G-EVE, in particular understanding the basic environment (ONAP/OSM) for on-boarding service frameworks and VNFs/CNFs as well as the computing constraints and user-plane limitations of the different sites. This is particularly the case for the French node since it is a distributed site with 4-5 distinct geographic locations. We propose at this time that the sites maintain a common real-time interactive slack channel (or equivalent) for the 5G-EVE facility which is coupled with wikipages covering all aspects related to software on-boarding. The content of the interactive channel (topics) is of course up to the site managers and the training coordinators and will evolve with time. These topics will clearly have different flavours for each site, and even the sub-sites in the case of France, and could be organised on a per site basis. Nevertheless, it is important to maintain a common

framework for the project in order to mutualize effort for training and information exchange as much as possible across the sites.

3.3 Phase 3 – Running Experiments and Live Demonstrations (M18-36)

This phase corresponds to where software has been on-boarded and experiments can be run. During this phase the procedures in T2.3 will be tested and refined and appropriate training to users will be given for collecting data and running experiments. We should stress that this will also include running of remote experiments real-time for demonstration purposes. Initially the experiments will be carried out with the operators/site-managers and vertical partners within 5G-EVE and then be extended to ICT-19 projects most likely at M24.

4 Tutorials, Workshops and Specific Training Actions

Tutorials at key IEEE/ACM conferences will be led by academic partners (ECOM, CNIT, UC3M) and will aim to highlight key innovations in technologies and methodologies related to the 5G-EVE facilities. In particular, we target ICC, Globecom, MOBIHOC as well as several Linux Foundation events such as ONS/ONS Europe, OCP Summit, KubeCon. These tutorials should aim to mix academic and industrial content. An example of a tutorial proposed by ECOM and ORA-Fr is provided in the Appendix.

Joint workshop and training initiatives will be proposed in the context of a collaboration with ICT-21 EMPOWER CSA in order to encourage collaboration with similar experimental platform initiatives in the USA and in particular with the *Platforms for Advanced Wireless Research (PAWR)* National Science Foundation (NSF) programme through joint training initiatives. The first such collaboration took place on June 25, 2019 at Nokia Bell Labs in New Jersey during the OpenAirInterface Bi-Annual Workshop.

Starting in the second half of 2019 ECOM will provide explicit training using the 5G-EVE site in France during OpenAirInterface Workshops.

5 Conclusions

This deliverable provided an overview of the strategy for training in 5G-EVE in preparation for the deployment phase of the project starting in M12. We first described the basic technologies and methodologies that will be covered by various training initiatives and material developed in the context of 5G-EVE. We then specifically addressed the phases for training in preparation for and to support partner ICT-19 projects in order to smoothly integrate their vertical use-cases. Finally, we consider specific training actions and provided an initial example of a one-day training session using a 5G-EVE facility which targets technology conferences in communication systems or computer science.

Appendix – Example of one-day Tutorial Material

<u>Title:</u> A hands-on overview of the softwarization tools in the French Node of the 5G-EVE ICT-17 Facility

<u>Motivation and context</u>

This tutorial presents a comprehensive end-to-end guide on how future mobile networks will be flexibly sliced to support vertical industries in multi-service and multi-tenant isolated environments. Here, slicing refers to the ability to dynamically create, manage, and orchestrate virtual networks, each programmable and customizable to meet the requirements of an end-to-end service. Considering 5G as a very active research area, it is important to offer to the scientific and industrial communities an analysis and evaluation of the recent achievements towards an operational 5G network infrastructure from both academic and industrial perspectives. This can promote further investigations and development towards a more advanced data-driven 5G networks. To this end, the main objectives of the proposed tutorial are:

1) to provide an overview of HW/SW tools for building open 5G RAN experimental facilities

2) to provide a comprehensive guide on mobile network slicing highlighting the importance and timeliness of network virtualization, in particular in the RAN.

3) to discuss the benefits and implications of network control, management, and orchestration in runtime to provide guarantee on the required per-user and per-slice QoS requirements.

4) to cover well-balanced research and development topics including challenges, key technologies, open-source tools, operational infrastructure, and lessons learned.

4) to provide hands-on demonstrations of these technologies on the 5G-EVE French Facility.

<u>Detailed Content</u>

The tutorial will be a combination of *ex cathedra* presentation and interactive using equipment both at the conference venue and remotely at the 5G-EVE facility. It is organized in 6 parts for the duration of 6 hours (full day) as follows:

1) Principles (45 minutes):

In this part, we highlight the main 5G use-cases and their requirements, followed by definitions, taxonomy, and design elements of network slicing. Then relevant standardization activities (3GPP, NGMN, ETSI, ONF, ORAN) and 5G-related activities (5G-PPP projects, 5G-Forum, opensource initiatives) will be provided.

2) Challenges (45 minutes):

In this part, we present the main challenges in realizing network slicing in an operational 5G networks with control, management, and orchestration subsystems. Implication, feasibility, and limitation of network slicing will be also discussed. Finally, we elaborate on how the divers vertical KPIs can be supported in a heterogeneous yet shared network infrastructure.

3) Technologies (45 minutes):

Here, we elaborate on network slicing properties such as isolation, resources sharing, customization and programmability, considering the 3GPP vision on 5G-RAN and 5G-CN slice orchestration. We present technologies, techniques and methodology to realize network control, management, and orchestration in operational 5G network infrastructure in both online and offline scenarios. Finally, we provide the lessons learnt when building an operational 5Gnetwork with slicing capabilities with both open-source and commercial platforms.

4) Prototyping and Validations (45 minutes):

In this part, we detail the design methodology in network slicing, and the main past and on-going efforts in prototyping network slicing highlighting their main features and objectives. Finally, recent findings and performance results available on network slicing and control will be presented.

5) 5G EVE French Facility (60 minutes)

Here, we provide an overview of the networking architecture and physical characteristics of the French node in 5G-EVE. Particular attention will be paid to the means for deploying vertical applications on the infrastructure and the ONAP-based orchestration component.

6) Hands-on experience with OpenAirInterface (OAI) 5G NR and Mosaic5G prototyping technologies. (60 minutes)

This part deals with the real-time software architecture of the OAI 5G radio-access solution and the service-oriented softwarization tools from Mosaic5G. The presentation is carried out both with local equipment and remotely at the EURECOM facility. In particular, we will detail how the tools are deployed and orchestrated on commodity servers and whitebox radio-frequency solutions. We provide details on the internal architecture of OAI and Mosaic5G elements.

7) Hands-on experience with Orange Labs Plug'in Platform (60 minutes):

This part gives a detailed overview of the internals of the Orange Plug'in platform: an operational 5G network open for experimentation, development, and testing of 5G software components and VNF chains, in a reproducible manner. Plug'in aims at transforming the research within the Mobile Network Operator Orange by allowing researchers to collaborate on a shared platform and make their developments and experiments reproducible. The key enablers to achieve such a platform are cloud computing, virtualization and automation.

Plug'in provides a sandbox where researchers and developers can experiment on existing software components (also called atoms), chain them, or develop new ones. An atom is defined by its metadata companion (a json file) defining the software's execution environment, affinities, and infrastructure constraints. Atoms of Plug'in are deployed leveraging standard virtualization technologies (Docker, VMs) regardless of their programming language.

8) Conclusion (10 minutes): In this part we summarize the efforts in building an operational yet open 5G network, and present the main conclusions and future directions.