5G Programmable Infrastructure Converging disaggregated network and compUte REsources

D7.4 Final dissemination and communication activities document

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5G PPP Research and Validation of critical technologies and systems

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1.0	Final revision and submission to the EC	Jesús Gutiérrez (**IHP**)	14/12/2019

Table of Contents

List of Figures

List of Tables

Executive Summary

This document provides an overview of the dissemination and communication activities carried out during the course of the 5G-PICTURE Project. This document presents the outcomes the project has achieved in this regard from the project starting date.

As a summary, the 5G-PICTURE Project has contributed to the research and development of 5G technologies from various perspectives. First, a high number of contributions have been made within the framework of 5G-PPP, ranging from contributions to joint activities, Working Groups, leadership of Chapters in books and White Papers, etc. Second, the 5G-PICTURE project has reached a successful number of publications to both high-ranked journals and important conferences worldwide. Third and finally, the project has achieved the goals of dissemination and communication to both 5G-related audience and general public beyond the 5G-PPP framework and the development of 5G in Europe.

1 Introduction

The goal of the eighth framework programme funding research, technological development and innovation (H2020 programme), implemented by the European Commission (EC), is to invest in research that will bring Europe at the heart of research and innovation and drive its economic growth. The ongoing research within the H2020 Programme and, more specifically, within the 5G Infrastructure Public Private Partnership (5G-PPP), would be incomplete if the results of the funded projects are not shared with industry and the public in general, and these results are not captured in standardisation bodies.

Dissemination and communication have been key to ensure the awareness and impact of the 5G-PICTURE project activities and results. In this context, the main pillars of the required measures to maximise the impact for the 5G-PICTURE project results have been:

i. Publications in top conferences and journals;
ii. Industry events and demonstration activities where the applications enabled by the 5G-PICTURE technology were showcased.

This deliverable presents an overview of 5G-PICTURE dissemination and communication activities carried out in the 5G-PICTURE project up to November 2019, the original end date of the Project. This document will focus mostly on the second reporting period activities and will present an overall view of the achievements of the project as a whole. It will provide quantitative and qualitative comparisons to the Key Performance Indicators (KPIs) defined in the description of work.

Organisation of the document

This document is structured in four sections. Following the introduction section, Section 2 describes the communication activities triggered within 5G-PICTURE from the starting date of the project. In Section 3, the updated dissemination plan and the contributions/activities carried out during the first reporting period are outlined. Finally, Section 4 concludes the document and provides pointers to upcoming work in these topics.

2 Communication activities

The communication activities within 5G-PICTURE have targeted the generation of visible impact to stakeholders, public, media, as well as to other communication targets. They have been adapted to audiences that go beyond the project's own community, including the media and the public in general.

2.1 Stakeholders

The 5G-PICTURE project stakeholders are outlined below:

- **Network Operators**: it is of the interest of the 5G-PICTURE Consortium to engage the network operators to adopt the 5G-PICTURE transport solution, or at least to incorporate the principles laid out in the 5G-PICTURE architecture.
- **SMEs**, being a key player in the European economy, their involvement has been fostered within 5G-PICTURE directly or indirectly, achieving, in general, a .
- **Open Source communities**: in 5G-PICTURE some of the developments are based on open source components (see Table 3-6 for more details).
- **SDOs**: 5G-PICTURE has been contributing to standardisation activities at a European and an international level. 5G-PICTURE deliverable D7.2 [1] reports the achieved results in this regard.
- **5G-PPP**: 5G-PICTURE has actively contributed to 5G-PPP activities since the project start date. Intense collaboration has been fostered from the Executive Board to achieve a big joint impact together with peer projects. Sections 3.1 and 3.4 provide a more detailed analysis of the contributions and impact achieved.
- **Scientific and Academic**. Although there is a lot of development work in 5G-PICTURE to build the different HW and SW solutions that conform the 5G-PICTURE overall architecture, there has been a huge effort in making contributions to scientific and academic venues. The assessment of the first reporting period was made in deliverable D7.3 [4], being Section 3.6 of this document the place where we report the detailed results in this regard.

2.2 Communication plan update

The communication activities were targeted at all the above stakeholders, as well as at the general public, and consumers outside of the technical knowledge of the project. All partners were actively involved in carrying out these activities. To that end, the 5G-PICTURE Consortium leveraged several tools for both internal and external communications. These were:

- An interactive **Website** for external communications, see section 2.3 for more details. Most of the public Website is publicly available, except an area for internal exchange of information within the Consortium and with the EC Project Officer and Experts.
- An internal document exchange is enabled by a project repository (**Sciebo**). In Sciebo takes place the internal communication: generation of highlights, presentation of management data (manpower, finances, deliverables, partner contacts, Gantt charts, etc.), organisation of meetings, a document library, discussion forum, etc.
- Regarding Social Media, the 5G-PICTURE Project did set up two communication channels: a **Twitter** account that was set-up in June 2017 (https://twitter.com/5G_PICTURE), and a **LinkedIn** account that was set-up in June 2017. The Project disseminated news and contributions made through these two channels. Sections 2.4.1 and 0 of this document refer to these channels.

2.3 Internal/External Communication

5G-PICTURE achieved a relevant impact within the 5G-PPP framework and, in general, in the 5G community in Europe. This section provides an insight on the ongoing Social Media activities, which make

known to the community the 5G-PICTURE demonstration activities of various use cases for both the ICT, but also vertical industries in support of the long term 5G vision.

The 5G-PICTURE project website [2], set up on July 2017, has been one of the key dissemination and communication channels within the project. It is maintained by the Project Coordinator (PC) and represents an essential tool for 5G-PICTURE's communication. The Website presents the project's objectives and includes a description of the partners. It includes as well links to the different social media channels, which can be utilized by any member of the project.

The Website has been populated with the latest 5G-PICTURE news. Figure 2-1 and Figure 2-2 show the current look of the News tabs of the latest 5G-PICTURE event, the Railway demonstration held in Barcelona in November 2019, and the latest publications of 2019, respectively.

Figure 2-1: 5G-PICTURE Website "Home" page.

Figure 2-2: Publications part of the Website, where deliverables, 5G-PPP Contributions and Open Source activities can be accessed.

Table 2-1: 5G-PICTURE Website statistics for both reporting periods.

	1st Reporting Period	2nd Reporting Period
Visits	10000	21600
Page views	14322	35860

The 5G-PICTURE Website statistics are only available from June 2018 on. Up to the end of November 2019, the following performance measures, shown in Table 2-1, have been obtained:

2.4 Social Media

2.4.1 Twitter

The 5G-PICTURE Twitter has got almost 1,400 profile visits, around 30000 impressions, 93 tweets published, and 720 followers. The integration and initial demonstration activities will be carried out in 2019 and the Consortium expects strengthening the social media activity accordingly. Table 2-2 reflects some of the performance achievements of the account in the first reporting period.

Table 2-2: Twitter performance during the Second Reporting Period.

	Results	
Year	First Reporting Period	Second Reporting Period
Followers	377	720
Total impressions	10093	30000
Total Profile Visits	650	1350

Table 2-3: 5G-PICTURE LinkedIn statistics.

	Results	
Year	First Reporting Period	Second Reporting Period
Connections	286	896

2.4.2 LinkedIn

5G-PICTURE set up a LinkedIn account in June 2017. The project is part of the 5G-PPP and has made many connections across Europe and abroad. 5G-PICTURE has boosted the number of connections when compared to the first reporting period, reaching almost 900, as shown in Table 2-3. The tool served to setting up links to other 5G-PPP Projects and making known the project activities and accomplishments. The profile can be accessed via: https://www.linkedin.com/in/5g-picture-project-9a931a152/.

2.4.3 Others

5G-PICTURE contributes to the 5G-PPP Communications Mailing List (Comms@5g-ppp.eu) with its achievements and new releases. Several of the 5G-PICTURE news have been reported to the Mailing list, thus appearing in the 5G-PPP website as news of our Project.

Moreover, information about the 5G-PICTURE is permanently hosted in COSMOTE's main website under URL: in Greek https://www.cosmote.gr/cs/otegroup/gr/5g_picture.html, and in English https://www.cosmote.gr/cs/otegroup/en/5g_picture.html.

Finally, 5G-PICTURE has been reported in the 2017[1] and 2018[2] (p.51/80) Annual Sustainability Reports of COSMOTE.

[1] https://www.cosmote.gr/fixed/documents/10280/788469/2017_sustainability_report_version2_eng.pdf/411410e4-71c3-40dc-b276-23f258db503e, (Report 1, page 55 and 56)

[2] https://www.cosmote.gr/otegroup_company/sustainability/reports/ote/gr/2018.pdf, (p.51/80)

3 Dissemination activities

The 5G-PICTURE dissemination activities have been ambitious in the second reporting period.

3.1 Contributions to 5G-PPP

In this section we describe our collaboration with the 5G-PPP and the various Working Groups (WGs) we are involved in.

3.1.1 Dissemination in Working Groups (WGs)

5G-PICTURE has participated since the starting date of the Project in most of the Working Groups (WGs) related to 5G-PPP, either triggered by the 5G IA or the 5G-PPP itself. We proceed to summarise the contributions per WG.

3.1.1.1 Architecture WG

The Architecture WG has been considered as one of the major targets of 5G-PICTURE. Our Technical Manager (TM), Dr. Anna Tzanakaki (**UNIVBRIS**), and the 5G-PICTURE PC, Dr. Jesús Gutiérrez (**IHP**), have been intensively engaged in the WG activities.

Apart from proposing the 5G-PICTURE architectural concept as a reference architecture for programmable 5G transport networks, the 5G-PICTURE above mentioned contributions have presented different results results on the optimisation of disaggregated compute resources. Additional up-to-date results extracted from the 5G-PICTURE architecture evaluations have been contributed in March 2019, which are part of deliverable D2.3 [3].

5G-PICTURE has participated in the F2F meeting held in Munich, on March 18th-20th 2019, held in NOKIA premises in Munich, for the preparation of Release 3 (v3.0) of the 5G-PPP Architecture WG White Paper Rev.3.0 [9]. In this meeting, the 5G-PICTURE Contributions took over the editorship of Chapter 4 of the White Paper “Core & Transport Architecture”. The White Paper was released in June 2019, at the time EuCNC 2019 was starting. More details on the dissemination of this activity are included in Section 3.4.2.

3.1.1.2 Spectrum WG

IHP has been taking part in the telephone conferences organized by WG Spectrum on a regular basis. The representative from 5G-PICTURE is Prof. Eckhard Grass (**IHP**). Prof. Grass has contributed with inputs in the following topics:

1. Active participation in technical discussions in Telephone Conferences organized by 5G Spectrum WG Chair (Giovanna D'Aria, Telecom Italia).
2. Contributions to the Document “Spectrum WG Response to the 5G IA Board on the RSPG 2nd Opinion” on the role of millimeter wave (mmWave) communications and antenna & beamforming technologies.
3. Contribution to the “Response to PC on the draft text of the 3rd RSPG Opinion on 5G”.
4. Contributions to the Document “Key recommended spectrum areas for FP9 - High-level overview”, in particular, on radio technology enhancements including the development of THz and sub-THz components and techniques as well as techniques for increased spectral efficiency.

After March 2019 the WG has been not that active as before. IHP will continue contributing on behalf of 5G-PICTURE till the end of the Project.

3.1.1.3 TB KPIs WG

Our colleagues Ioanna Mesogiti (**COSM**) and Kostas Katsalis (**HWDU**) represented 5G-PICTURE in the 5G Infrastructure TB discussions on KPIs.

They have been contributing to the different requests the KPI board was requesting. Ioanna did participate in the PPP Technical Workshop 2019 in Málaga (Spain) on October 2019.

Figure 3-1: 5G-PPP Workshop on performance KPIs that took place on October 2019 in Málaga.

3.1.1.4 5G IA Pre-Standardization WG

The 5G IA Pre-Standardization WG monitors continuously the 5G functionalities proposed and their mapping target SDOs indicated. The goal of this WG is to obtain information about current standardisation work or planned work in each of the 5G-PPP Projects. More concretely, this WG is interested in contributions to 3GPP, whose are not the main target of our Project.

We continue reporting our standardisation activities to this WG, which are captured in the 5G-PICTURE deliverable D7.2 [1].

3.1.1.5 5G Software Networks

Zeetta Networks (**ZN**) along with **UTH** and **UPB**, have been contributing to the Software Networks Working Group on behalf of 5G-PICTURE. The current focus of the working group is on Cloud Native Technologies and associated Vertical Services. A major output of this working group has been a white paper on 'Cloud-Native and Verticals' services' [5]. Within this white paper specific contributions of 5G-PICTURE include a description of the cloud native aspects of the projects different demonstrations.

As Zeetta Networks are involved in the Stadium/Mega Event vertical demo for 5G-PICTURE, we have also contributed to the relevant vertical specific sections within the white paper.

3.1.1.6 Trials WG

5G-PICTURE is monitoring the Trials WG is providing the required information related to the trials carried out in 5G-PICTURE. By the time this deliverable was written the Railway demonstration was already showcased in Barcelona, and its details and outcomes will be captured in the next release of the PPP Trials & Pilots document.

3.1.2 KPI Evaluation – Technology Board

Our colleagues Kostas Katsalis (**HWDU**) and Ioanna Mesogiti (**COS**) have been involved in the discussions aiming at assisting and harmonising the work performed across 5G-PPP projects, regarding the evaluation of 5G infrastructures on the basis of Specific, Measurable, Achievable and Realistic KPIs.

More specifically, the main work that has been performed included:

1. Early identification, definition, and iterative refinement of the KPIs to be measured and evaluated in 5G-PICTURE, along with information regarding the ways these will be measured including use cases', work-packages, demonstration activities' information; and communication of this information to the TB KPIs WG. This information has been reported in PPP Programme Management Report (finalised June 2019) (i.e. 5G-PPP Phase 2 KPIs – Annex to Programme Management Report).
2. Contribution and alignment of the 5G-PICTURE KPIs with the full list of KPIs refined and compiled in the context of TB KPIs WG,
3. Linking of the KPIs–related work performed in TB KPIs WG with the work performed in Test, Measurement, and KPIs Validation (TMV) Working Group as reported in: Test, Measurement, and KPIs Validation WG White Paper[3].

In the opposite direction, the work performed and information obtained in the context of TB KPIs WG, has been fused in the work related to the 5G-PICTURE solution(s) validation and evaluation, initially in the context of WP2 (deliverable D2.3 [3]), and in more detail and extent in the context of WP6 (on-going work to be reported in the upcoming deliverable D6.3).

3.1.3 2nd THz Workshop

One of the IHP colleagues working in mmWave and THz communications, Dr. Vladica Sark (**IHP**), took part in the 2nd THz Workshop held in Brussels and organised by the European Commission to discuss about the evolutions of the technology towards achieving high data rate at these frequencies over the air. The work carried out in 5G-PICTURE has been key in getting to know how to develop circuits and systems able to communicate at such high frequencies.

3.2 5G-PICTURE dissemination in Railway-related events

Given that the railway topic has been one of the key interests of the 5G-PICTURE consortium, being as well one of our main demonstration activities, as shown in the next section (Section 3.3), the project has dedicated effort in many ways to contribute and to disseminate the work carried out in this topic.

Some of our railway-related partners, such as **COMSA** and **FGC**, have made effort to promote over the course of the project the implemented solution that was showcased in November in Barcelona. They have engaged the largest Spanish operators, such as ADIF+RENFE, Metro Madrid, and FGC itself, to make them know more details of the millimetre wave (mmWave) solution and general concept of the demo for providing connectivity to the trains on the move. This effort still continues after the Railway

[3] "Validating 5G Technology Performance Assessing 5G architecture and Application Scenarios", Version 1.1., 25/06/2019 DOI: 10.5281/zenodo.3255307 (available at https://5g-ppp.eu/wp-content/uploads/2019/06/TMV-White-Paper-V1.1-25062019.pdf)

demonstration has been showcased, and the solution will be presented to additional stakeholders from November 2019 on.

5G-PICTURE has as well contributed with scientific publications to railway-related publishing venues, leveraging the work carried out by **UNIVBRIS** in this topic. Concretely, again in 2019 there has been a contribution to the Transport Research Arena (TRA) 2019 conference

Finally, our Project, and more concretely our Technical Manager, Dr. Anna Tzanakaki (**UNIVBRIS**), has been invited by the European Commission to contribute to the Digital Transport Days event, co-organized by MOVE B4 and CNECT E1 on the specific topic: "What can 5G bring to each mode of transport?". A presentation on the 5G-PICTURE proof-of-concept of 5G solutions for railways was presented and she did actively participate in a panel discussion on the topic. Figure 3-2 captures a moment of the panel discussion.

Figure 3-2: The 5G-PICTURE Technical Manager, Dr. Anna Tzanakaki (UNIVBRIS) – second from the right, participating in a Panel of the session "What can 5G bring to each mode of transport?".

3.3 5G-PICTURE Railway demonstration

The past November 13th 2019, in a reserved room in the Espai Provença station in Barcelona, took place the 5G-PICTURE Railway demonstration, happening in an operational network from FGC between the stations Olesa de Montserrat and Martorell. The technical details of the demonstration have been already given in deliverables D6.1 [6] and D6.2 [7], and the achieved results and extended technical details of the demonstration will be captured in the upcoming 5G-PICTURE deliverable D6.3.

The agenda of that day is shown in Table 3-1.

Table 3-1: Agenda of the 5G-PICTURE Railway demonstration held on November 13th 2019.

Time	Topic
08:15 – 09:45	Railway Demo presentations in *Espai Provença* (Meeting Room)
09:45 – 10:00	Coffee break
10:00 – 10:30	Bus transfer to Martorell station

10:30 – 13:30	**Railway Demonstration** • Visit to Martorell Control Centre • Visit Stanchion • Visit to Olesa station (Bus/Train) • Trip to Martorell Central station using the equipped train • Return trip to Olesa station

The day started with an overall presentation of the solution, starting with a Welcome message from the FGC Infrastructure Director, Mr. Albert Tortajada, who welcomed the Experts in charge of assessing the evolution of the project and the demonstration itself as well as the 5G-PICTURE Consortium attending the event.

After a short introduction from the 5G-PICTURE Coordinator, Prof. Eckhard Grass (**IHP**), the responsible people from each of the involved Partners, i.e. **FGC**, **COMSA**, **ADVA**, **BWT** and **CNIT**, provided an insight of the different parts of the presentation. The outline of the presentation is shown in Figure 3-3.

Figure 3-3: Outline of the Railway presentation given in *Espai Provença* (Barcelona).

Paula Ciria (**FGC**) started the presentation on the current context of FGC in terms of deployment on-board and at the infrastructure to make possible the different communications, from non-critical to critical, that an operative railway network must support to ensure both performance and safety. She identified the different solutions available as part of the Train Access Network (TAN) and the Train Control Network (TCN), and indicated the role 5G could play to both upgrade and enhance the infrastructure.

Manuel Alfageme (**COMSA**) was the next presenter and he delved deep into how the 5G-PICTURE solution can impact the railways considering a 5G upgrade, and the benefits this would entail. After Manuel, Dr. Jim Zou (**ADVA**), the Railway technical responsible together with Mr. Juan Agustí (**COMSA**), presented the high performance solution that the 5G-PICTURE project proposes as the way forward to adopt 5G in railway communications. He together with Dr. Peter Legg (**BWT**) and Dr. Salvatore Pontarelli (**CNIT**) presented the different solutions, from optical to wireless and the mobility function to orchestrate the connectivity. Jim gave additional details of the overall network architecture, configuration at the train and at the track sides, to then present the work plan carried out to evaluate the overall

solution in the lab, and then how the solution was installed and tested in the track (see Figure 3-4) and in the operational FGC train (Figure 3-5).

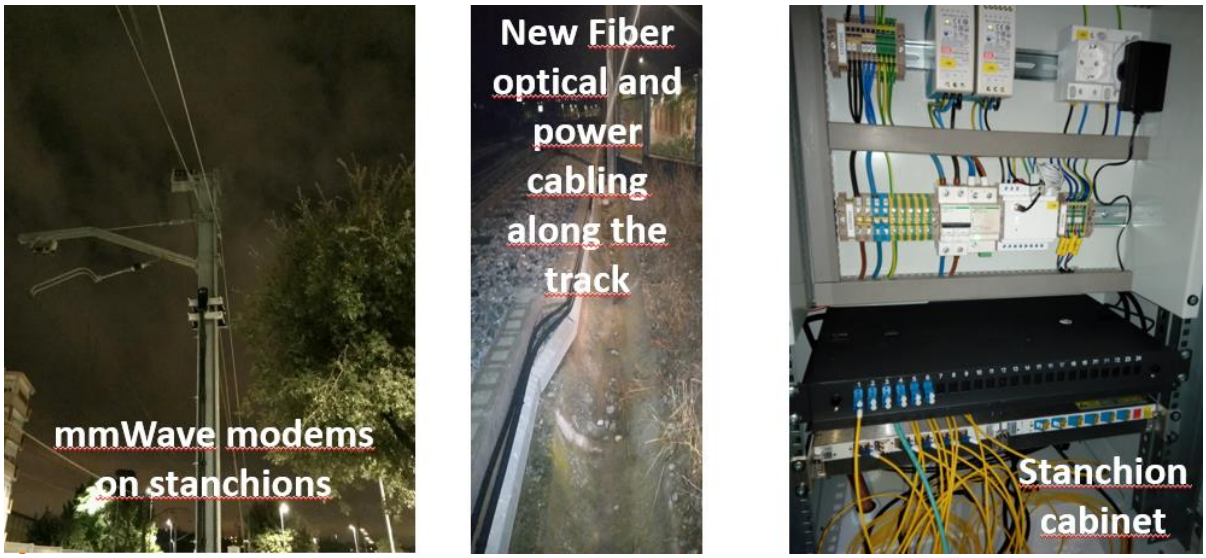

Figure 3-4: Different sites where the equipment was installed.

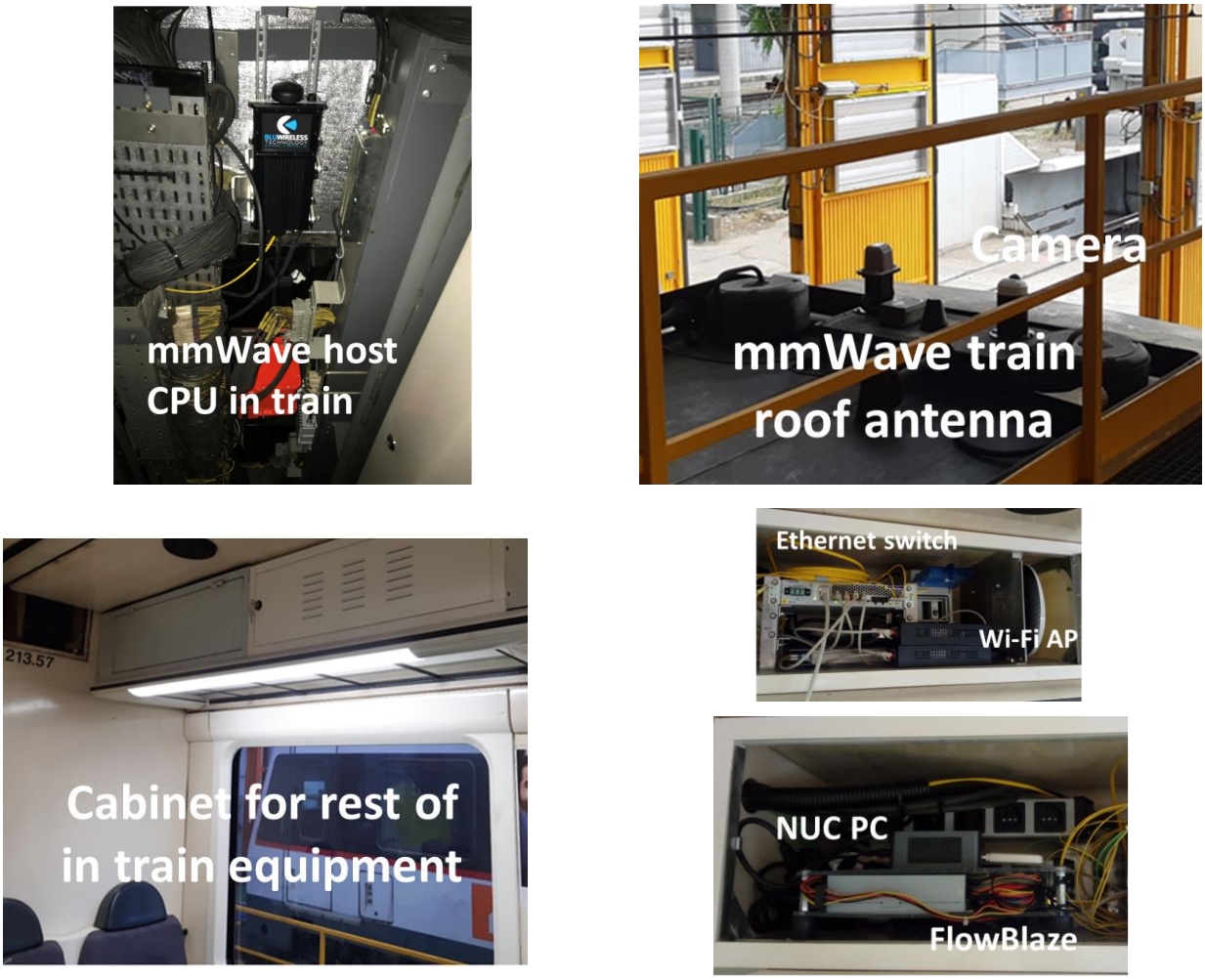

Figure 3-5: Equipment installed in the FGC train.

Finally, the different services running in the solution were presented and a brief overview of the measurements collected was presented. A detailed report of the results will be included in deliverable D6.3. Videos and additional material were generated and they will be shown to stakeholders to promote further the demonstration activity and to foster collaboration for a potential upgrade/extension of the tests.

A group photo was taken after the demo took place, before the 5G-PICTURE Consortium and the Experts left the station where the FGC train stopped (Figure 3-6).

Figure 3-6: Group photo taken at the end of the 5G-PICTURE Railway demonstration.

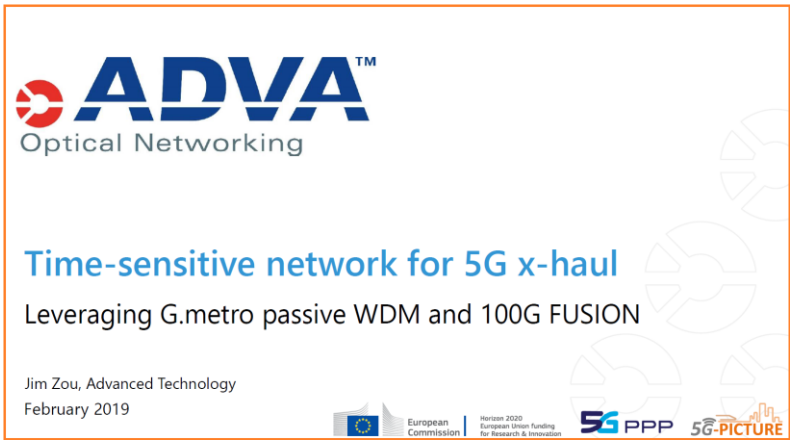

Figure 3-7: ADVA presenting 5G-PICTURE's TSN concept its Stand.

Figure 3-8: 5G-PICTURE was present at the 5G IA Exhibitor @ MWC 2019.

3.4 Participation of 5G-PICTURE in Events

5G-PICTURE has participated in several events since its starting date (July 1st 2017).

We include below a brief overview of those events, focusing on the ones happening in the second reporting period (October 2018 – November 2019).

3.4.1 Mobile World Congress 2019

The 5G-PICTURE Project was present at Mobile World Congress (MWC 2019) at the ADVA Optical Networking stand (Hall 7 / 7H31), where the time sensitive network solution for 5G converged front- and Backhaul that **ADVA** and TransPacket AS (**TP**) were developing in the project.

The stand was equipped with a large touch screen in the front of it, and a slides deck was shown describing the time sensitive network (TSN) for 5G converged front- and Backhaul that ADVA and TP are developing in the 5G-PICTURE project (see Figure 3-7).

The proposed solution leverages TransPacket's FUSION deterministic delay technology for guaranteed service transport, and ADVA's flexible G.metro DWDM optical layer.

Additionally, our project was involved in the preparation of the 5G-IA Exhibitor, where some brochures and additional information was available (Figure 3-8).

3.4.2 EuCNC 2019

The European Conference on Networks and Communications (EuCNC) was one of the key venues for dissemination of 5G-PICTURE activities. Whether it is as a single project, or in several joint activities and Working Groups' events, 5G-PICTURE puts a lot of effort in showcasing much of its participation in the 5G-PPP framework.

5G-PICTURE was present at EuCNC 2019 with the organisation of two Workshops:

- **Workshop 1** "Empowering Transatlantic Platforms for Advance Wireless Research". The 5G-PICTURE Project Coordinator, Dr. Jesús Gutiérrez Terán (**IHP**), presented 5G-VICTORI and its use cases to the audience.
- **Workshop 2** "From Cloud-ready to Cloud-native transformation", a workshop organized by the Software Networks Working Group, which revolved around the cloud native developments within 5G-PP that were included in the last release of the WG White Paper [5].

- **Workshop 3** "Photonic Technologies in 5G and Beyond", where some 5G-PICTURE colleagues gave their view on photonic technologies being leveraged in 5G-PICTURE.
- **Workshop 8** "5GArch 2019: International Workshop on 5G Architecture". More information is provided in Section 3.4.2.2.

5G-PICTURE contributed as well to EuCNC with five (5) publications:

- "Spectrum Coordination for Disaggregated Ultra Dense Heterogeneous 5G Networks", N. Makris, P. Karamichailidis, C. Zarafetas and T. Korakis.
- "A Fingerprint-based Bloom Filter with Deletion Capabilities", M. Kwon, V. Shankar, S. Pontarelli and P. Reviriego.
- "Pushing Services to the Edge Using a Stateful Programmable Dataplane", A. Tulumello, G. Belocchi, M. Bonola, S. Pontarelli, G. Bianchi.
- "C-RAN Employing xRAN Functional Split: Complexity Analysis for 5G NR Remote Radio Unit", J. K. Chaudhary, A. Kumar, J. Bartelt and G. Fettweis.
- "5G-PICTURE: A Programmable Multi-tenant 5G Compute-RAN-Transport Infrastructure", D. Camps-Mur, K. Katsalis, I. Freire, J. Gutiérrez, N. Makris, S. Pontarelli and R. Schmidt.

3.4.2.1 5G-PICTURE Exhibitor

5G-PICTURE was present at EuCNC 2019 with a large Exhibitor (see Figure 3-9) where several demos were showcased. The following demos were shown:

- Programmable Data Plane:
  - 5G-PICTURE /Metro-Haul joint demo – Optical metro solutions (Figure 3-10).
  - Point-to-Multipoint MAC processor for mmWave backhaul solutions
  - Joint Access/Backhaul Wi-Fi solution based on 802.11ac (Figure 3-11).
  - TSN with P4 programmability.
  - Programmable mobility function using FlowBlaze.
- Physical and Virtual Programmable functions
  - 5G functional splits over mmWave and Wi-Fi technologies.
  - Flexible functional splits using OpenAirInterface.
- 5G Operating System
  - Service orchestration in support of multi-version services (Figure 3-12).

Figure 3-9: Photo of the 5G-PICTURE Exhibitor @ EuCNC 2019 in Valencia.

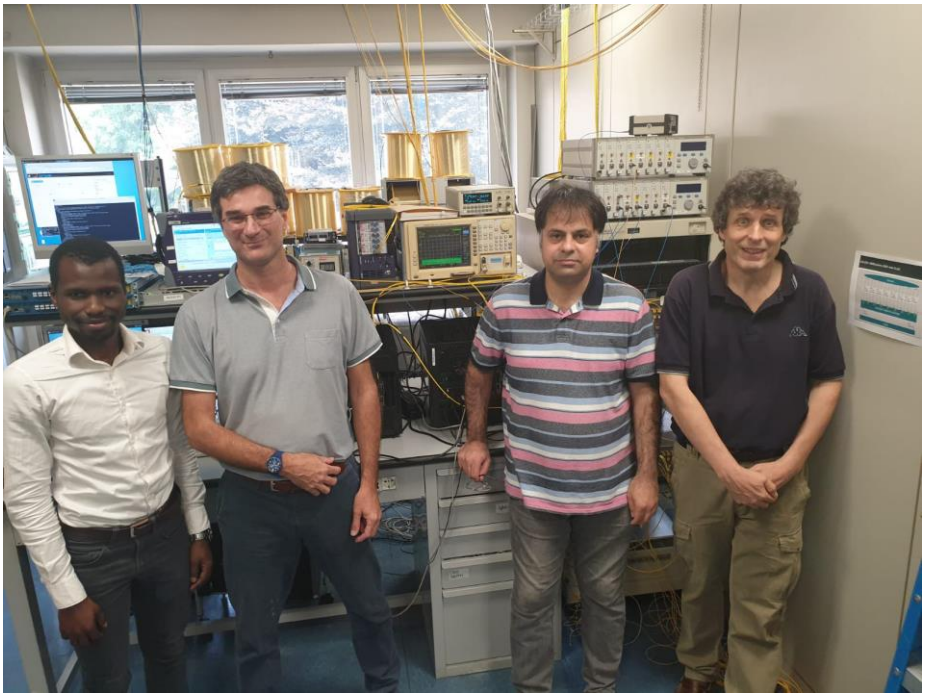

Figure 3-10: 5G-PICTURE & Metro-Haul colleagues who made possible the joint 5G-PPP demo for EuCNC 2019.

Figure 3-11: Daniel Camps and Ferrán Cañelles (I2CAT) showing the Joint Access/Back-haul Wi-Fi solution based on 802.11ac.

Figure 3-12: Hadi Razzaghi (UPB) presenting his demo on Service orchestration in support of multi-version services.

3.4.2.2 WG Architecture Workshop

5G-PICTURE had a strong participation in the WG Architecture workshop held at EuCNC 2019, entitled "5GArch 2019: International Workshop on 5G Architecture". As Chapter 4 editor of the White Paper v3.0 [9], the 5G-PICTURE PC, Dr. Jesús Gutiérrez (**IHP**), presented the work of several of the 5G-PPP Projects (including 5G-PICTURE) in the area of Core and Transport networks.

The workshop encompassed the presentations from the other chapters, being the Phase 2 and Phase 3 (ICT-17) projects the main contributors. Figure 3-13 (left) shows the Chair of the WG, Dr. Simone Redana (NOKIA Germany) introducing the Workshop. Figure 3-13 (right) shows a photo of the chapter editors once the Workshop came to an end.

Figure 3-13: 5G-PPP Architecture Workhshop held @ EuCNC 2019. WG Architecture Chairs (left) and the Editors of the White Paper Chapters (right).

3.4.2.3 WG Software Networks

5G-PICTURE participated in the Workshop organized by the WG Software Networks. The title of the workshop was "From Cloud-ready to Cloud-native transformation", and our 5G-PICTURE colleague Hadi Razzaghi (**UPB**) gave a talk entitled "*Kubernetes and OpenStack to support multi-version service chaining*" (see Figure 3-14). In this talk, UPB's latest development and research results on dynamically provisioning of heterogeneous resources such as containers, virtual machines, and GPUs for network services have been presented.

Figure 3-14: Hadi Razzaghi (UPB) presenting his talk in the Workshop.

3.4.3 ONDM 2019 and the 5G-PICTURE Summer School

The 5G-PICTURE Technical Manager, Dr. Anna Tzanakaki (**UNIVBRIS**), served in this year as the Chair of the Conference on Optical Network Design and Modelling (ONDM), which was held in Athens, Greece. This event was a great venue to show the evolution of the 5G-PICTURE project and we did put effort in organising there a Workshop and a Summer School as part of the commitments of the Description of Work (DoW).

3.4.3.1 Workshop "Optical Networking an enabler for 5G Solutions, Trials and Demonstrators"

This workshop aimed at discussing the role of optical technologies and networking in 5G network architectures, deployments as well as trials and demonstrators from different perspectives, addressing aspects such as:

- What is the role of optical technologies (transmission and switching) in 5G networks, especially in view of key challenges such as density of access points, energy savings, bandwidth, latency or reliability requirements?
- How can optical wireless network convergence facilitate efficient 5G transport solutions from both data and control plane perspectives?
- How can optical networks facilitate 5G virtualised network functions?
- How can optical layer programmability facilitate the vision of a unified 5G network control in multi-tenant environments supporting a variety of vertical industries?
- How can optical network solutions facilitate 5G field trials and demonstrations for ICT and vertical ecosystems?

The Workshop was organised by Dr. Anna Tzanakaki (**UNIVBRIS-HPN**), Technical Manager of 5G-PICTURE and by Prof. Reza Nejabati (**UNIVBRIS-HPN**).

Dr. Arash Farhadi Beldachi (**UNIVBRIS-HPN**), gave a presentation entitled "Active Optical Transport Network Solutions and Demonstration Activities" on the work University of Bristol carried out in 5G-PICTURE.

Figure 3-15: Our colleague Dr. Markos Anastasopoulos (UNIVBRIS) giving a presentation in the 5G-PICTURE Summer School at ONDM 2019.

Figure 3-16: Our colleague Dr. Navid Nikaein (EUR) giving a presentation in the 5G-PICTURE Summer School at ONDM 2019.

3.4.3.2 5G-PICTURE Summer School @ONDM 2019

The 5G-PICTURE Summer school was organised jointly by the EU projects 5G-PICTURE and the ERASMUS programme SMARTNET (http://www.ondm2019.com/summer-school/), in conjunction with ONDM.

Our 5G-PICTURE colleagues, Dr. Markos Anastasopoulos (**UNIVBRIS**) and Dr. Navid Nikaein (**EUR**), were part of the 5G-PICTURE crew in charge of providing talks and tutorials to the attendees. and capture a moment of their talks. The presentations were entitled:

- M. Anastasopoulos "Network Modelling and Optimisation" (Figure 3-15).
- N. Nikaein, "5G Networks: Technologies, Challenges, and Tools" (Figure 3-16).

3.4.4 Other Events

3.4.4.1 Participation of 5G-PICTURE in the 5G-PHOS Training School

The Phase 2 Project 5G-PHOS organised in 2019 a Training School on "Emerging technologies for 5G networks". The Training School took place at the Aristotle University of Thessaloniki (AUTH), at the facilities of the Wireless and Photonic Systems and Networks (WinPhoS) research group (http://winphos.web.auth.gr/).

The Training School was financially supported by the EUIMWP (CA 16220) COST Action and the 5G-PHOS H2020 5GPPP Phase II (GA No. 761989).

In this Training School, our Technical Manager, Dr. Anna Tzanakaki (**UNIVBRIS-HPN**) gave a presentation on the WP2 work her group carried out in 5G-PICTURE, and it was entitled "Optical networking an Enabler for 5G".

3.4.4.2 Presentation @ DEBS by UPB

Our colleague from University of Paderborn (**UPB**), Hadi R. Kouchaksarei, presented at the 13th ACM International Conference on Distributed and Event-based Systems (DEBS) the demo entitled "*Service Function Chaining Across OpenStack and Kubernetes Domains*" (see Figure 3-17).

Figure 3-17: Hadi Razzaghi (UPB) presenting a demo in DEBS 2019.

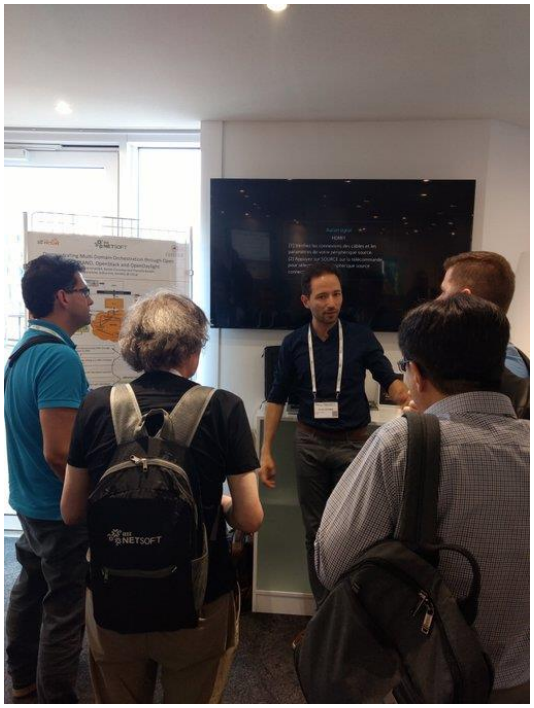

Figure 3-18: Dr. Kostas Choumas (UTH) presenting the 5G-PICTURE multi-domain orchestrator.

3.4.4.3 5G-PICTURE demo in #NetSoft2019

Our 5G-PICTURE colleague, Dr. Kostas Choumas (**UTH**), presented the multidomain orchestration of 5G-PICTURE at IEEE NetSoft 2019 (see Figure 3-18).

3.5 5G-PICTURE 5G-PPP publications

3.5.1 5G Annual Journal 2019

5G-PICTURE contributed for the second time to the European 5G Annual Journal, which last release (4th release) was published in May 2019, and where 5G-PICTURE included an overview of the technical contributions made within WP3, WP4 and WP5 to the three main use cases it will showcase: Railway, Smart City and Stadium.

3.6 5G-PICTURE Scientific Publications

5G-PICTURE has disseminated the work carried out in the project in different forms and in different venues. In this first reporting period the project has contributed to many presentations and publications, complying with that what was targeted in the DoW.

The project has contributed with a total of:

- 65 publications in Conferences (see Table 3-2 for more details).
- 19 demonstrations at Conferences and/or 5G-related events (see
- Table 3-3 for more details).
- 23 publications in high-ranked Journals (see Table 3-4 for more details).
- 22 presentations in 5G-related Workshops (see Table 3-5 for more details).

This is an outstanding achievement given the large amount of development work that the technical work and demonstration required.

Table 3-2: Conference papers belonging to the second reporting period.

	Venue	Date	Location	Type of contribution	Title	Author(s) / Presenter	Partner	Status
29	ECOC	2018	Rome, Italy	Paper	Service Chaining in MEC - Assisted Large Scale 5G Networks	M. Anastasopoulos, A. Tzanakaki, and D. Simeonidou	UNIVBRIS-HPN	Accepted
30	ECOC	2018	Rome, Italy	Paper	Experimental Demonstration of 5G Fronthaul and Backhaul Convergence Based on FPGA-Based Active Optical Transport	A. F. Beldachi, E. Huques-Salas, A. Tzanakaki, Y. A. Yan, R. Nejabati, and D. Simeonidou	UNIVBRIS-HPN	Accepted
31	PIMRC	2019	Istanbul, Turkey	Paper	Energy Efficiency Maximization in Massive MIMO-aided, Fronthaul-constrained C-RAN	J. Francis and G. Fettweis	TUD	Accepted
32	ONDM	2019	Athens, Greece	Paper	Techno-economic Aspects of 5G Transport Network Deployments	I. Mesogiti et al.	COS	Accepted
33	ONDM	2019	Athens, Greece	Paper	Resilient Cloud-RANs Adopting Network Coding	A. F. Beldachi, M. Anastasopoulos, A. Manolopoulos, A. Tzanakaki, R. Nejabati and D. Simeonidou	UNIVBRIS-HPN	Accepted
34	ONDM	2019	Athens, Greece	Paper	Dynamic Softwarised RAN Function Placement in Optical Data Centre Networks	N. Gkatzios, A. Tzanakaki, M. Anastasopoulos, and D. Simeonidou	UNIVBRIS-HPN	Accepted
35	ONDM	2019	Athens, Greece	Paper	Joint Fronthaul Optimization and SDN Controller Placement in Dynamic 5G Networks	V. M. Alevizaki, M. Anastasopoulos, A. Tzanakaki, and D. Simeonidou	UNIVBRIS-HPN	Accepted
36	WCNC	2019	Marrakesh, Morocco	Paper	Use of Machine Learning for energy efficiency in present and future mobile networks	D. Sesto-Castilla et al.	I2CAT	Accepted
37	WSA	2019	Vienna, Austria	Paper	Multi User Beam Selection Using Sequential Competition Test	M. Khalili, W. Rave and G. Fettweis	TUD	Accepted
38	WCNC	2019	Marrakech, Morocco	Paper	A practical approach to slicing Wi-Fi RANs in future 5G networks	J. J. Aleixendri, A. Betzler, D. Camps-Mur	I2CAT	Accepted
39	IEEE NetSoft	2019	Paris, France	Paper	SPRING: Scaling, Placement, and Routing of Heterogeneous Services with Flexible Structures	S. Dräxler and H. Karl	UPB	Accepted
40	IEEE NetSoft	2019	Paris, France	Paper	Demonstrating Multi-Domain Orchestration through Open Source MANO, OpenStack and OpenDayLight	P. Karamichailidis, K. Choumas and T. Korakis	UTH	Accepted
41	OFC	2019	San Diego, US	Paper	Zero-Touch Provisioning of Distributed Video Analytics in a Software-Defined Metro-Haul Network with P4 Processing	B.-M. Andrus, S. A. Sasu, S. K. Patri, T. Szyrkowiec, A. Autenrieth, M. Chamania, J. K. Fischer, S. Rasp	ADVA	Accepted
42	OFC	2019	San Diego, US	Paper	Enabling Heterogeneous Low Latency and High-Bandwidth Virtual Network Services for 5G Utilizing a Flexible Optical Transport Network	T. Diallo, A. F. Beldachi, A. S. Muqaddas, R. S. Silva, R. Nejabati, A. Tzanakaki, and D. Simeonidou	UNIVBRIS-HPN	Accepted
43	OFC	2019	San Diego, US	Paper	Remote Wavelength Tracking of Strongly Chirped Tunable 10G MEMS-VCSEL for Port-Agnostic WDM Fronthaul	J. Zou, M. Houri, H.-K. Chen, M. Eiselt	ADVA	Accepted
44	ICC	2019	Shanghai, China	Paper	Design and evaluation of a hierarchical SDN control plane for 5G transport networks	D. Giatsios, K. Choumas, P. Flegkas, T. Korakis, J. J. Aleixendri, D. Camps-Mur	UTH	Accepted
45	EuCNC	2019	Valencia, Spain	Paper	5G-PICTURE: A Programmable Multi-tenant 5G Compute-RAN-Transport Infrastructure	D. Camps-Mur, K. Katsalis, I. Freire, J. Gutiérrez, N. Makris, S. Pontarelli and R. Schmidt	I2CAT	Accepted
46	EuCNC	2019	Valencia, Spain	Paper	C-RAN Employing xRAN Functional Split: Complexity Analysis for 5G NR Remote Radio Unit	J. K. Chaudhary, A. Kumar, J. Bartelt and G. Fettweis	TUD	Accepted

47	EuCNC	2019	Valencia, Spain	Paper	Pushing Services to the Edge Using a Stateful Programmable Dataplane	A. Tulumello, G. Belocchi, M. Bonola, S. Pontarelli, G. Bianchi	CNIT	Accepted
48	EuCNC	2019	Valencia, Spain	Paper	A Fingerprint-based Bloom Filter with Deletion Capabilities	M. Kwon, V. Shankar, S. Pontarelli and P. Reviriego	CNIT	Accepted
49	EuCNC	2019	Valencia, Spain	Paper	Spectrum Coordination for Disaggregated Ultra Dense Heterogeneous 5G Networks	N. Makris, P. Karamichailidis, C. Zarafetas and T. Korakis	UTH	Accepted
50	IEEE Workshop on SDN-NFV	2019	Dallas, Texas, USA	Paper	Accelerating Packet Classification with Two Class Cuckoo Filters (TC-CF)	J. Martinez, P. Reviriego, S. Pontarelli	CNIT	Accepted
51	IEEE LANMAN	2019	Paris, France	Paper	Enabling Multi-Domain Orchestration using Open Source MANO, OpenStack and OpenDaylight	P. Karamichailidis, K. Choumas and T. Korakis	UTH	Accepted
52	IEEE LANMAN	2019	Paris, France	Paper	On Minimizing Service Access Latency: Employing MEC on the Fronthaul of Heterogeneous 5G Architectures	N. Makris, V. Passas, C. Nanis and T. Korakis	UTH	Accepted
53	ICC	2019	Shanghai, China	Paper	FlexVRAN: A Flexible Controller for Virtualized RAN over Heterogeneous Deployments	R. Schmidt, C.-Y. Chang and N. Nikaein	EUR	Accepted
54	ICC	2019	Shanghai, China	Paper	Recent Trials of G.metro-Based Passive WDM Fronthaul in 5G Testbeds	J. Zou, M. Eiselt, M. Alfageme, J. Agusti, C. Terés, P. Ciria, R. Veisllari, M. Fontaine, J.-P. Elbers	ADVA	Accepted
55	IEEE Globecom	2019	Waikoloa, HI, USA	Paper	Slice Scheduling with QoS-Guarantee towards 5G	R. Schmidt, C.-Y. Chang and N. Nikaein	EUR	Accepted
56	ECOC	2019	Dublin, Ireland	Invited Paper	Options for Time-Sensitive Networking for 5G Fronthaul	J. Zou, S. A. Sasu, J. Messenger, J.P. Elbers	ADVA	Accepted
57	ECOC	2019	Dublin, Ireland	Paper	A Novel PROGRAMABLE DISAGGREGATED EDGE NODE SUPPORTING HETROGENEOUS 5G ACCESS TECHNOLOGIES	A. Tzanakaki, A. F. Beldachi, M. P. Anastasopoulos, and D. Simeonidou	UNIVBRIS-HPN	Accepted
58	CNSM	2019	Halifax, Canada	Paper	Quantitative Analysis of Dynamically Provisioned Heterogeneous Network Services	H. R. Kouchaksaraei and H. Karl	UPB	Accepted
59	SDS	2019	Rome, Italy	Paper	Accelerating Packet Classification with Two Class Cuckoo Filters (TC-CF)	J. Martínez, P. Reviriego, S, Pontarelli	CNIT	Accepted
60	ICC	2020	Dublin, Ireland	Paper	Time-Sensitive Networking for 5G Fronthaul Networks	S. Bhattacharjee, R. Schmidt, K. Katsalis, C.-Y. Chang, T. Bauschertz, N. Nikaein	EUR	Submitted
61	ECOC	2019	Dublin, Ireland	Paper (elevated to Invited)	A Novel PROGRAMABLE DISAGGREGATED EDGE NODE SUPPORTING HETROGENEOUS 5G ACCESS TECHNOLOGIES	A. Tzanakaki, A. F. Beldachi, M. P. Anastasopoulos, and D. Simeonidou	UNIVBRIS-HPN	Accepted
62	Transport Research Arena (TRA)	2020	Helsinki, Finland	Paper	Multi-technology Wireless Access for Railway Cabin Services: Planning and Performance Evaluation	M. Anastasopoulos, A. Tzanakaki et al.	UNIVBRIS-HPN	Accepted
63	Transport Research Arena (TRA)	2020	Helsinki, Finland	Paper	Comparative Analysis of Autoencoder Neural Networks for Fault Detection in Railway Systems	M. Anastasopoulos, et al.	UNIVBRIS-HPN	Accepted
64	Photonics in Switching	2020	Fukuoka, Japan	Invited	Optical transport networks for 5G: an enabler for vertical industries	A. Tzanakaki, M. Anastasopoulos, and D. Simeonidou	UNIVBRIS-HPN	Accepted
65	Photonics in Switching	2020	Fukuoka, Japan	Invited	A Flexible X-haul Network for 5G and Beyond	J.-P. Elbers and J. Zou	ADVA	Accepted

Table 3-3: Demos at Conferences.

	Venue	Date	Location	Title	Author(s) / Presenter	Partner
6	IEEE NetSoft	2019	Paris, France	Demonstrating Multi-Domain Orchestration through Open Source MANO, OpenStack and OpenDayLight	P. Karamichailidis, K. Choumas and T. Korakis	UTH
7	OFC	2019	San Diego, US	Zero-Touch Provisioning of Distributed Video Analytics in a Software-Defined Metro-Haul Network with P4 Processing	B-M Andrus, S. A. Sasu, S. K. Patri, T. Szyrkowiec, A. Autenrieth, M. Chamania, J. K. Fischer, S. Rasp	ADVA
8	IEEE LANMAN	2019	Paris, France	Virtualized Heterogeneous 5G Cloud-RAN deployment over Redundant Wireless Links	N. Makris, C. Zarafetas, K. Choumas, P. Flegkas and T. Korakis	UTH
9	DEBS	2019	Darmstadt, Germany	Service Function Chaining Across OpenStack and Kubernetes Domains",	H. R. Kouchaksarei	UPB
10	P4 Workshop	2019	Stanford University, US	Sampling on Demand using P4 Programmable Switch in Hybrid Mode	M. Kadosh	MLNX
11	NetDev	2019	Prague, Czech Republic	Stateless IP based load balancing	M. Kadosh	MLNX
12	EuCNC	2019	Valencia, Spain	Point-to-Multipoint MAC processor for mmWave backhaul solutions	N. Maletic, V. Sark, J. Gutiérrez	IHP
13	EuCNC	2019	Valencia, Spain	Programmable mobility function using FlowBlaze	V. Bruschi, A. Tulumello, S. Pontarelli	CNIT
14	EuCNC	2019	Valencia, Spain	Joint Access/Backhaul Wi-Fi solution based on 802.11ac.	J. J. Aleixendri, F. Cañelles, D. Camps-Mur	I2CAT
15	EuCNC	2019	Valencia, Spain	TSN with P4 programmability	S. A. Sasu	ADVA
16	EuCNC	2019	Valencia, Spain	Service orchestration in support of multi-version services	H. R. Kouchaksarei	UPB
17	EuCNC	2019	Valencia, Spain	5G-PICTURE / Metro-Haul joint demo – Optical metro solutions	A. Percelsi, A. F. Beldachi	TIM / UNIVBRIS
18	EuCNC	2019	Valencia, Spain	5G functional splits over mmWave and Wi-Fi technologies	K. Choumas, N. Makris, P. Flegkas	UTH
19	EuCNC	2019	Valencia, Spain	Flexible functional splits using OpenAirInterface	O. Arouk, R. Schmidt, N. Nikaein	EUR

Table 3-4: Journal Papers belonging to the second reporting period.

	Venue	Title	Author(s)	Partner	Status
8	IEEE Journal of Lightwave Technology	Scenarios and Economic Analysis of Fronthaul in 5G Optical Networks	A. di Giglio and A. Pagano	TIM	Accepted
9	IEEE Vehicular Technology	Closing in on 5G Control Apps: Enabling Multiservice Programmability in a Disaggregated Radio Access Network	C-Y. Chang, N. Nikaein	EUR	Accepted
10	IEEE Access	RAN runtime slicing system for flexible and dynamic service execution environment	C-Y. Chang, N. Nikaein	EUR	Accepted
11	IEEE SDN Newsletter	Slicing and orchestration in service-oriented RAN architecture	C-Y. Chang, N. Nikaein	EUR	Accepted
12	Appl. Sci. 2018 Special Issue: Optical Communications and Networking	C-RAN Traffic Aggregation on Latency-Controlled Ethernet Links	F. Tonini, B. M. Khorsandi, S. Bjørnstad, R. Veisllari, C. Raffaelli	TP	Accepted
13	IEEE Journal of Lightwave Technology	Scalable Service Chaining in MEC-Assisted 5G Networks	M. Anastasopoulos, A. Tzanakaki, and D. Simeonidou	UNIVBRIS-HPN	Accepted
14	EURASIP Journal on Wireless Communications and Networking	Efficiency Gains in 5G Softwarised Radio Access Networks	N. Gkatzios, M. Anastasopoulos, A. Tzanakaki and D. Simeonidou	UNIVBRIS-HPN	Accepted
15	IEEE/OSA J. Opt. Commun. Netw.	Converged optical, wireless, and data center network infrastructures for 5G services	A. Tzanakaki, M. Anastasopoulos, and D. Simeonidou,	UNIVBRIS-HPN	Accepted
16	IEEE Communications Letters	Improving Packet Flow Counting with Fingerprint Counting	P. Reviriego, J. Martınez and S. Pontarelli	CNIT	Accepted
17	IEEE Communications Letters	CFBF: Reducing the Insertion Time of Cuckoo Filters With an Integrated Bloom Filter	P. Reviriego, J. Martínez, S. Pontarelli	CNIT	Accepted
18	IEEE Transactions on Network and Service Management	XTRA: Towards Portable Transport Layer Functions	G. Bianchi, M. Welzl, A. Tulumello, F. Gringoli, G. Belocchi, M. Faltelli, S. Pontarelli	CNIT	Accepted
19	IEEE Transactions on Network and Service Management	SODALITE: SDN Wireless Backhauling for Dense 4G/5G Small Cell Networks	A. Betzler, D. Camps-Mur, E. Garcia-Villegas, I. Demirkol, and J. J. Aleixendri	I2CAT	Accepted
20	Proceedings of the IEEE	Survey of Performance Acceleration Techniques for Network Function Virtualization	L. Linguaglossa et al.	CNIT	Accepted
21	Information Processing Letters	CuCoTrack: Cuckoo filter based connection tracking	P Reviriego, S Pontarelli, G Levy	CNIT	Accepted
22	Signal Processing Letters	Beam Selection Based on Sequential Competition	M. Khalili, W. Rave and G. Fettweis	TUD	Accepted
23	Springer Photonic Network Communications Journal	Macroscopic and Microscopic Techno-economic Analyses Highlighting Aspects of 5G Transport Network Deployments	I. Mesogiti, G. Lyberopoulos, F.Setaki, A. Di Giglio, A. Pelcelsi, L. Serra, Jim Zou, A. Tzanakaki, M. Anastasopoulos, E. Theodoropoulou	COS	Submitted

Table 3-5: 5G-PICTURE Presentations at Workshops.

	Venue	Date	Location	Type of contribution	Title	Presenter	Partner
11	The Digital Technology Symposium	Nov 5-6 2018	Athens, Greece	Presentation (in Greek)	«Ερευνητικά Έργα 5G Ομίλου OTE και προοπτικές συνεργασίας»	G. Lyberopoulos	COS
12	20th Infocom World	Nov 21 2018	Athens, Greece	Presentation	Cloud Computing and 5G Network Technologies' Advancements driving Advanced SLAs	E. Theodoropoulou	COS
13	ONDM	May 2019	Athens, Greece	Presentation	Recent Trends and Applications for Optical Networking	D. Simeonidou	UNIVBRIS-HPN
14	ONDM	May 2019	Athens, Greece	Presentation	Active Optical Transport Network Solutions and Demonstration Activities	A. Beldachi	UNIVBRIS-HPN
15	ONDM	May 2019	Athens, Greece	Invited talk (Industry Panel)	Precise timing and ultra-low latency technologies for transport of 5G services	A. Autenrieth	ADVA
16	EuCNC	June 2019	Valencia, Spain	Presentation	Chapter 4 of the 5G Arch White Paper @ 5GArch 2019: International Workshop on 5G Architecture Workshop	J. Gutiérrez	IHP
17	EuCNC	June 2019	Valencia, Spain	Presentation	Kubernetes and OpenStack to support multi-version service chaining @ From Cloud-ready to Cloud-native transformation Workshop	H. Razzaghi	UPB
18	DIGITAL TRANSPORT DAYS	October 2019	Helsinki, Finland	Presentation	5G-PICTURE on a proof-of-concept of 5G solutions for railways @ "What can 5G bring to each mode of transport?" Workshop	A. Tzanakaki	UNIVBRIS-HPN
19	ICT for RAILWAYS Workshop, organized by CENELEC	September 2019	Naples, Italy	Presentation	Train to ground connectivity activities and demonstration presented in collaboration with the Horizon 200 Shif2Rail Project In2DREAMS	A. Tzanakaki	UNIVBRIS-HPN
20	IEEE Photonics Conference (IPC 2019)	29 Sept – 3 Oct, 2019	San Antonio, TX, USA	Invited talk (Industry Panel)	5G-RAN: challenges and solutions for optical transport	J. Zou	ADVA
21	IEEE Summer Topicals Meeting Series 2019	8-10 July, 2019	Fort Lauderdale, FL, USA	Invited talk	Optical access technologies for time-sensitive fronthaul	J. Zou	ADVA
22	IEEE Summer Topicals Meeting Series 2019	8-10 July, 2019	Fort Lauderdale, FL, USA	Invited talk	On Ethernet-based Time Sensitive Networking for Converged 5G XHaul	J. Zou, R. Veisllari	ADVA / TP

Table 3-6: 5G-PICTURE Open Source releases.

	Title	Partner
1	Prototype of joint MANO for VNFs and cloud services on GitHub	UPB
2	MEF – Slicing Working Group: Contributed use cases and terminology definitions	ZN
3	TelecomInfraProject (TiP) – End-to-end Slicing Group: Contributed use-case review	ZN

4 Summary and Conclusions

This deliverable presented the dissemination and communication achievements of the 5G-PICTURE project during its second reporting period. Being this document the last deliverable addressing these topics, the overall assessment results satisfactory, as we have reached the goals set in the DoW, bringing the contributions and results of the project to a broader audience than that within 5G-PPP. The different communication channels have resulted a key tool to make 5G-PICTURE known beyond the 5G-PPP community.

From now on we will focus on the advertisement of two of our main demonstration activities, the Stadium demonstration and the Smart City demonstration, both taking place in Bristol in March 2020. The 5G-PICTURE project is willing to promote the demonstrations and the results obtained as part of the strategy to reach the maximum impact.

5 References

[1] 5G-PICTURE deliverable D7.2, “Final Standardisation Activities document”, December 2018.

[2] 5G-PICTURE Website, http://www.5g-picture-project.eu

[3] 5G-PICTURE deliverable D2.3, “Vertical services, architecture and final evaluations”, November 2019.

[4] 5G-PICTURE deliverable D7.3, “Initial dissemination and communication activities document”, December 2018.

[5] B. Sayadi et al., 5G-PPP Software Network Working Group “Cloud-Native and Verticals' services” – 5G-PPP projects analysis”. 10.13140/RG.2.2.23912.21763.

[6] 5G-PICTURE deliverable D6.1, “Specification of Vertical Use cases and Experimentation plan”, November 2018.

[7] 5G-PICTURE deliverable D6.2, “Vertical Demo and Testbed setup and Initial Validation Results”, July 2019.

[8] 5G-PICTURE LinkedIn page, https://www.linkedin.com/in/5g-picture-project-9a931a152/

[9] WG Architecture White Paper v3.0, https://5g-ppp.eu/5g-ppp-5g-architecture-wg-white-paper-rev-3-0-for-public-consultation/#

6 Acronyms

Acronym	Description
EC	European Commission
MWC	Mobile World Congress