H2020 5G-TRANSFORMER Project
Grant No. 761536

Initial Communication, Dissemination, and Exploitation Plan (CoDEP) draft including Standardization roadmap

Abstract

This document presents the initial communication, dissemination, and exploitation plan (CoDEP) for the 5G-TRANSFORMER project. Communication includes all the activities related with the promotion of the project and its results beyond the project's own community. This includes the interaction with other research projects (e.g., H2020 5G PPP) as well as communication of its research in a way that is understood by non-specialist, e.g., the media and the public. Dissemination includes activities related to raising awareness of results of the project in a technical community working on the same research field. In general, this will be done through peer-reviewed publications in academic conferences/journals and other venues, and participation and organization of technical events. Finally, exploitation (in accordance with the European IPR Helpdesk) covers activities aiming at using the results in further research activities other than those covered by the project, or in developing, creating and marketing products or processes, or in creating and providing a service, or in standardisation activities. The plan started at the proposal stage, continues during the project lifetime and aims at generating survivable results, through exploitation, after the project ends. A list of achievements so far is also presented.

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List of Acronyms

Acronym	Description
3GPP	Third Generation Partnership Project
5G PPP	5G Public Private Partnership
API	Application Programming Interface
BPON	Broadband Passive Optical Network
BTS	Base Transceiver Station
CDB	Common Dissemination Booster
CDN	Content Delivery Network
CEO	Chief Executive Officer
CPRI	Common Public Radio Interface
CSA	Coordination and Support Action
DETNET	Deterministic Networking WG (IETF)
DWDM	Dense Wavelength Division Multiplexing
E2E	End-to-end
EPC	Evolved Packet Core
ETP	European Technology Platform
ETSI	European Telecommunications Standards Institute
ICT	Information and Communication Technology
IEEE	Institute of Electronics and Electrical Engineering
IETF	Internet Engineering Task Force
IMT	International Mobile Telecommunications
IoT	Internet of Things
IP	Internet Protocol
IPR	Intellectual Property Rights
IRTF	Internet Research Task Force
ISG	Industry Specification Group (ETSI)
IT	Information Technology
ITS	Intelligent Transport Systems
ITU-T	International Telecommunications Union – Telecommunications standardization sector
LTE / -A	Long Term Evolution / -Advanced (3GPP)
MEC	Multi-Access Edge Computing
MME	Mobility Management Entity
MTP	Mobile Transport and Computing Platform
MVNO	Mobile Virtual Network Operator
NFV	Network Functions Virtualization
NFVRG	NFV Research Group (IRTF)
NGMN	Next Generation Mobile Networks
OBSAI	Open Base Station Architecture Initiative
ODL	OpenDayLight
OF	Open-Flow (ONF)
ONF	Open Networking Foundation
OPNFV	Open Platform for NFV
QoS	Quality of Service
RAN	Radio Access Network
RG	Research Group
SCF	Small Cells Forum
SDN	Software Defined Networks
SDNRG	SDN Research Group (IRTF)

SDO	Standard Development Organization
SO	Service Orchestrator
S-/P-GW	Serving / Packet Data Network Gateway
SLA	Service Level Agreement
V2X	Vehicle-to-everything
VNF	Virtual Network Function
VNFM	Virtual Network Function Manager
VS	Vertical Slicer
WG	Work Group
WG	Working Group

Executive Summary

The main contributions of this document are:

- Refinement of the plan for communication, dissemination, and exploitation (CoDEP) of 5G-TRANSFORMER, which already started at the proposal preparation phase. A relevant role of this plan is given to standardization activities.

- Presentation of the early achievements according to this plan.

As for the communication, dissemination, and exploitation plan (CoDEP) for the 5G-TRANSFORMER project, a refinement is presented, which, at the same time, is the initial plan if we only focus on the project lifetime. *Communication* includes all the activities related with the promotion of the project and its results beyond the projects own community. This includes the interaction with other research projects (e.g. H2020 5G PPP) as well as communication of its research in a way that is understood by non-specialist, e.g. the media and the public. Notice, though, that even if collaboration with other projects is presented under communication, it also spans dissemination and exploitation. *Dissemination* includes activities related with raising awareness of its results in a technical community working on the same research field. In general, this will be done through publications, and participation and organization of technical events. Finally, *exploitation* (in accordance with the European IPR Helpdesk) covers activities aiming at using the results in further research activities other than those covered by the project, or in developing, creating and marketing a products or processes, or in creating and providing a service, or in standardization activities.

The CoDEP plan (see Figure 1 for a complete scheme) started at the proposal stage with the NDA signature and the identification of the various components of the project that could have an impact not only from a research point of view, but also from an exploitation point of view. Once the grant was awarded to 5G-TRANSFORMER, the grant preparation phase, through the consortium agreement, served to define governance rules, including innovation management, IPR ownership rules, and establishment of access rights, among others.

The CoDEP activities will reach their cusp during the project lifetime. During the *Raise Awareness* phase, at the initial stages of the project, the focus is on communication (e.g., setting up the web portal and social media accounts and high-level project presentations) to make the project known not just to the technical community but to a larger audience outside the project topics including the public. Dissemination and standardization activities also start in this phase with preliminary technical ideas and by setting the ground towards a successful exploitation (e.g., through the Common Dissemination Booster, jointly with other projects). In the *Presentation of Results* phase, dissemination and exploitation activities increase their intensity, once the first sound results are produced. Initial demonstrations are also expected during this phase. A singular case of that will be participation in open source projects. However, it is in the *Integrated Technical Demonstration* phase where demonstration activities take more relevance and experimental results are obtained to validate the main architectural concepts of the project in an integrated way.

Furthermore, the project aims at generating sustainable results, through exploitation, after the project ends. This will happen by continuing researching on the proposed ideas

in follow-up research work and projects by the various partners, but more specifically by incorporating the studied ideas in projects and services of the various companies involved, as well as patenting and licensing of IPR. These activities conform the *Long-lasting Impact* phase.

The above CoDEP activities already resulted in some relevant results:

- Communication
    - Design of promotion material, website, and creation of news, social media accounts, along with initial actions to raise awareness about the project through these means.
    - Eight communication talks in various events to present the scope of the project.
    - Three events organized targeting general public (e.g., high school students).
    - Inputs to various courses taught at university by academic partners.
    - Participation to various work groups to join efforts with other 5G PPP projects (e.g., Software Networks, Trials, Automotive).
- Dissemination
    - Seven accepted publications.
    - Two technical dissemination talks (e.g., tutorials).
    - Co-organization of two past workshops and one special session.
    - Co-organization of two workshops to take place next year.
    - Five PhD Thesis and 3 bachelor/master theses related with the project finished or ongoing.
- Exploitation
    - 5G-TRANSFORMER (jointly with 5G-Coral and 5G-Crosshaul) granted support from Common Dissemination Booster (CDB), a free EU-funded service by the European Commission to maximize impact of projects to the market.
- Standardization
    - Participation in meetings of various standards development organizations (SDOs) and monitoring of groups of interest for potential contribution.
    - Active participation in IRTF NFVRG, IETF SFC, IETF DETNET, ETSI MEC.
    - Participation and/or contribution in open source projects (OSM, ONAP, OPNFV, Open Air Interface).

Finally, annexes present detailed information on some of the activities undertaken in accordance with the CoDEP plan.

1 Introduction

The Communication, Dissemination, and Exploitation Plan (CoDEP) of 5G-TRANSFORMER includes the three following groups of activities as follows [1][2]:

- Communication: It includes all the activities related with the promotion of the project and its results beyond the project's own community. This includes the interaction with other research projects (e.g., H2020 5G PPP) as well as communication of its research in a way that it is understood by non-specialist, e.g., the media and the public.

- Dissemination: It includes activities related with raising awareness of its results in a technical community working on the same research field. In general, this will be done through peer-reviewed publications in academic conferences and journals, and participation and organization of technical events.

- Exploitation: In accordance with the European IPR Helpdesk, it covers activities aiming at using the results in further research activities other than those covered by the project 1) in developing, creating and marketing products or processes, 2) in creating and providing a service, or 3) in standardization activities.

The CoDEP was conceived at the proposal stage and includes all phases of the project (i.e., proposal, grant preparation, project lifetime, and after the project ends), where the focus is on activities tailored to each period. A summary of the plan is presented in Figure 1.

The goal of the proposal stage was to lay down the foundations for all activities following in the project execution phases both in technical and legal terms. Technical challenges were identified at the proposal phase and corresponding research topics with potential to generate exploitation impact were selected for the project execution phases. The proposal stage also served to set the legal and organizational framework, including the signing of the NDA, the identification of responsibilities (e.g., innovation manager), or the per-partner IPR management. More specifically, it included:

- Identification of high-impact verticals.

- Identification of key challenges.

- Identification of innovation potential accounting for prior-art.

- Identification of current products and standards impacted.

- Identification of impact on market and society.

- Measures to maximize impact included in CoDEP.

- Actions to implement CoDEP.

- Innovation management.
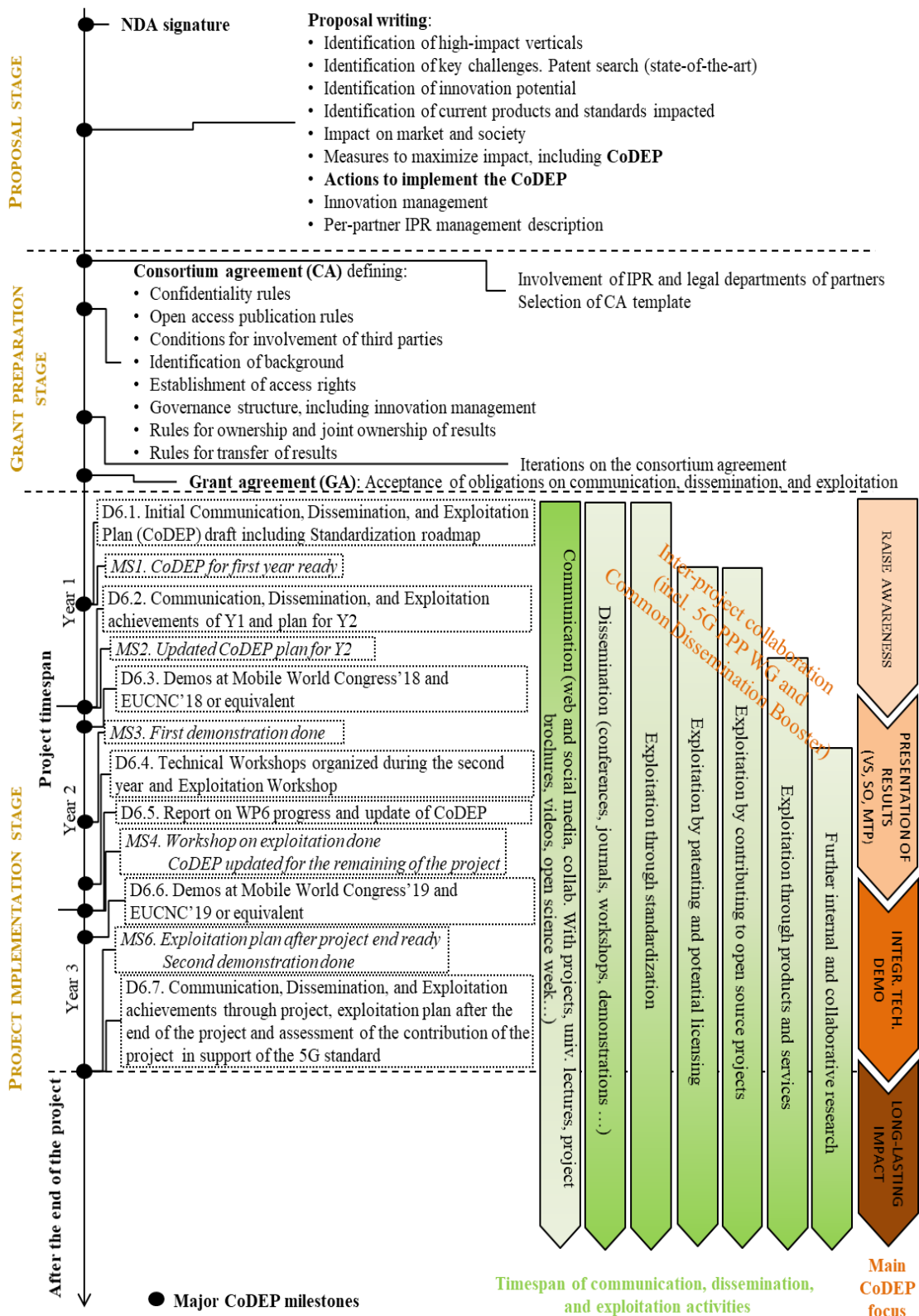
- Per-partner IPR management description.

FIGURE 1: ILLUSTRATION OF THE COMMUNICATION, DISSEMINATION, AND EXPLOITATION PLAN (CODEP) OF 5G-TRANSFORMER.

Once the grant was awarded to 5G-TRANSFORMER, the grant preparation phase involved the legal departments of the consortium members to more clearly specify the legal framework. Therefore, the consortium agreement served to define governance rules, including innovation management, IPR ownership rules, and establishment of access rights, among others. More specifically, it includes:

- Confidentiality rules.

- Open access publication rules.

- Conditions for involvement of third parties.

- Identification of background.

- Establishment of access rights.

- Governance structure, including innovation management.

- Rules for ownership and joint ownership of results.

- Rules for transfer of results.

The CoDEP activities will gain momentum during the project execution phase. All activities will we carried out in parallel, but the emphasis of each of them will be different depending on the phase of the project. During the *Raise Awareness* phase, at the initial stages of the project, the focus is on communication (e.g., setting up the web and social media and high-level project presentations) to make the project known not just to the R&D community but to a larger audience outside the project including the public. Dissemination and standardization activities also start in this phase with preliminary technical contributions. More specifically, all the activities below are initiated in this phase:

- Web portal and social media accounts.

- Project brochure.

- Project poster.

- High-level project presentation and participation at events to explain project scope.

- Videos.

- Participation in events for a general audience (e.g., open science week).

- Collaboration with other projects.

- University lectures.

The above activities are allocated more efforts at the beginning of the project due to the preparation of the initial communication resources and framework needed throughout the project, but they continue until the end of the project and after the project ends.

In the *Presentation of Results* phase, dissemination and exploitation activities increase their intensity. Initial demonstrations are expected during this phase (e.g., at events such as Mobile World Congress or EUCNC). More specifically, these activities include:

- Dissemination

- o   Publication of research results in technical journals and conferences.

- o   Enrolment of PhD and Master students on the topics of 5G-TRANSFORMER.

- o   Participation in public exhibitions and demonstrations.

- o   Organization of special events (e.g., technical workshops).

- Exploitation

  - o   Technology roadmap (including improvement to products and services).

  - o   Contribution to standardization bodies.

  - o   Patents and licensing.

  - o   Contribution to relevant open source software projects.

  - o   Use of Common Dissemination Booster (CDB) [3] services jointly with 5G-Crosshaul and 5G-Coral.

Furthermore, it is in the *Integrated Technical Demonstration* phase where demonstration activities take more relevance and experimental results are obtained to validate the main architectural concepts of the project in an integrated way.

Finally, the project aims at generating sustainable results, through exploitation, after the project ends. This will happen by continuing researching on the proposed ideas in follow-up research work and projects by the various partners, but more specifically by incorporating the studied ideas in projects and services of the various companies involved, as well as patenting and licensing of IPR. These activities conform the *Long-lasting Impact* phase. This impact will be reinforced thanks to the services offered by the Common Dissemination Booster (CDB) of the European Commission, which is done in coordination with the 5G PPP 5G-Crosshaul and 5G-Coral projects.

Though the plan and planned activities are clear, it may be adapted during the project lifetime if new relevant opportunities appear (e.g., new standardization groups are created). Therefore, the CoDEP will be periodically updated based on these opportunities.

The following sections describe in detail the work plan for each of the CoDEP activities.

2 Communication plan

This section outlines an initial plan for CoDEP communication activities including synergies and cooperation with other projects.

2.1 Work Plan

The main objective of 5G-TRANSFORMER communication plan is to raise awareness of the 5G-TRANSFORMER project vision, concept, objectives, and results among the various stakeholders. Table 1 lists each activity, the scope of the activity, timing, and the corresponding metrics to measure progress and success.

TABLE 1: COMMUNICATION ACTIVITIES IN 5G-TRANSFORMER

Audience	Activity	Timing	Metric
General audience	A project **website** will be designed, implemented and maintained. **Social media** accounts will also be created. They will include information about concepts, vision, objectives and expected outcomes as well as public documents deriving from the project work, which will be regularly updated, offering links to other relevant sites and links to partner' websites.	Initial content, and after that, event driven	Number of unique visits, Pages most visited, Papers most download, LinkedIn and Twitter metric
General audience (mostly technical)	**Project brochures and videos** with information on the project scope and results, demonstrations carried out, and any relevant event related with the project activities.	Initial content, and event-driven	Number of downloads and number of times video played
Other research projects	**Collaboration with other EU and international research projects** (e.g., through 5G PPP working groups, or working groups of other platforms, such as networld2020, will also be key towards a coordinated action inside the 5G PPP and with other H2020 projects related with the vertical industry involved in the project. One of the expected results is the joint production of white papers.	5G PPP WGs and ad hoc bi-lateral collaboration	Number of meetings attended (target: at least two per year) Number of joint documents generated (target: at least two per year)
Grad and undergrad students	Introducing 5G-TRANSFORMER concepts and results to **lecture materials** prepared by academic partners for undergraduate and graduate students.	Potential input every semester	Number of courses related with project topics
Society at large	Press releases in newspapers and magazines. Generic **communication activities for society at large** will be	Pre-scheduled yearly events plus ad hoc	Published press releases (target: two global press releases, backed

undertaken by partners in various forms. For instance, open days taking place in the premises of the partners will serve to explain and demonstrate projects results and their implications to the general public. In a similar way, participation in the Science Week where lectures to approach technology to society will also be exploited in this direction. Appearance in general media will also be exploited as communication channel to a wider audience	continuous actions	by all partners per year) Number of events organized/attended (target: at least one organized per year)

2.2 Synergies with other projects

Synergies with other (mostly) 5G PPP projects are considered in order to maximize the impact of 5G-TRANSFORMER. Though these activities are presented as a subsection of communication, these collaborations are transversal in the sense that they also include dissemination and exploitation, and so, they have an impact throughout the whole CoDEP. These activities will target the establishment of links with other relevant research actions, projects, and alliances, in particular within the framework of European H2020 Information and Communication Technology (ICT) research focused on next generation communication networks. The following paragraphs explain the actions carried out in this respect.

Within 5G PPP, the project will participate in the cross-project work groups (WG) [4], where the work of multiple projects can converge into identifying the shared issues and developing supported program level position on technical and strategic items. 5G-TRANSFORMER actively participates in seven working groups. Table 2 only lists the main representatives of the project. Other partners may participate as well. The following paragraphs describe the scope of each of the groups.

TABLE 2: 5G-TRANSFORMER REPRESENTATIVES INTO 5G PPP CSA WORKING GROUPS

5G PPP CSA working group	5G-TRANSFORMER representative
Pre-Standardization WG	IDCC
5G Architecture WG	NEC
Software Networks WG	NOK-N, UC3M
Vision and Societal Challenges WG	TEI
Trials WG	UC3M
Network Management & QoS WG	POLITO
Automotive WG	CRF

More specifically, the *pre-standardization working group* strives:

- To identify standardization and regulatory bodies to align with e.g. ETSI, 3GPP, IEEE and other relevant standards bodies, and ITU-R and the World Radiocommunication Conference (WRC) (including, e.g., Electronic

Communications Committee Project Team 1, responsible for International Mobile Telecommunications, or IMT)

- To develop a roadmap of relevant standardization and regulatory topics for 5G by also evaluating existing roadmaps at international level, and to propose its own roadmap for 5G being aligned at international level.
- To influence pre-standardization on 5G and related R&D by potentially proposing where topics should be standardized.
- To influence timing on R&D work programs (e.g., European Commission Work Programmes).

The goal of the *5G Architecture WG* is to serve as a common platform to facilitate the discussion between 5G PPP projects developing architectural concepts and components and to foster the discussions on the basis of the KPI's described in the 5G PPP contract. The group could also facilitate consensus building on the 5G architecture.

Another relevant working group [4] for discussion among 5G PPP projects is the *Software Networks* one, in which NOK-N, ATOS, and UC3M not only represent 5G-TRANSFORMER but actively participate and co-chaired the group until November 2017. The goal of this group is to analyze and address unification and applicability of key research topics related to Software Networking including software defined concepts, infrastructures, systems and components for Wire and Wireless Networks, including Networked Clouds, IoT and Services, i.e., Software Defined Networks (SDN) and Network Function Virtualization (NFV), as developed and promoted by the 5G PPP projects.

Additionally, the *Vision and Societal Challenges WG* works for:

- Developing a consensus in Europe on 5G systems / infrastructures / services.
- Identifying vertical application domains which would benefit from 5G (views of other sectors   on 5G requirements) and associated challenges.
- Identifying the societal, economic, environmental, business and technological benefits obtainable from the realization of 5G main concepts.
- Collecting publicly available visions and major technical trends from industry, research community and available information from other regions.
- Identifying commonalities, bottlenecks and differences in visions and technical trends.
- Preparing input documents for Pre-Standardization and Spectrum Working Groups and International Cooperation Activity.
- Developing H2020 call proposals for 5G PPP in partnership with the EC.

Furthermore, the project also participates actively in the *Trials WG* [4] of the 5G Infrastructure Association, and whose objectives are:

- To develop the European Trial Roadmap based on the 5G Manifesto.
- To facilitate the involvement of verticals in the trials roadmap.
- To discuss and define business principles underpinning the economic viability of trials.
- To consider and coordinate the activity on trials with other relevant initiatives at international level (e.g., proposal from China Mobile).

- To investigate and propose how to link trials to Horizon 2020 5G PPP Phase 3 in order to get funding for parts of the overall trial roadmap.

Network Management, Quality of Service and Network Security are three themes closely correlated. This is the scope of the *Network Management & QoS WG*, by considering its impact to control and data planes.

Finally, the *Automotive Working Group* has the goal to serve as a common platform to facilitate the discussion between 5G PPP projects developing V2X and Vehicle-as-Infrastructure concepts and components. Indeed, there are several 5G PPP projects dealing with automotive: 5GCAR, NGPaaS, 5G-XCast and ONE5G. The main objectives are:

- To perform the business analysis.
- To collect and analyze information from relevant 5G PPP projects as well as other global projects and initiatives on V2X research solutions and results.
- To facilitate consensus building on the 5G automotive roadmap strategy. The 5G Automotive WG contributions and input towards standardization will only take place in collaboration with the pre-standards WG and Spectrum WG.
- To provide support to the projects and other WGs in V2X related aspects. Foster collaboration between projects on the aspect of overall 5G system - to 5G automotive system.

Additionally, the project is also represented in the technical board and steering board of 5G PPP projects.

As for collaboration with specific research projects, Table 3 lists the projects, provides a short description of their scope, and identifies the specific topics in which collaboration activities are expected. Tight links with these projects will be set by exploiting the common partners. In fact, these partners are in the best position to understand the work in both projects and to spot specific technical topics for collaboration as well as opportunities for joint communication, dissemination, and/or exploitation (e.g., joint workshops). Of course, this list does not preclude potential collaboration with other projects or on other topics with these same projects. This will be adapted during the project lifetime according to their evolution.

Additionally, 5G-TRANSFORMER will also exploit other groups organized by coordination and support actions, like To-Euro-5G [8], towards joint inter-project communication, for instance.

TABLE 3: POTENTIAL COLLABORATION WITH OTHER PROJECTS

Project name	Short Description	Technical relationships
5G-Crosshaul (EU/H2020)	Develop an adaptive, sharable, cost-effective 5G Transport network solution integrating the fronthaul and backhaul segments of the network.	SDN/NFV virtualization
SLICENET (EU/H2020)	Slicenet will design and develop a management and control framework to build "slices" of network resources in support of 5G vertical services, exploiting advanced software networking and cognitive network management.	NFV/MEC
5G Coral (EU/TW H2020)	Leverages on the pervasiveness of edge and fog computing in the Radio Access Network (RAN) to create a unique opportunity for access convergence	Service Orchestration/Edge /Fog/MEC
5GEx (EU/H2020)	Enable cross-domain orchestration of services over multiple administrations or over multi-domain single administrations.	NFV/Resource federation
Coherent (EU/H2020)	Unified programmable control framework to coordinate the underlying heterogeneous mobile networks as a whole. Applying Cloud, SDN, NFV principles in RAN	Coupling of SDN with MEC. RAN monitoring and reconfiguration.
5G!Pagoda (EU/JP H2020)	Using the available network infrastructure to improve scalability, programmability, agility, and customization of services maintaining a common orchestration framework.	Network Slicing, Service orchestration.
SONATA (EU/H2020)	Provide service patterns and description techniques for composed services in 5G networks.	Service Orchestration Platform, Network Service Instances repository and request management module, Service placement plug-in
Superfluidity (EU/H2020)	Instantiate services on-the-fly, run them anywhere in the network (core, aggregation, edge) and shift them transparently to different locations.	SDN, NFV, virtualization, MEC
Supersede (EU/H2020)	Contextual data analysis, decision making support in software evolution and adaption applied to vCDNs.	Online modification of virtual function based on user context
NeMo	NeMo will act as catalyst across the entire energy management cycle of electro mobility, including battery and smart grid recharging management.	NeMo actors as vertical users of 5G-TRANSFORMER, requirements and use cases
ESSENCE (EU/H2020)	5G ESSENCE addresses the paradigms of Edge Cloud computing and Small Cell-as-a-Service (SCaaS) by fueling the drivers and removing the barriers in the Small Cell (SC) market, forecasted to grow at an impressive pace up to 2020 and beyond and to play a key role in the 5G ecosystem.	SDN, NFV, virtualization, MEC
5G Car (EU/H2020)	5G Car develops an overall 5G system architecture providing optimized end-to-end V2X network connectivity for high reliable and low-latency V2X services, which supports security and privacy, manages quality of service and provides traffic flow management in a multi-rat and multi-link V2X communication system	V2X communication, multi-RAT, multi-Link

5G MoNArch (EU/H2020)	It is assumed that 5G requires a flexible, adaptable, and programmable architecture. 5G Monarch strives to bring into practice and to provide experimental results on the extension of existing architectural design with key enabling innovations, such as inter-slice control and cross-domain management, experiment-driven modelling and optimization, native cloud-enabled protocol stack. Additionally, it will contribute to functional innovations on resilience and security, and resource elasticity. Finally, it will also experimentally deploy and validate the architecture in two use cases, namely sea port and touristic city.	Network Slicing, Service orchestration.
5G PICTURE (EU/H2020)	5G-PICTURE will design and develop an integrated, scalable and open 5G infrastructure with the aim to support operational and end-user services for both ICT and "vertical" industries.	A converged fronthaul and backhaul solution, integrating advanced wireless access and novel optical network domains.
5GTango (EU/H2020)	5GTANGO puts forth the flexible programmability of 5G networks. Reduce the time-to-market for networked services by shortening the service development cycle and by qualifying those network services to be adopted.	Network Slicing, Service orchestration.
5G MATILDA (EU/H2020)	MATILDA aims to devise and realize a radical shift in the development of software for 5G-ready applications, as well as virtual and physical network functions and network services, through the adoption of a unified programmability model, the definition of proper abstractions and the creation of an open development environment that may be used by application as well as network functions developers.	Network Slicing, Service orchestration.
5G NGPaaS (EU/H2020)	An ideal 5G Platform-As-A-Service (PaaS) should not only facilitate building, shipping and running classical virtual network applications (VNF) with "telco-grade" quality, it should also combine all sorts of third-party applications with those VNF for creating new more versatile and powerful cloud objects, breaking silos between connectivity and computing	SDN, NFV, virtualization,

3 Dissemination plan

This section describes the dissemination plan of 5G-TRANSFORMER. This dissemination plan will be executed along the following directions:

- **Publication of research results:** The academic and industrial partners will engage into publishing the research outcome of the project in high-profile scientific conferences and journals. In addition to individual publications, joint ones are also planned for selected high-visibility venues (the envisioned venues are detailed in Table 4). Furthermore, particular efforts will be put on publishing the results in specialized workshops related with vertical industries and venues with increased visibility at the EU level, such as EuCNC, and the First Workshop on Control and management of Vertical slicing including the Edge and Fog Systems (COMPASS), co-located with IEEE WCNC'18.

- **Academic activities:** 5G-TRANSFORMER aims to use the academic activities of the partners as a further vehicle for dissemination. Particularly, the partners intend to accomplish several master theses and initiate a number of Ph.D. theses on the topics studied by 5G-TRANSFORMER.

- **Technology demonstration:** The goal of the project is to demonstrate the feasibility and innovation potential by means of proof-of-concept realizations (note that two demonstration deliverables are planned). As a critical dissemination action, key components of 5G-TRANSFORMER will be demonstrated at conferences and technology fairs, with the goal of having presence in at least two events per year. The consortium members are planning to have an exhibition at each year's EuCNC conference, starting from year 2018, while the partners will aim at presenting demonstrations at flagship conferences such as ACM MobiCom, ACM MobiSys, IEEE INFOCOM, etc. Further targets include industrial events, such as the Mobile World Congress, where consortium members have regular presence. Given the topics addressed by the project, vertical oriented events will be targeted, such as the New European Media Summit and the ITS World Congress.

- **Organization and Participation in events:** Consortium members will organize at least one workshop co-located with a major event. At the same time, they will be actively participating in scientific conferences and industrial venues by organizing and chairing panels and special sessions dedicated to topics related with 5G-TRANSFORMER.

The following table summarizes the different actions. For each action, the first column indicates the target audience, the second provides details on the activities involved, the third shows the timing of each activity, i.e., whether it takes place in a continuous, periodic, or event-driven manner, and the fourth presents the metrics that will be applied to measure the success of the action.

TABLE 4: DISSEMINATION ACTIVITIES.

Audience	Activity	Timing	Metric
Academic and industrial researchers	**Publications**: 5G-TRANSFORMER partners will publish their works at high-profile conferences, magazines and journals in the fields of communications/network softwarization, such as IEEE INFOCOM, ACM MOBICOM, IEEE ICC/Globecom, as well as journals like ACM/IEEE Transactions on Networking, IEEE Transactions on Network and Service Management, IEEE JSAC - Network Softwarization Series, IEEE Communications Magazine, and Elsevier Computer Networks. All the above are established, highly regarded venues for academic and industry publishing; they have recently experienced an increase in the number of authors and attendees coming from the industry. Note that project partners have regular presence in the above conferences/journals and are active in their organization. Moreover, the partners will participate and disseminate the project results in very specific workshops, such as those dedicated to vertical industry.	Continuous	Average of 8 papers per year.
Academic	**Academic activities:** Academic partners envision the enrolment of several PhD and master-level theses focusing on the project topics. This will allow to raise awareness on the 5G-TRANSFORMER vision among the very same people that, upon joining the workforce in a few months, will be in charge of carrying it on.	Event-driven (theses)	At least two master theses will be carried out per academic partner over the course of the project. At least two PhD theses will start in the context of 5G-TRANSFORMER during the project's time span.
Industry and Academic	**Technology demonstration:** 5G-TRANSFORMER partners aim to participate in demonstrating the project components in exhibitions booths at flagship conferences	Event-driven, approximately once	Technology demonstration in at least two events per year.

	(e.g., ACM MobiCom, ACM MobiSys, IEEE INFOCOM) and scientific/technological fairs. The consortium members are planning to have an exhibition at each year's EuCNC conference, starting from year 2018, and will also target venues such as the Mobile World Congress (MWC), as well as vertical oriented events, such as ITS World Congress and European Media Summit. Furthermore, partners will participate to industry-oriented gatherings on 5G and the related technologies, such as MEC Congress and 5G World events.	every six months	
Industry and Academia	**Organization of events:** To enforce the project's impact and visibility, 5G-TRANSFORMER will organize one workshop co-located with a major event, and subsets of the partners will participate in the organization of at least one other event per year. The 5G-TRANSFORMER workshop will be held in conjunction with one of the following events: EuCNC'18, IEEE WCNC'19, IEEE ICC'19, IEEE INFOCOM'19, IEEE Globecom'19.	Event driven (one workshop over the project's duration; participation in the organization of one event per year).	Organization of one 50-person workshop with a score of at least 70% in the attendee satisfaction poll, co-located with a major event. Organization of one 30-person exploitation workshop approximately at M20 with at least 70% satisfaction as measured in the attendee poll. Participation in the organization of one event per year.

4 Exploitation plan

This chapter presents an initial attempt to capture the paths for exploitation of the technology features that will be developed in 5G-TRANSFORMER project. Exploitation is expected in four areas: 1) product and services, 2) standardization, 3) open source, and 4) patents and licensing. Exploitation is also the way to achieve the following two expected impacts of the project [7]:

- Novel business models through innovative sharing of network resources across multiple actors (all strands).
- Proactive contribution to the 3GPP standardization activity on 5G, and to other standardization activities, e.g., ONF, ETSI-NFV, IEEE (all strands).

The following initial exploitation plan is based on the technological objectives, goals and developments of the project, as well as the business cases, products and objectives of the partners in the project. This will serve as a basis for 5G-TRANSFORMER project to establish its strategy towards a successful exploitation.

To further boost exploitation opportunities, 5G-TRANSFORMER plans to use the Common Dissemination Booster (CDB) [3], jointly with 5G-Crosshaul and 5G-Coral, to maximize the dissemination and exploitation potential by leveraging the synergies amongst related projects with a dedicated service offering. The used services are: Portfolio Identification Service; Stakeholder/End-user mapping; Portfolio Dissemination Plan Development; Portfolio Dissemination Capacity Building; and Dissemination Campaign in Practice.

The architecture and the relevant building blocks of 5G-TRANSFORMER are broad enough so that basically all actors of the ICT domain are involved in its key innovations and they can, in perspective, exploit the project outcomes achieved in the three architectural building blocks around which the project is organized [5]: **Vertical Slicer** (VS), **Service Orchestrator** (SO), and **Mobile Transport and Computing Platform** (MTP). Partners in the 5G-TRANSFORMER project can be basically categorized in 5 profiles, presenting different exploitation opportunities:

- **Vertical Industries** are mostly interested in the slicing capabilities of the system, including the VS for the blueprint definition. Vertical industries have today enhanced technical capacity available to trigger the development of new products and services. The role of vertical industries, therefore, is crucial for identifying key vertical sectors' requirements, for anticipating relevant trends and mapping them into blueprints used to create network slices by exploiting the resources offered by the lower layers.

- **Operators and Network providers** focus mainly on how to move from a bit pipe business to a service business. The conventional view in the industry is that becoming a bit pipe would reduce margins for telecom companies, which risk not being able to provide profitable new services to customers due to the emergence of over-the-top services that run over their bit pipes and are not controlled by the operator itself. Therefore, these partners have a key interest in the slicing concept as an enabler for providing (virtual) infrastructure to vertical industries (VS) as a service. Operators are involved in almost all facets of this project, including the

definition of concepts such as orchestration and federation of resources (SO) or the evolution of the transport network (MTP).

- **Equipment Vendors and Solution Providers** see this project as a great opportunity to open new markets. In this context, they are particularly interested in the control plane of the network, that is, the design and development of system orchestrators with enough intelligence to gain control of complex network and in evolving their fronthaul/backhaul network portfolio and MEC products.

- **SMEs** can benefit from the advent of SDN/NFV technologies to implement their innovative ideas in a common framework, working mainly at the VS and SO blocks.

- **Academia and Research Communities** pursue the knowledge of new technologies to train new students in the area, by impacting course syllabi, to provide PhD thesis topics and to transfer technology to industrial partners and possibly create new spin-offs. Significantly, the interaction between the research community and the vertical sectors is a key positive point of the project, since typically this interaction is not possible or very difficult to achieve.

4.1 Products and Services

Products, prototypes, and solutions reported by 5G-TRANSFORMER partners, with the potential to evolve and support new 5G-TRANSFORMER features are grouped following the three main architectural building blocks envisioned by the project: Vertical Slicer, Service Orchestration and Mobile Transport Platform. This facilitates conceptually grouping and reporting how results and outcomes achieved in the three building blocks will be exploited during the project. In this direction, there will be a continuous monitoring task to identify the key technology innovations and to evaluate how they may impact the products and services developed by the partners. The following sub-sections and Table 5, Table 6, and Table 7, provide the expected impact on platforms and products from relevant 5G-TRANSFORMER partners, respectively for the VS, SO, and MTP building blocks.

4.1.1 Vertical Slicer (VS)

ATOS will mostly focus on the media distribution vertical industry. ATOS, the Worldwide Information Technology Partner for the Olympic & Paralympic Games, needs new transport technology able to cope with the expected increase of bandwidth requirements coming from the advent of 4K/8K and High Dynamic Range (HDR) streams. Outcomes of the project will be considered in ATOS SMART PLATFORM. The media and entertainment content provided by the SMART PLATFORM can be distributed through 5G-TRANSFORMER infrastructure instead of traditional CDNs. This will enhance the service offered providing a flexible on-demand content distribution based on dynamic allocation of VNFs to support specific user needs. ATOS, which is also a Cloud Infrastructure Provider will exploit the technology developed in the project to integrate its Cloud Infrastructure with the transport networks of operators.

CRF is an independent legal entity even if integral part of Fiat Chrysler Automobiles (FCA) Research and Development. Therefore, the transfer of related project outcomes will be done with a direct link to support planning of novel vehicles and backend solutions.

For what concerns 5G-TRANSFORMER, FCA is already analyzing 5G technologies and mobile operators leveraging the deployment of connected services to the worldwide markets. In fact, the availability of 5G technology is expected to create a drastic change in vehicle connectivity. Low latency in 5G can be used also for safety-critical applications like automated vehicles. The availability of 5G can create a booming effect on all vehicle connected services and functions thanks to its intrinsic characteristics. CRF plans to transfer the 5G-TRANSFORMER results to FCA by frequent internal dissemination events targeting new FCA models within 5 years (medium-term) of the end of the project.

Managing connected devices across diverse industries and communication network requires a horizontal platform that acts as a fabric between data acquisition systems, data services, and applications.

For **IDCC**, the CHORDANT platform is particularly relevant for potential exploitation of the vertical slicer. The platform allows verticals to enable their own solutions by consolidating, exposing and monetizing their data. It supports diverse types of devices, data and services, along with standards-based architecture and APIs that hide complexity from application developers, so they can focus on creating amazing applications for cities, consumers and enterprises. 5G-TRANSFORMER Vertical Slicer hides the complexity of the transport network to the verticals, in a similar way the CHORDANT platform does it to the verticals.

BCOM plans to exploit the results of the project to evolve its experimental Convergent Unifier Gateway (UGW), which integrates computing and networking capabilities in a single node. Possible impacts of project outcomes on the UGW: extending the UGW capabilities to Radio backhaul; introducing network slicing management and configuration capabilities; experimenting micro services architecture and orchestration and going beyond MEC architecture using SDN and micro services. BCOM intends to demonstrate the Convergent GW to internal subscribers and experiment with different usages and traffic. BCOM will finally push the Convergent GW into a product state, transferring this technology to Partners of BCOM, i.e., large industrial companies and SMEs, or other companies in a period of 3 years.

NXW aims at exploiting the project results to enhance its know-how in NFV, SDN and MEC areas and apply it to consultancy services as 3rd party developer for ICT solutions and training courses on NFV products, cloud and MEC services. Moreover, the knowledge acquired on vertical requirements in 5G will be transferred to the product division to drive company products for automation, A/V entertainment and building management towards IoT-based and virtualized services exploiting cloud and MEC technologies. Target products are Symphony and Sealux where re-engineering of product components towards NFV-based deployments can provide more efficient, flexible, and customizable IoT-based solutions that exploit cloud technologies for the delocalization of storage, control and backend functions. NXW is a small company with a very agile development process, expecting that project-inspired evolution of products are in place by the last 10 months of the project.

TABLE 5: VERTICAL SLICER – IMPACT ON PLATFORMS/PRODUCTS

	Platform/product	Impact on platforms/products
ATOS	SMART	The media and entertainment content provided by the SMART PLATFORM can be distributed through 5G-TRANSFORMER infrastructure instead of traditional CDNs. ATOS, which is also a Cloud Infrastructure Provider will exploit the technology developed in the project to integrate its Cloud Infrastructure with the transport networks of operators.
CRF	FCA future vehicles	The transfer of 5G-TRANSFORMER project outcomes will be done with a direct link to support planning of novel vehicles and backend solutions The availability of 5G technology is expected to create a drastic change in vehicle connectivity. Low latency in 5G can be used also for safety-critical applications like automated vehicles. The availability of 5G can create a booming effect on all vehicle connected services and functions thanks to its intrinsic characteristics.
IDCC	CHORDANT	The CHORDANT platform allows verticals to enable their own solutions by consolidating, exposing and monetizing their data. The platform supports diverse types of devices, data and services, along with standards-based architecture and APIs that hide complexity from application developers, so they can focus on creating amazing applications for cities, consumers and enterprises. 5G-TRANSFORMER Vertical Slicer hides the complexity of the transport network to the Verticals, in a similar way the CHORDANT platform does it to the Verticals. The VS design is therefore relevant for potential impact on the CHORDANT platform.
BCOM	Convergent Unifier Gateway (UGW)	Extending the UGW capabilities to Radio backhaul; introducing network slicing management and configuration capabilities; experimenting micro services architecture and orchestration and going beyond MEC architecture using SDN and micro services.
NXW	Symphony and Sealux	Target products are Symphony and Sealux where re-engineering of product components towards NFV-based deployments can provide more efficient, flexible, and customizable IoT-based solutions that exploit cloud technologies for the delocalization of storage, control and backend functions.

4.1.2 Service Orchestrator (SO)

The SO has the role of federating transport networking and computing resources from multiple domains and allocating them to slices.

NEC will use the results of the project to evolve the current fronthaul/backhaul product portfolio towards the fronthaul/backhaul integration paradigm, and to develop an added-value management and orchestration platform that brings the flexibility of SDN/NFV to NEC line of products, impacting the Mobile Radio Access Networks and Mobile Wireless Networking business units. NEC Backhaul Resource Manager (BRM) will be extended with Fronthaul management, and NFV placement functionalities and end-to-end network slicing algorithms. In addition, NEC will use the project results to demonstrate the benefits of the proposed architecture both to its internal development groups and to potential customers, e.g., European network operators.

MIRANTIS will contribute to the ONAP MultiVIM APP-C and appropriate controller subprojects to trial ETSI Open Source MANO (OSM) service and resource orchestrator components to support of the network slicing and functions introduced by VS of the 5G-TRANSFORMER. These extensions will be contributed back to the OSMONAP project upstream codebase and will be available publicly for the global community. Additionally, MIRANTIS plans to explore applicability of the Apache Aria/Cloudify TOSCA-based orchestration platforms for 5G-TRANSFORMER cases and contribute back to the open source upstream developed software plugins and components

TABLE 6: SERVICE ORCHESTRATOR – IMPACT ON PLATFORMS/PRODUCTS

	Platform /product	Impact on platforms/products
NEC	BRM	NEC Backhaul Resource Manager (BRM) will be extended with Fronthaul management, NFV placement functionalities and network slicing algorithms.
MIRANTIS	ONAP	Contribute to the ONAP MultiVIM APP-C and appropriate controller subprojects to trial network slicing and functions introduced by Vertical Slicer of the 5G-TRANSFORMER. These extensions will be contributed back to the ONAP project upstream codebase and will be available publicly for the global community.

4.1.3 Mobile Transport and Computing Platform (MTP)

NOK-N will consider the project results to increase flexibility and resilience of its 5G-BTSs (Base Transceiver Station) deployed as VNFs, allowing better resource utilization and supporting mission critical traffic on the BTSs. From the project, NOK-N will gain a better understanding of deployment and integration scenarios of its products into operator and vertical environments. In addition, 5G-TRANSFORMER will impact the following NOK-N portfolio:

- Airframe. The cloud-based base station may be extended with the interfaces towards the MTP to improve its control by a Virtual Network Function Manager (VNFM).
- Airframe data center. The cloud platform may be extended with interfaces and functionality for the compute part of the MTP and be better used in regional data centers and for deployment of vertical services.

- NFV-based packet core. These VNFs may be extended with service-aware monitoring as defined in 5G-TRANSFORMER. With or without this extension, the VNFs may be deployed directly from templates of network services.
- MEC Platform. The MEC software platform may be extended with the interfaces and functionalities defined within 5G-TRANSFORMER. It would become more useful for vertical industries.

NEC will exploit the project results to improve its Control Platform: Extensions on already commercialized OpenFlow solutions, vEPC (Virtualized Evolved Packet Core: vMME and vS/P-GW) and vMVNO-GW. Management extensions to NEC iPASOLINK wireless transport equipment including mmWave and microwave.

Ericsson TEI will consider 5G-TRANSFORMER results as input for developing new transport solutions and to further preserve value of the existing ones. TEI also intends to better understand requirements from partner verticals to further increase capacity, coverage and flexibility of its radio access and transport platforms.

The impact of 5G-TRANSFORMER outcomes on Ericsson product portfolio will primary address the Ericsson Fronthaul 6000 product family. It is a flexible and complete portfolio supporting high performance E2E solutions for low latency transport of CPRI, OBSAI and Ethernet. It consists of Fronthaul 6080 passive solution with DWDM pluggable transceivers and passive optical components, Fronthaul 6080 active solutions for managed DWDM networking and Fronthaul 6392 microwave radio. In the project, TEI will primarily consider results relevant to optical transport/DWDM for radio access network. TEI will evolve its line of optical hybrid switches (designed in cooperation with 5G-Crosshaul) following the path of the MTP.

5G-TRANSFORMER is also expected to impact the Ericsson Cloud System portfolio in terms of architecture and building blocks, to support vertical services.

IDCC EdgeHaul management is already software-driven and an integration with 5G-TRANSFORMER will enable the support of various vertical traffic requirements over mmWave.

MIRANTIS will provide a platform for automatic 5G-TRANSFORMER MTP layer deployment using an OPNFV reference scenario, which includes OpenStack, SDN Controller and might also be enhanced with the Kubernetes container management platform for lightweight MEC applications. This will enable automatic MTP and virtualization layer deployment across multiple locations.

Extensions of the Mirantis Cloud Platform (MCP) and relevant NFV extensions for network slicing will be contributed back to the Salt system public repository and further might be used by any partner deploying private clouds using MCP as the open source VIMs for NFV deployments.

As a solution for Edge/MEC Clouds and lightweight virtualization layer, Mirantis will consider 5G-TRANSFORMER use cases during planning of the Virtlet project roadmap (https://github.com/Mirantis/virtlet). As a result, the Virtlet platform will have capabilities to enable 5G-TRANSFORMER MEC and NFV workload onboarding, instantiation and service function chaining.

TABLE 7: MOBILE TRANSPORT AND COMPUTING PLATFORM - IMPACT ON PLATFORMS/PRODUCTS

	Platform/product	Impact on platforms/products
NEC	NEC Controller Platform	Extensions on already commercialized OpenFlow solutions, vEPC (Virtualized Evolved Packet Core: vMME and vS/P-GW) and vMVNO-GW.
NEC	iPASOLINK	Management extensions to NEC iPASOLINK wireless transport equipment including mmWave and microwave.
NOK-N	Airframe	The cloud-based base station may be extended with the interfaces towards the MTP, such that its control by a VNFM can be improved.
NOK-N	Airframe data center	The cloud platform may be extended with interfaces and functionality for the compute part of the MTP and be better used in regional data centers and for deployment of vertical services.
NOK-N	NFV-based packet core	These VNFs may be extended with service aware monitoring as defined in 5GTRANSFORMER. With or without this extension, they may be used directly from templates of network services.
NOK-N	MEC Platform	The MEC software platform may be extended with the interfaces and functionalities defined within 5G-TRANSFORMER. It would become more useful for vertical industries.
TEI	Ericsson Fronthaul 6000	The Ericsson Fronthaul 6000, a transport solution, will be evolved to support the federation scenario that will be defined in 5G-TRANSFORMER.
TEI	Ericsson Cloud System	The project is expected to impact the Ericsson Cloud System portfolio in terms of architecture and building blocks, to support vertical services.
IDCC	EdgeHaul™	EdgeHaul is a mmWave fronthaul and backhaul transport solution featuring support of an SDN-based control and integration of MEC applications. 5G-TRANSFORMER MTP's goal to integrate MEC with the transport network resources is clearly relevant to EdgeHaul.
MIRANTIS	Mirantis Cloud Platform	MTP cases will be integrated into the OPNFV reference scenario, which includes OpenStack, SDN Controller and might also be enhanced with the Kubernetes container management platform for lightweight MEC applications.
MIRANTIS	VirtLet	Mirantis will consider 5G-TRANSFORMER use cases during planning of the Virtlet project roadmap (https://github.com/Mirantis/virtlet). As a result, Virtlet platform will have capabilities to enable 5G-TRANSFORMER MEC and NFV workloads onboarding, instantiation and service function chaining.

4.2 Patents and licensing

The 5G-TRANSFORMER project addresses an area which provides significant opportunities for standard essential patents. All 5G-TRANSFORMER partners are committed to producing European IPR as important channel for exploiting project outcomes.

Partners have declared a strong background of over 40 patents related to 5G-TRANSFORMER area. At least 5 patents are expected to be filed in the project deployment, targeting VS, SO, and MTP. This may lead to subsequent licensing, depending on the interests of the partners.

4.3 Standardization

The standardization framework of 5G-TRANSFORMER is wide thanks to its mixture of enabling technologies such as NFV, SDN, and MEC, which are hot areas of standardization and open source developments in various Standard Development Organizations (SDOs) and forums (e.g., 3GPP, ETSI, IETF, IEEE, ONF). This is clearly advantageous, as 5G-TRANSFORMER does not necessarily depend on one SDO to achieve its targeted impact on standards, as outlined above: *Proactive contribution to the 3GPP standardization activity on 5G, and to other standardization activities, e.g., ONF, ETSI-NFV, IEEE (all strands).*

Despite being part of exploitation activities, the participation in standardization efforts of 5G-TRANSFORMER also offers an indirect way to disseminate the results of the project to the industrial community.

Nevertheless, other non-traditional ways of standardizing are also considered (e.g., ETSI OSM), such as contributing, and publishing open source software, which may eventually become a de facto standard.

The following objectives are targeted for the standardization activities in 5G-TRANSFORMER:

- Create and maintain a project standardization activity roadmap. This roadmap will capture the standardization activities that may influence or get influenced by the project technological innovations. It will help 1) keep track of existing or upcoming industry specifications or recommendations that might affect the project technological choices; and 2) identify opportunities for the project to contribute its proposed solutions to present and future standardization groups.

- Disseminate the project into the standardization forums to raise awareness and help create an opportunity for standardization exploitation.

- Contribute through the partners (individually or jointly) with project-related technology proposals into the relevant standardization forums. At least 10 contributions will be targeted in the various SDOs.

Towards the above objectives, 5G-TRANSFORMER will be creating a standardization advisory committee (SAC) composed of standardization experts supporting 5G-TRANSFORMER in all the key relevant SDOs. These include 3GPP, IETF, ETSI MEC, and IEEE, in particular. Members and Moderator of the SAC will be appointed from the

below list of experts (Table 8) supporting the project. The SAC will be meeting regularly and on-demand as needed. The SAC will be responsible of:

- Setting up the standardization activity roadmap in the very few months from project kick-off, and continuing to update this roadmap as the work in the project and these SDOs progress.

- Coordinating the project and standardization groups through constant monitoring of activities and regular conference calls with standardization experts.

- Helping to identify opportunities to push technology contributions into ongoing specifications.

- Helping to improve and to socialize contributions ahead of standard meetings.

- Helping to promote the project at standardization-related workshops, panels, and summits.

Table 8 presents the complete list of expert researchers from partners of 5G-TRANSFORMER involved in each of the SDOs, which will certainly contribute to the standardization impact of the results.

4.4 Open Source

Open source software is, in some cases, becoming the de facto standard for areas in which the traditional standardization process is not fast enough. Parts of all the software produced in the project will be published as open source, e.g., in the framework of ETSI OSM, led by one of the partners of the project.

Details on code publishing are regulated by the consortium agreement (CA). Based on current interest of the project and its partners, contributions will be mainly aligned with the following open source projects: OPNFV, Open Source MANO, ONAP, OpenStack, and Open Air Interface.

Considering recent industry shift to the containers and light-weight virtualization, the consortium will also follow the development of container-oriented platforms and solutions, particularly Kubernetes and Virtlet, which are suitable for MEC and Edge cloud cases.

The interested reader may refer to section 4.1 for some specific examples of expected contributions.

TABLE 8: PARTNER EXPERTS IN RELEVANT SDOS

No.	SDO	Expert Name	Expert Role	Partner Name
1	3GPP	Matthew Baker	Vice Chairman RAN1	NOK-N
2	3GPP	Peter Leis	Vice Chairman CT1	NOK-N
3	3GPP	Olof Liberg	GERAN Chair	TEI
4	3GPP	Atle Monrad	CT Chair	TEI
5	3GPP	Jonas Sundborg	RAN AHG-ITU Board Chair, Board FOE chair	TEI
6	3GPP	Ulises Olivera-Hernandez	3GPP expert (in particular SA/CT groups)	IDCC
7	3GPP	Thouraya Toukabri	3GPP expert in SA2 group	ORANGE
8	ETSI	Diego López	ETSI NFV ISG Chairman	TID
9	ETSI	Nader Zein	Vice-chair and Secretary ETSI mWT	NEC
10	ETSI	Pekka Kuure	Vice-Chairman ETSI ISG MEC	NOK-N
11	ETSI	Dirk Weiler	Chairman ETSI Board	NOK-N
12	ETSI	Julien Maisonneuve	Vice Chairman, ETSI ISG EVE	NOK-N
13	ETSI	Jan Ignatius	Vice Chairman, ETSI ISG IFA	NOK-N
14	ETSI	Thinh Nguyenphu	Vice Chairman, ETSI ISG SOL	NOK-N
15	ETSI	Luca Cominardi	MEC (rapporteur of the WI on slicing, MEC 0024)	UC3M
16	IEEE	Janos Farkas	IEEE 802.1 CM Chair	TEI
17	IETF	Akbar Rahman	IETF expert	IDCC
18	IETF	Óscar González	CCAMP WG Secretary	TID
19	IETF	Diego López	IRTF NFV RG Chair	TID
20	IETF	Carlos J. Bernardos	IPWAVE WG co-chair, INTAREA directorate coordinator and active participant to several WGs	UC3M
21	ITU	Steve Trowbridge	ITU-T SG15 chair	NOK-N
22	ITU	Fabio Cavaliere	ITU-T SG15, G.metro editor	TEI
23	ITU	Stefano Ruffini	ITU-T SG15 Q13 Rapporteur	TEI
24	NGMN	Jan Ellsberger	Ericsson Representative	TEI
25	OPNFV	Gregory ElkinBard	FUEL@OPNFV Project Technical Leader	MIRANTIS
26	OSM	Carmine Rimi	Founding member and member of TSC	MIRANTIS
27	MEF	Dave Sinicrope	Director	TEI
28	ONF + ON.Lab	Sibylie Schaller	Architecture WG Chair (under restructuring)	NEC
29	ONF	Fabian Schneider	ONF Board member	NEC

5 Early achievements

5.1 Communication activities

5.1.1 Web, social media, and project communication material

Following the project kick-off on June 1, 2017 in Stockholm, activities have been undertaken towards fulfilling the objectives set above. The following figures (Figure 2 and Figure 3) present the poster and leaflet of the 5G-TRANSFORMER project. Additionally, the official project press release was released in Madrid, Spain in June 2017. Additionally, partners also released their own internal (company-wide) and external press releases (see Annex A). More details can also be found in the project website (http://5g-transformer.eu/).

The social media accounts of 5G-TRANSFORMER are the following:

- Twitter: https://twitter.com/5g_transformer
- LinkedIn: http://linkedin.com/in/5g-transformer-eu-project-a05311144
- Instagram: https://www.instagram.com/5g_transformer/
- YouTube: https://www.youtube.com/channel/UClQXD0lCxTK9eh_mQzMweww

5.1.2 Communication Talks and other actions

The following talks have been given since the project started as part of the *Raise Awareness* Phase of the CoDEP. In this sense, the scope of the talks is general, and the focus is on explaining the high-level goals, main building blocks, and verticals involved, including the general technological framework of the project (e.g., SDN, NFV, slicing, federation):

- 5G-TRANSFORMER: 5G Mobile Transport Platform for Verticals. Project overview presentation at 5G PPP Brussels. June 2017.
- 5G-TRANSFORMER: 5G Mobile Transport Platform for Verticals. Project overview presentation at EUCNC17. 5G PPP phase 2 projects session. June 2017.
- 5G-TRANSFORMER poster in the EUCNC17 exhibition area. June 2017.
- 5G-TRANSFORMER: 5G Mobile Transport Platform for Verticals. Project overview presentation at EU-Taiwan event on Industry of the Future. June 2017. Information available at: https://www.b2match.eu/eu-taiwan-2017
- 5G-TRANSFORMER: 5G Mobile Transport Platform for Verticals. Project overview presentation at IEEE 5G Symposium in Thessaloniki, Greece. July 2017.
- 5G-TRANSFORMER: 5G Mobile Transport Platform for Verticals. Project overview presentation at Talk at Automotive and 5G workshop. July 2017.
- Towards 5G Mobile Transport Platforms for Industry Verticals. Project overview presentation at the IEEE VTC Backnets workshop (http://www.ieeevtc.org/vtc2017fall/workshops.php#wkshp
- 5G-TRANSFORMER: 5G Mobile Transport Platform for Verticals. Project overview presentation at Talk at WWRF39. Session co-organized by 5G-

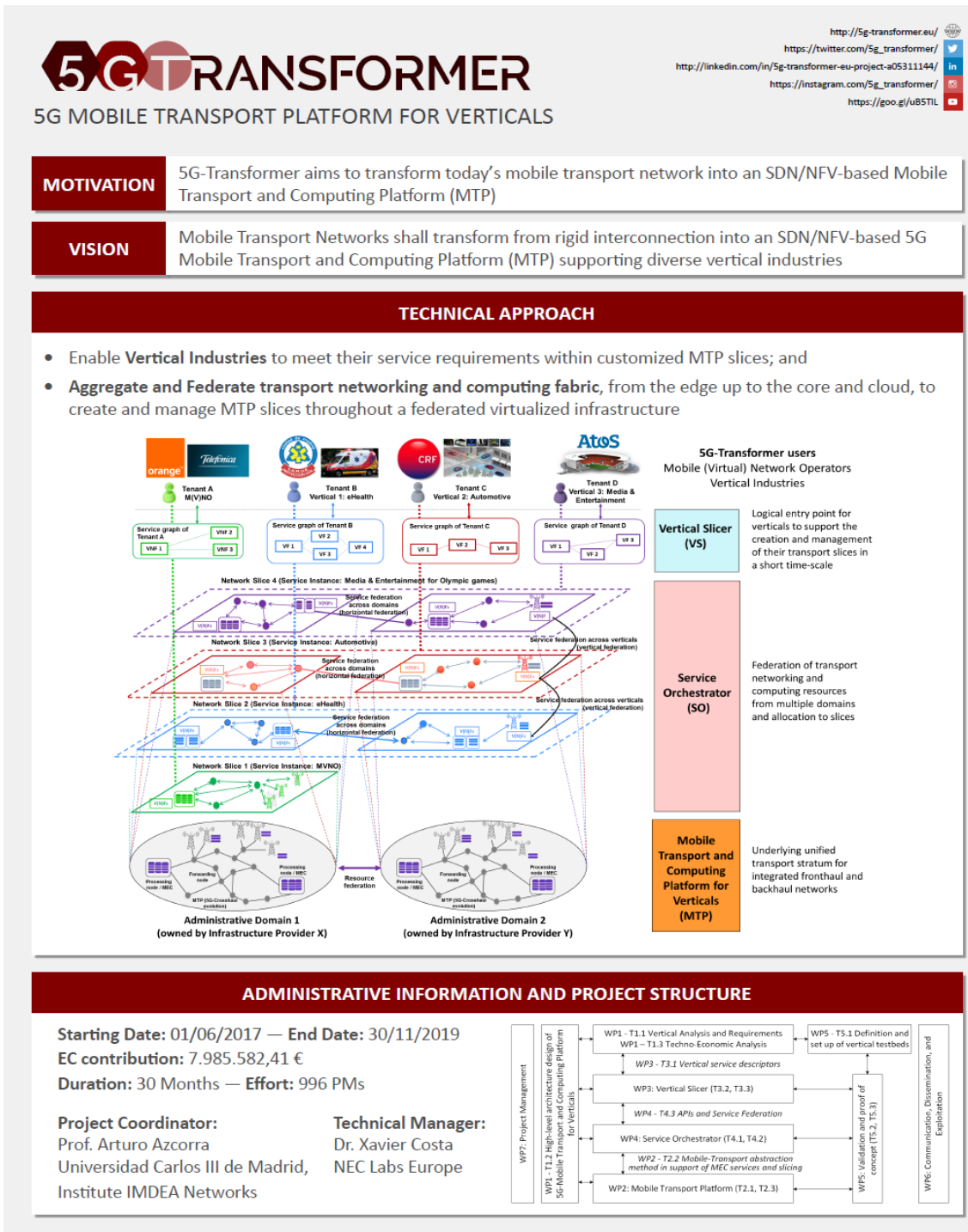TRANSFORMER and 5G-Crosshaul on 5G Mobile Transport Networks. October 2017.

FIGURE 2: 5G-TRANSFORMER POSTER

5GTRANSFORMER
## 5G MOBILE TRANSPORT PLATFORM FOR VERTICALS

VISION

Mobile Transport Networks shall transform from rigid interconnection into an SDN/NFV-based 5G Mobile Transport and Computing Platform (MTP) supporting diverse vertical industries.

TECHNICAL APPROACH

Media

Automotive

Healthcare

M(V)NO

- Enable Vertical Industries to meet their service requirements within customized MTP slices; and
- Aggregate and federate transport networking and computing fabric, from the edge up to the core and cloud, to create and manage MTP slices throughout a federated virtualized infrastructure.

MAIN BUILDING BLOCKS
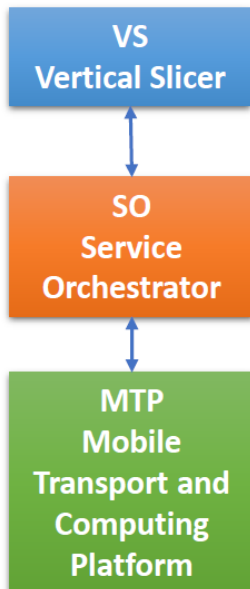
VS Vertical Slicer

Logical entry point for verticals to support the creation of their transport slices in a short time-scale.

SO Service Orchestrator

Federation of transport networking and computing resources from multiple domains and allocation to slices.

MTP Mobile Transport and Computing Platform

Underlying unified transport stratum for integrated fronthaul and backhaul networks.

Starting Date: 01/06/2017

End Date: 30/11/2019

Cost: 7.985.582,41 €

Project Coordinator:
Dr. Arturo Azcorra
Universidad Carlos III
de Madrid

Technical Manager:
Dr. Xavier Costa
NEC Labs Europe

More information at:
http://5g-transformer.eu/

https://twitter.com/5g_transformer/

https://goo.gl/uB5TlL

https://www.instagram.com/5g_transformer/

https://www.linkedin.com/in/5g-transformer-eu-project-a05311144/

FIGURE 3: 5G-TRANSFORMER LEAFLET

Additionally, internal communication actions have also been undertaken inside the partner organizations, through internal news and talks.

There have also been talks to a wider audience:

- Three-hour course taught at the National Chiao Tung University (NCTU) in Taiwan on topics related with 5G-TRANSFORMER.
- A talk on 5G in general, and more specifically, on 5G-TRANSFORMER was given to high-school students and general public in the context of 22nd Open Science Week (Setmana de le Ciència) in November 2017. It is organized by the Catalan Research and Innovation Foundation (FCRi). Information available at: http://www.cttc.cat/the-cttc-will-participate-in-the-22nd-edition-of-the-science-week-2017/
- Organization of the Internet Festival (http://www.internetfestival.it/), the Robotics Festival 2017 (http://www.festivalinternazionaledellarobotica.it/en/)

Furthermore, academic partners of the consortium prepared several courses on SDN/NFV-related topics that are taught to graduate and undergraduate students, which benefit from the 5G-TRANSFORMER work. Among these, we can highlight the Master in NFV and SDN for 5G networks from UC3M, that during the 2017-2018 academic year will include for the first time advanced topics of 5G, in addition to NFV and SDN.

5.1.3 Synergies with other projects

In addition to direct interaction with the projects mentioned in section 2.2, there are others that are related with some of the aspects dealt with in 5G-TRANSFORMER. An example is project "5G experimentation in the cities of Bari and Matera in the 3.6 – 3.8 GHz band (C Band)" sponsored by the Italian Ministry of Industry Development (MISE) or project "Enabling Virtual RAN and EPC expeRiments in WISHFUL (EVER-WISFUL)." In general, all partners participate in various 5G-related projects through various sources of funding, including industrial contracts.

Additionally, 5G-TRANSFORMER actively participates in joint efforts in the framework of 5G PPP work groups to coordinate all 5G projects. More specifically, this is exemplified by the participation in seven work groups, including Pre-Standardization, 5G Architecture, Software Networks, Vision and Societal Challenges, Trials, Network Management & QoS, and Automotive (section 2.2). Various activities have been undertaken in the framework of the WG meetings. For instance, the project was presented to the Software Networks group on Oct. 24, 2017.

The project is also represented in the technical board and steering board of 5G PPP projects.

5.2 Dissemination activities

The achievements in terms of dissemination activities are presented in this section.

5.2.1 Publications and technical dissemination

An Open Access repository has been provided complying with the Open Access rules of H2020 [6].

Additionally, the following papers presenting preliminary project ideas and results have been accepted:

- "Network Orchestration in Reliable 5G/NFV/SDN", B. Martini, M. Gharbaoui, S. Fechera and P. Castoldi, 19th International Conference on Transparent Optical Networks (ICTON 2017), July 2nd to 6th, 2017, Girona Conference Centre, in Girona, Spain.
- "Impact of RAN Virtualization on Fronthaul Latency Budget: An Experimental Evaluation", F.Giannone, H. Gupta, D. Manicone, K. Kondepu, A. Franklin, P. Castoldi, L. Valcarenghi, accepted at the International Workshop on 5G Test-Beds and Trials – Learnings from implementing 5G (5G-Testbed 2017) co-located with Globecom 2017.
- "Sharing of Crosshaul Networks via a Multi-Domain Exchange Environment for 5G Services", Luis M. Contreras, Carlos J. Bernardos, Antonio de la Oliva, Xavier Costa-Pérez, in Proc. of IEEE Conference on Network Softwarization (NetSoft), Bologna, Italy, 2017.
- "Virtualized eNB latency limits", L. Valcarenghi, F. Giannone, D. Manicone, P. Castoldi, 19th International Conference on Transparent Optical Networks (ICTON 2017), July 2nd to 6th, 2017, Girona Conference Centre, in Girona, Spain.
- "Software Defined 5G Converged Mobile Access Networks: Energy Efficiency Considerations," A. Marotta, K. Kondepu, S. Doddikrinda, D. Cassioli, C. Antonelli, L. Valcarenghi. Asia Communications and Photonics Conference, Nov. 10-13, 2017, Ghuangzhou, China
- "SDN-enabled Latency-Guaranteed Dual Connectivity in 5G RAN," K. Kondepu, A. Giorgetti, F. Giannone, A. Marotta, F. Cugini, P. Castoldi, L. Valcarenghi. Asia Communications and Photonics Conference, Nov. 10-13, 2017, Ghuangzhou, China
- "Orchestrating Lightpath Adaptation and Flexible Functional Split to Recover Virtualized RAN Connectivity." Ultra Reliable Low Latency Communications (URLCC), London, Nov. 2017. (Poster)

Technical dissemination talks have also been given:

- The ingredients of the new networks: SDN, NFV and Slicing in the evolution towards 5G, Presentation at the University of Tokyo, Japan. June 2017.
- Multi-domain federation: Scope, challenges, and opportunities. IEEE NetSoft 2017, Bologna, July 2017 (Tutorial)

5.2.2 Event organization

Various events are planned throughout the project lifetime so as to create an appropriate environment for the exchange of ideas with the research and industrial community involved in topics related with the project. The following events co-organized by 5G-TRANSFORMER have already taken place:

- Organization of the "5G technology for automotive domain" workshop in Turin including industrial and academic presentations. Given the nature of this workshop and its relevance not just towards research but also potential exploitation, a detailed explanation is provided in Annex B.
- Co-organization of a special session on 5G Mobile Transport Networks jointly with the 5G-Crosshaul project at Wireless World Research Forum (WWRF) 39

> meeting in Barcelona, October 2017. More information available at: http://wwrf39.ch/WWRF.html
- Co-organization of O4SDI 2017, Third IEEE International Workshop on Orchestration for Software Defined Infrastructures, jointly with the 5G-Ex and Sonata projects. It was held in conjunction with the 3rd IEEE Conference on Network Function Virtualization and Software Defined Networks (NFV-SDN 2017), November 2017, Berlin. Information available at: http://www.o4sdi.unibo.it/o4sdi3

Additionally, two more workshops co-located with IEEE conferences were accepted. First, a workshop co-located with one of the flagship conferences of IEEE on wireless networking was accepted and will be co-organized by the project. This is the first Workshop on Control and Management of Vertical Slicing including the Edge and Fog Systems (COMPASS), co-located with IEEE Wireless Communications and Networking Conference (WCNC) 2018 to be held in Barcelona in April. Second, the second edition of COMPASS will be co-located with IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB) 2018, to be held in Valencia.

5.2.3 Bachelor, Master and PhD Theses

A number of students pursued or are currently pursuing their degrees in the framework of 5G-TRANSFORMER:

- PhD thesis: Francesco Giannone is pursuing his Ph.D. in SSSA and is working on topics related to 5G-T such as eNB split functions (Distributed Unit --- DU --- and Central Unit --- CU) virtualization and its impact on fronthaul available latency budget.
- PhD thesis: Silvia Fichera is pursuing her Ph.D. in SSSA and is currently working on Resource Orchestration in Virtualized Networks through SDN-enabled OpenStack in collaboration with CTTC within the 5G-TRANSFORMER project.
- PhD thesis: Software Defined Networking based mobility management in small cells (Luca Cominardi). In preparation.
- PhD thesis: Design and optimization of solutions for discovery and federation for NFV in edge & fog scenarios (Jorge Martin-Perez). In preparation.
- PhD thesis: Mechanisms to integrate and enhance NFV and MEC (Kiril Antevski). In preparation.
- Master thesis: Multi-domain VNF mapping algorithms (Jorge Martin-Perez). Presented in September 2017.
- Bachelor thesis: Análisis de un orquestador NFV/SDN para redes de operador (Cristian Arribas). Presented in October 2017. (in Spanish)
- Bachelor thesis: Service Function Chaining en NFV: Evaluación práctica con OpenStack (Javier Bautista). Presented in October 2017. (in Spanish)

5.3 Exploitation activities

Exploitation activities are expected to increase their intensity in a more advanced phase of the project, once sound architectural designs and results are obtained. This initial period of the project was devoted to set the ground to maximize the impact of the project in the various exploitation actions defined in the plan (section 4).

5.3.1 Products and services

The detailed analysis of specific impact of the 5G-TRANSFORMER designs on products and services will be carried out in a more advanced phase, once results are produced. However, in this direction, 5G-TRANSFORMER, jointly with 5G-Coral and 5G-Crosshaul, have been granted support from the Common Dissemination Booster (CDB), a free EU-funded service by the European Commission to maximize impact of projects to the market. More specifically, the project will benefit from the following services:

- Service 1: Portfolio Identification Service.
- Service 2: Stakeholder/End-user mapping.
- Service 3: Portfolio Dissemination Plan Development.
- Service 4: Portfolio Dissemination Capacity Building.
- Service 5: Dissemination Campaign in Practice.

5.3.2 Standardization

Standardization efforts already started from various perspectives, namely exploratory and active participation, depending on the item. As for the former, project partners have attended the IETF 99 in Prague in July 2017 and IETF 100 in November 2017 in Singapore. Other SDOs have equally been followed (e.g., ETSI NFV, ETSI MEC) to identify potential standardization efforts from the project, which leads to the active participation perspective. In fact, these exploratory efforts resulted in the submission of an ETSI MEC ISG contribution on the 5G-TRANSFORMER project use cases and requirements in June 2017 and a presentation at the ETSI MEC ISG meeting in New York in October 2017.

Other specific contributions include:

- IRTF: at the NFVRG, 5G-TRANSFORMER researchers are co-authors of an adopted document: draft-irtf-nfvrg-gaps-network-virtualization. We are collaborating with 5GEx to join forces in an existing multi-domain draft (draft-bernardos-nfvrg-multidomain). We are also preparing a potential draft on virtualization optimizations (containers, unikernels, etc.).
- IETF: mainly SFC for service function chaining (focusing on extensions required to support edge/fog), and DETNET for deterministic networking required at the fronthaul/backhaul. Monitoring Common Operation and Management on network Slicing (COMS) Birds of a Feather (BoF).
- ETSI MEC: the project seeded the successful launch of a new work item (WI) in ETSI MEC ISG entitled "MEC support for network slicing and federation", leading to the creation of MEC024. In fact, the rapporteurs of the WI are researchers involved in 5G-TRANSFORMER (Luca Cominardi and Luis Contreras).

Active participation in open source projects is also starting and/or ongoing, e.g., Open Source MANO (OSM), ONAP, OPNFV, Open Air Interface.

6 References

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7 Annex A. News and Press releases

The news that the project generates are available at: http://5g-transformer.eu/index.php/news/. Other relevant activities are publicized through the various social media accounts of the project (see Section 5.1). A list of some of the news on 5G-TRANSFORMER that have appeared, either published by partners or by as news in other websites are (as of 23rd November 2017):

- https://www.mirantis.com/blog/network-slicing-and-5g-and-wireless-oh-my/
- http://www.globenewswire.com/news-release/2017/06/21/1027019/0/en/European-Industrial-and-Academic-Partners-Join-to-Develop-a-5G-Mobile-Transport-Platform-for-Verticals.html
- http://www.cttc.cat/european-industrial-and-academic-partners-join-to-develop-a-5g-mobile-transport-platform-for-verticals/
- https://www.ericsson.com/research-blog/5g-transformer-eu-project-underway/
- https://5g-ppp.eu/european-industrial-and-academic-partners-join-to-develop-a-5g-mobile-transport-platform-for-verticals/
- https://5g-ppp.eu/newsflash-october-2017/
- https://www.sdxcentral.com/articles/news/new-european-5g-group-will-focus-on-network-slicing-industry-verticals/2017/06/

8 Annex B. Detailed information for the "5G for automotive" industry-academia workshop

On July 5th, 2017, CRF and POLITO organized in FCA a dissemination workshop on "5G for Automotive". The aim of the workshop was to investigate and discuss the impact of the 5G technology on the automotive sector.

A total of 19 speakers from the academic and the industrial world presented their view, and addressed relevant aspects such as technology availability and standardization, possible use cases, the comparison between Wireless Access for Vehicular Environments, or WAVE/ITS-G5, and cellular based V2X (C-V2X), the impact on the vehicle architecture, and the role of cloud computing service providers. The workshop was a great success, with about 135 attendees (see Figure 4).
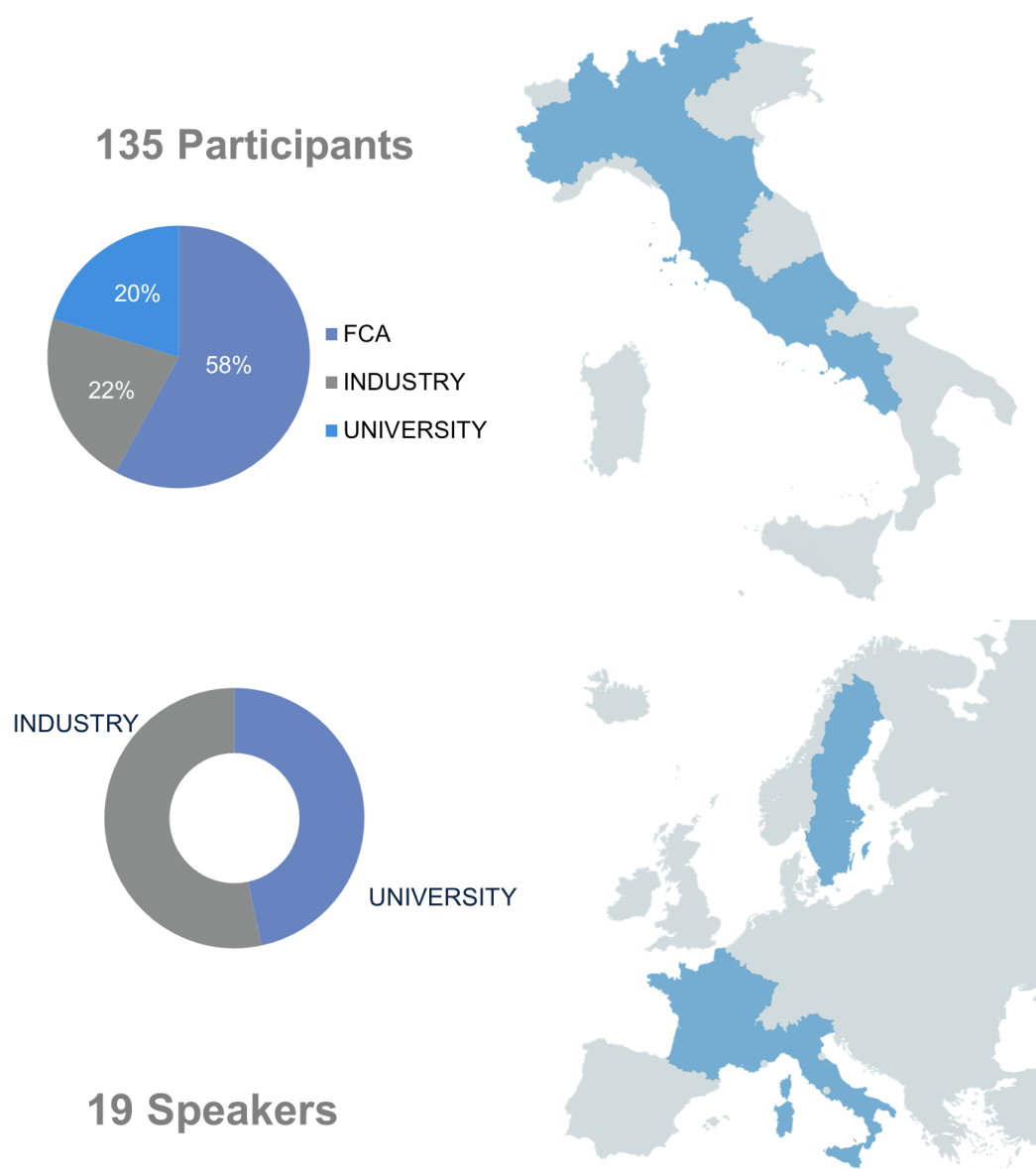

FIGURE 4: STATISTICS ON THE WORKSHOP SPEAKERS AND ATTENDEES.

The workshop was opened by the chief of FCA Product Development and CRF CEO, and by the CRF Head of Electric/Electronic and Innovation. The FCA Product Development managers were present and participated in the selection of the speakers. Also the academic world was strongly represented, thanks to the organizational support of Politecnico di Torino. The agenda of the workshop is showed in Figure 5.

Workshop: "5G Technology for Automotive Domain"

July 5th 2017

Workshop official Opening 09:45 – 09:55

Francesco Lilli, *FCA*
Andrea Bianco, *Politecnico di Torino*

Technology and Standard 09:55 – 11:15

09:55 **5G and Automotive. The Perfect Storm?**
Carla Fabiana CHIASSERINI, *Politecnico di Torino, ITALY*
10:15 **Timely and Reliable Wireless Vehicular Communications,**
Elisabeth UHLEMANN, *University of Malardalen, SWEDEN*
10:35 **V2X Communications in future 5G Automotive and Transportation.**
Jerome HÄRRI, *Eurecom, FRANCE*
10:55 **Cybersecurity for Automotive and 5G Applications.**
Antonio LIOY, *Politecnico di Torino, ITALY*

Coffee Break

In vehicle Integration 11:45 – 12:45

11:45 **Vision, Roadmap & Deployment, Opportunities for Automotive Domain.**
Sebastiano DI FILIPPO, *Qualcomm, ITALY*
12:05 **Beamforming on large scale antenna systems for 5G RAN.**
Riccardo MAGGIORA, *Politecnico di Torino, ITALY*
12:25 **EM Simulation for V2X Communication.**
Davide TALLINI, *CST, ITALY*

Networking Lunch

Applications 14:00 – 15:25

14:00 **5G for Automotive Applications.**
Claudio Ettore CASETTI, *Politecnico di Torino, ITALY*
14:05 **5G data sharing for cooperative driving.**
Michele SEGATA, *Università di Trento, ITALY*
14:25 **5G: Exceleration for IoT**
Alessandro ANANIA, Domenico SPANÒ, *Wind Tre, ITALY*
14:45 **5G & Automotive: Technical Standards and Innovation Opportunities.**
Pierpaolo MARCHESE, *TIM, ITALY*
15:05 **5G: Building blocks and rationale for a new wireless technology.**
Alessandro GOIA, Tommaso VIO, *Vodafone, ITALY*

Coffee Break

Infrastructure 15:40 – 16:20

15:40 **5G Networks to realize networking society.**
Paola IOVANNA, *Ericsson, SWEDEN*
16:00 **5G: Opportunities for developers and business powered by AWS.**
Donatello A. GASSI, *Amazon Web Services, FRANCE*

Round Table 16:20 – 17:00

Moderator: Claudio Ettore CASETTI, *Politecnico di Torino, ITALY*

Closure 17:00

FIGURE 5: AGENDA OF THE WORKSHOP ON 5G FOR AUTOMOTIVE DOMAIN

The 5G-Tranformer project was presented by:

- Francesco Lilli (CRF), at the opening, who talked about the opportunity, given by the project, to gain knowledge on 5G, to provide input and requirements for the architecture outline, and to experience benefits introduced by the 5G technology;
- Prof. Carla Chiasserini (POLITO), who talked about the 5G-TRANSFORMER architecture;
- Paola Iovanna (TEI), who presented the project contents and outlined the e-industry use case.