Beyond 5G Multi-Tenant Private Networks Integrating Cellular, Wi-Fi, and LiFi, Powered by Artificial Intelligence and Intent Based Policy

5G-CLARITY Deliverable D6.1

Plan for Exploitation and Dissemination of the Project Results

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3GPP	Third Generation Partnership Project
5G	Fifth Generation
5G NR	5G New Radio
5G PPP	5G Infrastructure Public Private Partnership
5GC	5G Core
5QI	5G Quality of Service Indicator
ACM	Association for Computing Machinery
AD	Area Director
AGV	Automated Guided Vehicles
AI	Artificial Intelligence
ANIMA	Autonomic Networking Integrated Model and Approach
AP	Access Point
API	Application Programming Interface
ARIB	Association of Radio Industries and Businesses
ATIS	Alliance for Telecommunications Industry Solutions
ATSSS	Access Traffic Steering, Switch and Splitting
BGP	Border Gateway Protocol
BSCW	Basic Support for Cooperative Work
CCSA	China Communications Standards Association
CLA	Contributor License Agreement
CLI	Command Line Interface
CN	Core Network
COINRG	Computing in the Network Research Group
CSD	Criteria for Standards Development
CT	Core Network & Terminals
CU	Centralized Unit
DFSG	Debian Free Software Guidelines
DSS	Dynamic Spectrum Sharing
DU	Distributed Unit
E2E	End-to-end
ECOC	European Conference on Optical Communication
EM	Element Manager
EM	Element Management
ENI	Experiential Networked Intelligence
eNPN	enhanced support of Non-Public Networks
ETSI	European Telecommunications Standards Institute
EU	European Union
EuCNC	European Conference on Networks and Communications
FG-ML5G	Focus Group on Machine Learning for Future Networks
GBR	Guaranteed Bit Rate
GMPLS	General Multiprotocol Label Switching

GPL	General Public License
GR	Group Report
gRPC	Google Remote Procedure Call
GS	Group Specifications
GUI	Graphical User Interface
H2020	Horizon 2020
HetNet	Heterogeneous Network
HetRAT	Heterogeneous Radio Access Technology
HNF	Hybrid Network Function
HW	Hardware
IAB	Internet Architecture Board
IBN	Intent-Based Networking
ICT	Information and Communication Technology
ID	Internet Draft
IEEE	Institute of Electrical and Electronics Engineers
IEEE GLOBECOM	IEEE Global Communications Conference
IEEE ICC	IEEE International Conference on Communications
IEEE INFOCOM	IEEE International Conference on Computer Communications
IEEE PIMRC	IEEE International Symposium on Personal, Indoor and Mobile Radio Communications
IEEE VTC	IEEE Vehicular Technology Conference
IEEE WCNC	IEEE Wireless Communications and Networking Conference
IESG	Internet Engineering Steering Group
IETF	Internet Engineering Task Force
IIoT	Industrial Internet of Things
IM	Information Model
IoT	Internet of Things
IPR	Intellectual Property Rights
IP	Internet Protocol
IRSG	Internet Research Steering Group
ISG	Industry Specification Groups
ISOC	Internet Society
ISWCS	International Symposium on Wireless Communication Systems
IT	Information Technology
ITU-T	International Telecommunication Unit-Telecommunication Standardization Sector
JCR	Journal Citation Report
KPI	Key Performance Indicator
LAN	Local Area Network
LC	Light Communications
LiFi	Light Fidelity
LTE	Long Term Evolution
M2M	Machine to Machine
MAC	Media Access Control
MAN	Metropolitan Area Network

MANO	Management and Orchestration
MAPRG	Measurement and Analysis for Protocol Research Group
MDT	Minimization of Drive Tests
MEC	Multi-access Edge Computing
ML	Machine Learning
mmWave	millimeter Wave
mmWT	millimeter Wave Transmission
MNO	Mobile Network Operator
MON	Monitoring Module
MPLS	Multiprotocol Label Switching
MWC	Mobile World Congress
NETCONF	Network Configuration
NFV	Network Function Virtualization
NFVI	Network Functions Virtualization Infrastructure
NMRG	Network Management Research Group
NPN	Non-Public Networks
NSD	Network Service Descriptor
NSH	Network Service Header
NSI	Network Slice Instance
NST	Network Slice Template
OAM	Operation, Administration and Management
OCC	Optical Camera Communications
OCS	Orchestration and Control System
O-CU	O-RAN Central Unit
O-DU	O-RAN Distributed Unit
OFC	Optical Fiber Communications
ONAP	Open Networking Automation Platform
ONDM	Optical Network Design and Modelling
ONOS	Open Networking Operating System
OPEX	Operational Expenditure
OPs	Organizational Partners
ORAN	Open Radio Access Network
OSF	OpenStack Foundation
OSFG	Open Source Focus Group
OSG	Open Source Group
OSI	Open System Interconnection
OSM	Open Source MANO
PAR	Project Authorization Request
PDCP	Packet Data Convergence Protocol
PHY	Physical layer
PNF	Physical Network Function
PoC	Proof-of-Concepts
POL	Policy Module
R&D	Research and Development

RACH	Radio Access Channel
RAT	Radio Access Technology
RCA	Root Cause Analysis
REST	Representational State Transfer
RFC	Request for Comments
RG	Research Group
RIC	Radio Intelligent Controller
RRU	Radio Remote Unit
RT	Real Time
SA	Services & Systems Aspects
SA	Standards Association
SDFG	Standard Development Focus Group
SDN	Software Defined Network
SDO	Standard Developing Organization
SFC	Service Function Chaining
S-GW	Serving Gateway
SI	Study Items
SLA	Service Level Agreement
SME	Small and Medium-sized Enterprise
SNMP	Simple Network Management Protocol
SNPN	Standalone Non-Public Network
S-NSSAI	Single – Network Slice Selection Assistance Information
SON	Self-Organizing Network
STD	Standard
SW	Software
TEAS	Traffic Engineering Architecture and Signalling
TEE	Trusted Execution Environments
TG	Task Group
THz	Terahertz
TIFG	Test & Integration Focus Group
TN	Transport Network
TSDSI	Telecommunications Standards Development Society of India
TSG	Technical Specification Groups
TSN	Time-Sensitive Networking
TTA	Telecommunications Technology Association
TTC	Telecommunication Technology Committee
UE	User Equipment
UPF	User Plane Function
URLLC	Ultra-Reliable and Low Latency Communications
VIM	Virtualized Infrastructure Manager
VM	Virtual Machine
VNF	Virtual Network Function
VNFD	Virtual Network Function Descriptor
vRAN	virtual Radio Access Network

WAN	Wireless Area Network
WAT	Wireless Access Technology
WG	Working Group
WI	Working Items
Wi-Fi	Wireless Fidelity
WLAN	Wireless Local Area Network
WNG SC	Wireless Next Generation Standing Comity
WP	Work Package
WTC	WeTheCurious
ZSM	Zero-touch network and Service Management

Executive Summary

This document represents the deliverable D6.1 “Plan for Exploitation and Dissemination of the project results”, envisaged in the framework of 5G-CLARITY’s Work Package 6 (WP6), including the communication plan for the project. This plan considers all the activities related to the promotion of the 5G-CLARITY project and its results beyond the project own community. This also includes the dissemination of 5G-CLARITY contributions in a way that is easily understood by a non-specialist audience, e.g., the media and the general public.

The dissemination plan for the first year, the exploitation plan, and the standardization plan are also reported. The Dissemination plan includes activities boosting awareness of 5G-CLARITY results in the scientific community, working on the same research field. In general, this will be carried out through publications in high impact journals/magazines, and participation and organization of technical events. The exploitation plan covers activities aiming at using the results in further research activities other than those covered by the project, such as developing, creating and marketing products or processes, creating and providing a service. The standardization plan seeks to ensure that the key concepts of the 5G-CLARITY contributions are proposed and adopted in the relevant standards. This document also identifies relevant open-source activities to be developed along the project execution.

This first 5G-CLARITY deliverable also briefly reports early exploitation and dissemination achievements.

As part of the Work Package 6 (WP6), the plan included here will be complemented by the following deliverables. For each document, the delivery date is also provided:

- D6.2 Interim report on innovation management: Month 9.
- D6.3 Mid-term report on dissemination and communication activities: Month 15.
- D6.4 Mid-term report on standards engagements: Month 18.
- D6.5 Final report on innovation management, exploitation and Intellectual Property (IPR): Month 27.
- D6.6 Final report on dissemination and communication: Month 30.

1 Introduction

This deliverable presents the project plan concerning with the dissemination actions and an initial roadmap for the exploitation activities and reporting on the establishment of the External Advisory Board.

1.1 Organisation of the document

This document is structured in eight sections. Following the introduction section, Section 2 describes the target audience, Section 3 includes the communication plan of the project. Section 4 provides the dissemination plan. Section 5 describes 5G-CLARITY exploitation plan, including a) product and services, b) products/platforms for vendors Small and Medium-sized Enterprises (SMEs) and verticals; and c) patents and licensing. Section 6 gathers the standardization plan and roadmap as well as open-source activities. Section 7 reports the early achievements, including communications, dissemination, standardization, exploitation actions and the establishment of the External Advisory Board. Finally, Section 8 concludes the document and provides pointers to upcoming work in these topics.

2 Communication and Dissemination Target Audience

Table 2-1 describes both the 5G-CLARITY communication and dissemination target audience along with their main interests in the project. The classification considers different types of target audience, i.e., industry verticals, vendors and service providers, network operators, SMEs, open-source communities, SDOs, academia and research centres, and generic public.

Table 2-1: Target audience for communication and dissemination activities

Target Audience	Description	Interest in 5G-CLARITY project
Industry Verticals	They are companies that offer niche products and services in a specific market (e.g., automotive, energy, food and agriculture, city management, healthcare, manufacturing, public transportation, etc.).	Industry verticals could leverage the work carried out in 5G-CLARITY to boost the digitalization of the industry procedures in their own venues, improving in this way the operational efficiency of these procedures. Additionally, 5G-CLARITY contributions will enable them to open up new business opportunities through the sharing of their own network infrastructures with different network operators (neutral host).
Vendors and Service Providers	They are organizations that provide Information Technology (IT) solutions and/or services to end users or third parties.	Vendors and Service Providers could require the 5G-CLARITY contributions in order not to be limited by the deployment of novel Fifth Generation (5G) services via public networks only (i.e., those managed by network operators), but also considering the use of private networks of industry verticals (e.g., extending coverage area and/or increasing capacity using additional access technologies such as Wireless Fidelity (Wi-Fi) and Light Fidelity (LiFi)).
Network Operators	They are the companies that currently provide network services through their own wireless infrastructure to end-users. In the years to come, they will also provide these services to industry verticals (i.e., using network slicing).	Network operators can adopt the 5G-CLARITY solutions to deploy end-to-end 5G services along public (i.e., their own wireless infrastructure) and private networks (i.e., infrastructure of industry verticals). Thereby, operators could easily offer 5G capabilities short term to industry verticals and increase the coverage and capacity (e.g. indoors) that otherwise their public wireless infrastructure would not be able to achieve.
Small and Medium	Representing the 99% of all businesses in the European Union (EU), they are non-subsidiary, independent	Being SMEs key players in the EU economy, they must have more visibility and active participation in the advancements performed in 5G networks. For that reason, 5G-CLARITY

Entreprises (SMEs)	companies which maintain revenues, assets, or a number of employees below a certain threshold.	advocates the direct and/or indirect involvement of SMEs in the integration of cellular, Wi-Fi and LiFi technologies along public and private networks.
Open-Source Communities	They are communities which develop software whose source code is made freely available to any interested person.	Due to the rise of Open Source Communities and their benefits, some of the developments carried out in 5G-CLARITY will be based on open source contributions such as Open Source MANO (OSM), Open Network Operating System (ONOS), OpenStack, free5GC, etc.
Standard Developing Organizations (SDOs)	They are organizations which are responsible for developing technical standards to address the needs of specific fields.	5G-CLARITY plans to contribute to standardization and regulatory-related activities in key SDOs for 5G: 3rd Generation Partnership Project (3GPP), Internet Engineering Task Force (IETF), European Telecommunications Standards Institute (ETSI), Open Radio Access Network (ORAN), and Institute of Electrical and Electronics Engineers (IEEE).
Academia and Research Centres	They are institutions whose main activities are focused on addressing unsolved technical issues in specific areas.	Since the Information and Communication Technology (ICT)-20 call encompasses 5G Long Term Evolution, most of the 5G-CLARITY project activities will involve novel contributions with the aim of improving current solutions for 5G implementations. 5G-CLARITY will create new research directions with advanced testbeds and novel scenarios.
General Public	Anyone interested in the 5G-CLARITY project.	5G-CLARITY can draw the attention of people interested in the technological viewpoint of the project (e.g., integration of multiple radio access technologies) as well as the business perspective (e.g., legal issues to manage the public and private networks). Additionally, 5G-CLARITY can boost the citizenship perspective about EU research projects.

3 Communication Plan

The communication plan of 5G-CLARITY aims to engender a distinguishable impact on the project's stakeholders and the audiences that go beyond the project's own community, including the general public and the medias. This section defines the project identifier, the communication activities that will be carried out in 5G-CLARITY project throughout its lifetime, the external/internal communication channels, and social medias.

3.1 Project Identifier

The first task in the communication and dissemination of the main activities carried out by 5G-CLARITY is the definition of a unique identifier that easily allows the target audience to identify the project. For that reason, the 5G-CLARITY consortium has established a dedicated logo for the project as **Figure 3.1** shows. This logo is included in all the 5G-CLARITY communication channels, deliverables, presentation slides, leaflets, posters, etc.

Figure 3.1: 5G-CLARITY project logo

3.2 Communication channels

The communication activities will be targeted at the audience described in **Table 2-1**. To carry out these activities, all partners in the 5G-CLARITY consortium will be actively involved in a) internal communication channels, b) external communication channels and c) social media. This section provides a detailed insight into the tools used for these channels.

3.2.1 Internal Communication Tools

For internal communications between partners, 5G-CLARITY consortium uses Basic Support for Cooperative Work (BSCW) Workspace server as a repository. BSCW, which was developed by the Fraunhofer Society, is a workspace software package for collaboration over the web. This software enables the partners exchange materials: document library, deliverables, partner's information, etc. The aim of this repository is to ease the organization of the internal work throughout the project lifetime. In **Figure 3.2**, a screenshot of the 5G-CLARITY internal repository is shown.

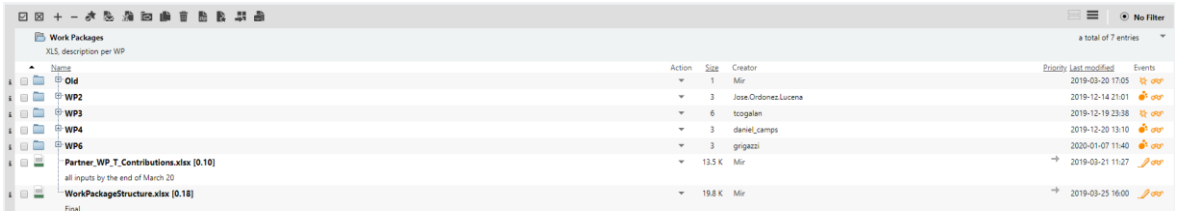

Figure 3.2: 5G-CLARITY's BSCW web interface

3.2.2 External Communication Tool: Project website

The most important communication tool for external communications is the official project website (http://www.5gclarity.eu/ , http://www.5gclarity.com/). Depicted in **Figure 3.3**, this website was launched in December 2019 with the purpose of allowing the target audience to understand the scope, goals and achievements of this project.

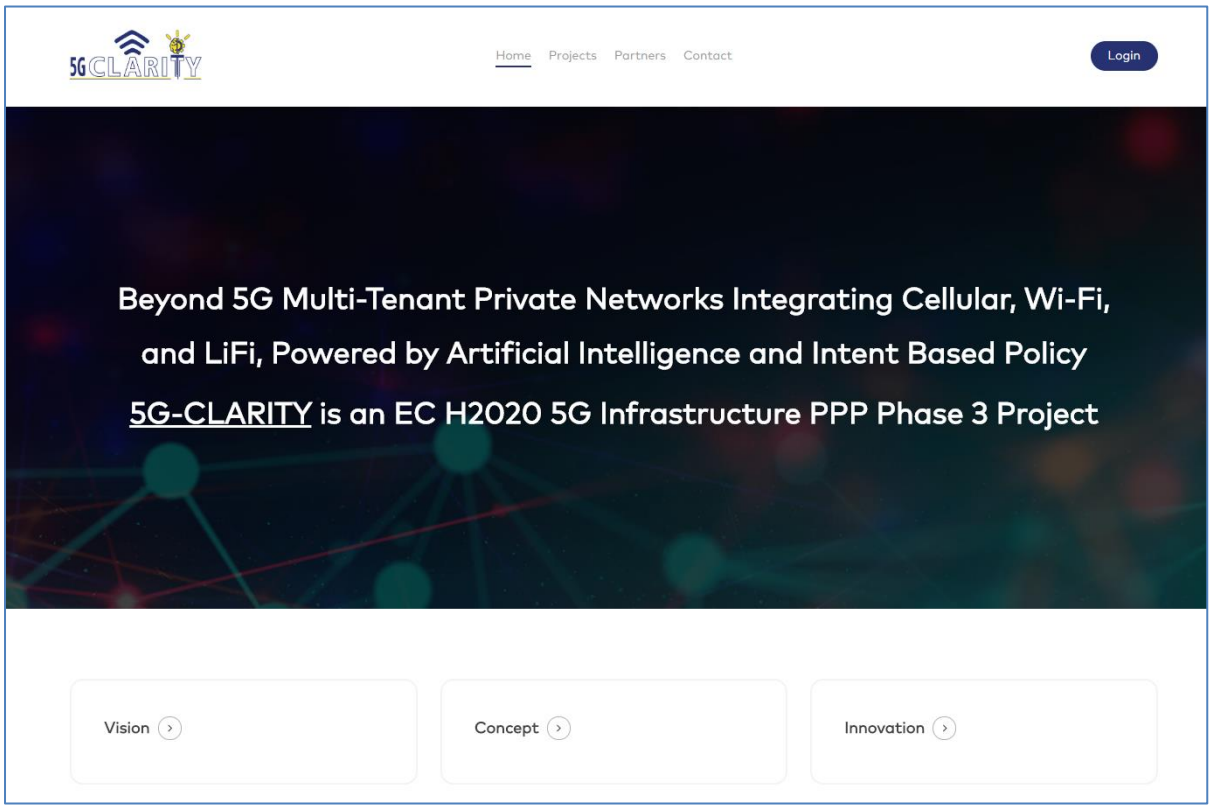

Figure 3.3: 5G-CLARITY project website home page

Website content will be regularly updated and maintained until the end of the project by all the partners of 5G-CLARITY consortium. To ease accessibility, the website content has been split in the following sections:

- Home: It is the main page of 5G-CLARITY website, which enables an easier browsing of the website content. It also contains links to the social media channels (see section 3.2.3).
- Project: It contains an overall description of this project, gathering the 5G-CLARITY vision, concept, innovation, demonstrators and impact.
- News: Includes relevant news about 5G-CLARITY activities and results, which will also be spread through the 5G-CLARITY social media channels to increase the project visibility.
- Events: Publishes the main events related to the 5G-CLARITY project.
- Dissemination: It lists all the publicly accessible deliverables produced by 5G-CLARITY and presents the contributions to standardisation bodies and the publications in high impact peer-reviewed journals, magazines and conferences.
- Partners: It provides a description of each partner of 5G-CLARITY consortium.

- Contact: It contains a contact form to send a message to the project coordinator, project manager and technical coordinator for all relevant communications with the 5G-CLARITY consortium.

To measure the impact of 5G-CLARITY project website, we collect performance statistics such as: number of users visiting the website, number of sessions, average session duration, bounce rate, etc.

3.2.3 Social Media tools: Twitter, LinkedIn, YouTube, Others

5G-CLARITY exploits relevant social medias such as Twitter, LinkedIn and YouTube to promote the potential benefits of the solutions proposed in the project. All the project social media accounts can be accessed from the project website and target to have at least 100-200 followers by the end of the project. The actions carried out in each social media account are briefly described in the following sections.

3.2.3.1 Twitter

Twitter is one of the most popular social networks and is widely used by the scientific community as a tool to communicate their results. In the same way as other 5G-PPP projects, 5G-CLARITY consortium has set up a Twitter account (https://twitter.com/5G_CLARITY) on 8th of November 2019 with the aim of providing information about the ongoing activities throughout the project lifetime. **Figure 3.4** shows a screenshot of the main 5G-CLARITY Twitter page.

Figure 3.4: 5G-CLARITY project Twitter account

3.2.3.2 LinkedIn

LinkedIn is a business and employment-oriented social network. Since LinkedIn is tailored for professionals, it is well suited to communicate the activities and contributions carried out in 5G-CLARITY project. To that end, 5G-CLARITY consortium has created a LinkedIn group (https://www.linkedin.com/groups/12331231/) in December 2019. The main purpose of this group is to open 5G-CLARITY target audience. The LinkedIn group intends to foster discussions on relevant aspects of the project, advertise news and events, and collect stakeholder' opinions. **Figure 3.5** shows a screenshot of the LinkedIn group.

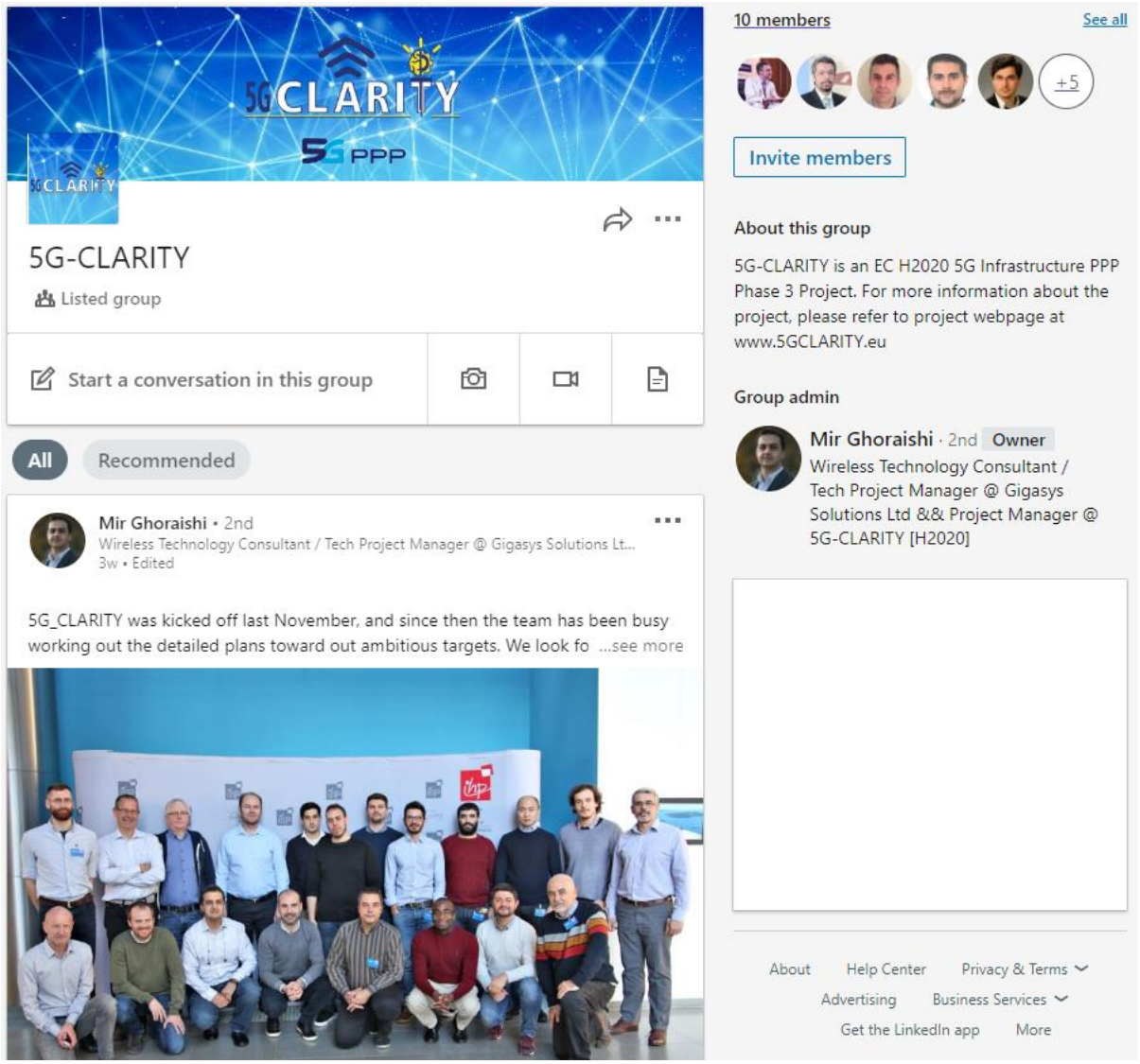

Figure 3.5: 5G-CLARITY project LInkedIn account

3.2.3.3 YouTube

YouTube is the most popular video-sharing platform in the world, thus it is the perfect social channel to broadcast the main activities carried out in the project. For that reason, 5G-CLARITY hosts a YouTube channel (https://www.youtube.com/channel/UCtAZgpXA-Ud-l8TMfTBPxxw/about) that provides video content produced by the project to stakeholders. **Figure 3.6** presents a screenshot of the YouTube channel.

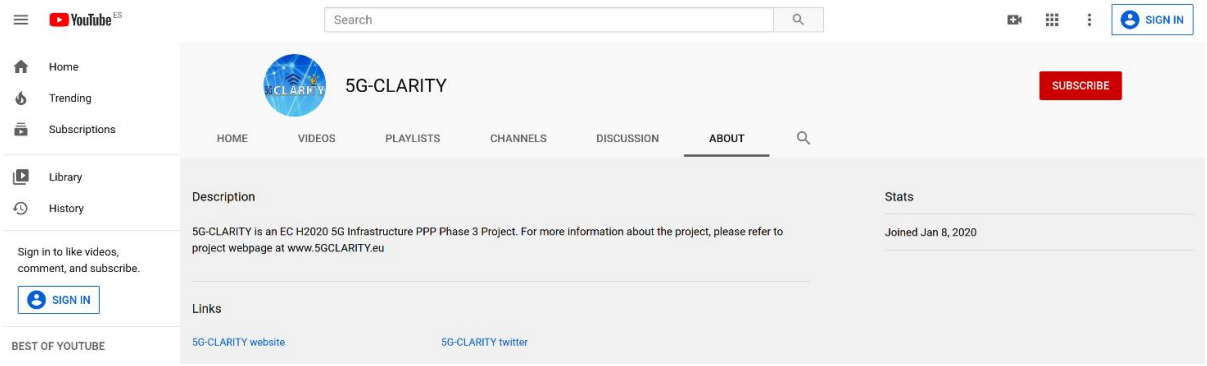

Figure 3.6: 5G-CLARITY project YouTube channel

3.2.3.4 Others

In addition to the social media channels set up by the 5G-CLARITY consortium, the 5G-PPP channels (i.e. 5G-PPP website, 5G-PPP channels for Twitter, LinkedIn, YouTube) also announce the most relevant achievements of 5G-CLARITY project as well as its main news and events. As an example, **Figure 3.7** shows the 5G-PPP communication of the starting of 5G-CLARITY project within the 5G-PPP Phase 3 projects (see https://5g-ppp.eu/5g-ppp-phase-3-projects/).

Figure 3.7: News about the 5G-CLARITY project kick-off within the 5G-PPP Phase 3 projects.

4 Dissemination Plan

The objective of the Horizon 2020 (H2020) programme is to invest in research that will bring Europe at the heart of research and innovation and drive its economic growth. This goal cannot be achieved if the outcomes of funded projects are not properly communicated to Industry, Academia and the public in general.

In this sense, to maximise the social, economic and technical benefits of 5G-CLARITY, maximum priority will be given to dissemination.

Particularly, 5G-CLARITY dissemination consists of providing information to key actors on the initiatives and results of the project that means a real advance in the frontier of knowledge. In terms of 5G-CLARITY, this involves spreading the word about the scientific project successes and outcomes as far as possible.

For the abovementioned goal, this section reports the envisaged 5G-CLARITY dissemination actions, including the estimated outcomes for year 1 for all the partners (**Table 4-1**), as well as potential synergies and collaborations to be established with other projects.

Table 4-1: Dissemination outcomes for Year 1

PARTNER	ACTION			
	Publications	**Talks/Panels**	**Workshops**	**Demonstrations**
IHP	2	2	0	0
ACC	0	1	0	0
BOSCH	0	2	0	0
GIGS	0	2	0	0
I2CAT	2	2	1	0
TID	1	2	0	0
IDCC	1	1	0	1
LMI	1	0	0	0
PLF	1	1	0	0
UEDIN	1	1	0	0
UGR	11	0	1	0
UNIVBRIS	2	3	0	0
TOTAL	**22**	**19**	**2**	**1**

4.1 Dissemination Actions

At the outset of the project, the following ambitions related to the dissemination plan can be reported:

Scientific Publications in leading conferences and journals: to generate awareness and induce constructive comments and feedback from the scientific and industrial research community.

Organization of magazines and journal special issues, and books: The members of the consortium have been, and are very active, in organizing journal special issues related to the 5G-CLARITY research areas. These constitute very important forums for presenting the achieved results to the scientific and industrial communities.

Participation in program committees and editorial boards: The 5G-CLARITY project members are highly involved in international programme committees and editorial boards of key conferences and

journals. Examples of program committees and editorial boards project members are involved in are: Optical Network Design and Modelling (ONDM), Optical Fiber Communications (OFC), and European Conference on Networks and Communications (EuCNC).

4.1.1 Scientific Publications

One of the activities envisioned in the 5G-CLARITY dissemination plan is the scientific publication in leading conferences and journals.

The scientific results of the project will be described and exposed in papers of prestigious international journals and conferences. These publications will be referenced on the project's website.

5G-CLARITY will target high-level IEEE conferences and peer-reviewed journals related to the project's topics. The targeted conferences are, amongst others, **IEEE International Conference on Communications** (**IEEE ICC**), **IEEE International Symposium on Personal, Indoor and Mobile Radio Communications** (**IEEE PIMRC**), **IEEE Global Communications Conference (IEEE GLOBECOM)**, **IEEE Wireless Communications and Networking Conference** (**IEEE WCNC**), **EuCNC**. We will also target top peer-reviewed journals as **Table 4-2** shows, including, amongst others, IEEE Transactions on Network and Service Management, IEEE Transactions on Mobile Computing, IEEE Communication Magazine, and IEEE Wireless Communications Magazine. The project aims to have an average of more than 10 publications submitted per year in such journals and/or conferences.

Table 4-2: List of relevant journals to 5G-CLARITY

Journal Name	Year	Category	Quartile	Impact Factor
IEEE Transactions on Network and Service Management	2018	Computer Science, Information Systems	Q1	4.682
IEEE Transactions on Mobile Computing	2018	Telecommunications	Q1	4.474
IEEE Communication Magazine	2018	Telecommunications	Q1	10.356
IEEE Wireless Communications	2018	Telecommunications	Q1	11.000

4.1.2 Talks/Panels/Webinars/Whitepapers

Among the dissemination tasks of the project, there are other kinds of scientific dissemination activities such as talks, panels, webinars and whitepapers. In these mentioned activities, 5G-CLARITY will also spread features and benefits of the developed technologies and innovations to the research community.

4.1.3 Workshops

Another target of dissemination in 5G-CLARITY is the organization of highly directed workshops**.** 5G-CLARITY members are very active and feature a vast expertise in organising flagship conference workshops and special sessions in the technical areas of the project. For example, members of the project organized workshops in the last three EuCNCs. Following this consolidated strategy, 5G-

CLARITY will take the lead in organizing at least one international workshop (possibly with collaboration with other H2020 projects), as a premiere opportunity to present project results in a very interactive and formal environment.

4.1.4 Demonstrations

The demonstration of 5G-CLARITY use cases, characterized by a high density of devices and heterogeneous services, will create new and realistic opportunities for generating competitive advantages for private venue owners and Mobile Network Operators (MNOs). In this project, the following demonstrations will be performed:

- **Demonstration in the WeTheCurious (WTC) museum**: There will be a system-level demonstration of the 5G-CLARITY architecture enabling a beyond 5G application in a private venue, where museum visitors enjoy an enhanced human-robot interaction. 5G-CLARITY will leverage the 5GUK testbed facility already available in Bristol and maintained by UNIVBRIS. It is worth noting that this facility has already been used to support demonstrations in various 5G-PPP projects, such as 5G-XHaul (Phase-1), 5G-PICTURE (Phase-2). It will also be used to support 5G-VICTORI (Phase-3), and several national 5G projects in the UK.
- **Demonstration in the BOSCH factory**: It consists of another system-level demonstration in a BOSCH factory, of how 5G-CLARITY architecture enables enhanced positioning for Automated Guided Vehicles (AGV) monitoring, and network slicing to support Industry 4.0 applications. The demonstration of factory related use cases considered in 5G-CLARITY will contribute to the improvement of the social well-being of citizens because of the increment of factory productivity and the quality enhancement of the goods produced.

4.2 Collaborations with other projects

The 5G Infrastructure Public Private Partnership (5G-PPP) is a joint initiative between the European Commission and European ICT industry. It was created with the purpose of reinforcing the leadership of European industry in 5G technology to successfully compete on global markets and open new innovation opportunities.

5G-CLARITY was retained in response to the 5G-PPP ICT-20-2019 call. The Project is one of the members (out of eight (8) projects) that belong to 5G PPP Phase 3, Part 4. The “5G Long Term Evolution” title implicitly defines the nature of the work it is expected in the next 30 months. More generally, and according to 5G-PPP [1]:

Whilst 5G early introduction targets “local” network improvements (e.g. at radio access level), the longer term vision targets the realisation of pervasive mobile virtual services, through a network managing compute, storage and transport connectivity functions in an integrated way. The challenge is to transform the network into a low energy distributed computer, where processes and applications are dynamically created, moved and suppressed, depending on the information flows, customer needs, and where new terminal types in cars, objects, appliances, and new interfaces based on gestures, facial expressions, sound and haptics may be the basis of the interaction between humans and the infosystems.

5G-CLARITY will actively collaborate with other 5G-PPP and non-5G-PPP projects given the framework of collaboration (Collaboration Agreement) embedded in the Grant Agreement of ICT-20 projects, where the information can be shared with peer projects. 5G-CLARITY builds up on previous work that the project partners have carried out in past H2020 and national Research and Development (R&D).

Table 4-3 describes the relation between 5G-CLARITY and previous projects.

Table 4-3: Potential areas of contribution between 5G-CLARITY and other running projects.

Project	Partners involved	Areas of contribution
H2020 5G-PICTURE (Phase-2)	I2CAT, IHP, UNIVBRIS	5G-CLARITY will feed from 5G-PICTURE contributions that feature Sub-6 and millimeter Wave (mmWave) platforms to achieve high accuracy positioning and synchronization capabilities.
H2020 5GCity (Phase-2)	I2CAT, UNIVBRIS, ACC	5GCity builds an SDN/NFV based multi-tenant distributed cloud and radio platform that enables municipalities and infrastructure owners to act as 5G neutral hosts. This platform will be used as the basis for the SDN/NFV management platform used in 5G-CLARITY.
H2020 5G-TRANSFORMER (Phase-2)	IDCC, TID	5G-TRANSFORMER defines a Software Defined Network (SDN)/Network Function Virtualization (NFV) based architecture using slicing, Multi-access Edge Computing (MEC) and federation as key concepts to meet vertical industries' (eHealth, automotive, Industry 4.0 and media) requirements in 5G mobile networks. 5G-CLARITY will study the end-to-end slicing concepts developed in 5G-TRANSFORMER.
H2020 5GinFIRE	TID	5GinFIRE develops an Open, and Extensible 5G NFV-based Reference (Open5G-NFV) ecosystem of Experimental Facilities that lays down the foundations for instantiating fully softwarised architectures of vertical industries and experimenting with them. 5G-CLARITY will use the OSM deployed for 5GinFIRE baseline orchestration solution, extending it with necessary features for NF sharing and Heterogeneous Radio Access Technology (HetRAT) management integration.
H2020 5G-VINNI (Phase-3)	TID	5G-VINNI provides an end-to-end facility spanning various European sites that validates the performance of new 5G technologies by operating trials of advanced vertical sector services. 5G-CLARITY will leverage from 5G-VINNI: (i) the model-based solutions for network slicing management and (ii) the monitoring mechanisms to allow data-driven lifecycle management of E2E slices with great level of automation.
EPSRC 5G Testbed and Trials	UNIVBRIS	Programme created to boost the UK digital infrastructure by setting up the 5G testbed facilities across UK as part of the trials. The testbed developed in Bristol provides a platform for development of several use cases in the context of an integrated Smart City. 5G-CLARITY will leverage this existing testbed for Key Performance Indicator (KPI) validation and to support the museum use case.
EPSCR TOUCAN	UNIVBRIS, UEDIN, PLF	TOUCAN aims to achieve ultimate network convergence enabled by a technology agnostic architecture targeting a wide range of applications and end users. This architecture will facilitate optimal interconnection of any network technology domains, networked devices and data sets with high flexibility, resource and energy efficiency. 5G-CLARITY will build on the architectural principles for convergence developed in TOUCAN.
EU/H2020 EMPOWER	IDCC	The project focuses on advanced wireless experimental platforms for 5G and Beyond 5G. The insights gained from EMPOWER regarding experimental platforms and optimization tools are quite relevant to 5G-CLARITY.
EU/H2020 5G-CORAL	IDCC	5G-CORAL proposes the distributed EFS, constituting Multiple Radio Access Technologies (RATs); managed and controlled by an Orchestration and Control System (OCS). IDCC was Technical Manager

		and WP2 leader in 5G-CORAL. The 5G-CORAL Multi-RAT convergence aspects and the distributed computing platform are particularly relevant to 5G-CLARITY.
EU/H2020 5GZORRO	I2CAT TID	5GZORRO investigates application of blockchain technologies to 5G. In particular, 5GZORRO incorporates a use case for dynamic spectrum allocation based on transactions executed in a blockchain powered market. 5G-CLARITY will consider the bandwidth management requirements spanning from that use case, and will feed to 5GZORRO the bandwidth management capabilities for 5G, Wi-Fi and Li-Fi developed in the project.
EU/H2020 5G-COMPLETE	ACC IHP UNIVBRIS	Any of the developments and enhancements to be done on the ACC's dRAX platform as part of 5G-CLARITY could potentially be integrated and considered also in the ACC dRAX platform to be used in 5G-COMPLETE. There could be potential common papers, presentations, workshops, between both projects within the context of the use of virtual Radio Access Network (vRAN) and ORAN architectures in 5G projects. IHP will build up a multi-core baseband processor platform for Terahertz (THz) communications. The lessons learned on positioning and synchronization can be incorporated to solutions for THz communications. Additionally, the solution developed in 5G-COMPLETE could be potentially integrated in factory environments.
EU/H2020 5GENESIS	IHP	The work of IHP in 5GENESIS focuses on the development of an outdoor millimetre wave solution for terrestrial backhaul applications. Additional features will be added to this solution in the framework of 5G-CLARITY to equip the solution with positioning and network synchronization capabilities.
EU/H2020 5G-VICTORI	I2CAT IHP UNIVBRIS	5G-VICTORI demonstrates advanced media, energy and transportation vertical use cases making use of ICT-17 testbeds. 5G-CLARITY will consider the approach to integrate local test-sites and ICT-17 platforms adopted in 5G-VICTORI, and to devise mechanisms to integrate private and MNO networks. Some management components developed in 5G-VICTORI and preceding projects, such as the I2CAT RAN Controller or the UNIVBRIS 5GUKEx, will also be considered as building blocks for the 5G-CLARITY management plane developed in WP4.
EU/H2020 5G-Enhance	ACC	Since 5G-ENHANCE started in 2018 and is currently on M17 any contributions from 5G-CLARITY towards 5G-ENHANCE will be unlikely
EU/H2020 WORTECS	PLF, IHP	WORTECS and 5G-CLARITY both explore the possibility of LiFi technique in novel networks of either ultra-high capacity or capability of being integrated with 5G and Wi-Fi.
EU/H2020 ARIADNE	TID	ARIADNE focuses on enabling high-bandwidth wireless communications by developing three complementary but critical new technologies for Beyond 5G networks in an integrated and innovative way: i) new radio technologies for communications using the above 100 GHz D-Band frequency ranges; ii) advanced connectivity based on metasurfaces, for shaping the propagation environment in D-band; iii) Machine Learning (ML)/AI techniques to provide continuous reliable high bandwidth connections using D-Band for Beyond 5G scenarios. 5G-CLARITY can leverage ARIADNE insights on D-Band to explore the applicability of this frequency ranges to provide extremely high throughputs and reliable connectivity within indoor, private environments such as factories.

EU/H2020 INSPIRE-5GPlus	TID	iNSPIRE-5Gplus project aims to serve the crucial objectives of intelligent security and pervasive trust required in private industrial environments, where interworking with public networks is expected for coverage and service continuity purposes. 5G-CLARITY will feed INSPIRE-5GPlus with industry 4.0 use cases and related requirements, so security-related assets such as Trusted Execution Environments (TEEs), remote attestation/path proof/Root Cause Analysis (RCA), and end-to-end liability management between different parties, i.e. verticals and mobile network operators, can be applied and assessed.
EU/H2020 MonB5G	LMI	MonB5G aims to develop zero-touch management and orchestration in the support of network slicing at massive scales for 5G Long Term Evolution (LTE) and beyond. The area of Artificial Intelligence (AI)/ML supported slice management is being investigated in both MonB5G and 5G-CLARITY. Both projects will contribute to this topic and benefit from sharing insights gained.
EU/H2020 TERAWAY	TID	TERAWAY will develop a disruptive generation of THz transceivers that can overcome the current limitations of THz technology and enable its commercial uptake, leveraging optical concepts and photonic integration techniques for this end. Similarly to ARIADNE, 5G-CLARITY can leverage TERAWAY outcomes on THz band to assess their applicability into indoor, private environments such as factories.

5 Exploitation Plan

5.1 Product and services

The exploitation plan has been arranged for each partner category (verticals, vendors and service providers, network operators, small and medium enterprises, academia and research centers) as reported in the following sections.

5.1.1 Verticals

As one of the reference companies around the world, the objective for BOSCH is to improve their strong position as innovation leader and increase their market share by introducing 5G-CLARITY results technologies. In addition, BOSCH seeks the enhancement and accuracy of his own production, leading improved production, logistic and quality methods, which could supply products with a competitive advantage.

The application of the 5G-CLARITY results in the factory will improve the working environment for workers and engineers, opening the possibility to allocate workers in positions requiring less physical effort and in tasks more attractive to do.

The initial exploitation routed to be executed by BOSCH will be based in the technology application and transfer of the knowledge, technologies and machines developed to other BOSCH factories, including factories working in different activity sectors and assembly lines with different features.

The internal exploitation of results makes a better and direct understanding of the technology requirements and cutting-edge technologies by the managers of the BOSCH group. Other BOSCH´s factories for transference will be selected based on objective criteria such as current facilities, AGV availability, etc.

The Bosch group consists of Robert Bosch GmbH and it comprises more than 300 subsidiaries and regional companies in approximately 60 countries, with a total of 30,000 researchers and developers in charge of the company.

Beyond the internal exploitation, the demonstration of the 5G-CLARITY results in different factories open up new market opportunities.

Other exploitation activities can be listed as follows:

- Productisation/operationalisation, further developments, integration into other services.
- Showcase the 5G-CLARITY technologies developed.
- Modelling systems able to sensibly address new concept in use of digitalization of the industry procedures and flexibility to Layout changes.
- Incorporating results into existing factories (clients, suppliers and other enterprises).
- Background knowledge gained from 5G-CLARITY, national and internal programs, opening the possibility to launch new RTD project at the cutting edge of the technology.

5.1.2 Vendors and service providers

5.1.2.1 InterDigital

Through its participation in 5G-CLARITY, InterDigital (IDCC) intends to develop novel technologies spanning across smart multi-connectivity solutions and AI-based management platforms. Being InterDigital an active contributor in various SDOs, such as 3GPP, IETF and IEEE, major focus will be directed toward identifying gaps in relevant standards that will be filled based on the project results and experimentations. As an example, InterDigital is keen on exploring AI-based solutions considering recommendations published by the ITU-T focus group on Machine Learning for Future Networks (FG-ML5G) and potentially influencing other standards. In addition, InterDigital plans to integrate some of the 5G-CLARITY solutions into Proof-of-Concepts (PoC), as shown in **Figure 5.1**, which will be demonstrated at relevant exhibitions and conferences, including the Mobile World Congress (MWC) and the European Conference on Networks and Communications (EuCNC). More specifically, a 360-degree video and robotic application will be enhanced by assessing new hybrid slicing solutions allowing to simultaneously meet high-bandwidth demand and low-latency requirement dictated by such applications. This is meant to support monetization by means of technology licensing or spin-off and joint ventures toward commercial solutions offering.

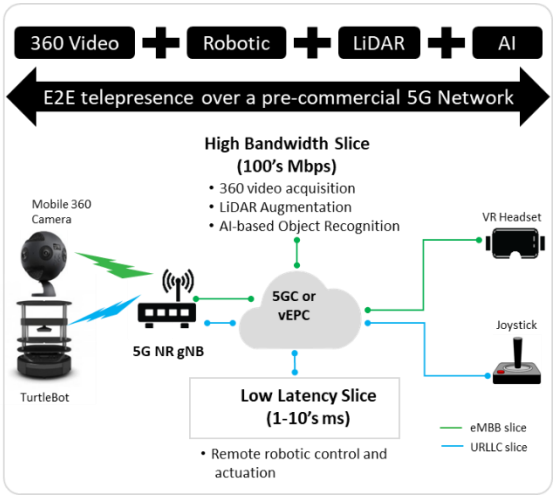

Figure 5.1: Immersive telepresence PoC with robot actuation.

5.1.2.2 Ericcson LMI

Ericsson is one of the leading providers of Information and Communication Technology (ICT) to telecommunication service providers, with a focus on developing game-changing technology and services that are supported by artificial intelligence and machine learning (AI/ML). In this regard, Ericsson seeks to transfer knowledge gained from developing AI/ML components in 5G-CLARITY into existing Ericsson trials and products.

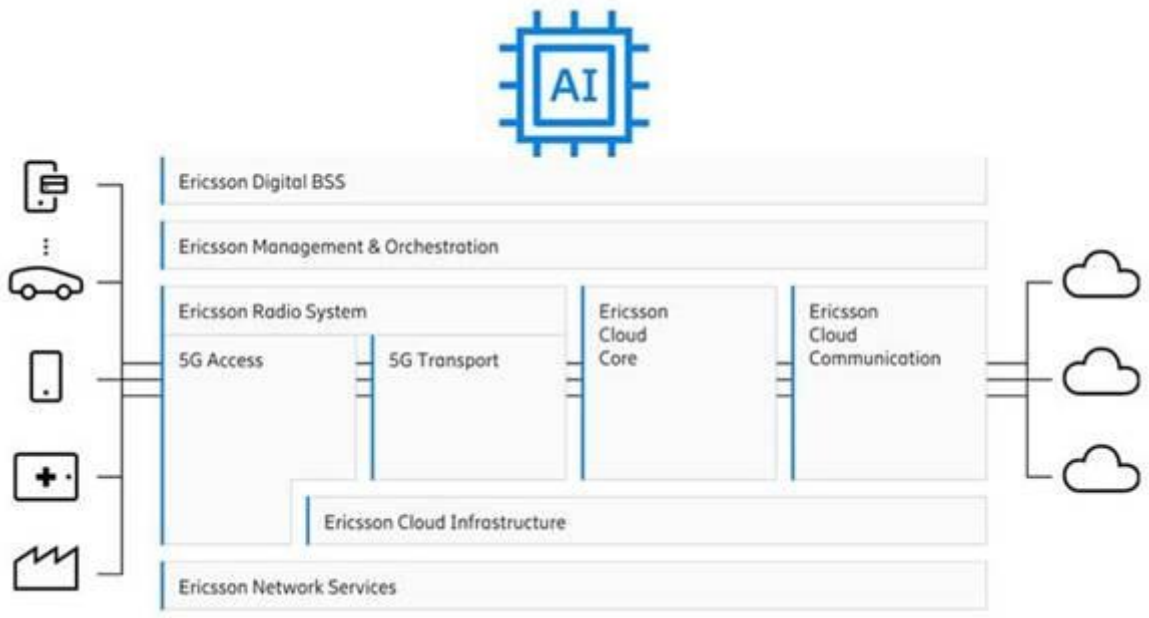

Figure 5.2: AI and automation help Ericsson to move towards zero-touch networks.

https://www.ericsson.com/en/ai-and-automation

While AI is helping to advance technology in many different areas of telecommunication (see **Figure 5.2**), one of Ericsson Ireland's (LMI) main areas of interest is driving R&D in automating network management and orchestration. In the context of 5G-CLARITY, LMI will investigate the use of AI/ML for network management automation by leading the development of an AI/ML supported management component. The developed tools will be evaluated on the 5G-CLARITY use cases in a multi-Wireless Access Technology (WAT), ultrahigh-capacity and ultralow-latency scenario, with a view to integrating the lessons learned into the Ericsson Network Manager software suite as well as contributing aspects of the work to the Open Networking Automation Platform (ONAP) platform and the O-RAN architecture and interfaces.

5.1.3 Network operators

As the innovation company of a global integrated network service provider, TID will seek for exploitation activities related to direct technology transfer to the relevant Business Units of *Telefónica*. 5G-CLARITY will provide a much wider, diverse and realistic environment for the exploration and demonstration of vertical applications in novel indoor scenarios, focusing on (a) the use and combination of different access technologies within the private venue, including 5G New Radio (5G NR), Wi-Fi and LiFi; and (b) the integration of public network with the private venue's network (i.e. non-public network), in terms of connectivity (infrastructure layer) and interworking (management and orchestration layer), to support the end-to-end execution of considered use cases.

TID will apply the experience gained in the 5G-CLARITY project to provide *Telefónica* business units with a better and direct understanding of the requirements that they interplay with private venue infrastructure operators will bring, and how *Telefónica* (taking the role of mobile network operator) may rely on this interplay to expand their service footprint at reduced costs. Furthermore, with the OSM extensions for multi-technology access support, TID foresees a direct enhancement of the

experimentation and demonstration capabilities of 5TONIC facility (testlab fostered by *Telefónica*), consolidating its position as a global reference for the evolution of 5G.

The target of this exploitation activities will be business units of the Telefónica Group in Europe and worldwide, for which TID plans to:

- Showcase the 5G-CLARITY innovative technologies and features.
- Demonstrate the industry 4.0 applications to support the technological and business validation of connectivity services scoping beyond 5G era.
- Study and measure impact resulting from the extension of OSM functionality and demonstrate through the different proof-of-concepts that this extension provides OSM with capabilities to support holistic orchestration.
- Provide the technology base and experience for the design and development of advanced, beyond 5G services benefiting from the synergetic relations with private venue infrastructure operators.

5.1.4 Small and medium enterprises

5.1.4.1 Accelleran (ACC)

Accelleran is an industrial SME delivering RAN/vRAN Software Solutions, Products and Services with a very strong focus on the delivery of carrier grade virtualized, open and disaggregated RAN components for ultra-dense 4G/5G networks. Within the scope of this project Accelleran seeks to generate USPs and IPR that it can incorporate in their flagship dRAX™ Open Interface RAN Intelligence product (See **Figure 5.3**) and enhance it with Heterogeneous Network (HetNet) capabilities integrating efficiently different access technologies beyond LTE and 5G-NR, such as Wi-Fi and LiFi. Having a dRAX aligned to O-RAN Alliance defined open and interoperable interfaces in addition to the ones defined within 3GPP will enable the interworking with interoperable third-party components, be it white label thin radio Hardware (HW) components or virtualised and orchestrated Software (SW) components service chained to deliver end-to-end solutions. The strategic approach to leverage on interoperable and open interfaces can not only enable the individual exploitation and offering of Accelleran components to end customers and system integrators, but also allow for joint exploitation with other members of the consortium or disaggregated virtualised RAN ecosystem.

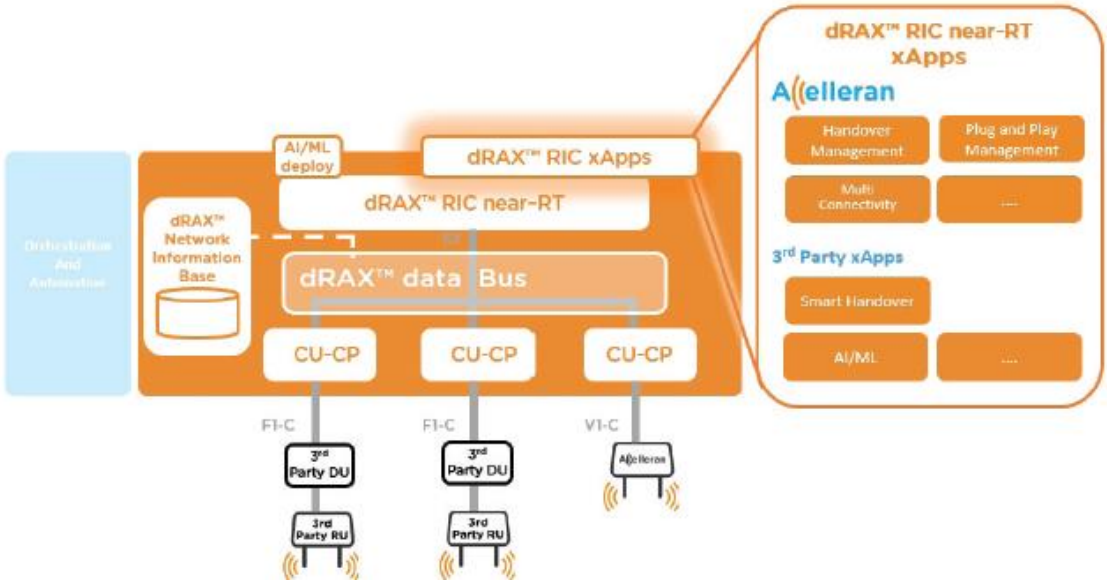

Figure 5.3: Accelleran dRAX Open RAN Intelligence.

5.1.4.2 Gigasys Solutions (GIGS)

Gigasys Solutions (GIGS) is a startup on wireless consultancy and project management in the area of collaborative R&D in ICT. Gigasys Solutions will use selected 5G-CLARITY results for strengthening its consulting competency and to deliver value to its clients in the telecommunications industry across Europe. The exploitation of 5G-CLARITY results by GIGS follows a three-step process:

- Identification of exploitable project results on a continuous basis by key personnel,
- Generation of White Papers and other information items based on the identified exploitable project results,
- Value creation for clients through discussions, follow-up research and innovation as well as consulting on emerging networks, services, and applications related to the identified exploitable project results.

In particular, Gigasys Solutions will advise its telco clients and partners via bi- and multi-lateral exchanges, targeted workshops, and community-internal White Papers. Furthermore, Gigasys Solutions will use 5G-CLARITY results to advise its clients on opportunities and risks arising from 5G-CLARITY results and the impact they may have.

As 5G-CLARITY project manager, Gigasys Solutions has a key role in supporting the dissemination of technical results obtained along the course of the project, such as arranging workshops, preparing brochures and leaflets, etc. Gigasys Solutions also will support the project's Innovation Manager (pureLiFi) to foster the project's ambitious targets in exploitation of the results, and in managing and monitoring the innovation process in the project.

5.1.4.3 pureLiFi Ltd (PLF)

PureLiFi Ltd (PLF) is a leader in the commercialisation of LiFi, developing and delivering technology since 2006 for secure, reliable, high-speed communication networks that seamlessly integrate data and lighting utility infrastructures and significantly reduce energy consumption.

Since 5G-CLARITY use cases are key scenarios for integrating LiFi technology to the fabric of 5G systems, PLF's key personnel will identify exploitable project results on a continuous basis. PLF intends to exploit the acquired knowledge by contributing some of the most promising project results in LiFi

standardisation activities. PLF aims to employ the project outcomes to improve product capability and integrate into next generation HetNets. Meanwhile, PLF will use the findings of the project to align its strategies and marketing. With the ideal ecosystem 5G-CLARITY provides for LiFi, PLF intends to exploit the experience in building important business alliances and engaging new customers.

PLF will also support the project by taking on the role of innovation manager and assist in the creation of new business opportunities.

5.1.5 Academia and research centres

5.1.5.1 University of Granada (UGR)

University of Granada (UGR) aims at presenting the results of the project in the main relevant conferences, such as IEEE GLOBECOM, IEEE ICC, IEEE International Conference on Computer Communications (IEEE INFOCOM). Furthermore, the most important results will be submitted to highly ranked journals specialised specialized on the field, such as IEEE Transactions on Networking, Communications of the Association for Computing Machinery (ACM), IEEE Network, IEEE Transactions on Communications, and IEEE Communications Surveys and Tutorials. To impact on a broader audience, we consider submitting the overall results to high impact IEEE Magazines.

The knowledge generated in the 5G-CLARITY project will be incorporated into UGR's academic activities, and considered in the undergraduate, master and PhD syllabus. This way, students will benefit from the project's state-of-the art results. Additionally, we expect to generate 5 bachelor thesis, 7 master thesis, 4 PhD thesis. As an exploitable result, parts of a simulator, as well as extensions for well-known simulator (as NS3 or OMNET++) will be set public as open source, so the academic and research communities can build future projects based on these tools.

The results obtained within the UGR's research will be considered for publication as a patent. We also contemplate the creation of a spin-off.

5.1.5.2 University of Edinburgh (UEDIN)

As a public institution of higher education, the University of Edinburgh (UEDIN) is a non-profit organization that will not perform commercial exploitation of the project's results. Nevertheless, the results may be used for research of advanced techniques and promoted to enable technology transfer to industry.

The simulations and results of the 5G-CLARITY project will be submitted to high-impact scientific publications and will be disseminated in social media and on the University's website for wider reach. The University of Edinburgh regularly submits publications to high impact journals such as IEEE/OSA Journal of Optical Communications and Networking, IEEE Transactions on Wireless Communications and IEEE Communications Magazine; and conferences like IEEE PIMRC, IEEE WCNC, International Symposium on Wireless Communication Systems (ISWCS), IEEE Vehicular Technology Conference (IEEE VTC) and IEEE ICC.

The developed framework for interconnection of 5G, Wi-Fi, LiFi (see **Figure 5.4**) will be deployed in the demonstration site in the University of Edinburgh. This demonstrator is used as a reference platform for researchers and PhD students to evaluate the performance of new techniques and decision algorithms to maximize the user experience of wireless communications.

Figure 5.4: Wi-Fi/LiFi testbed (University of Edinburgh)

University of Edinburgh prepares custom designs for industrial partners, showing the suitability of optical wireless as a complement to well-established RF techniques. By integrating the results of the 5G-CLARITY project, in particular the multi-technology coexistence framework for 5G/Wi-Fi/LiFi networks, it is expected to widen the interest and facilitate the adoption by companies in multiple sectors, as the reservations against a new technology are mitigated by existing deployments.

5.1.5.3 Fundació I2CAT (I2CAT)

I2CAT plans to evolve its R&D assets through the project in the following way. First, the I2CAT RAN controller platform, which currently manages LTE Small Cells and Access Points (APs), will be extended in T4.1 to control 5GNR gNBs and LiFi APs. This work will be performed together with ACC and following the O-RAN architecture. Thus the outcome of this work is expected to result in a potential transferable asset from I2CAT.

Second, the i2CAT positioning solution based on Optical Camera Communications (OCC) will be further evolved, and potentially integrated with other technologies (LiFi, mmWave) in T3.4. Finally, the I2CAT white box AP solution will be enhanced with the multi-connectivity and the 5G integration frameworks developed in T3.2, which will better position the Wi-Fi solution from I2CAT for future 5G projects.

I2CAT intends to exploit all these R&D assets through scientific publications in peer reviewed journals and conferences, e.g. IEEE Transactions on Service and Network Management, or IEEE ICC, and through further research projects (e.g. new 5G-PPP projects). I2CAT will also actively explore the commercial exploitation of these technologies by means of IPR licensing agreements with the industrial partners of the project.

Finally, I2CAT will use the project outcomes to impact 5GBarcelona (www.5gbarcelona.org), which is a private public partnership devoted to foster the validation of 5G verticals in the metropolitan area of Barcelona.

5.1.5.4 University of Bristol (UNIVBRIS)

UNIVBRIS will contribute to the dissemination activities, by producing publications of high-quality results in international media like peer reviewed journals and conferences (e.g., IEEE/OSA Journal of Optical Communications and Networking, IEEE Transactions on Service and Network Management, IEEE Communication Magazine, European Conference on Optical Communication (ECOC) 2020, OFC 2021, ICC 2021, etc.). On these articles, the objective will be to present results from studies and experiments obtained from the planning, implementation and demonstration phases of use cases in

Bristol.

UNIVBRIS will develop key framework for future Public and Private Co-existed networks with interconnection of 5G, Wi-Fi, and LiFi. AI/ML will be developed to generate intelligent network configuration policies within the 5G-CLARITY scenario, and will be demonstrated in the developed testbed, to pave the way for deployments of AI in 5G networks. All the relevant technologies will be demonstrated in the 5G-UK testbed in the University of Bristol. The UNIVBRIS will disseminate the public demonstration information through social media and other websites, to reach more wide users and leverage the impact of the research.

5.1.5.5 IHP GmbH (IHP)

The goal of IHP within 5G-CLARITY is to boost the development of positioning and synchronization algorithms running on top of the different platforms available internally. Resulting localization HW cores and SW implementations can be exploited together with the platforms via IHP's daughter company "IHP Solutions". IHP plans as well to exploit the results academically via its annual summer school, and lectures given at Universities in Berlin and the graduate school supporting PhD students at IHP. Additionally, IHP plans to disseminate the work carried out in the project in high-ranked journals and conferences.

5.2 Exploitation plan of products/platforms for vendors, SMEs and verticals

The exploitation plan of products/platforms has been arranged among individual partners. Each partner's interest in the exploitation within the scope of 5G-CLARITY project is described in **Table 5-1**, as well as the routes for exploitation and the potential target audience.

Table 5-1: Exploitation plan of products/platforms within the scope of 5G-CLARITY project

PARTNER	INTEREST IN THE EXPLOITATION	ROUTES FOR EXPLOITATION	TARGET AUDIENCE
BOSCH	**BOSCH** sees 5G-CLARITY as a very strategic project, as it is fully in line with its current developments and roadmap since provide additional benefits since the productivity is expected be enhanced by improving the accuracy and the quality BOSCH exploitation plans lie in: • One of the most important activity of exploitation of results identified by BOSCH will be the demonstration and implementation in the different factories of the company at first level and then export this model to other companies in different	BOSCH Internal collaborative network Involvement of BOSCH´s plants director and managers direct showcases in the BOSCH factory	Other BOSCH´s factories, both at National (Spain) and International level

	activity sectors with assembly lines. • The demonstration results open up the market opportunities. • The pilot and application experiments and their feedback that will increase the application use cases and the visibility of BOSCH robots. Finally, the working environment from the perspective of the worker will be improved. Workers can be allocated to other tasks more attractive, and with less physical effort and harm on the worker's body.		
ACC	The main Accelleran product involved is the dRAX™ Open Interface RAN Intelligence which will be enhanced to support the integration of LTE and 5G-NR with other access technologies such as Wi-Fi and LiFi.	Via delivery of enhancements in dRAX™ Open Interface RAN Intelligence roadmap	Accelleran dRAX™ Open Interface RAN Intelligence customer base
PLF	PLF is the market leader in LiFi commercialization and its product, LiFi-XC, is the world's first certified, complete LiFi system. 5G-CLARITY considers the key scenarios for integrating LiFi technology to the fabric of 5G systems. PLF intends to exploit the developments of the product in accuracy, quality and capability while combining with Wi-Fi and 5G technology. A better understanding of market potentials and business impacts will also be the target of the exploitation.	PLF will work closely with other partners for integrating LiFi technology to the 5G-CLARITY architecture. There are also on-site test facilities to assist in the debug and validation of the systems.	Academic, Commercial
TID	TID will apply the experience gained in the 5G-CLARITY project to provide Telefónica Group with a direct understanding of the requirements that the interplay with venue infrastructure operators will bring, and how Telefónica as an	The activities conducted as part of the TID's exploitation plan can be arranged into three main groups. First, showcase the 5G-	Business units of the Telefónica Group in Europe and worldwide

	MNO may rely on this interplay to i) expand their service footprint at reduced costs, and ii) to find new revenue sources through Network-Slice-as-a-Service (NSaaS) model. TID will also leverage to enhance the mechanisms supporting edge and in-network computing services and their management by the Telefonica Group. Furthermore, with the OSM extensions for advanced access network support, TID foresees a direct enhancement of the 5TONIC experimentation and demonstration capabilities (lab fostered by Telefonica), consolidating its position as a global reference for the evolution of 5G globally, and in particular, for Telefonica Group.	CLARITY innovative technologies. Secondly, study and measure impact resulting from the extension of OSM functionality, and demonstrate through the different proof-of-concepts that this extension provides OSM with capabilities to support holistic orchestration in the overall system. Finally, provide Telefónica group with the technology base and experience for the design and development of advanced products and services benefiting from the synergetic relations with venue infrastructure operators.	
IDCC	InterDigital aims at developing smart multi-connectivity solutions and AI-based management platforms. Furthermore, the outcomes of 5G-CLARITY will be used to steer the standardization activities, in particular within the 3GPP. Finally, InterDigital intends to showcase novel 5G-CLARITY technologies integrated into a PoC that will be showcased in relevant venues. This will help to build potential collaborations and partnerships with industry players and vertical consumers.	Technology showcase in relevant venues Licensing Partnership development	Industry players Vertical consumers
LMI	Ericsson seeks to transfer knowledge gained from developing AI/ML platforms and components into existing line-ups to strengthen	Insights gained from Proof-of-Concept development as well as the developed	Ericsson internal R&D, open source community

	our portfolio in AI/ML R&D, particularly in the area of automating network management and orchestration	technologies will be made available to Ericsson internal R&D and potentially to the open source community	

6 Standardization plan

6.1 Plan for Year 1

The project has set the following three objectives for the standardization activities:

1. 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 keep track of existing or upcoming industry specifications or recommendations that may affect the project technological choices and identify opportunities for the project to contribute its proposed solutions to present and future standardization groups.
2. Disseminate the project into the standardization forums to raise awareness and help create an opportunity for standardization exploitation.
3. Contribute through the partners (individually or jointly) with project-related technology proposals into the relevant standardization forums.

The above objectives remain applicable over the whole project duration. With focus on Year 1, it is anticipated that the activities will first involve the creation of the project standardization activity roadmap. As the design of the project solutions progresses, we anticipate seeing more efforts spent on standardization dissemination and contributions.

6.2 Relevant standardization activities

6.2.1 3GPP

3GPP covers cellular telecommunications technologies, including radio access network (RAN), core network (CN) and service capabilities, which provide a complete system description for mobile telecommunications. The 3GPP specifications provides hooks for non-radio access to the core network, and for interworking with non-3GPP networks. 3GPP specifications and studies are contribution-driven, by member companies, in Working Groups and at the Technical Specification Group level. The three Technical Specification Groups (TSG) in 3GPP are; Radio Access Networks (RAN), Services & Systems Aspects (SA), Core Network & Terminals (CT).

As shown in **Figure 6.1,** 3GPP connects seven standard development organizations (Association of Radio Industries and Businesses (ARIB), Alliance for Telecommunications Industry Solutions (ATIS), China Communications Standards Association (CCSA), ETSI, Telecommunications Standards Development Society of India (TSDSI), Telecommunications Technology Association (TTA), Telecommunication Technology Committee (TTC)), known as “Organizational Partners (OPs),”, which take part in the project coordination group, whose responsibility is to manage and coordinate activities inside the three technical specification groups. Furthermore, written contributions are submitted to 3GPP meetings by 3GPP member organizations. The meeting calendar describes the schedule of the meetings. 3GPP Release cycle is approximately 15 months. There are plenary sessions that approve the content of the release before the release cycle starts.

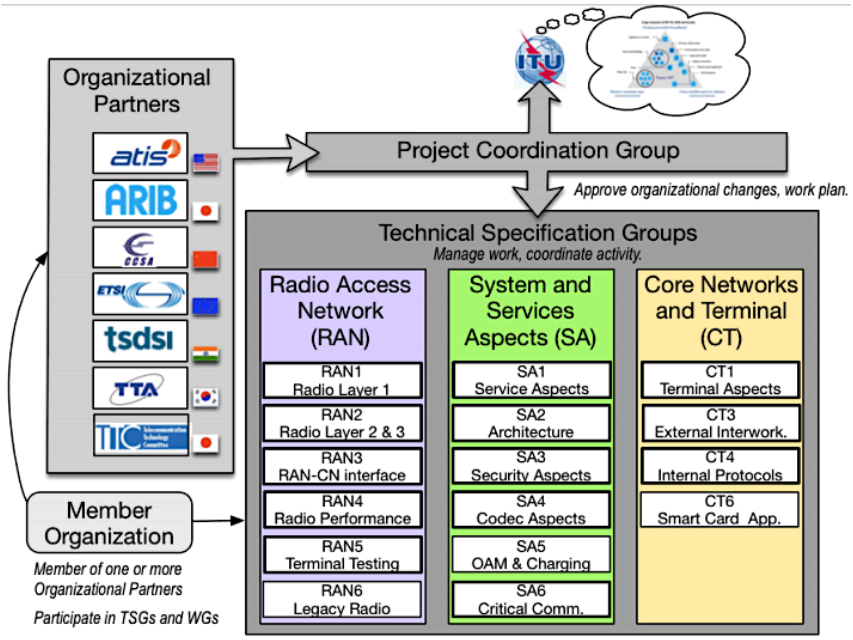

Figure 6.1: 3GPP organization.

3GPP is the main SDO in the 5G-CLARITY project targeting at specifications of radio access networks (RAN) and core networks (CN) of cellular communication systems.

As shown in **Figure 6.2**, the specifications of Rel-16 is to be completed on the Q1 of 2019 and the Release 17 is just about to start. The release 17 is anticipated to be completed in Q2 of 2021 and release 18 is expected to follow the release 1. As a result, 5G-CLARITY is expected to be able to impact 3GPP activities in Release 17 and to set the stage for new study items that may be covered in Release 18.

Several Study Items (SI) and Working Items (WI) relating to 5G-CLARITY have been identified by 3GPP in SA and RAN working groups in release 17, addressing aspects such as Industrial IoT & Ultra-Reliable and Low Latency Communications (URLLC), RAN Data collection enhancements, Network Data Analytics, Non-Public Networks, 5G-Local Area Network (LAN) type service, Edge Computing on 5G Core (5GC).

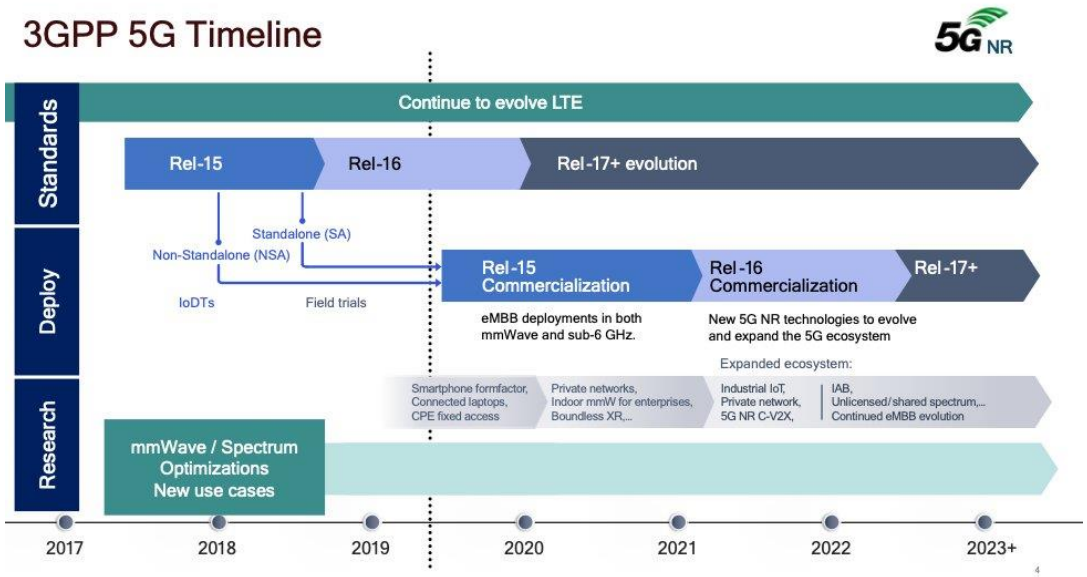

Figure 6.2: 3GPP 5G NR timeline.

In the following, we present some of the 3GPP activities that will be relevant in 5G-CLARITY:

- **RAN1/RAN2**
  - *NR Dynamic Spectrum Sharing (DSS):* this work item intends to investigate how LTE and NR systems can share the same carrier, specifically how to ensure sufficient scheduling capacity for NR users, as the number of NR devices in the network increases.
- **RAN2/RAN3**
  - *Non-Public Networks Enhancements*: this study item looks to enhance RAN support to non-public networks based on new features defined in the SA2 technical group.
  - *NR Positioning enhancements*: this study item aims at exploring solutions to support high accuracy, low latency, network efficiency and device efficiency requirements for commercial use cases, as well as studying solutions to support integrity and reliability of assistance data and position information.
- **RAN2**
  - *NR for Industrial Internet of Things (IIoT):* The work item should specify techniques to support Packet Data Convergence Protocol (PDCP) duplication with higher reliability and/or better efficiency, intra-UE prioritization/multiplexing, and mechanisms catering for Time-Sensitive Networking (TSN) traffics. Furthermore, it also specifies necessary enhancements required to support identification and selection of non-public networks.
- **RAN3**
  - *NR SON/Minimization of Drive Tests (MDT) enhancements*: this work item looks to enhance the support to of data collection for Self-Organizing Network (SON) features, including inter-system inter-RAT energy saving, 2-step Radio Access Channel (RACH) optimization, mobility enhancement optimization and leftovers of Rel-16 work items.
- **RAN SA2**
  - *Study on enhanced support of Non-Public Networks (FS_eNPN– enhanced support for Non-Public Networks)*: this study item will investigate further enhancements to the

5GS support for NPNs, including User Equipment (UE) onboarding and remote provisioning, support for equivalent Standalone Non-Public Network (SNPN) and for non-3GPP access for SNPN services.

- *Study on Access Traffic Steering, Switch and Splitting support in the 5G system architecture Phase 2 (FS_ATSSS_Ph2):* this study item will focus on extending the Access Traffic Steering, Switch and Splitting (ATSSS) feature which enables the UE to simultaneously be connected to both 3GPP access and non-3GPP access. The specific aspects will include traffic splitting support for Guaranteed Bit Rate (GBR) traffic, more advanced steering modes, additional steering methods, as well as certain roaming scenarios that were not supported in Rel-16.
- *Study on enhancement of support for 5G LAN-type service (FS_5GLAN_enh)*: this study item will evaluate solutions to meet SA1 5G LAN-type service requirement specified in TS 22.261, such as enhancement of 5G VN group management and 5G VN group communication

- **RAN SA5**
  - *Study on management aspects of non-public networks (FS_OAM_NPN):* this study item discusses use cases and requirements for the management of stand-alone Non-Public Networks (NPNs) and public network-integrated NPNs, from the service-based management architecture viewpoint.

In addition, **Table 6-1** provides an overview of the 3GPP study items that might be relevant to 5G-CLARITY.

Table 6-1: Summary of 3GPP study items potentially relevant to 5G-CLARITY.

WG	Study item	On-going work relevant for 5G-CLARITY
RAN1/RAN2	DSS	Spectrum sharing is one of the main 5G-CLARITY research topics. This study item first investigates solutions for spectrum sharing between NR and LTE.
RAN2/RAN3	NPN_enh	In 5G-CLARITY, non-public networks play a big role and any enhancement will be investigated during the architecture development phase.
	FS_NR_pos_enh	Positioning enhancements will be a key topic in 5G-CLARITY and this study item well fits with ambitions of the project
RAN2	NR_IIOT	RAN enhancements for Industrial IoT use cases will be of interest in 5G-CLARITY, as the project involves industrial use cases.
RAN3	NR_ENDC_SON_MDT_enh	This item aims to improve the 3GPP data collection feature, which in 5G-CLARITY will be essential to feed the AI sub-system.

SA2	FS_eNPN	The core network enhancements for NPNs support will also be strategical in 5G-CLARITY.
	FS_ATSSS_Ph2	This study item can impact on potential solutions devised to enable multi-WAT connectivity in 5G-CLARITY.
	FS_5GLAN_enh	5G LAN enhancements may be relevant to the use cases proposed in the projects, i.e., AR and Industry 4.0.
SA5	FS_OAM_NPN	The management of NPNs will also be investigated based on the requirements characterizing the use cases

6.2.2 ETSI

European Telecommunication Standardization Institute (ETSI) is a non-for-profit SDO that produces globally applicable standards for the ICT industry. It scopes multiple technology areas, including fixed, mobile, radio, broadcast, multimedia, internet and aeronautical, among others.

To ensure ETSI outcomes are of high quality and produced efficiently, ETSI standardization work [2] follows a proven standards-making process based on consensus and openness. Most of this technical work is carried out by committees. These committees meet typically between two and six times and year, either on ETSI premises or elsewhere. There is a range of different types of committees for different tasks:

- **Technical Committees** – responsible for the definition of different work programmes, each addressing various standardization activities in a given technology area. To fulfil these activities, every work programme is made up of individual work items. Each technical committee establishes and maintains a different work programme. Collectively, the work programmes of all ETSI technical committees constitute the ETSI Work Programme.
- **ETSI Projects –** similar to technical committees, but with two main differences:
  - they are established to meet a particular market sector rather than centred around a basic technology;
  - they last for a fixed period, as they can be discontinued after the necessary work is done, i.e. when the market requirements cease to exist.
- **ETSI Partnership Projects –** set up when there is a need to cooperate with complementary organizations to achieve a standardization goal. Examples of these projects are 3GPP and oneM2M [3].
- **Industry Specification Groups (ISG) –** operate alongside the traditional standards-making mechanisms, focusing on a very specific activity. ISGs are self-contained, decide their own work programme and approve their own technical documents. These documents can be of two types: informative documents (Group Report, GR) and standards documents (Group Specifications, GS).

An up-to-date view of the ETSI technical groups specified above can be found in [4]. **Figure 6.3** shows the interactions of these groups with other bodies, including Special Committees, General Assembly and ETSI board.

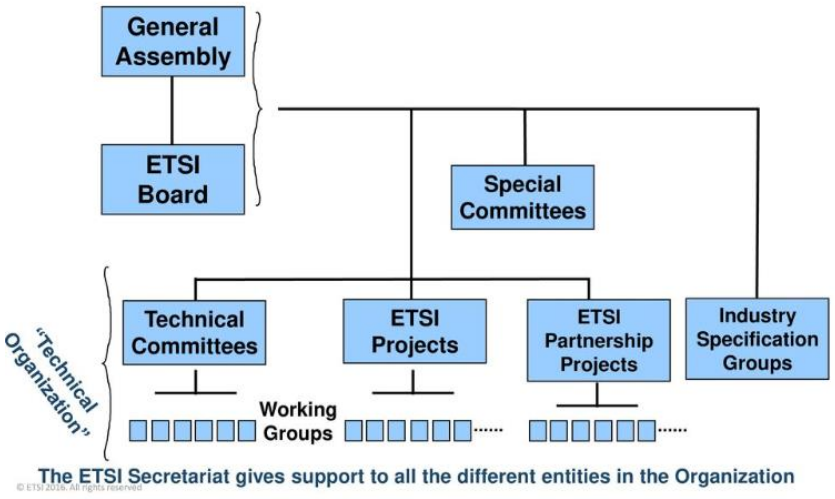

Figure 6.3: ETSI organization.

5G-CLARITY will keep track of the standardization activities carried out in five ETSI ISGs: **NFV** (Network Functions Virtualization), **MEC** (Multi-access Edge Computing), **ENI** (Experiential Networked Intelligence), **ZSM** (Zero-touch network and Service Management) and **mmWT** (millimetre Wave Transmission). While the four first ISGs are all related to *network transformation* [5], the mmWT ISG assess the implications of using frequencies of E-and W-bands. **Table 6-2** provides a summary of these ISGs, including information on their scope and goals, their current phase and their relevance for 5G-CLARITY project.

Table 6-2: ETSI ISGs within the scope of 5G-CLARITY project.

ISG	Scope and goal	On-going work relevant for 5G-CLARITY	Additional comments
NFV	End-to-end, uniform operation and management of network services deployed in virtualized environments, i.e. scenarios where functionality (software) can be decoupled from capacity (hardware).	Specification of Network Service Descriptor (NSD)/ Virtual Network Function Descriptor (VNFDs) and NFV interfaces, according to the work carried out in NFV-IFA WG (requirements and information model) and NFV-SOL WG (solutions and data models).	NFV is in its fourth two-year cycle[1] (NFV Phase 4), released in 2019.
MEC	Homogeneous, holistic operation and management mechanisms for (3rd party) service functions deployed at the edge of the network.	Solutions based on the MEC reference architecture to host latency-sensitive applications providing information on positioning and synchronization.	NFV is in its second two-year cycle[1] (MEC Phase 2), released in 2019.

[1] This ISG is appointed for a limited period, requiring explicit renewal.

ENI	Reference architectural framework enabling closed-loop network operations and management leveraging AI.	ENI work on normalization and pre-processing of data, to facilitate their consumption by 5G-CLARITY AI modules.	NFV is in its second two-year cycle[1] (MEC Phase 2), released in 2020.
ZSM	End-to-end network and service automation by means of an overarching integration framework designed following a service-based approach.	Reusing principles behind ZSM-based integration fabric to allow automation and consistency in cross-domain control and management.	ZSM is in its second two-year cycle[1] (MEC Phase 2), released in 2020.
mmWT	Wireless transport profile for standard SDN northbound interfaces, when using frequencies in the E- and W-bands.	On-going studies in mmTW ISG will foster research work on the use of millimetre wave technology in private venues taken part in the project.	N/A

For the 5G-CLARITY project, there are also opportunities to demonstrate and validate solutions specified in GSs/GRs resulting from these IGSs, and to contribute project results to them. To this end, those consortium's partners that are ETSI members (e.g. *Telefónica*, InterDigital) will take the lead in the submission processes, following ETSI rules.

6.2.3 IETF

The Internet Engineering Task Force (IETF) is an international and open community of network designers, operators, vendors, and researchers concerned with the evolution of the Internet architecture and the smooth operation of the Internet. The mission of the IETF is to make the Internet work better by producing high quality, relevant technical documents that influence the way people design, use and manage the Internet. These documents, which constitute the outcome of IETF work, are known as Request for Comments (RFCs). Every RFC is authored by IETF contributors in the form of memorandum describing methods, behaviours, research, or innovations applicable to the working of the Internet and Internet-connected systems.

The technical work of the IETF is done in Working Groups (WG), which are organized by topic into several Areas (see **Figure 6.4**). Although IETF organizes three (face-to-face) meetings per year, much of work in IETF is handled via WG-specific email lists, allowing contributors to exchange comments online to foster progress.

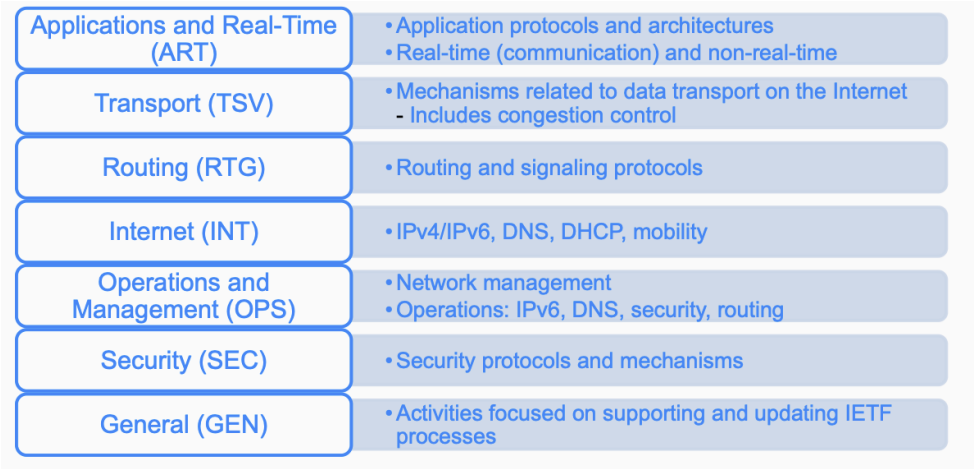

Figure 6.4: IETF areas

In parallel to IETF, there exists the Internet Research Task Force (IRTF). The main differences between both task forces are summarized as follows:

- IETF deals with the short-term issues of engineering and standards making, while IRTF focuses on longer term research issues.
- The technical work at IETF is done in Working Groups (WGs), while IRTF work is organized into Research Groups (RGs). Today, IETF consists of 128 active WGs (grouped into 7 areas) and IRTF has 14 active RGs.

A simplified view of IETF/IRTF organization is shown in **Figure 6.5**. As seen, IETF is structured into WGs that are managed by Area Directors (ADs). The ADs are members of the Internet Engineering Steering Group (IESG), which is responsible for technical management of IETF activities and the Internet Standards process. The General AD chairs the IESG and IETF, and is an ex-officio member of the Internet Architecture Board (IAB), which in turns gives input to the IESG about the architectural oversight and the standards process As IAB works at a high level, some of its tasks are related also to the adjudications of appeals in case there are complains about the decisions from IESG, assuring democratic ways of working. For these situations, the IAB and IESG are chartered by the Internet Society (ISOC).

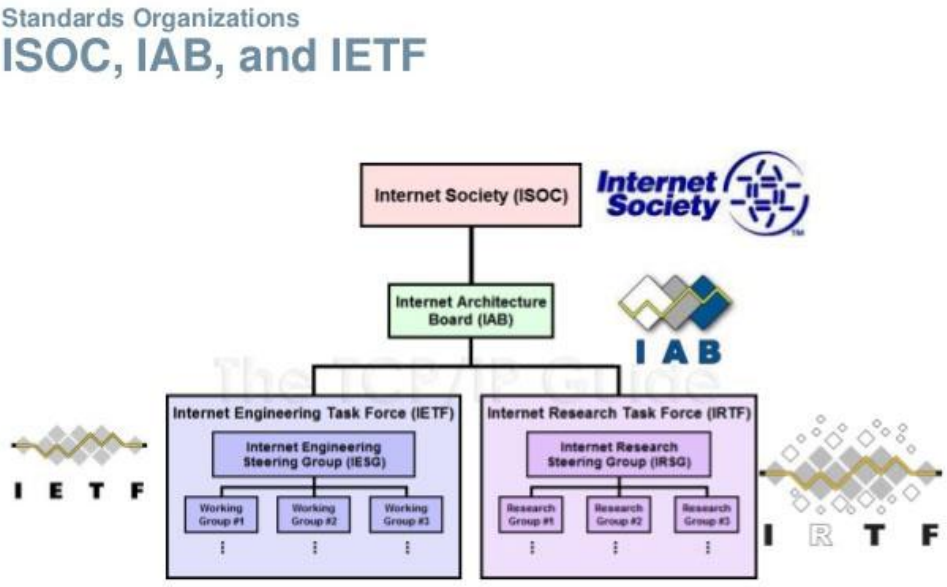

Figure 6.5: IETF top-level organization

The Internet Research Steering Group (IRSG) is similar to the IESG, but defined within the IRTF domain. Unlike IESG, IRSG receives very weak (almost zero) influence from decisions taken by ISOC and IAB. The independence of the IRSG with the rest of the organigram stress even more the real difference between IETF (standards-making task force) and IRTF (research-oriented task force).

5G-CLARITY will keep track of the standardization activities carried out in four IETF WGs and three IRTF RGs. The IETF WGs that are within the 5G-CLARITY's radar are **SFC** (Service Function Chaining), **TEAS** (Traffic Engineering Architecture and Signalling), **NETCONF** (Network Configuration) and **BMWG** (Benchmarking Methodology Working Group). SFC and TEAS WGs are defined into the Routing Area (RTG), while NETCONF and BMWG belongs to Operations Management Area (OPS). On the other hand, the IRTF RGs whose topics may be impacted by the work executed in 5G-CLARITY project are **NRMG** (Network Management Research Group), **COINRG** (Computing in the Network Research Group) and **MAPRG** (Measurement and Analysis for Protocol Research Group). **Table 6-3** provides a summary of these ISGs, including information on their scope and goals and their relevance for 5G-CLARITY project.

Table 6-3: IETF and IRTF activities within the scope of 5G-CLARITY project.

Organization	Group	Scope and Goal	On-going work relevant for 5G-CLARITY
IETF	**SFC**	Development of an architecture and the Network Service Header (NSH) for SFC. Discussion on aspects related to the architecture Operation, Administration and Management (OAM mechanisms and YANG models) and/or protocols to be used (with security and transport considerations)	YANG models for the management of SFC components, fostering automation in data collection and other run-time activities executed over virtual (network / application) functions, including their dynamic composition into network services and slices.

IETF	**TEAS**	Definition of Internet Protocol (IP), Multiprotocol Label Switching (MPLS) and General Multiprotocol Label Switching (GMPLS) traffic engineering architecture, and identification of required related control-protocol functions, i.e. routing and path computation element functions.	MPLS specifications for Wireless Area Network (WAN) connectivity (data plane connectivity between NPNs and public networks). Follow-up activities carried out in the so-called *Network Slicing Design Team*, set up in TEAS with the purposes of defining an information model for Transport Network (TN) slicing (including requirements and associated Application Programming Interfaces [APIs]).
IETF	**NETCONF**	Development and maintenance of NETCONF/ RESTCONF protocols (and associated transports and encodings) for YANG data model-driven management.	NETCONF protocol may be used for configuration, monitoring, telemetry and zero-touch activities over 5G-CLARITY data plane functions, which in turn expose their capabilities using YANG data model language.
IETF	**BMWG**	To produce a series of benchmarks for network devices, systems and services. These benchmarks will foster comparisons between physical and virtual functions, covering unique features of NFV systems. Specifications for test system calibration in virtualized environments are also in-scope	Methods developed to assess platform capacity as well as performance characteristics of Virtual Network Functions (VNFs) (e.g. vFirewalls, Serving Gateway [S-GW]/User Plane Function (UPF), signalling control gateways, etc.) and their unique supporting infrastructure (e.g. SDN controllers and vSwitches). These methods might well be implemented for the use case trialling activities carried out for 5G-CLARITY pilots validation.
IRTF	**NRMG**	To provide a forum for researches to explore new technologies for the management of networks and services deployed across the Internet. This WG works on solutions for problems that are not yet considered well understood enough for engineering work at IETF.	Work on intent-based networking (IBN), and on autonomic networking, including considerations for Distributed Detection of Service Level Agreement (SLA) violations.
IRTF	**COINRG**	To explore existing research and foster investigation of “Compute in the Network” and resultant impacts	Work on industrial use cases for in-network computing, and considerations on the end-to-end

		on the data plane, debating whether the ongoing shift from data center toward edge computing can be viewed as a cloud continuum, and the implications this shift will have on the whole Internet network.	orchestration between the data center and the edge. 5G-CLARITY might draw inspiration from current approaches (e.g. Kubernetes) that are likely to need updating/extending/simplifying in multi-domain network environments.
IRTF	**MAPRG**	Exploration of Internet conditions by measurement with the aim to inform protocol engineering and operator practice, so as to avoid undesirable situations, i.e. multiple protocols with overlapping scopes, and protocols themselves to be reused and abused in ways initially unforeseen.	Exchange of measurement-derived insight; discussion on techniques and best practices for measurement relevant to protocol.

Apart from monitoring the activities carried out by the above-referred working/research groups, 5G-CLARITY projects also expect to submit contributions to these groups, particularly to TEAS and NMRG. The desirable outcome of 5G-CLARITY project contributions to IETF is to be recognized (on behalf of one of the consortium's partners) as author of a published RFC. For this end, the 5G-CLARITY projects shall follow the steps declared in RFC 2026 [6]. A brief summary of this procedure is shown in **Figure 6.6**, and described below:

1. The first thing that needs to be done is to submit the contribution (for consideration by the IETF and IESG) in the form of *Internet Draft* (ID). The IETF publishes a set of guidelines that specify how IDs must be created and submitted.
2. The submitted ID is usually revised many times based on feedback from others in various WGs within the IETF.
3. If an ID has been reviewed and is considered valuable, well-understood and stable (meaning that it is not being rapidly updated with new revisions), it may become a candidate for standardization. In such a case, the IESG can place the Draft on the Internet standards track by changing its status to *Proposed Standard*. Documents of this status are considered mostly complete, but may still be revised based on further review, testing and experimentation with the technology.
4. Once the specification is sufficiently mature and widely accepted, it may be elevated from *Proposed Standard* to *Draft Standard*. A key requirement for such advancement is that the technology must be demonstrated to be functional on at least two independent and interoperable implementations. This proves that the standard is sufficiently clear and complete that at least two different groups have been able to implement it compatibly.
5. The final "station" on the Internet standards track is *Internet Standard*. This designation is only applied to very mature specifications that are popular and that have been widely implemented. A document that reaches this status often describes a technology that is or will become universally-implemented, and is assigned an "STD" ("standard") number.

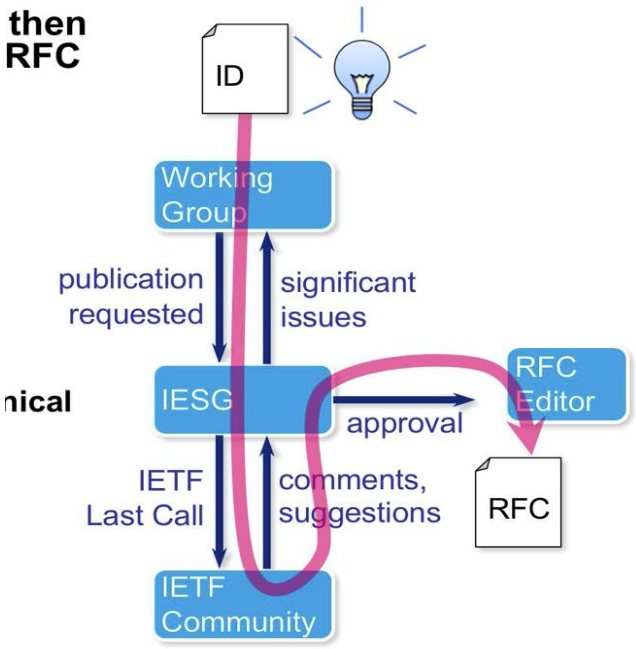

Figure 6.6: IETF ways of work - from an ID to an RFC

The RFC development process can take months or even years, depending on how complex the technology is, how many changes are required to the documents, and whether or not the proposal is considered important or interesting. Many RFCs never make it officially to Internet Standard status; Draft Standard status is generally considered sufficiently stable that the technology is often just implemented by companies when that level is reached. Some RFCs never even make it to Draft Standard status and the technologies they describe are still used in products.

Once an RFC is published, it cannot be changed. This is a specific policy decision intended to avoid the confusion that would otherwise result due to there being multiple versions of the same RFC. The RFC publication process incorporates a number of steps at which RFC authors can revise their documents, and check for editorial omissions and errors.

6.2.4 IEEE

Institute of Electrical and Electronics Engineers (IEEE) Standards Activities offers a collaborative platform for wireless communities that engage in, and enable the development of new, innovative, and relevant use cases and standards which, in turn, accelerate the time to market of consensus-developed technologies with regards to fifth-generation wireless systems (5G) and beyond. The IEEE 802.11 family is the branch of the wireless LAN initiatives with a rather big number of standards addressing current hot topics in the 5G community: high data rate communications, e.g. 802.11ay; localization, e.g. 802.11az; and light communications, e.g. 802.11bb.

IEEE 802.11 is a set of Media Access Control (MAC) and physical layer (PHY) specifications for implementing wireless local area network (WLAN) computer communication in the 900 MHz and 2.4, 3.6, 5, and 60 GHz frequency bands. They are created and maintained by the Institute of Electrical and Electronics Engineers (IEEE) LAN/Metropolitan Area Network (MAN) Standards Committee (IEEE 802). The base version of the standard was released in 1997 and has had subsequent amendments. The standard and amendments provide the basis for wireless network products commonly recognized as Wi-Fi©.

5G-CLARITY will be involved in relevant (active) IEEE standards, represented by the Partners TID, PLF and IHP, having each of them different targets that match their expertise. The following contributors mapped to the standards are expected:

- IHP, focusing on IEEE 802.11az, IEEE 802.ay and Wi-Fi sensing – new sensing topic interested group (SENS TIG)
- PLF, focusing on IEEE 802.11bb.

IHP is mainly involved in the IEEE 802 standardization activities, i.e. main focus being IEEE 802.11 Working Group (WG) as well as IEEE 802.15 WG.

In the past IHP has contributed to IEEE 802.11az. The standard being developed is standardizing localization functionality of the future Wi-Fi networks. The IHP's contributions were in the form of presenting approaches and results, which were obtained during past projects and, at that time, current projects. At present, the IEEE 802.11az is in its final stage, expected to be finished by the end of 2021. A draft version of the standard was already published. At the moment, different comments are being resolved. Therefore, IHP can only contribute by helping in comments resolution. Hence, IHP would actively monitor the activity of IEEE 802.11az in order to help in comment resolution for the comments for which IHP has the necessary expertise.

Another interesting standard for IHP is the IEEE 802.11ay. This standard is extension of the IEEE 802.11ad, which is an amendment of the IEEE 802.11 Wi-Fi standard, defining a new physical layer for 802.11 networks operating in the 60 GHz band, i.e. mmWave. This standard is also in its final stage, i.e. Initial Standards Association (SA) ballot is scheduled for March 2020, which leaves minimal opportunities for contributing with new results and approaches developed in the framework of 5G-CLARITY.

An interesting topic appeared lately is the so-called Wi-Fi sensing. This topic was actively being discussed under the Wireless Next Generation Standing Comity (WNG SC). The main idea behind the Wi-Fi sensing is to use the available radio for RF sensing applications. The possible applications include human presence detection for automatic light and/or air conditioning control, localization of persons within a room, counting number of persons, pet detection, person fall detection for use in hospitals, detect persons in car and where are they seated etc. The Wi-Fi sensing is based on methods which are common in some types of RADAR and to methods that are used in some RF localization approaches. This opens a possibility to contribute to the WNG SC and to present approaches which can be used in localization as well as in Wi-Fi sensing. This contribution can be made by the end of the second year or in the third year of the project, since significant advancements in the in the field of indoor localization within the framework of 5G-CLARITY project can be expected. These advancements can be presented in the WNG SC. Additionally, if a significant interest in Wi-Fi sensing is shown, a new Task Group (TG) can be formed for this topic. This would open new possibilities for further contributions from the 5G-CLARITY project, i.e. from IHP. Currently, there is a consensus for terminating the TIG and writing a Project Authorization Request (PAR), which would probably lead to a new TG that would work on standards for sensing.

In November 2016, the IEEE 802.11 created a Topic Interest Group on Light Communication (LC), later named TGbb, with a target to integrate this new physical link, i.e., LC, into the next evolution of the Standard. IEEE 802.11 TGbb focuses on the development of Light Communications (LC or LiFi) with broad industry support from a comprehensive ecosystem of partners including chipset vendors, infrastructure providers, device manufacturers, lighting companies, telecom operators and end

customers. Key envisioned use-cases are the mass market deployment in enterprise, homes, manufacturing and more as part of a truly heterogeneous network. The following items were originally envisaged to be addressed by TGbb during the standard development process:

- Integration with and extension to 802.11 MAC.
- Low-latency data delivery.
- Asymmetric device capability support (power, directivity, wavelength, sensitivity, backhaul network latency timings, etc.).
- Peer-to-peer communications.

PLF will contribute to the IEEE 802.11bb standard. The IEEE 802.11bb Task Group on Light Communications is focused on introducing necessary changes to the base IEEE 802.11 standards to enable communications in the light medium - access to the approved Project Authorization Request (PAR) and the Criteria for Standards Development (CSD). The IEEE 802.11bb is the only standardization effort on light communications that is still open to technical contributions after the completion of the IEEE 802.15.13 and the International Telecommunication Unit-Telecommunication Standardization Sector (ITU-T) G.9991. PLF, in the 5G-CLARITY project, will follow the following working groups: TGbb, TGbe. The Chair of the Light Communication (LC) Task Group (TG) is Dr. Nikola Serafimovski (nikola.serafimovski@purelifi.com), who will contribute from the 5G-CLARITY project.

6.2.5 O-RAN Alliance

6.2.5.1 Overview

The O-RAN Alliance is an initially operator founded industry alliance later joined by vendors, system integrators, software component providers, hardware component providers which seeks to define Next Generation RAN Architecture and Interfaces leading the industry towards open, interoperable interfaces and RAN virtualization.

O-RAN Alliance members and contributors have committed to evolving radio access networks towards a foundation of virtualized network elements, white-box hardware and standardized interfaces that fully embrace its core principles of intelligence and openness.

The O-RAN Alliance's work will embody two core principles:

- Openness: bringing service agility and cloud scale economics to the RAN requires open interfaces to enable smaller vendors and operators to introduce their own services, or customize the network to suit their own unique needs. Open interfaces also enable multi-vendor deployments, enabling a more competitive and vibrant supplier ecosystem. Similarly, open source software and hardware reference designs enable faster, more democratic and permission-less innovation
- Intelligence: networks are becoming increasingly complex with the advent of 5G, densification and richer and more demanding applications. To tame this complexity, the industry cannot use traditional human intensive means of deploying, optimizing and operating a network. Instead, networks must be self-driving, they should be able to leverage new learning based technologies to automate operational network functions and reduce Operational Expenditure OPEX. The O-RAN alliance strives to leverage emerging deep learning techniques to embed intelligence in every layer of the RAN architecture. Embedded intelligence, applied at both component and network levels, enables dynamic local radio resource allocation and optimizes network-wide efficiency. In combination with standardized southbound interfaces, AI-optimized closed-loop automation is

achievable and will enable a new era for network operations

The reference O-RAN Architecture leverages on the definition of 3GPP RAN split architecture (Centralized Unit [CU], Distributed Unit [DU], Radio Remote Unit [RRU]) and 3GPP interfaces enabling Control User Plane Separation (E1 interface between CU CP and CU UP), interoperability between CU and DU via F1 interface, etc). Additionally, O-RAN defines further interfaces like O1 for the management/orchestration of RAN functions and the A1 for enabling the split of RAN network functions between Real Time and non-Real Time functionality in an interoperable manner. **Figure 6.7** shows the O-RAN Reference Architecture as defined in [13].

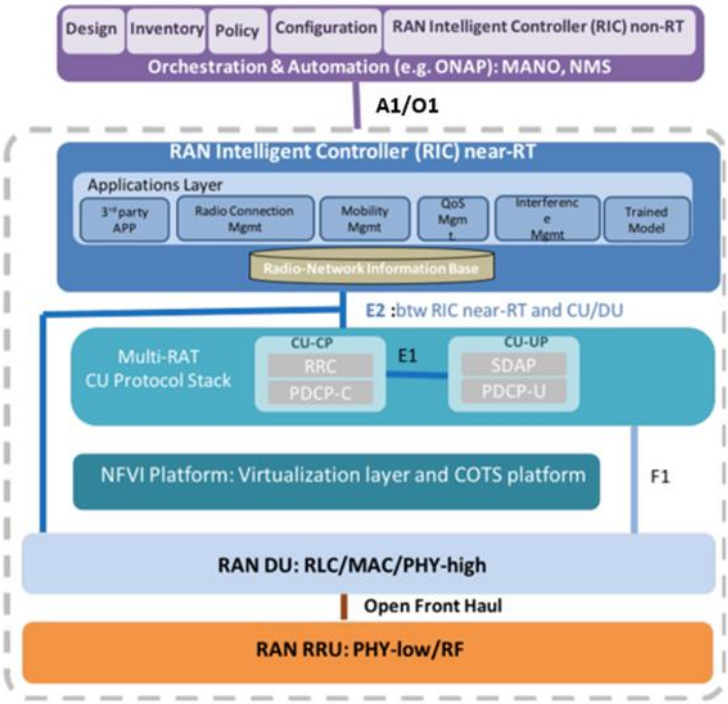

Figure 6.7: O-RAN Architecture

6.2.5.2 Structure

The O-RAN Alliance is composed of the following workgroups and committees.

- Operator Working Group
- Technical Steering Committee
- Technical Working Groups
    - WG1 - Use Cases and Overall Architecture Workgroup

      It has overall responsibility for the O-RAN Architecture and Use Cases. It identifies tasks to be completed within the scope of the Architecture and Use Cases and assigns task group leads to drive these tasks to completion while working across other O-RAN work groups.
    - WG2 - The Non-real-time RAN Intelligent Controller and A1 Interface Workgroup

      The primary goal of Non-RT RIC is to support non-real-time intelligent radio resource management, higher layer procedure optimization, policy optimization in RAN, and providing AI/ML models to near-RT RIC.

- WG3 - The Near-real-time RIC and E2 Interface Workgroup

  The focus of this workgroup is to define an architecture based on Near-Real-Time Radio Intelligent Controller (RIC), which enables near-real-time control and optimization of RAN elements and resources via fine-grained data collection and actions over E2 interface.

- WG4 - The Open Fronthaul Interfaces Workgroup

  The objective of this work is to deliver truly open fronthaul interfaces, in which multi-vendor DU-RRU interoperability can be realized.

- WG5 - The Open F1/W1/E1/X2/Xn Interface Workgroup

  The objective of this work is to provide fully operable multi-vendor profile specifications (which shall be compliant with 3GPP specification) for F1/W1/E1/X2/Xn interfaces and in some cases will propose 3GPP specification enhancements.

- WG6 - The Cloudification and Orchestration Workgroup

  The cloudification and orchestration workgroup seeks to drive the decoupling of RAN software from the underlying hardware platforms and to produce technology and reference designs that would allow commodity hardware platforms to be leveraged for all parts of a RAN deployment including the CU and the DU.

- WG7 - The White-box Hardware Workgroup

  The promotion of white box hardware is a potential way to reduce the cost of 5G deployment that will benefit both the operators and vendors. The objective of this working group is to specify and release a complete reference design to foster a decoupled software and hardware platform.

- WG8 - Stack Reference Design Workgroup

  The aim of this workgroup is to develop the software architecture, design, and release plan for the O-RAN Central Unit (O-CU) and O-RAN Distributed Unit (O-DU) based on O-RAN and 3GPP specifications for the NR protocol stack.

- Focus Groups
  - OSFG - Open Source Focus Group
  - SDFG - Standard Development Focus Group
  - TIFG - Test & Integration Focus Group
- O-RAN Software Community

6.2.5.3 Relevant O-RAN Working Groups for 5G-CLARITY

Most current activity in O-RAN relates to the O1, A1 and E2 interfaces. It is deemed that the most relevant working groups in the context of 5G-CLARITY are WG1, WG2 and WG5, and to a certain extent WG6.

O-RAN WG1 maps well on the use case and architectural activities undertaken within 5G-CLARITY WP2. O-RAN WG2 is very relevant in the context of the 5G-CLARITY WP3 (Control and User Plane) and WP4 (Management) activities since it defines the Non-Real Time RIC functionality logically located in

the management plane of 5G-CLARITY (WP4) and A1 interface towards the Real Time operation of the access network which is within the scope of 5G-CLARITY Control and User Plane (WP3).

O-RAN WG5 is also very relevant since it is responsible for the use of important standardized 3GPP interfaces such as F1/E1 to drive the user plane functions at the CU level and also the support of interoperability of control and user plane DUs with RRUs. Considering that O-RAN WG5 focuses on 3GPP standardized interfaces and can, from an O-RAN point of view, suggest enhancements needed in these 3GPP interfaces to achieve the objectives of O-RAN, potential contributions from 5G-CLARITY to standardization affecting these 3GPP interfaces can be articulated with a combination of 3GGP and O-RAN led fronts. O-RAN WG6 could also be relevant to leverage some inputs to the orchestration of the RAN components of 5G-CLARITY. Since O-RAN WG3 scope is the Near Real Time RIC and A2 interface between this component and the CU CP and both of these components are within Accelleran dRAX™, this WG3 is deemed not critical in order to guarantee interoperability with third party components. **Table 6-4** summarizes the relationships between the 5G-CLARITY WPs and O-RAN WGs.

Table 6-4: Mapping Between 5G-CLARITY WPs and O-RAN WGs

5G-CLARITY WPs	O-RAN WGs
WP2	WG1
WP3	WG2, WG5
WP4	WG5, WG6

6.3 Standardization activity roadmap and open-source timeline

Based on the standardization activities identified above, we provide a mapping between the key technology areas covered by 5G-CLARITY and the standardization groups, as shown in **Table 6-5**.

Table 6-5: Mapping of technology areas to the standardization groups

#	Key Technology development area of the project	Standardization groups
1	LiFi technology	IEEE 802.11bb
2	Multi-technology coexistence framework for private and public 5G/Wi-Fi/LiFi networks	3GPP SA2, 3GPP SA5, 3GPP RAN2, 3GPP RAN3
3	5G/Wi-Fi/LiFi multi-connectivity framework	3GPP SA2, ORAN WG1/2/5, IETF NETCONF
4	5G/Wi-Fi/LiFi Localization and Synchronization	IEEE 802.11az, 3GPP RAN2, 3GPP RAN3
5	AI-driven 5G/Wi-Fi/LiFi autonomic network management	ETSI ENI, ETSI ZSM, ETSI NFV, ONAP, IETF SFC, IETF DMM, IETF ANIMA, IETF NRMG

In **Table 6-6**, we also present an overview of the standardization groups, briefly describing specific study items in line with the 5G-CLARITY research objectives.

Table 6-6: Summary of SDOs and standardization activities covered in 5G-CLARITY.

SDO	Working Groups	Study Item
3GPP	RAN2, RAN3, SA2, SA5	Industrial IoT & URLLC, RAN Data collection enhancements, 5G-Lan type service, Edge Computing on 5GC, Non-Public Networks, NR positioning
IETF & IRTF	SFC WG, ANIMA WG, DMM WG, NMRG, RAW, COINRG	Automation and data collection support, network slicing, multi-WAT management
ETSI	ETSI NFV, ETSI ZSM, ETSI ENI, ETSI MEC	Interface specifications, closed-loop network operations and management, end-to-end network and service automation
IEEE	IEEE 802.1, IEEE 802.11	LiFi, Wi-Fi, positioning, network synchronization
ORAN	WG1, WG2, WG5	Control and user plane management, interface definition

Finally, **Figure 6.8** presents the standardization and open source activity roadmap expected until mid-2022. This is also aligned with the 5G-CLARITY activities roadmap, which is anticipated to provide three standardization roadmap refinements.

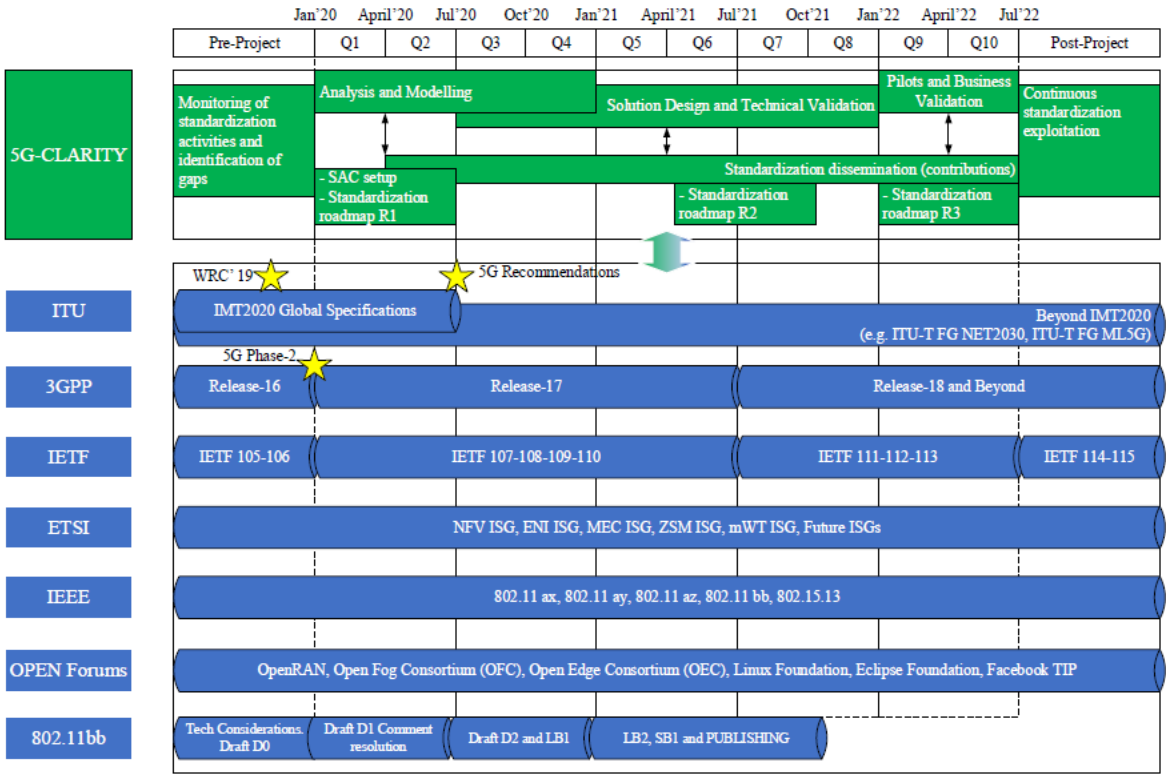

Figure 6.8 Standardization and open source activities.

6.4 Relevant open-source activities

6.4.1 OpenStack

OpenStack is a cloud operating system that controls large pools of compute, storage, and networking resources throughout a datacentre, all managed and provisioned through APIs with common authentication mechanisms [7]. Beyond taking the role of a standard Virtualized Infrastructure Manager (VIM) (providing standard infrastructure-as-a-service functionality in virtualized environments), OpenStack also provides *value-added services* related to orchestration and fault management, to ensure high availability of user applications, and a *user-friendly dashboard*, to give OpenStack administrator control while empowering their users to provision resources through a web interface.

The OpenStack software suite is developed in the context of the OpenStack project [8]. The ways of working of this project lies on the so-called four *opens*:

- **Open Source** – creating open source software that is fully usable (not feature or performance limited) and scalable. OpenStack software is based on Apache License 2.0, which means it is Open System Interconnection (OSI) approved, as well as General Public License (GPL)v3/Debian Free Software Guidelines (DFSG) compatible.
- **Open Design** – every development cycle the OpenStack community holds face-to-face events, which are open to anyone, to gather requirements and provide specifications for upcoming releases.
- **Open Development** – making source code repository publicly available, making the whole development process transparent.
- **Open Community** – open to industry and academia partners, who can become OpenStack project members without any type of fees.

OpenStack project is governed by a non-profit foundation, OpenStack Foundation (OSF), and its three governance bodies: the *board of directors*, which has oversight over the OSF and its related political matters; the *technical committee*, which has oversight over technical matters in the OpenStack project; and the *user committee*, which represents the downstream users of the OpenStack software components.

Series	Status	Initial Release Date	Next Phase	EOL Date
Ussuri	Development	2020-05-13 *estimated* (schedule)	Maintained *estimated 2020-05-13*	
Train	Maintained	2019-10-16	Extended Maintenance *estimated 2021-04-16*	
Stein	Maintained	2019-04-10	Extended Maintenance *estimated 2020-10-10*	
Rocky	Maintained	2018-08-30	Extended Maintenance *estimated 2020-02-24*	
Queens	Extended Maintenance	2018-02-28	Unmaintained *TBD*	
Pike	Extended Maintenance	2017-08-30	Unmaintained *TBD*	
Ocata	Extended Maintenance	2017-02-22	Unmaintained *TBD*	
Newton	End Of Life	2016-10-06		2017-10-25
Mitaka	End Of Life	2016-04-07		2017-04-10
Liberty	End Of Life	2015-10-15		2016-11-17
Kilo	End Of Life	2015-04-30		2016-05-02

Figure 6.9: OpenStack Release Series. Source [9]

OpenStack community operates around a six-month, time-based release cycle with frequent development milestones, following a branching model close to the NVIE model. After the initial release, additional stable releases will be released in each release series. For a detailed description on all aspects concerning the definition and maintenance of an OpenStack release, see [10]. **Figure 6.9** shows an up-to-date view of OpenStack releases. As it can be seen, the latest release series is Train, with initial release date on 2019/10/16. At this stage, series immediately preceding Train, namely 2017-2018 series like Stein, Rockey, Queens or Pike are kept maintained, allowing fallback. However, earlier series like Newton or Mitaka are no longer maintained, since it is considered they have reached their end of life.

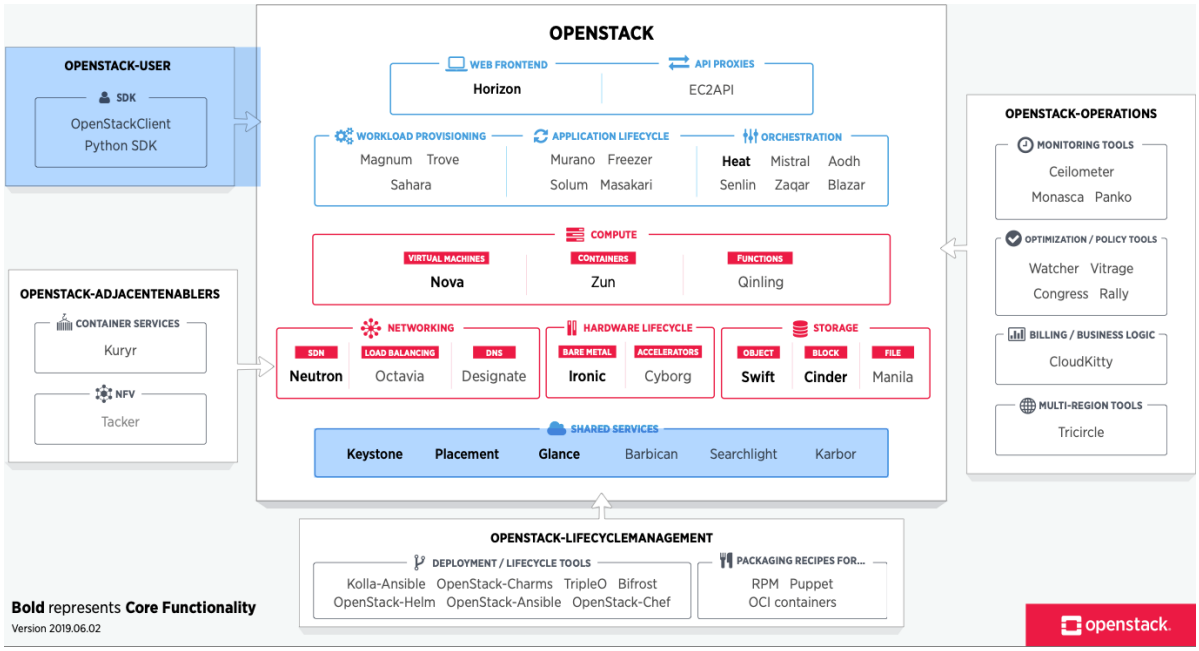

Figure 6.10: Map of OpenStack services. Source: [11]

5G-CLARITY will take OpenStack as the de-facto VIM implementation at each private venue, using it to manage Virtual Machines (VMs) throughout their lifetime while orchestrating their underlying resources. Although OpenStack software suite consists of multiple services (see complete list in **Figure 6.10**), 5G-CLARITY will only make use of those that are relevant for the project's outcomes. This include basic services like Nova (compute service), Cinder and Swift (storage services), Neutron (networking services), Glance (images services), Keystone (identity service) and Ceilometer (monitoring service). Other value-added OpenStack services like Cybor (hardware accelerator service), Blazar (resource reservation service) and Sahara (Big data provisioning service) are optional, and their installation is up to the private venues available for pilot execution: the museum facility (Bristol, UK) and the Bosch factory (Barcelona, Spain). For more information on these services, see [12].

6.4.2 ONOS

The Open Network Operating System (ONOS) is an open source, extensible and distributed SDN control platform used to simply the management and configuration of future-proof programmable networks. It allows transition from legacy "brown field" networks to "green field" networks, by providing value-added capabilities like those listed below:

- **Scalability** – ONOS offers virtually unlimited replication for scaling control plane capacity, as needed.
- **High availability & resiliency** – ONOS provides necessary protection mechanisms to ensure customers do not experience network downtime
- **Performance at scale** – ONOS is architected and built to provide the highest performance possible for scaled network operations, supporting millions of application intent requests while maintaining less than 50 ms (even less) response time for network events.
- **Modular design** – making ONOS software components easier to read, test and maintain.
- **Northbound abstractions** – to simplify the creation, deployment and operation of multiple network applications, thus allowing ease of network programming for automation and control. These applications can be easily added to run "on-box" using native interfaces, or "off-box" using Representational State Transfer (REST) and/or Google Remote Procedure Call (gRPC) interfaces.
- **Southbound interfaces** – enabling an easy adaption to legacy or new (native SDN data plane) devices. For this end, ONOS follows a plug-in architecture that abstracts device characteristics, so that the core operating system does not have to be aware of the particular protocol being used to control and configure the device. ONOS has an extensive and growing list of southbound support including OpenFlow, P4, NETCONF, Simple Network Management Protocol (SNMP), Command Line Interface (CLI), Border Gateway Protocol (BGP), RESTCONF and more.
- **Graphical User Interface (GUI) framework & Base UI** – provides a user-friendly view of the multi-layer network and allows the customer to explore the state of individual nodes and links.
- **YANG toolchain** – provides a compiler capable of parsing YANG source files and generating Java artifacts, which can be used for writing network applications against the abstractions defined by the YANG models.

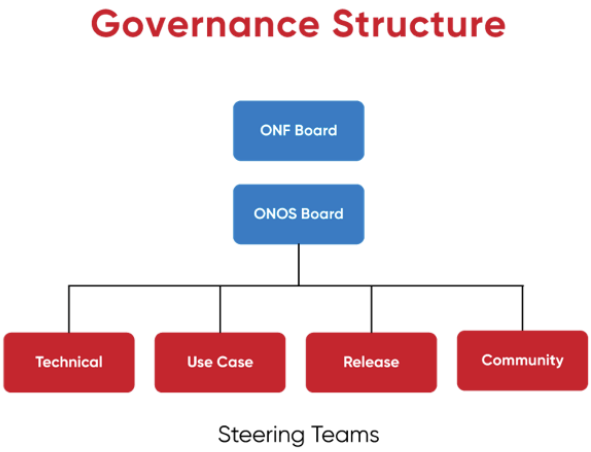

Figure 6.11: ONOS Governance Structure

ONOS governance structure, depicted in **Figure 6.11**, is based on a board of directors and four steering teams: the technical steering team, the use case steering team, the release management team, and the community steering team. The *technical steering team* is responsible for all the ONOS technical decisions, including the content and structure of the code as well as the prioritization of the technical features. The *use case steering team* is responsible for prioritizing the use cases that will be developed and for the specification of their customer requirements, as input to the ONOS technical team. The *release management team* coordinates the release management process, defining the priority of the features in the different releases. Finally, the *community steering team* is in charge of feeding and growing the community.

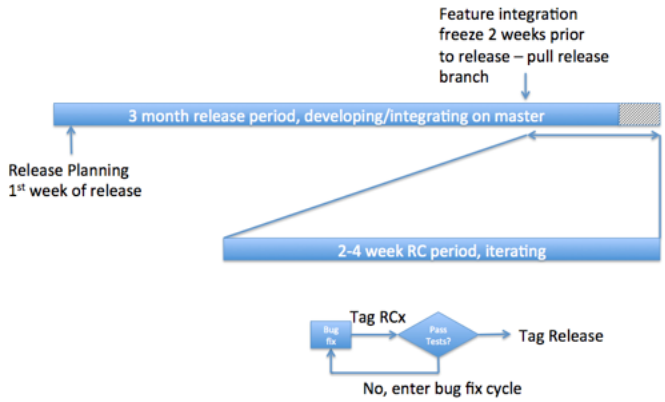

Figure 6.12: Details of an ONOS Release Cycle. Source: [13]

ONOS releases are based on three-month cycles (see **Figure 6.12**) and they are delivered at the end of February, May, and December. The maintenance is guaranteed for the last two releases. The only changes allowed on these releases are security patches and critical defects that are blocking deployments. For a more detailed information on all aspects concerning the definition and maintenance of any ONOS release (e.g. release cycles, branching, versioning & tags, naming, etc.), see [13]. **Figure 6.13** shows an up-to-date view of ONOS releases. As it can be seen, the last available release is Sparrow, released in 2019 Q3. This means that the only Releases that are kept under maintenance are Raven (2019 Q2) and Quail (2019 Q1).

Name	Version	JAVA API	Date	File types
Sparrow	2.2.0	API-2.2.0	Aug 30,2019	tar.gz
Raven	2.1.0	API-2.1.0	Apr 30, 2019	tar.gz
Quail	2.0.0	API-2.0.0	Jan 18, 2019	tar.gz
Peacock	1.15.0	API-1.15.0	Nov 29, 2018	tar.gz
Owl	1.14.0	API-1.14.0	Sep 4, 2018	tar.gz
Nightingale	1.13.3	API-1.13.3	Sep 5, 2018	zip, tar.gz
	1.13.2	API-1.13.2	July 11, 2018	zip, tar.gz
	1.13.1	API-1.13.1	May 2, 2018	zip, tar.gz

Figure 6.13: ONOS Releases. Source: [14]

The 5G-CLARITY project might take ONOS as the reference platform for infrastructural SDN control within the logical perimeter of a private venue. In such a case, ONOS can be used to programmatically configure and manage x-haul (e.g. fronthaul, midhaul, backhaul) resources, allowing "on-the-fly" intra-slice connectivity at the private venue's infrastructure layer. The ONOS release to be used is up to each private venue, although most recent releases are highly recommended (no earlier than 2019).

Although 5G-CLARITY project's original plan does not include taking part in the development of ONOS source code, it may well occur that some of the project's outcomes could be relevant for ONOS community. In such a case, 5G-CLARITY could submit a contribution to the source code (released under the Apache 2.0 license), subjected to previous sign of the ONOS Contributor License Agreement (CLA).

6.4.3 OSM

The Open Source MANO (OSM) [15] is an open-source project for the development of an End-to-End (E2E) network service orchestration framework aligned with ETSI NFV specifications. It is an ETSI-hosted initiative that aims to provide a software solution that facilitates the use of maturation of NFV technology, gives access to a huge ecosystem of VNF vendors, and allows testing and monitoring between the orchestrator and the rest of elements (Network Functions Virtualization Infrastructure [NFVI], VNFs and Physical Network Functions [PNFs], etc.). Although it was originally focused on NFV Management and Orchestration (MANO), the scope of OSM is currently more ambitious, with the definition of a micro-service architecture composed of fine-grained modules carrying out activities beyond NFV scope, including:

- **Network slicing management**, with the definition of an Information Model (IM) that support slicing through the definition of Network Slice Templates (NSTs), for the deployment and operation of instances from different network slices. OSM IM extends existing NFV information models, i.e. NSDs and VNFDs, with the incorporation of 3GPP-based slicing parameters (e.g. Single-Network Slice Selection Assistance Information [S-NSSAI], 5G Quality of Service Indicator [5QI]) and considering isolation settings across Network Slice Instances (NSIs) (e.g. VNF sharing).
- **NF application layer configuration and management,** over deployed VNFs, PNFs and Hybrid Network Functions (HNFs). This allows OSM to also take the role of Element Managers (Ems), today falling out of the scope of NFV.

- **Policy-based performance assurance and fault supervision**, with the definition of a monitoring module (MON) and a policy module (POL) that enables OSM to create, manage and trigger alarms based on NFVI and VNF metrics.

OSM is one of the first projects of the OSG (Open Source Group), an ETSI entity that allows open-source projects to be developed under ETSI, and that has strong connection with the European Commission to foster their use in European research projects.

Similarly to OpenStack, releases in OSM are based on six-month cycles. OSM releases are delivered biannually, and they are named with a number name in capital letters: (ZERO, ONE, TWO). Current software version is OSM Release SEVEN. The project developers agree on a blueprint for each coming release by deciding on priorities over different evolution proposals.

5G-CLARITY project plans to use OSM software suite as the baseline implementation of SDN/NFV platform, connecting in with OpenStack (via an OSM-provided VIM plug-in) and with ONOS (via an OSM-provided SDN plug-in). In order to facilitate the operation of the project's pilots and allow reproducibility of results across the different proof-of-concepts, stable and mature OSM releases are usually preferred. This means that by the time WP5 activities starts, the OSM release used might not be beyond OSM Release 7.

Apart from making use of OSM capabilities for pilot execution, 5G-CLARITY also expects to submit contributions to OSM, especially in the field of model-based telemetry (streaming telemetry based on the use of open data models). For this end, 5G-CLARITY needs to follow OSM formal procedures: first, providing a Contribution Agreement acknowledgement (Apache 2.0 License), and then make the corresponding contribution as a source code commits or as documentation to the open source project.

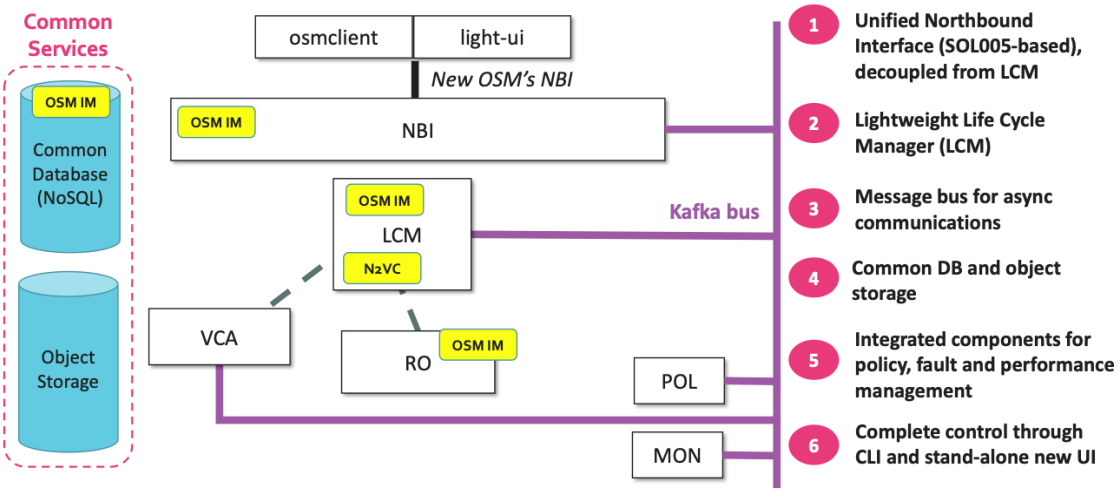

Figure 6.14: OSM architecture

7 Early Achievements

7.1 Communication activities

In this subsection we report the early achievements of the project related to communication activities. The following sections will deal with some specific aspects of communication activities that have taken place since the project Kick-Off Meeting on November 19, 2019 at IHP GmbH (Innovations for High Performance Microelectronics/ *Leibniz-Institut für innovative Mikroelektronik*) in Frankfurt (Oder), Germany.

The first official project press release was issued by InterDigital on the 24th of January 2020 [16]. Additionally, partners also released their own internal (company-wide) and external press releases. More details can also be found in the project website (https://5g-ppp.eu/5g-clarity/ and http://www.5gclarity.eu/).

As an example, Ericsson LMI presented the following poster of the 5G-CLARITY project (see **Figure 7.1**) at Ericsson's year open Tech Day. This event was attended by approx. 1700 people between Ericsson workers and international customers.

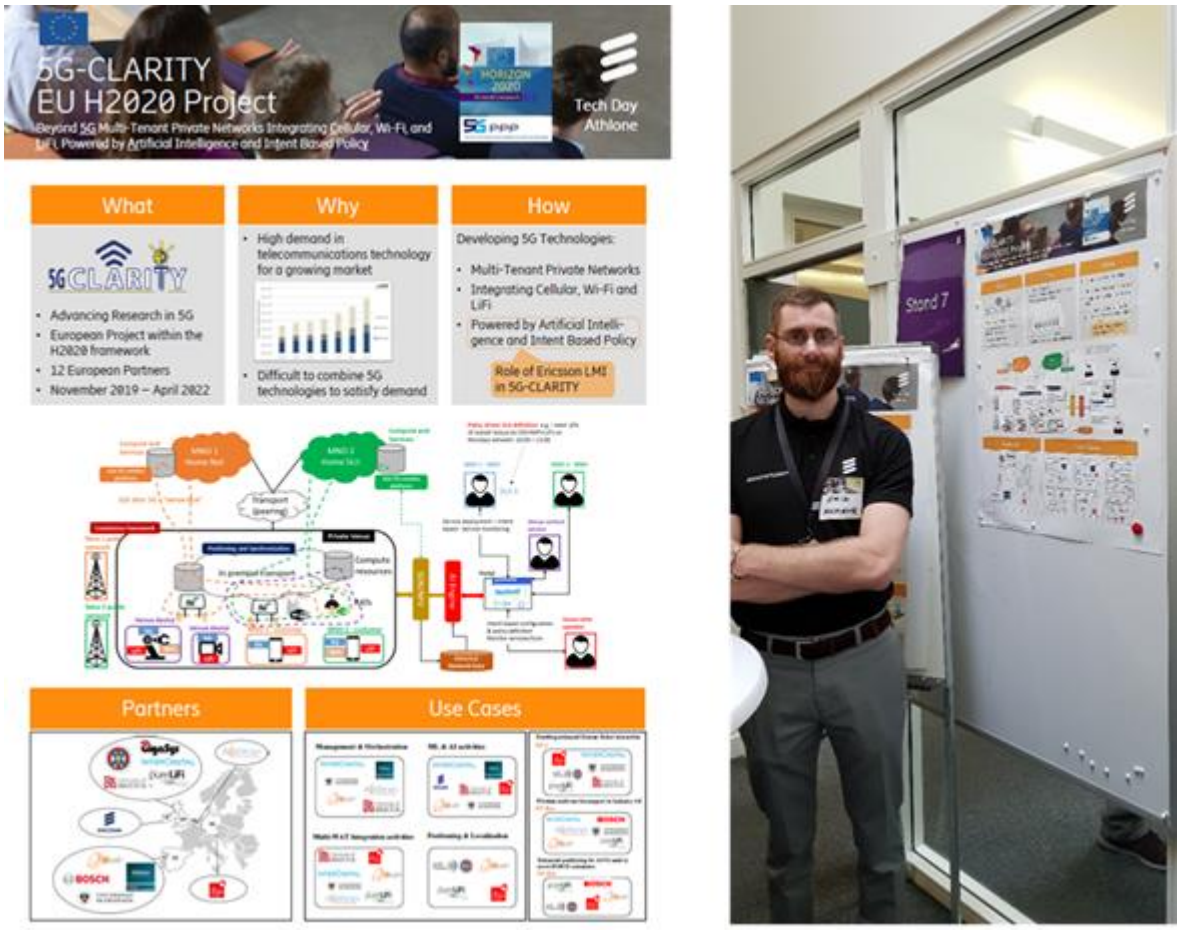

Figure 7.1: Poster of the 5G-CLARITY project

The project website has been established at the beginning of the project and it is reachable at the following URL: http://www.5gclarity.eu/. Additionally, the main information from the project is also available in the 5G-PPP website at the following URL: https://5g-ppp.eu/5g-clarity/ (see **Figure 7.2**).

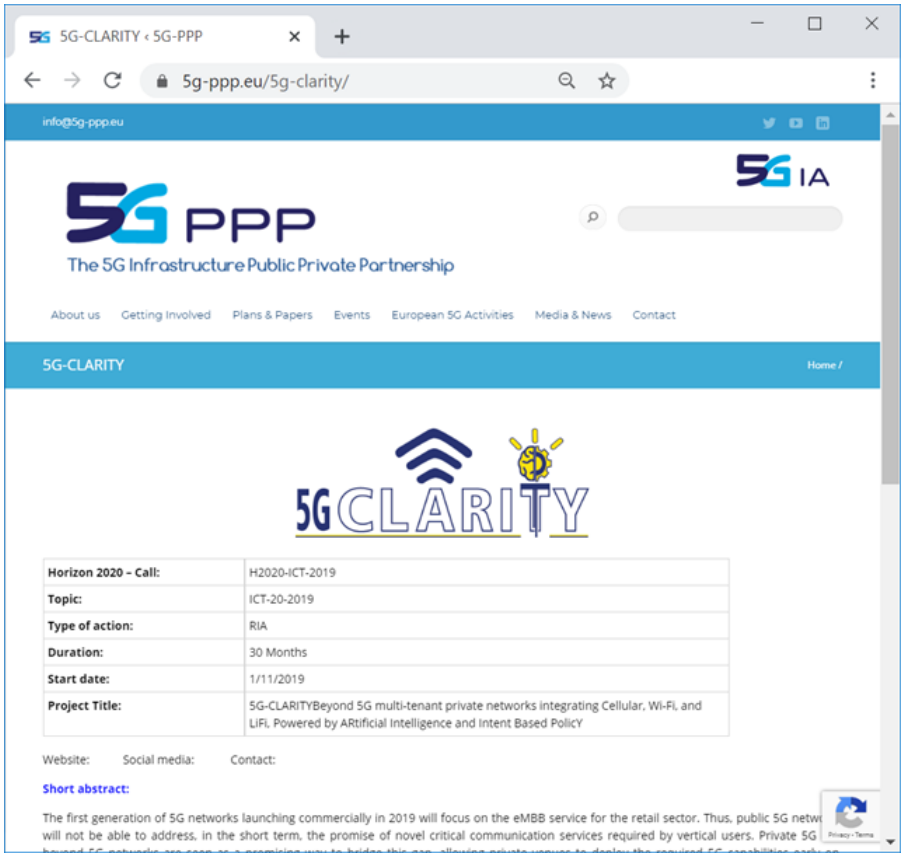

Figure 7.2: 5G-PPP's 5G-CLARITY website.

The project has been very active on other social media such as LinkedIn and Twitter. LinkedIn and Twitter accounts are the following:

- LinkedIn 5G-CLARITY Group: https://www.linkedin.com/groups/12331231/
- Twitter: https://twitter.com/5G_CLARITY

Figure 7.3 reports that 5G-CLARITY LinkedIn Group gathered many members and viewers since the beginning of the project and already has 38 members. This figure just shows a sample period of the evolution of views.

Table 7-1 reflects some of the current performance achievements of Twitter account, i.e., number of tweets, followers, follower ratio, tweets with mentions, number of retweets, etc.

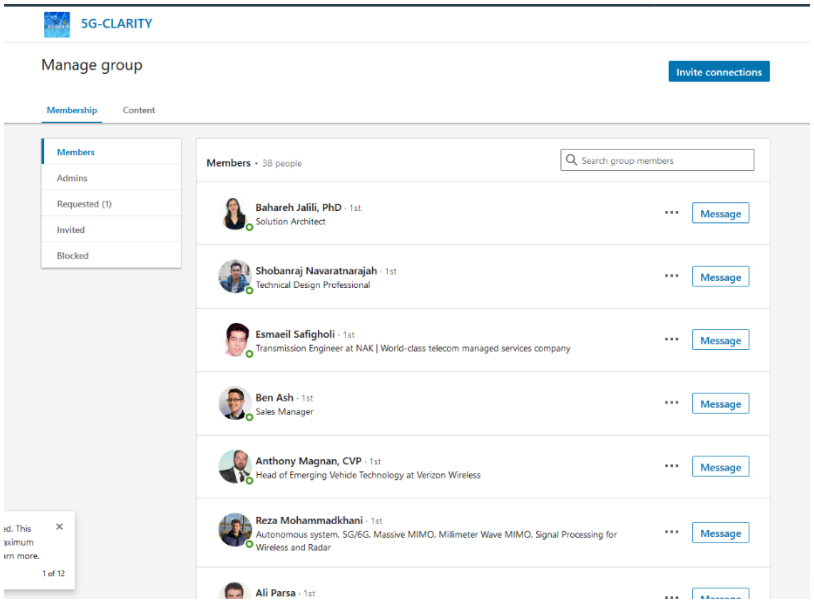

Figure 7.3: 5G-CLARITY LinkedIn profile viewers.

Table 7-1: Statistics (obtained January 23, 2020) for 5G-CLARITY project Twitter account

Statistics	Value
Tweets	7
Followers	29
Following	30
Follower ratio	0.97
Tweets with mentions	3
Number of retweets	3
Listed	2

7.1.1 Mobile World Congress 2020

5G-CLARITY will be represented at the Mobile World Congress (MWC) 2020 held in Barcelona through a panel session entitled "What do We Need to Do to get 5G to Really Support AI/ML?" moderated by InterDigital and featuring Dr. Daniel Camps Mur, TM of 5G-CLARITY. In addition, some of the consortium partners, i.e., InterDigital, i2CAT and Accelleran, will be showcasing technologies and solutions that will be integrated into the 5G-CLARITY framework. The brochure designed to promote the project throughout this event is shown in **Figure 7.4**.

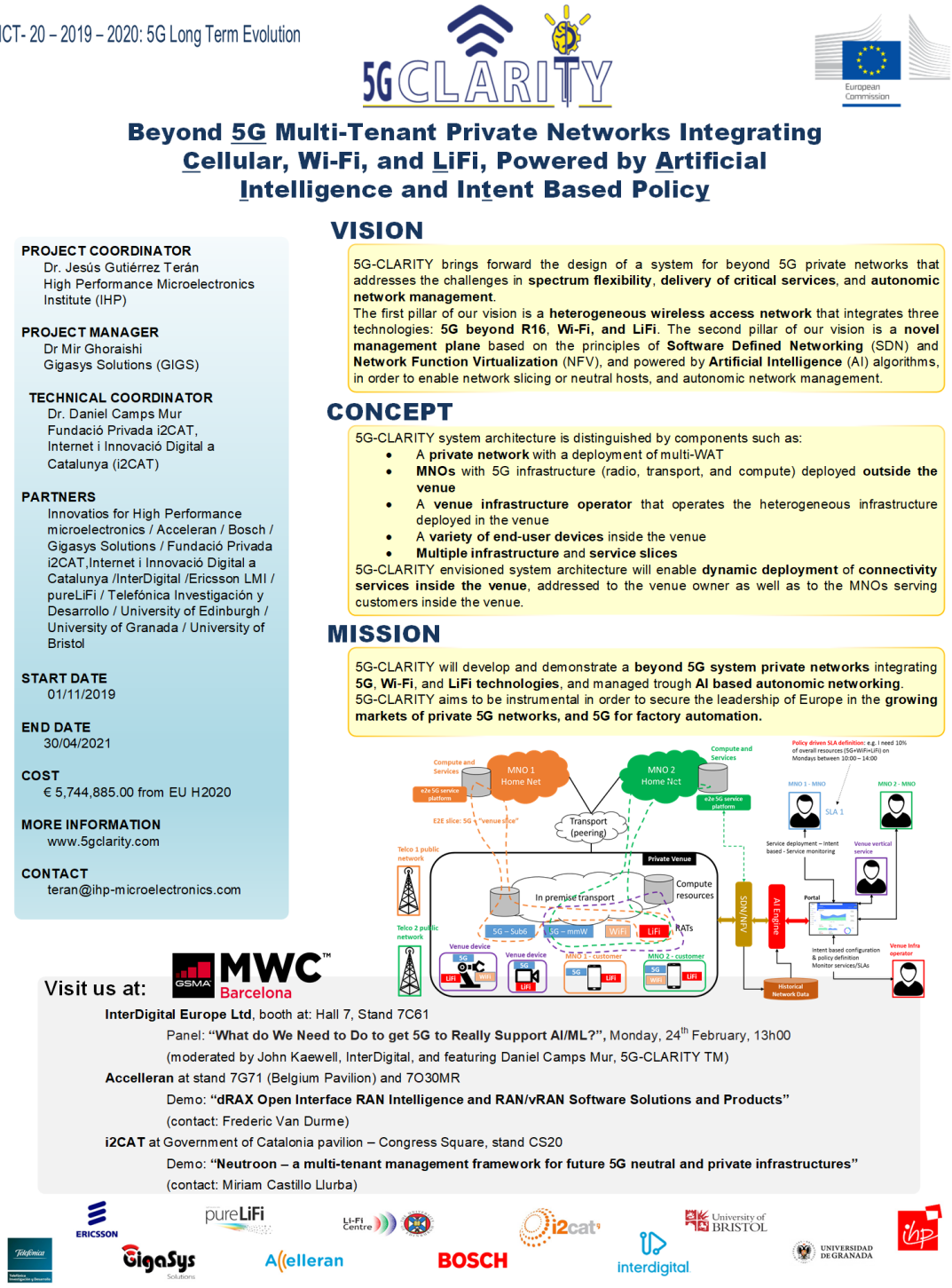

Figure 7.4 Project brochure designed for MWC'20.

7.2 Dissemination activities

In this subsection we report the dissemination activities of the project. 5G-CLARITY has carried out multiple dissemination activities, even though the project is still at its early stage.

The following publications have been accepted/submitted to Journal Citation Reports (JCR) journals (with acknowledgments to this project):

- Jonathan Prados-Garzon, Pablo Ameigeiras, Juan J. Ramos-Munoz, Jorge Navarro-Ortiz, Pilar Andres-Maldonado, Juan M. Lopez-Soler, "Performance modeling of softwarized network services based on queuing theory with experimental validation," IEEE Transactions on Mobile Computing. **DOI:** 10.1109/TMC.2019.2962488
- Jorge Navarro-Ortiz, Pablo Romero-Diaz, Sandra Sendra, Pablo Ameigeiras, Juan J. Ramos-Munoz, Juan M. Lopez-Soler, "A Survey on 5G Usage Scenarios and Traffic Models," submitted to IEEE Surveys & Tutorials.

One expected result is the writing of several Ph.D. theses directly related to this project. In particular, there are already some ongoing Ph.D. theses:

- "Orchestration and management of virtualized independent networks for supporting new 5G services," José Antonio Ordóñez Lucena. Supervisors Pablo Ameigeiras and Juan M. Lopez-Soler. University of Granada.
- "Multi-domain orchestration mechanisms for network slicing," Óscar Ramón Adamuz Hinojosa. Supervisors Pablo Ameigeiras and Juan M. Lopez-Soler. University of Granada.

It is also expected that the project will directly contribute, in terms of funds, objectives and activities, to several new Ph.D. theses. In particular the following thesis will be developed in 5G-CLARITY:

- 5G multi-domain and multi-technology public-private networks. University of Granada.
- Resource management for 5G public-private networks using AI and ML techniques. University of Granada.

8 Conclusions

This deliverable includes the initial communication, dissemination, exploitation, and standardization plans intended to maximize the impact of the project and to ensure the fulfilment of the 5G-CLARITY's dissemination objectives. Although these plans are subject to modifications, they constitute the framework of reference that will drive the coordination, implementation, and supervision of 5G-CLARITY dissemination and communication activities. Also, they ensure that 5G-CLARITY achievements are widely spread over the 5G-CLARITY target audience to enhance the project 's impact and visibility to the European Union (EU) and the entire world.

The project identifier, the communication activities that will be carried out in the 5G-CLARITY project throughout its lifetime, the external/internal communication channels, and social media have been defined in the communication plan. For internal communications of the partners, the project consortium uses BSCW Workspace server as a repository. As a principal external communication channel, a project website has been developed and launched in December 2019. Besides, social media accounts (i.e., Twitter, LinkedIn, and YouTube), which are accessible from the project website, have been created to enhance the visibility of the project and to distribute the potential benefits derived from the solutions proposed in the project.

This document also presents the dissemination plan to communicate the project outcomes to the Industry, Academia, and the public in general. The key envisaged activities in this regard are the production of scientific publications in leading international conferences and journals, the organization of journal/magazines special issues and books, and the participation in program committees and editorial boards. Specifically, 22 scientific publications, 17 panels, the organization of 2 workshops, and two demonstrations have been anticipated as a primary result of the 5G-CLARITY dissemination plan.

Regarding the standardization plan, this deliverable identifies the primary SDOs whose activities are aligned with the project. Specifically, the SDOs considered are 3GPP, ETSI, IETF, IEEE, and O-RAN Alliance. The standardization plan includes a roadmap that captures the standardization activities that may influence or get influenced by the project's technological innovations. It also describes the leading open-source related activities and the expected contributions to them where applicable. In this regard, OpenStack, ONOS, and OMS are considered as the tools to implement the SDN/NFV orchestration solution proposed in the 5G-CLARITY project. Moreover, the project expects to contribute to OSM, especially in the realm of model-based telemetry. Last, the project also contemplates the possibility of submitting source code contributions to ONOS brought about by potential project's outcomes.

Finally, this document summarizes the communication, dissemination, exploitation, and standardization activities that have already been carried out in the early stages of the project. Among them, it is worthy of mentioning the organization of internal events to disseminate the 5G-CLARITY vision, the inclusion of the project description in the 5G-PPP website, the design of the project poster and leaflet, and the first publications in top indexed journals.

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