Project Title	Virtual Presence in Moving Objects through 5G
Project Acronym	PriMO-5G
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Instrument	Research and Innovation Action
Topic	The PriMO-5G project addresses the area of "a) Focus on mmWave and super broadband services" in the call "EUK-02-2018: 5G" of the Horizon 2020 Work Program 2018-2020.
Start Date of Project	01.07.2018
Duration of Project	36 Months
Project Website	https://primo-5g.eu/

D6.3 ROLLING DISSEMINATION AND EXPLOITATION PLAN AND REPORT

Work Package	WP6, Dissemination, standardization, and regulation
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Dissemination Level

X	PU: Public
	PP: Restricted to other programme participants (including the Commission)
	RE: Restricted to a group specified by the consortium (including the Commission)
	CO: Confidential, only for members of the consortium (including the Commission)

Disclaimer

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Executive Summary

The PriMO-5G project is leveraging mission-critical use cases (firefighting) to inspire research and technology advancements in the 5G radio access, core and edge segments. Moreover, the project targets to implement local and cross-continental testbeds validate some of these developments and demonstrate end-to-end operations of 5G system for vehicular and aerial (drone) setups that enable novel services, such as, immersive video services. The insights and results from these project activities are considered of interest to stakeholders in four identified primary focus areas, namely: communication technologies, public safety, drones and machine learning.

To that end, the communications, dissemination and exploitation activities reviewed in this deliverable are critical to ensure that the PriMO-5G reach the right external stakeholders in an accessible and timely manner. Specifically, this covers the activities implemented in the first half of the project M1-M18. Moreover, this deliverable review exploitation activities and provides recommendations on how to ensures that those results have an impact and/or exploitation potential beyond the project itself.

In all aforementioned cases, those M1-M18 communications, dissemination and exploitation activities have been evaluated based on measurable objectives and key performance indicators (KPIs) specified previously in *D6.2 Dissemination and Exploitation Plan*. Consequently, the deliverable report revises KPIs were performance far exceeded set targets or recommends interventions for the second of the project (M19-M36) were the performance fell below targets.

List of Acronyms

Acronym	Definition
5G	Fifth-Generation Mobile Network
5GC	5G Core
ARF	Aalto Radio Framework
CAA	Civil Aviation Authority
CAU	Chung-Ang University
CCE	Critical Communications Europe
CCW	Critical Communications World
CIS	Computational Intelligence Society
CMC	Cumucore
COMSOC	Communications Society (IEEE)
CS	Computing Society
DoA	Description of Action
EAB	Ericsson AB
EC	European Commission
EENA	European Emergency Number Association
eMBB	Enhanced Mobile Broadband
eMBMS	Evolved Multimedia Broadcast Multicast Services
eNB	Evolved Node B
ETSI	European Telecommunications Standardisation Institute
EU	European Union
EUC	EUCAST
EUCNC	European Conference on Networks and Communications
GLOBECOM	Global Communications Conference
gNB	Next Generation Node B
ICML	International Conference on Machine Learning
ICT	Information and Communication Technologies
IEEE	Institute of Electrical and Electronics Engineers
IEEE CIS	IEEE Computational Intelligence Society
IEEE CS	IEEE Computer Society
IEIE	Institute of Electronics and Information Engineers
IITP	Institute for Information and communication Technology Promotion
IJCAI	International Joint Conference on Artificial Intelligence
IPR	Intellectual Property Rights
ITU	International Telecommunications Union
LTE	Long Term Evolution
KAIST	Korean Advanced Institute of Science and Technology
KCL	Kings College London
KT	Korea Telecom
KTH	Royal Institute of Technology in Stockholm
KU	Korea University
MANO	Management and Orchestration
MCPTT	Mission-Critical Push-to-Talk
Mxx	Month xx
N/A	Not applicable
NFV	Network Function Virtualisation
NI	National Instruments
NSA	5G Non-Standalone Architecture
NTN	Non-Terrestrial Networks

Acronym	Definition
NWDAF	Network Data Analytics Function
OAI	Open Air Interface
PoC	Proof of Concept
PSC	Public Safety Communications
PSCE	Public Safety Communications Europe
PU	Public (deliverable)
RIA	Research & Innovation Action
SA	5G Standalone Architecture
TCCA	The Critical Communications Association
ToC	Table of Contents
UPF	User Plane Function
URLLC	Ultra Reliable Low Latency
VTC	Vehicular Technology Conference
WP	Work Package
WPL	Work Package Leader
YU	Yonsei University

1   Introduction

1.1   Scope of the document

The PriMO-5G project involves partners from several countries from Europe and a number of partners from South Korea, who together will be addressing objectives of the 'EUK-02-2018:5G' call in the area "*a) Focus on mmWave and super broadband services*". Specifically, the PriMO-5G EU aims to demonstrate an end-to-end 5G system providing immersive video services for moving objects. This is achieved by cross-continental testbeds that integrate radio access and core networks developed by different project partners. The cross-continental testbeds will show the end-to-end operations of envisaged use cases.

The purpose of this document is to review activities by the PriMO-5G consortium in the first 18 months of the project for the promotion of the project and its results, as well as, leveraging the project results by the in different exploitation actions by consortium members (and external partners). To that end, this report will analyse the activities by leveraging measurable objectives specified previously in *D6.2 Dissemination and Exploitation Plan* [PriMO-5G_D6.3]. Consequently, the deliverable report revises KPIs were performance far exceeded set targets or recommends interventions for the second of the project (M19-M36) were the performance fell short.

1.2   Structure of the document

This deliverable document is organised as follows. In Section 2, the PriMO-5G communications, and dissemination activities in M1-M18 are described in broad detail by reviewing each key activity type. The final part of Section 2 reviews the communications and dissemination activities against measurable objectives and key performance indicators (KPIs) specified in D6.2 [PRIMO-5G_D6.3]. Similarly, Section 3 reviews exploitation activities in M1-M18 based on reports of individual exploitation actions of the different partners in the PriMO-5G consortium. As before, the exploitation activities also evaluated against some previously specified success criteria in D6.2 and plans or interventions for the second half of the project lifetime are described. Finally, the conclusions and future monitoring checkpoints are presented in Section 4.

1.3 Relationship to other project outcomes

The overall work structure of PriMO-5G is shown in Figure 1. In this work structure, WP1 provides the use cases that inspire research and technology developments in WP2, WP3, and WP4. Whereas, WP5 establishes the local and cross-continental testbeds to demonstrate end-to-end operations of 5G system for vehicular and aerial (drone) setups that enable novel services, such as, immersive video services. The communications, dissemination and exploitation activities reviewed in this deliverable meant to ensure that the PriMO-5G project and its results from WP1 to WP5 reached the right external stakeholders in an accessible and timely manner during the period under review (M1-M18) and could be sustained if not improved further in second half of the project (M19-M36). Similarly, this deliverable ensures that those results have an impact and/or exploitation potential beyond the project itself by reviewing was achieved so far how it could be boosted in M19-M36.
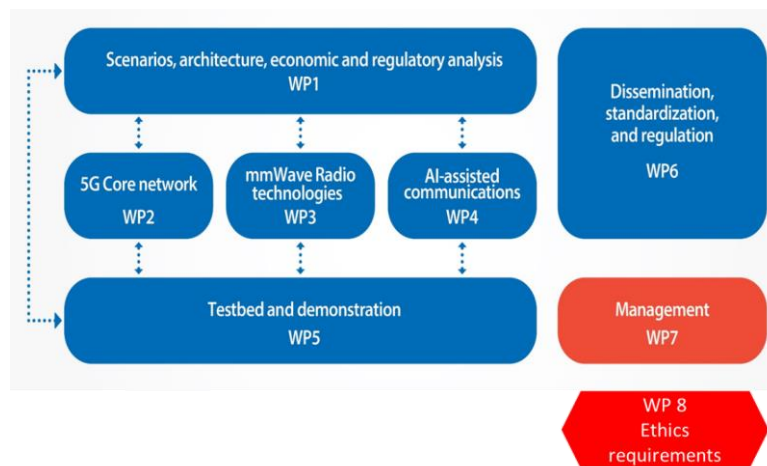
Figure 1 PriMO-5G work structure

2   Review of Communications and Dissemination Activities

2.1   Recalling PriMO-5G communications, dissemination, and exploitation strategy

The processes of communications, dissemination and exploitation in PriMO-5G (and Horizon 2020 projects in general [EU2018]) aim to maximize the impact of the results produced by the project. The achievement of envisioned impacts by the PriMO-5G communications, dissemination and exploitation activities requires a consortium-wide understanding of the overall strategic goals of each category, related measurable objectives, plan of actions towards achieving those objectives, continuous monitoring and improvements (or adjustments) throughout the project lifetime, and sustainability measures after the project ends. To that end, the overall strategic goals for PriMO-5G communications, dissemination and exploitation actions are summarized as follows:

- *PriMO-5G communications*: To facilitate outreach to society with aim of highlighting the potential impact and benefits of the PriMO-5G activities and results, particularly in providing solutions that addresses specific societal challenges.
- *PriMO-5G dissemination*: To transfer new knowledge and results with the aim of maximizing the impact of the project's results by enabling wider use and take up of project's results.
- *PriMO-5G exploitation*: To transform the project's actions and results into concrete value through scientific, technological, commercial or regulatory (or policy) exploitation routes.

In terms of the actions described above, the PriMO-5G project has four primary focus areas where the project is likely to address different target groups or stakeholders listed in Table 1.

Table 1 PriMO-5G focus areas and relevant target groups within each area

PriMO-5G focus areas	Target groups within each focus area
Communications technologies (5G)	• 5G equipment/infrastructure vendors • Network operators and service providers • Open source communities and projects • National regulatory authorities (NRAs) and policy makers • 5G standards development organisations (SDOs) • Academic research community
Public safety	• General public and mainstream media • Public safety equipment vendors • PSC operators and service providers • Public safety regulatory and policy making bodies • Public safety initiatives or alliances • Emergency response organisations • SDOs • Academic research community
Drones	• Civil Aviation Authorities (CAAs) • Drone regulatory and policy making bodies

PriMO-5G focus areas	Target groups within each focus area
	• Drone industry alliances • SDOs • Academic research community
Machine learning	• Machine learning /AI industries • Machine learning / AI alliances and fora • Academic research community

In addressing the aforementioned focus areas and target groups, the project has adopted a proactive strategy of continuously assessing the opportunities for communicating and disseminating results from ongoing research activities. Whereas, the project's results presenting exploitation opportunities, are typically expected to manifest at the latter stages of the project lifetime. To that end, two main strategic phases are considered the project:

i. *Awareness-building and technical leadership phase (M1-M24)*: During this phase, the project utilizes its communications channels and dissemination activities to share results and insights from the project, as well as, to exchange knowledge with different target groups in the project's focus areas. In this phase, there is also opportunity to carry out some preliminary experimental demonstrations.

ii. *Societal impact and exploitation Impact enhancement phase (M25-M36)*: In this period, the project research output and demonstrations are at an increased level of maturity and the potential of impact is higher. Therefore, different stakeholders targeted by the project can be addressed with insights that are more comprehensive. To that end, in this phase the project should be able to communicate in concrete terms on how society could reap the benefits from the research carried out in PriMO-5G. Exploitation activities are also a higher priority at this stage to provide pathways for transforming project results (research output) into patents, standards, products and so on.

2.2   Review of communications activities in M1-M18

The PriMO-5G project utilizes multiple communications materials and channels to be able to convey the project messaging and updates to relevant target groups across all PriMO-5G focus areas. These communications assets includes both offline and online materials and channels, which allow conveying of project messaging both remotely (virtually) and directly at face-to-face events. Overall, the joint use of these communications materials and channels is to *collectively* establish, maintain and communicate to key stakeholders a clear, consistent and compelling vision of PriMO-5G project's purpose, goals, benefits, as well as, showcasing project's results in a timely and accessible manner.

The rest of Section 2.2 reviews activities and effectiveness/outcomes across different PriMO-5G communications channels.

2.2.1   Project Website

The website of the PriMO-5G project is available at https://primo-5g.eu/ and is responsive to the browser, making it readable across all device platforms (desktop, tablet, mobile). All pages of the website feature the PriMO-5G logo at the top and at the Furthermore, navigation of the website is enhanced by having at the top of each page a menu with links to the main home page and the rest of the pages in the website (see Figure 2).
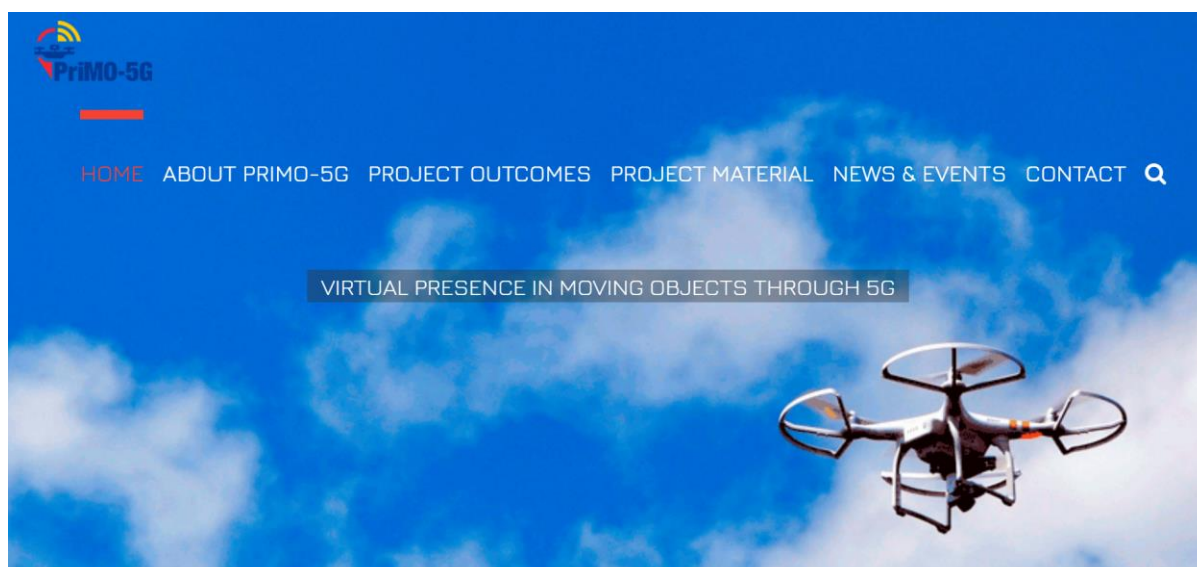
Figure 2 Screenshot of project website

The description of the different pages (and subpages) in the PriMO-5G website and is shown in Table 2. The website includes pages (*Home*, *About PriMO-5G* pages) that primarily target to inform (build-awareness) about the project. These pages hold general information about the project and that is usually unchanged. Additionally, there are pages (*Project Outcomes, Project Materials, News and Events* pages) that are more regularly updated to promptly share project related events or results. These regular updates helps maintain a timely profile of the project and keeps the project in the stakeholders' thoughts. The statistics on page views have been gathered using Google Analytics tools since February 2019 and are show in Table 2. This delay in setting up the website analytics tools was to ensure first that the website and tools used adhered to General Data Protection Regulation (GDPR) as outlined in PriMO-5G ethical deliverables *D8.1 M Requirement No. 1* and *D8.2 GEN - Requirement No. 2*.

Table 2 Description of PriMO-5G website pages and number of visits as of M18

PriMO-5G website page	Page description/contents	Number of page views[1] as of M18
Home	Summarises the project goal, use case and provides partner list. The page also includes a gallery for showcasing photos from different project events or demos.	1,423
About PriMO-5G	Describes the three main project objectives and lists the project partners.	677
Project Outcomes	Presents the use case(s) in more detail and describes briefly the project testbeds in Europe and Korea. Furthermore, the page includes the list of project deliverables which also includes download links for deliverables classified as Public.	834
Project	This page includes links for downloading project communications materials (e.g. flyers) and relevant presentations by different project partners.	460

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[1] Since February 2019

PriMO-5G website page	Page description/contents	Number of page views[1] as of M18
Materials	Moreover, the page includes section listing scientific publications. The publications classified as open access publications will include links for downloading the papers.	
News and Events	Includes project news articles released by the project, as well as, news about PriMO-5G from third party channels. Also includes a feed from the project Twitter account. Moreover, the page includes listing of current and past events by the project.	338
Contact	Provides the project contact information.	79

The analysis of the PriMO-5G page views by location of viewer also presents some additional insights. In Figure 3 below, the page views for the PriMO-5G Home page is illustrated by disaggregation of locations. It is noted that a significant number of page views are also from countries not represented in the project consortium, including, United States, France and China.

Countries	Pageviews
Finland	338
South Korea	232
Sweden	130
United Kingdom	112
United States	75
France	64
Germany	64
Spain	64
Italy	35
China	34

report generated by GADWP

Figure 3 Number of page views (listing top 10 countries in terms of visitors) for PriMO-5G Home web page as of M18

Additionally, as noted above the project website provided the channel for download of project deliverables marked as public in accordance with the EC recommended practice of making public outputs of EC-funded actions. To that end, the general procedure in PriMO-5G has been to upload completed public deliverables to the website and produce a web news release on the deliverable and a corresponding tweet. In the period up M18, the PriMO-5G deliverables were downloaded over 930 times. The breakdown of the number of downloads per public deliverable is shown below in Table 3.

Table 3 Deliverables available on project website and number of downloads as of M18

Nr#	Deliverable name	WP	Type[2]	Diss. level	Date	Number of downloads as of M18
D1.1	PriMO-5G use case scenarios https://primo-5g.eu/download/357/	WP1	R	PU	M8	261
D2.1	Initial design of MEC and Network Slice Manager https://primo-5g.eu/download/389/	WP2	R	PU	M10	143
D3.1	Intermediate report on enhanced 5G radio access technologies https://primo-5g.eu/download/421/	WP3	R	PU	M10	101
D4.1	Intermediate report on AI-assisted networking and edge computing https://primo-5g.eu/download/391/	WP4	R	PU	M10	144
D5.1	Demonstration plan https://primo-5g.eu/download/418/	WP5	R	PU	M12	112
D6.1	Project website https://primo-5g.eu/download/425/	WP6	DEC	PU	M1	84
D6.2	Dissemination and exploitation plan https://primo-5g.eu/download/415/	WP6	R	PU	M3	86

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[2] Type: R = Document, report (excluding the periodic and final reports); DEC = Websites, patents filing, press & media actions, videos, etc.

2.2.2 Social Media

The communication of project information via the website is complemented by the PriMO-5G social media channels. Two of the social media channels already established (Twitter and YouTube) are described briefly below.

2.2.2.1 Twitter

The project Twitter feed is accessible via https://twitter.com/PriMO5G (see Figure 4). The project's Twitter account provides a channel for a relatively more frequent sharing of project micro-updates (including sharing links of updates appearing on the project website). The updates included tweets about the project news and outputs, and promotion of events (co-)organised by the project. The PriMO-5G Twitter feed has been used to retweet most relevant updates or tweets from third parties, including other EC-funded projects (research similar areas) and significant developments from industries relevant to PriMO-5G (drones, public safety, etc.).

Figure 4 Screenshot of PriMO-5G Twitter page

2.2.2.2 YouTube

The PriMO-5G YouTube provides a channel for archiving and sharing videos from project events, demos, presentations, partner interviews and so on (see Figure 5). As of M18, the YouTube channel has hosted a few videos related to project testbed or early demo activities, but the number of uploaded videos has been limited due to GDPR concerns. However, as end-to-end system demo and project dissemination events activities pick up in the second half of the project it is anticipated that the number of videos will increase accordingly.
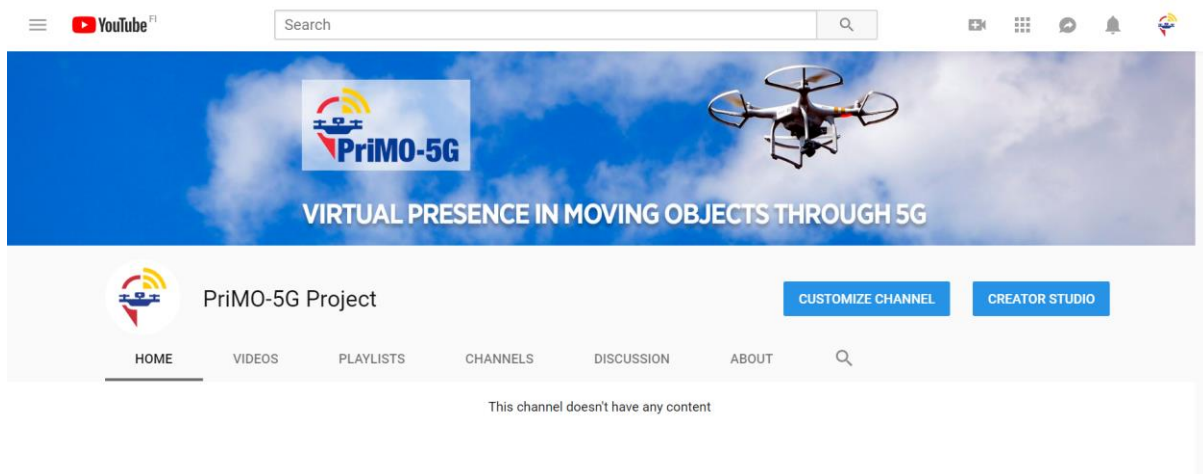
Figure 5 Screenshot of PriMO-5G project YouTube channel to be replaced

2.2.3 Flyers and rollup

The portfolio of project communications assets includes printed communications materials. These materials include flyers distributed to relevant stakeholders or displayed as a rollup banner in face-to-face events. The project materials have found use in events in which the project participated in and allowed for the project to further promote its objectives to the event participants. An example use in a high-profile event is shown in Figure 6 below.

Figure 6 PriMO-5G rollup banner on display at EuCNC 2019

2.3 PriMO-5G dissemination activities

Dissemination: The action of public disclosure of the project results by any appropriate means (other than resulting from protecting or exploiting the results), typically includes scientific publications and demonstrations.

The PriMO-5G dissemination activities provide means for more detailed disclosure of the results from the project's research and innovation activities. These dissemination activities generally may include (but is not limited to):

- Scientific papers and other publications
- Externally organized events
- Events (co-)organized by PriMO-5G partners
- Technical exchanges with other projects

These dissemination activities that occurred in M1-M18 are reviewed in the remainder of Section 2.3.

2.3.1 Journal papers and other conference publications

The PriMO-5G project consortium includes European and Korean partners from academic and research-focused organizations, which combine ambitions on applied research with quest for scientific excellence. Typically, these partners have local strategies and researcher development activities that strongly encourage sharing of their research output from the project through papers presented in conferences (oral paper or poster presentations) or published in reputable journals, book chapters, scientific magazines in the different primary focus areas the project.

Table 4 PriMO-5G journal papers and magazine articles published or accepted as of M18

Nr#	PriMO-5G journal paper or magazine article	PriMO-5G partners involved	Impact Factor (Year)	PriMO-5G focus areas covered
1.	H. Hellaoui, O. Bekkouche, M. Bagaa and T. Taleb. "Aerial Control System for Spectrum Efficiency in UAV-to-Cellular Communications". In: IEEE Communications Magazine (Oct. 2018), pp. 108–113. issn: 0163-6804. doi: 10.1109/MCOM.2018.1800078.	AALTO	9.27 (2018)	Communications Drones
2.	S. Kim et al. "Sense-and-Predict: Harnessing Spatial Interference Correlation for Cognitive Radio Networks". In: IEEE Transactions on Wireless Communications (May 2019), pp. 2777–2793. issn: 1536-1276. doi:10.1109/TWC.2019.2908168.	YU	5.888 (2018)	Communications
3.	E. Y. Menta et al. "On the Performance of AoA–Based Localization in 5G Ultra–Dense Networks". In: IEEE Access 7 (2019), pp. 33870–33880. issn: 2169-3536. doi: 10.1109/ACCESS.2019.2903633.	AALTO	3.557 (2017)	Communications
4.	M. Shin, J. Kim, and M. Levorato. "Auction-Based Charging Scheduling With Deep Learning Framework for Multi-Drone Networks". In: IEEE Transactions on Vehicular Technology (May 2019), pp. 4235–4248. issn: 0018-9545. doi: 10.1109/TVT.2019.2903144.	CAU	4.432 (2018)	Communications Machine learning Drones
5.	T. Xie et al. "On the Power Leakage Problem in Millimeter-Wave massive MIMO with Lens Antenna Arrays". In: IEEE Transactions on Signal Processing (2019), pp. 1–1. issn: 1053-587X. doi: 10.1109/TSP.2019.2926019.	YU	5.23 (2018)	Communications
6.	C. Zhu et al. "Folo: Latency and Quality Optimized Task Allocation in Vehicular Fog Computing". In: IEEE Internet of Things Journal (June 2019), pp. 4150–4161. issn: 2327-4662. doi:	AALTO	9.515 (2018)	Communications Machine learning

Nr#	PriMO-5G journal paper or magazine article	PriMO-5G partners involved	Impact Factor (Year)	PriMO-5G focus areas covered
	10.1109/JIOT.2018.2875520.			
7.	M. Choi, D. Yoon, and J. Kim. "Blind Signal Classification for Non-Orthogonal Multiple Access in Vehicular Networks". Accepted for IEEE Transactions on Vehicular Technology (2019), pp. 1-1. issn: 0018-9545. doi:10.1109/TVT.2019.2932407.	CAU	4.432 (2018)	Communications Machine learning
8.	J. Choi et al. "Random Access with Opportunity Detection in Wireless Networks". In: IEEE Wireless Communications Letters (2019), pp. 1-1., issn: 2162-2337. doi: 10.1109/LWC.2019.2921367.	YU	3.546 (2018)	Communications
9.	J. Song and W. Choi. "Mobility-Aware Content Placement for Device-to-Device Caching Systems". In: IEEE Transactions on Wireless Communications (July 2019), pp. 3658{3668. issn: 1536-1276. doi: 10.1109/TWC.2019.2916781	KAIST	5.888 (2018)	Communications
10.	M. Choi, A. No and M. Ji and J. Kim. "Markov Decision Policies for Dynamic Video Delivery in Wireless Caching Networks". Accepted for IEEE Transactions on Wireless Communications (2019).	CAU	5.888 (2018)	Communications Machine learning Drones
11.	N. H. Motlagh, M. Bagaa and T. Taleb, "Energy and Delay Aware Task Assignment Mechanism for UAV-Based IoT Platform," in IEEE Internet of Things Journal, vol. 6, no. 4, pp. 6523-6536, Aug. 2019. doi: 10.1109/JIOT.2019.2907873	AALTO	9.515 (not known)	Communications Drones
12.	M. Maiouak and T. Taleb, "Dynamic Maps for Automated Driving and UAV Geofencing," in IEEE Wireless Communications, vol. 26, no. 4, pp. 54-59, August 2019. doi: 10.1109/MWC.2019.1800544	AALTO	11 (not known)	Communications Drones

The PriMO-5G partners target regular presentations at a wide range of dissemination events of varying size (conferences, workshops, symposiums, forums, colloquiums, etc.), which cover any of the four primary focus areas of the project (5G communications technologies, public safety, drones and machine learning). Majority of the conference papers have involved single partners (that is, authored from single organization). This is indeed also the case for the journal papers and magazine articles described previously in Table 4. However, internal discussions in the project have highlighted the need for more collaboration between partners, not just in terms of development of project deliverable reports and integrated experimental demos, but also in terms of joint publishing of project results and visions. An exemplary case of this is the PriMO-5G project position paper, which was presented at the 2019 IEEE 2nd 5G World Forum (5GWF) in Dresden, Germany (see row 24 in Table 5).

Table 5 PriMO-5G conference papers presented as of M18

Nr#	PriMO-5G papers presented in conferences (or other event with peer review practice)	PriMO-5G partners involved	Number (type of participants)	PriMO-5G focus areas covered
1.	B. Jin, J. Woo, and Y. Yi. "On the Asymptotic Content Routing Stretch in Network of Caches: Impact of Popularity Learning". In: International Conference on Network Games, Control, and Optimization (NETGCOOP 2018). Ed. by J. Walrand et al. New York, Nov. 2018, pp. 145–163.	KAIST	100 (Academia, Industry)	Communications Machine learning
2.	M. Ullmann, "Porting the Open Air Interface protocol stack to NI Linux Real-Time OS on USRP-2974", Joint ETSI - OSA Workshop: Open Implementations and Standardization, Sophia Antipolis, Dec 2018	NI	100-200 (Academia, Industry, Policy)	Communications

Nr#	PriMO-5G papers presented in conferences (or other event with peer review practice)	PriMO-5G partners involved	Number (type of participants)	PriMO-5G focus areas covered
3.	D. Kwon and J. Kim, "Optimal Trajectory Learning for UAV-BS Video Provisioning System: A Deep Reinforcement Learning Approach," in Proceedings of the IEEE International Conference on Information Networking (ICOIN), Kuala Lumpur, Malaysia, January 2019.	YU	300 (Academia, Industry)	Communications Machine learning Drones
4.	M. U. Sheikh, K. Ruttik, and Riku Jäntti. "Analysis of Indoor Solutions for Provisioning of Indoor Coverage at 3.5 GHz and 28 GHz for 5G System". 26th IEEE International Conference in Telecommunications (ICT'19). Hanoi, Apr. 2019.	AALTO	400 (Academia, Industry)	Communications
5.	M. U. Sheikh, K. Ruttik, and Riku Jäntti. "Performance Analysis of Vertical and Higher Order Sectorization in Urban Environment at 28 GHz". 26th IEEE International Conference in Telecommunications (ICT'19). Hanoi, Apr. 2019.	AALTO	400 (Academia, Industry)	Communications
6.	M. U. Sheikh, K. Ruttik, and Riku Jäntti. "Performance Evaluation of Switched Beam Antenna with Different Configurations at 28 GHz". IEEE Wireless Communications and Networking Conference (WCNC) 2019. Marrakech, Apr. 2019.	AALTO	700 (Academia, Industry)	Communications
7.	H. Hellaoui, A. Chelli, M. Bagaa and T. Taleb, "Towards Efficient Control of Mobile Network-Enabled UAVs," IEEE Wireless Communications and Networking Conference (WCNC) 2019. Marrakech, Apr. 2019.	AALTO	700 (Academia, Industry)	communications
8.	O. Bekkouche, T. Taleb, M. Bagaa and K. Samdanis, "Edge Cloud Resource-aware Flight Planning for Unmanned Aerial Vehicles," IEEE Wireless Communications and Networking Conference (WCNC) 2019. Marrakech, Apr. 2019.	AALTO	700 (Academia, Industry)	communications
9.	H. Cha and S. Kim. "A Reinforcement Learning Approach to Dynamic Spectrum Access in Internet-of-Things Networks". 2019 IEEE International Conference on Communications (ICC 2019). May 2019, pp. 1–6. doi:10.1109/ICC.2019.8762091.	YU	1000 (Academia, Industry, Policy)	Communications Machine learning
10.	M. Choi et al. "Probabilistic Caching Policy for Categorized Contents and Consecutive User Demands". In: 2019 IEEE International Conference on Communications (ICC 2019). May 2019, pp. 1–6. doi:10.1109/ICC.2019.8761047	CAU	1000 (Academia, Industry, Policy)	Communications
11.	D. Kim et al. "Learning to Schedule Communication in Multi-agent Reinforcement Learning". Seventh International Conference on Learning Representations (ICLR 2019). New Orleans, May 2019.	KAIST	550 (Academia, Industry)	Communications Machine learning
12.	M. Shin and J. Kim. "Randomized Adversarial Imitation Learning for Autonomous Driving". In: 2019 International Joint Conference on Artificial Intelligence (IJCAI). Macao, May 2019.	CAU	100 (Academia, Industry)	Machine learning
13.	K. Son et al. "QTRAN: Learning to Factorize with Transformation for Cooperative Multi-Agent Reinforcement Learning". 36th International Conference on Machine Learning (ICML 2019). Long	KAIST	6000 (Academia, Industry)	Machine learning

Nr#	PriMO-5G papers presented in conferences (or other event with peer review practice)	PriMO-5G partners involved	Number (type of participants)	PriMO-5G focus areas covered
	Beach, Jun. 2019.			
14.	D. Kwon, S. Park, and J. Kim, "Poster: Multi-Agent Deep Reinforcement Learning for Connected Vehicles," in Proceedings of the ACM International Conference on Mobile Systems, Applications, and Services (MobiSys) (Extended Abstract), Seoul, Korea, June 2019.	CAU	440 (Academia, Industry)	Machine learning
15.	M. Noreikis, Y. Xiao, and Y. Jiang. "Edge capacity planning for real time compute-intensive applications". IEEE International Conference on Fog Computing (ICFC 2019). Prague, Jun. 2019.	AALTO	unknown (Academia, Industry)	Communications
16.	J. Costa-Requena and A. Mohammedadem. "5G Network Slicing based on SDN and Machine Learning". 2019 European Conference on Networks and Communications (EuCNC). Valencia, Spain, June 2019.	AALTO	600 (Academia, Industry, Policy)	Communications Machine learning
17.	Y. Hong, Y. Kyung, and S.-L. Kim. "Multi-Robot Cooperative Patrolling Algorithm with Sharing Multiple Cycles," 2019 European Conference on Networks and Communications (EuCNC), Valencia, Spain, June 2019.	YU	600 (Academia, Industry, Policy)	Communications Machine learning
18.	J. Jeon, J. Kim, K. Kim, J. Kim, A. Mohaisen, and J.-K. Kim, "Privacy-Preserving Deep Learning Computation for Geo-Distributed Medical Big-Data Platforms," in Proceedings of the IEEE/IFIP International Conference on Dependable Systems and Networks (DSN) (Fast Abstract), Portland, Oregon, USA, June 2019.	CAU	300 (Academia, Industry)	Machine learning
19.	M. Shin and J. Kim, "Adversarial Imitation Learning via Random Search," in Proceedings of the IEEE International Joint Conference on Neural Networks (IJCNN), Budapest, Hungary, July 2019.	CAU	unknown (Academia, Industry)	Machine learning
20.	D. Kim, J. Kim, J. Kwon, and T.-H. Kim, "Depth-Controllable Very Deep Super-Resolution Network," in Proceedings of the IEEE International Joint Conference on Neural Networks (IJCNN), Budapest, Hungary, July 2019.	CAU	unknown (Academia, Industry)	Machine learning
21.	S. Park, J. Kim, D. Kwon, M. Shin, and J. Kim, "Joint Offloading and Streaming in Mobile Edges: A Deep Reinforcement Learning Approach," in Proceedings of the IEEE Asia Pacific Wireless Communications Symposium (APWCS), Singapore, August 2019.	CAU	unknown (Academia, Industry)	Communications Machine learning
22.	M. U. Sheikh, K. Ruttik, and Riku Jäntti. "DAS and UDN Solutions for Indoor Coverage at Millimeter Wave (mmWave) Frequencies". in Proceedings of the IEEE 90th Vehicular Technology Conference (VTC' Fall 2019). Honolulu, Sept. 2019.	AALTO	1000 (Academia, Industry)	Communications
23.	M. U. Sheikh, F. Ghavami, K. Ruttik, and Riku Jäntti. "Drone Detection and Classification Using Cellular Network: A Machine Learning Approach". in Proceedings of the IEEE 90th Vehicular Technology Conference (VTC' Fall 2019). Honolulu, Sept. 2019.	AALTO	1000 (Academia, Industry)	Communications Machine learning
24.	K. W. Sung et al. "PriMO-5G: making firefighting smarter with immersive videos through 5G". in Proceedings of the 2019 IEEE 2nd 5G World Forum (5GWF). Dresden, Sept. 2019.	AALTO, CAU, CMC, EAB, KCL, KTH, NI, YU	500 (Academia, Industry, Policy)	Communications Machine learning Drones Public safety

Nr#	PriMO-5G papers presented in conferences (or other event with peer review practice)	PriMO-5G partners involved	Number (type of participants)	PriMO-5G focus areas covered
25.	M. U. Sheikh et al. "Usability Benefits and Challenges in mmWave V2V Communications: A Case Study". in Proceedings of the IEEE International Conference on Wireless and Mobile Computing, Networking and Communications (WiMOB). Barcelona, Oct. 2019.	AALTO	300 (Academia, Industry)	Communications
26.	D. Kwon and J. Kim. "Multi-Agent Deep Reinforcement Learning for Cooperative Connected Vehicles". in Proceedings of the 2019 IEEE Global Communications Conference (GLOBECOM 2019). Hawaii, Dec. 2019.	CAU	1000-2000 (Academia, Industry)	Communications Machine learning
27.	O. Bekkouche, M. Bagaa, and T. Taleb, "Toward a UTM-based Service Orchestration for UAVs in MEC-NFV Environment," in IEEE Globecom'19, Hawaii, USA, Dec. 2019	AALTO	1000-2000 (Academia, Industry)	Communications Drones
28.	H. Hellaoui, A. Chelli, M. Bagaa, and T. Taleb, "Efficient Steering Mechanism for Mobile Network-enabled UAVs," in IEEE Globecom'19, Hawaii, USA, Dec. 2019	AALTO	1000-2000 (Academia, Industry)	Communications Drones

2.3.2   Other invited presentations at externally organized events

The project partners have also given invited presentations about the project in events, which do not necessarily require submission of peer-review papers (see Table 6). Typically, these events have provided a platform for conveying project results, enhancing networking opportunities within different communities (e.g. technology, scientific, end users, regulators, policy makers etc.), and raising further awareness of the project.

Table 6 Other PriMO-5G presentations at externally organised events

Nr#	Other PriMO-5G presentations at externally organised events	Number (type of participants)	PriMO-5G partners involved
1.	12th Europe-Korea Conference on Science and technology (EKC), Vienna, Austria from 15 - 19 July 2019	600 (Academia, Industry, Policy)	KTH
2.	6G Wireless Summit, 24-26 March 2019, Levi, Finland	300 (Academia, Industry, Policy)	AALTO, YU
3.	3rd Korea-EU Coordinated Calls R&D Conference 2018, 12th October 2018, in Seoul, Republic of Korea	100-200 (Academia, Industry, Policy)	YU
4.	Joint ETSI - OSA Workshop: Open Implementations and Standardization, Dec 2018	100-200 (Academia, Industry, Policy)	NI

2.3.3   Events (co-)organized by PriMO-5G partners

The project has taken measures to amplify the dissemination of project's results by organizing events by projects partners or in partnership with other projects. Typically, these events could be workshops collocated with prominent conferences or demo events in some of the partner sites. These, also events provided an opportunity to strengthen external collaborations the event organization partners (e.g. other projects) and with participants to the PriMO-5G events. The events (co-)organized by the project at the time of reporting are described briefly below (this includes confirmed events already in preparation to be held after M18).

2.3.3.1   5G-OPEN event December 2018

The PriMO-5G Korean partners YU and KT co-organised event called 5G OPEN (Open Platform for Evolved Networks), on 6 December 2018 at YU around 5G multi-disciplinary research. The event provided an opportunity to showcase the 5G-OPEN testbed deployed by KT at YU. This testbed provides the platform for most of the PriMO-5G system demonstrations in Korea. The 5G-OPEN also provided the opportunity to introduce the PriMO-5G project to local industry, academic and government stakeholders (see program in Figure 7).

Figure 7 Program of the 5G OPEN 2018 event

2.3.3.2   Visit of the delegation of President of Korea

The President of the Republic of Korea, Mr. Moon Jae-in, visited Aalto University as part of his state visit to Finland on 10 June 2019. During the visit, the President and his delegation met technology start-up companies and representatives of selected research projects. To that end, the PriMO-5G project was showcased to the delegation in a presentation on Aalto 5G Research by Professor Riku Jäntti who is the PriMO-5G coordinator. In his presentation, Professor Jäntti highlighted how PriMO-5G addresses challenges of public safety through use of 5G enabled drones (see Figure 8). The visit and PriMO-5G

presentation was reported in media outlets including a report on Yonhap News Agency[3]. Furthermore, the visit encouraged AALTO and YU collaborated to setup a direct high-capacity connection between the testbed at Aalto University 5G network and the YU – KT 5G Open network ahead of schedule. This intercontinental link will be used by PriMO-5G to demonstrate end-to-end immersive video services.

Figure 8 PriMO-5G coordinator Prof. Jäntti presenting PriMO-5G to the President of Korea and his delegation

2.3.3.3   PriMO-5G workshop at ICEIC 2020

The PriMO-5G project has organized a workshop that will held in conjunction with ICEIC 2020[4], the 19th International Conference on Electronics, Information, and Communication, which will be held at Jan.19-22, 2020 in Barcelona, Spain. The ICEIC 2020 conference is co-organised by Korea's Institute of Electronics and Information Engineers (IEIE) and IEEE Consumer Electronics Society (CES).

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[3] https://news.v.daum.net/v/20190610222332610

[4] http://www.iceic.org/2020/

Figure 9 Banner of the ICEIC 2020 conference

The format of the PriMO-5G workshop titled "Architecture and AI-Assisted Technologies for Immersive Drone Communications" is a based on a selection of technical presentations from the PriMO-5G project describing research results and demos from WP1 to WP5 of the project (see Table 7). The presentations will be given by multiple PriMO-5G project partners from both Europe and Korea. The workshop will be open to all registered participants of the ICEIC 2020 conference.

Table 7 Program of the PriMO-5G workshop at ICEIC 2020

Time	Title	Presenter
	Morning session	
08:00 – 08:30	**Venue setup and arrival of participants**	
08:30	**Event start**	
08:30 - 08:40	**PriMO-5G Project Overview (10 min)** - Main goals/objectives, Consortium, Work structure	AALTO/YU
08:40 - 09:00	**5G Network Architecture for Drones for Public Safety (20 min incl. Q&A)**	András Zahemszky, EAB, Sweden
09:00 - 09:20	**From 5G core interoperability to UAV streaming: work of Cumucore (20 min incl. Q&A)**	Jose Costa-Requena, Cumucore, Finland
09:20 - 09:45	**Computing and communication trade-off in low delay end-to-end services: PriMO-5G testbeds (25 min incl. Q&A)**	Seong-Lyun Kim, YU, Korea
	Afternoon session	
11:30 – 11:50	**Learning based Connectivity-Constrained Trajectory Optimization for Uplink mmWave UAVs by (20 min incl. Q&A)**	Konstantinos Antonakoglou, KCL, UK
11:50 – 12:10	**Sparse channel estimation in mmWave band with a new method of geometric sequence decomposition (20 min incl. Q&A)**	Woonghee Lee, KTH, Sweden
12:10 – 12:30	**Distributed Cooperation through Multi-agent Reinforcement Learning: Role of 5G (20 min incl. Q&A)**	Yung Yi, KAIST, Korea
12:30	**Event end**	

2.3.3.4   AERCOMM workshop at WCNC 2020

The PriMO-5G project is collaborating with H2020 EU 5G!Drones[5] project to co-organise Workshop on "Aerial Communications in 5G and Beyond Networks (AERCOMM)"[6] to be held in conjunction with IEEE WCNC 2020 in 6-9 April 2020, in Seoul, South Korea. The AERCOMM workshop aims to provide a venue for exchanging of latest developments on aerial communications (particularly with UAVs) amongst an audience that includes (but not limited to) academic researchers, vendors, operators, verticals and regulators.

Figure 10 Banner of the AERCOMM Workshop

The AERCOMM workshop will be full day event consisting of six distinguished speakers providing perspectives from both industry and academia. The papers accepted for presentation at the workshop will be presented in an interactive session with posters (and some cases video demos) that allow for maximum interaction and deeper discussions. The tentative number of presentations is shown below.

Number of refereed papers: 15 (presented as posters).

Invited speakers: 6

- Prof. Fabrizio Granelli, University of Trento, Italy

- Dr. Sunghyun Choi, Samsung Research, Korea

- Prof. Jinho Choi, Deakin University, Australia

- Mr. Tero Vuorenmaa, CEO Robots.expert, Vice President at World UAV Federation - Finnish Chapter, Finland

- Prof. Tarik Taleb, Aalto University, Finland

- Dr. Christos Tsokos, National Technical University of Athens, Greece

2.3.4   Technical exchanges with other research projects

The PriMO-5G project has actively sought technical interactions and collaborations with other research projects that have common interests in one or more of the primary focus areas of PriMO-5G. The outcomes of these interactions may include (but not necessarily limited to) joint, joint experimental demonstrations, joint publications and collaborations for follow-up research projects. To that end, exchanges with other H2020 projects are particularly attractive as they mostly adapt an open model for sharing of project results (e.g. deliverables). Moreover, these projects are usually collaboration projects

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[5] H2020 EU project Unmanned Aerial Vehicle Vertical Applications' Trials Leveraging Advanced 5G Facilities (5G!Drones) https://5gdrones.eu/

[6]   AERCOMM   workshop   https://wcnc2020.ieee-wcnc.org/workshop/aerial-communications-5g-and-beyond-networks-aercomm

with participants from academia, industry and end user organizations, which supports PriMO-5G objective of interacting with partners of different type (not just academia). The H2020 projects or programmes that are of particular interest for technical exchanges are profiled below including details of interactions with PriMO-5G in M1-M18.

2.3.4.1   EU-Korea projects

The PriMO-5G project is part of a cluster of three EU-Korea projects funded under the H2020-EUK-2018 call. These three projects have exact timelines, which facilitates technical exchanges at more aligned. However, the focus of these projects is differentiated to allow for diverse research themes within the EU-Korea collaboration context. However, some common themes with PriMO-5G could still be identified that could justify technical exchanges. The other EU-KR project profiles and their interactions with PriMO-5G are shown in Table 8. As noted in the table the interactions have been relatively low in M1-M18, but there is expected to be some synergies in second half of the project (particularly with 5G ALL-STAR).

Table 8 Interactions between PriMO-5G and other EU-KR projects

EU-Korea Project	Commonalities with PriMO-5G primary focus areas		PriMO-5G interactions with the project
5G ALL-STAR (*5G AgiLe and fLexible integration of SaTellite And cellular*)[7]	5G technologies	• 5G-NR mmWave access for low latency services • Spectrum sharing approaches	• Discussions held with 5G ALLSTAR on co-organising joint workshop. This collaboration may occur for EuCNC2020 in the context of workshop also involving other 5G-related international corporation H2020 projects.
	Public safety	• Support for mission critical applications	
	Drones	• n/a	
	Machine learning	• n/a	
DECENTER (*Decentralised technologies for orchestrated cloud-to-edge intelligence*)[8]	5G technologies	• MEC, fog computing	• No interactions of note so far
	Public safety	• n/a	
	Drones	• n/a	
	Machine learning	• AI application-aware orchestration and provisioning of resources	

2.3.4.2   5G-PPP projects

The 5G Infrastructure Public Private Partnership (5G-PPP)[9] is a 5G collaborative research program represented by the 5G Infrastructure Association (5G-IA) on the private side and the EC on the public side. The 5G-PPP constitutes projects are implemented in three phases. The 5G-PPP Phase 1 projects where completed before PriMO-5G kicked-off, which rules out active exchanges. Similarly, alignment

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[7] EU-KR 5G ALL-STAR project website https://5g-allstar.eu/

[8] EU-KR 5G DECENTER project website https://www.decenter-project.eu/

[9] 5G-PPP website https://5g-ppp.eu/

is also difficult with 5G-PPP Phase 2 projects[10] mostly active from mid-2017 to early 2020, as the ending of these Phase 2 projects come at midway point PriMO-5G project when results are beginning to mature. Inter-project collaborations are more likely for 5G-PPP Phase 3 projects[11] as the projects mostly active from year 2019. The early Phase 3 projects will focus on conducting large-scale trials and pilots for different 5G vertical use cases including public safety. These include projects focusing use of drones in their use cases, providing further overlap with PriMO-5G focus areas. Additionally, the projects coming at latter part of Phase 3 will focus on developing the Long Term Evolution of 5G [5GPPP2019]. Table 9 below describes two 5G-PPP Phase 3 projects which have had active collaborations with PriMO-5G in M1-M18.

Table 9 Interactions between PriMO-5G and other EU-KR projects

EU-Korea Project	Commonalities with PriMO-5G primary focus areas		PriMO-5G interactions with the project
5G!Drones (*Unmanned Aerial Vehicle Vertical Applications' Trials Leveraging Advanced 5G Facilities*)[12]	5G technologies	• Network slicing • Mobile edge computing	• Co-organisation of the AERCOMM workshop at WCNC 2020 (see Section 2.3.3.4) • AALTO is also a partner in 5G!Drones. Therefore, within AALTO there is now a drones SIG to enhance collaboration between researchers working in the two projects
	Public safety	• PPDR use case	
	Drones	• Software enhancements automate the run of drones trials in different verticals	
	Machine learning	• n/a	
TERAWAY (*Terahertz technology for ultra-broadband and ultra-wideband operation of backhaul and fronthaul links in systems with SDN management of network and radio resources*)[13]	5G technologies	• 5G-NR mmWave access • Network slicing	• PriMO-5G project provided the insights and inputs in preparation of TERAWAY via AALTO and CMC • In the future AALTO will provide the test site for TERAWAY further leveraging experiences PriMO-5G demos conducted in AALTO site • TERAWAY coordinator will participate as keynote speaker AERCOMM workshop co-organised by PriMO-5G
	Public safety	• n/a	
	Drones	• Drone base stations, mmWave connected drones	
	Machine learning	• AI for radio resource management	

2.4   Evaluation of activities against defined objectives

The PriMO-5G project communications, dissemination and exploitation action plans outlined previously requires the definition of measurable objectives based on quantifiable key performance indicators (KPIs) for each category of targeted actions. These measurable objectives facilitate periodic assessment of the progress (and/or effectiveness) of the planned communications, dissemination and exploitation activities. Furthermore, it provides triggers for initiation of interventions where necessary to ensure defined communications, dissemination and exploitation objectives are met (or exceeded), throughout the project lifetime. The KPI assessment triage and colour coding used in this project reporting is shown in Table 10.

Table 10 KPI assessment, rationale and related interventions

KPI assessment	Rationale and interventions	Color code
Immediate action necessary	*Reasoning*: KPI is substantially below expected (success criteria) value. *Interventions*: Creation of high-priority action items by Coordinator/Project Manager, assigning or reassigning of responsibilities to certain partners, adapting activity plans, and/or effort reallocation to improve activities relevant to the KPI.	(red)
Needs further attention	*Reasoning*: KPI is slightly below expectation or may deserve attention for other reasons, e.g. external recommendations. *Interventions*: Issue addressed in the general project teleconference and further measures for KPI improvement need discussed consortium-wide. Actions to taken are to be carried out by specific partners assigned in the teleconference.	(yellow)
Good progress	*Rationale*: KPI on track with current plans. *Interventions*: No specific intervention action. Continuation of existing positive actions.	(green)
Overachievement	*Rationale*: KPI significantly exceeds expectation. *Interventions*: Potential adjustments of KPI targets considered to account for previous underestimation of communication, dissemination or exploitation results.	(blue)
Not applicable, change of plans or measures	*Rationale*: KPI cannot be evaluated at current point due to changes in plans or newly introduced measures. *Interventions*: Actions to be carried out need to include adjustment for enabling future tracking of KPI.	(grey)

2.4.1   Evaluation of communications KPIs against initial objectives

The KPI data for the different communications channels is gathered based on built-in analytics interfaces available in channel (with data available at different granularity levels, daily, week, monthly etc.). The KPIs for the communications activities as of M18 activities is shown in Table 11. In this current reporting period, the performance of the project website and twitter feed have demonstrated good performance against previously stated success criteria. However, the project YouTube channel has performed less well due to the limited actions on posting project videos due to privacy concerns and so on. A number of interventions are being planned for M19-M24. Firstly, the emphasis will towards producing and sharing more videos of project demos and technical presentations in a way that minimizes exposures of persons and so on. Furthermore, videos posted on the project YouTube

channels will be embedded on in project online news page and tweets, which have a much better reach.

Table 11 Communications KPIs realised as of M18

Comm. channels	KPI	KPI ID	Success criteria	Realised as of M18	Comment
Website	Number of page views	COM_1	≥ 60 per month (720 per year)	346 per month (3811 February-December 2019)	Overachievement →Need to revise KPI target
	Time spent on website	COM_2	Average visit ≥ 1:30 minutes	2:12 minutes	Good progress, on track
	Number of web (news) articles	COM_3	≥ 2 per month	1 per month	Need further attention →Frequent updates include more partner stories
Twitter	Number of Twitter Followers	COM_4	≥ 20 after year 1 ≥ 40 after year 2	36	Good progress, on track
	Number of Twitter Posts	COM_5	≥ 2 per month	3.5 per month	Good progress, on track
	Tweet impressions[14]	COM_6	≥ 500 per month	Averaging 1600 per month (Oct-Dec 2019)	Overachievement →Need to revise KPI target
YouTube	Video uploads	COM_7	≥ 4 per year	4 in 1.5 years	Needs further attention →More videos of technical nature with less ethical concerns
	Video impressions[15]	COM_8	≥ 20 per video	828 (averaging > 200 per video)	Overachievement →Need to revise KPI target
	Impressions click-through rate[16]	COM_9	5% per video	3.9%	Need further attention → More engaging videos or demos or

[14] Tweet impressions are the number of times project's Tweets have shown up in other Twitter account timelines in a month (or number of times a user is served a Tweet in timeline or search results) https://sproutsocial.com/insights/twitter-impressions/

[15] How many times project video thumbnails were shown to viewers on youtube.com

[16] How often viewers watched a video after seeing a thumbnail

Comm. channels	KPI	KPI ID	Success criteria	Realised as of M18	Comment
					presentations → Embedding videos in project news pages and twitter feeds

It was also noted in Table 11 that some of the communications KPI overachievements where perhaps based on pessimistic success criteria. Therefore, some of the KPIs concerned have their success criteria redefined for M19-M36 to allow project to have targets that are more ambitious in the coming periods (see Table 12).

Table 12 Revised communications KPIs success criteria for M19-M36

Comm. channels	KPI	KPI ID	Success criteria for M1.M18	Success criteria for M19-M36
Website	Number of page views	COM_1	≥ 60 per month (720 per year)	≥ 250 per month (≥ 3000 per year)
	Time spent on website	COM_2	Average visit ≥ 1:30 minutes	Same
	Number of web (news) articles	COM_3	≥ 2 per month	Same
Twitter	Number of Twitter Followers	COM_4	≥ 20 after year 1 ≥ 40 after year 2	Same
	Number of Twitter Posts	COM_5	≥ 2 per month	Same
	Tweet impressions[17]	COM_6	≥ 500 per month	≥ 1000 per month
YouTube	Video uploads	COM_7	≥ 4 per year	Same
	Video impressions[18]	COM_8	≥ 20 per video	≥ 200 per video
	Impressions click-through rate[19]	COM_9	5% per video	Same

2.4.2 Evaluation of Dissemination KPIs against initial objectives

The project has specified guidelines for partners reporting of dissemination activities to the project

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[17] Tweet impressions are the number of times project's Tweets have shown up in other Twitter account timelines in a month (or number of times a user is served a Tweet in timeline or search results) https://sproutsocial.com/insights/twitter-impressions/

[18] How many times project video thumbnails were shown to viewers on youtube.com

[19] How often viewers watched a video after seeing a thumbnail

mailing list. This data together with periodic tallying of the dissemination activities provides input to the KPI data gathering. The KPIs for the dissemination activities as of M18 is shown in Table 13. Overall the different dissemination actions have surpassed the previous defined success criteria, due to intense level of publishing and active participation in dissemination events. As noted previously, an area of improvement would be to have dissemination activities that mostly target the public safety communities/audience.

Table 13 Dissemination KPIs realised as of M18

Dissemination actions	KPI	KPI ID	Success criteria	Realised as of M18	Comment
Journal papers and magazine articles	Number of papers/articles	DISS_1	≥ 4 per year	12 (see Table 4)	Overachievement, →Need to revise KPI target and also address drone and public safety focus areas
Externally organized events	Number of paper/poster presentations	DISS_2	≥ 4 per year	28 (see Table 5)	Overachievement, →Need to revise KPI target and also address drone and public safety focus areas
	Number of demo/exhibitions	DISS_3	≥ 4 per year	>8 (ref. D5.1)	Overachievement →Need to revise KPI target as demo activities increase in M19-M36
Organized/co-organized events	Number of workshops/seminars	DISS_4	≥ 1 per year	4 (see Section 2.3.3)	Good progress Note: Organisation of two of those events started before M18 even though they will be held after M18.
Technical exchanges with other projects	Number of new partnership with other H2020 projects	DISS_5	≥ 1 per year	3	Good progress Note: Partnerships not formally agreed with MoUs, but already active in event co-organisation etc.

The overachievement in a number of dissemination KPIs (as noted in Table 13) has necessitated a revisit of previously defined success criteria. The revisions in Table 14 allow more ambitious dissemination targets to be pursued for M19-M36.

Table 14 Revised dissemination KPIs success criteria for M19-M36

Dissemination actions	KPI	KPI ID	Success criteria for M1.M18	Success criteria for M19-M36
Journal papers and magazine articles	Number of papers/articles	DISS_1	≥ 4 per year	≥ 6 per year
Externally organized events	Number of paper/poster presentations	DISS_2	≥ 4 per year	≥ 10 per year
	Number of demo/exhibitions	DISS_3	≥ 4 per year	≥ 6 per year
Organized/co-organized events	Number of workshops/seminars	DISS_4	≥ 1 per year	Same
Technical exchanges with other projects	Number of new partnership with other H2020 projects	DISS_5	≥ 1 per year	Same

3   Exploitation updates and future directions

The PriMO-5G project is investigating 5G end-to-end system developments for very demanding use cases resulting in substantial research output and technical developments across radio access, edge and core network segments. The PriMO-5G exploitation activities are specified to maximize the ways in which the project results are leveraged for developing new standards, products, processes or services, or utilizing the results for further research activities beyond the scope of the existing project.

As previously noted in Section 2, exploitation activities are expected to be more significant in *societal impact and exploitation Impact enhancement phase (M25-M36)* of the project. This is particularly the case for industry partners who are targeting more product development, standardization, patenting and other exploitation actions with potential commercial value. On the other hand, the research-oriented (academic) partners focus more on capacity building, new research opportunities and other scientific exploitation activities.

This section provides an overview some of early exploitation activities by different partners, provides updates on any change in plans beyond what was outlined by the individual exploitation plans of D6.2 [PRIMO-5G_D6.3]. This section also explores in some cases the exploitation context or environment, and how it influences the project's exploitation activities.

3.1   Contributions to standards

3.1.1   *Potential standardisation opportunities*

The PriMO-5G relies heavily on wireless technologies where the main standardization body is 3GPP. The PriMO-5G project has vendors aligned to the project that can influence the direction and the details of the standardization. The PriMO-5G project can also indirectly influence 3GPP standardization by successful dissemination of research results that positively can influence the direction of the industry and the ecosystem related to 3rd Generation Partnership Project (3GPP). The results can impact the context into which the standardization will base its direction on. The actual standardization topics are negotiated among active members were many considerations and priorities are taken into the account. It is challenging for research projects to have direct influence on 3GPP without having actual partners of 3GPP standardization aligned to the project.

3GPP unites seven telecommunications standard development organizations (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC), known as "Organizational Partners" and provides their members with a stable environment to produce the Reports and Specifications that define 3GPP technologies.

The project covers cellular telecommunications technologies, including radio access, core network and service capabilities, which provide a complete system description for mobile telecommunications. The 3GPP specifications also provide hooks for non-radio access to the core network and for interworking with non-3GPP networks. To that end, the 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 (see also Figure 11);

- Radio Access Networks (RAN)
- Services & Systems Aspects (SA)
- Core Network & Terminals (CT)

Figure 11 Overview of 3GPP standardisation (source: 3GPP)

The PriMO-5G project will fit into the radio access evolution beyond 5G or adding on to initial release of 5G-NR. As noted in the timeline of Figure 11, 3GPP Release 17 overlaps significantly with PriMO-5G project timeline which opens up for larger impacts on R18 and onwards. The developments in 3GPP Release 17 target to further drive the 5G NR evolution to meet the needs of multitude of vertical stakeholders (including public safety) from the traditional commercial cellular players.

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Overall RAN timeline

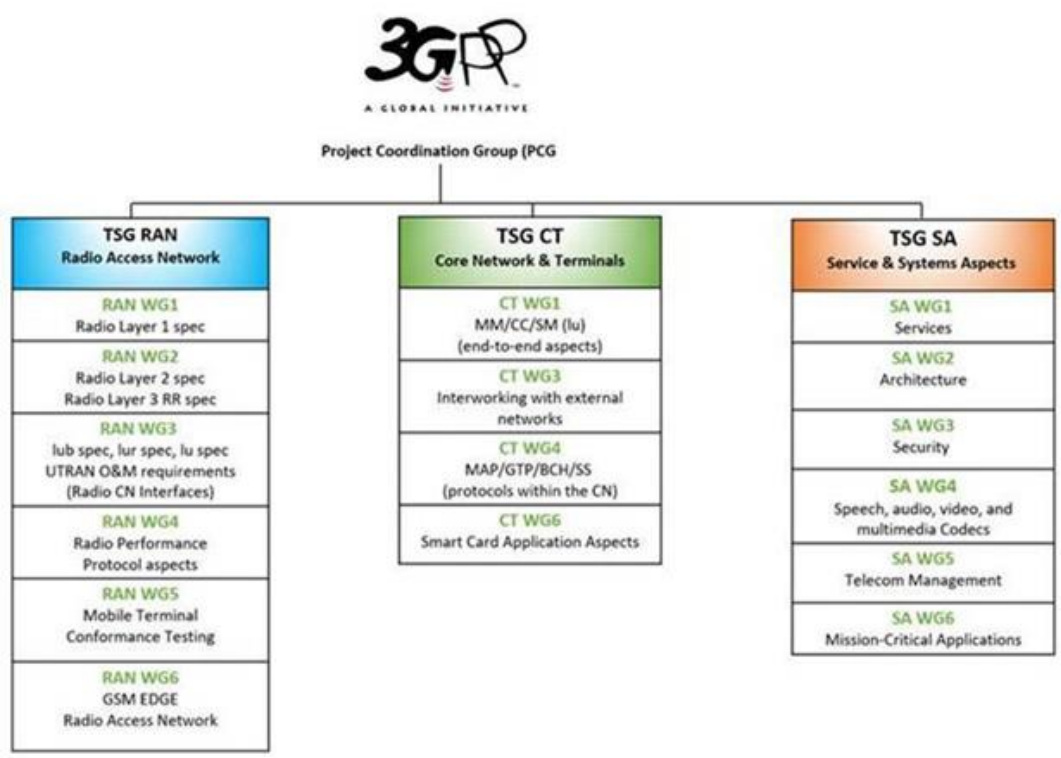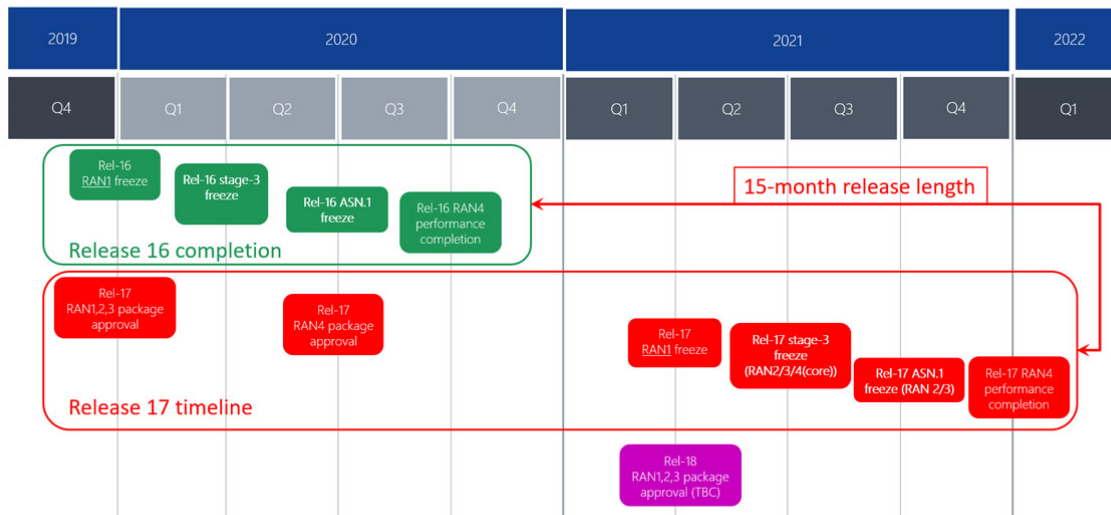Figure 12 Times for 3GPP Release 17 RAN milestones (source: 3GPP[20])

The PriMO-5G project will fit into the radio access evolution beyond 5G or adding on to initial release of 5G-NR. As noted in the timeline of Figure 11, 3GPP Release 17 overlaps significantly with PriMO-5G project timeline which opens up for larger impacts on Release 18 and onwards. The developments in 3GPP Release 17 target to further drive the 5G NR evolution to meet the needs of multitude of vertical stakeholders (including public safety) from the traditional commercial cellular players. The PriMO-5G project will be ending in mid-2021, a time in which Release 17 will be frozen and process for specifying study/work items for Release 18 will be underway.

Other potential standardization bodies open for impact by PriMO-5G research includes the European Telecommunications Standards Institute (ETSI). ETSI has standardization activities that specifies requirements and potential enablers or building blocks for an overall 5G system. This includes key aspects, such as, Network Function Virtualisation (NFV), MEC and Management and Orchestration (MANO), which has alignment to PriMO-5G research in WP2. The standardization work in is organized in different ETSI Industry Specification Groups (ISGs), Technical Committees (TCs) and projects that have active collaboration with 3GPP and, in some cases, provide direct input to 3GPP.

Also of interest is International Telecommunication Union (ITU), which coordinates the development of global telecommunications standards in addition to fostering the growth and sustained development of the sector and ensuring universal access. The activities of ITU activities are focused on three core sectors, namely: Standardization (ITU-T) which standardizes global telecommunications; (2) Radiocommunications (ITU-R) sector, which manages the international RF spectrum and satellite orbit resources, and Development (ITU-D) that supports the ITU mission to ensure equitable, sustainable and affordable access to ICT. Some ITU activities of interest includes ITU-R WP5D: Future IMT spectrum for WRC-19 and IMT-2020 evaluation.

On high level, PriMO-5G is supporting a transition from voice centric Public safety solutions to data-centric Public safety solutions, which includes new components as e.g. edge clouds, aerial

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[20] https://www.3gpp.org/news-events/2098-5g-in-release-17-%E2%80%93-strong-radio-evolution

devices/equipment and embedded AI solutions. With the 5G technology innovation many new advancements can be offered, such as e.g. slicing concepts and the ability to support advanced AR/VR video services. As the context of Public safety solutions are changing the overall potential impact on standardization has the potential to be significant, the PriMO-5G can influence not only details but also the overall direction for standardization development of Public safety solutions. The technology developments across WP2-WP4 with potential impact to standards impacts to standards are summarized in Table 15.

Table 15 Technology developments in different WPs with potential impact to standards

Work Package	Technology developments with potential impact to standards
WP2: 5G Core network	The technical developments in WP2 include the implementation of Multi-Access Edge Computing (MEC) and integration with network slice manager (NSM). This objective will deliver an AI based MEC that dynamically moves the processing to the specific location to fulfil 5G requirements in terms of latency for PriMO-5G use cases. To that end, the research on MEC service discovery and association of User Plane Function (UPF) data plane in WP2 has potential to impact 3GPP Release 17 (or beyond) standards on Service Based Architecture (SBA) and new user plane for edge applications. In that scope, some of ongoing relevant work items include: • 830032 FS_enh_EC Study on enhancement of support for Edge Computing in 5GC[21] • 830034 FS_UPCAS Study on UPF enhancement for control and SBA[22]
WP3: Enhanced 5G radio access technologies	In WP3, there are activities with significant alignment to study/work items in 3GPP Release 17 that may potentially be continued in Release 18. Among these, the *Physical layer enhancements (RAN1)* includes enhancements to MIMO, Spectrum Sharing enhancements, UE Power Saving and Coverage. In addition, several features have been approved to address different needs of vertical industries: Furthermore, sidelink enhancements to address critical communication needs (include public safety) and positioning enhancements. Moreover, 3GPP is gradually ramping up work on 5G-NR enhancements to support non-terrestrial networks (NTN), such as, drones, which is of course PriMO-5G focus area. Other developments of interest to WP3 (and WP1 architecture developments) include enhancements from 3GPP Release 17 *radio protocol and architecture enhancements (RAN2 and RAN3)*. For instance the added support for multicast transmissions is a key feature for broadcast of video from drones in PriMO-5G firefighting use cases. Others include architectures for 3GPP non-public networks, which would be of great use of public safety scenarios.
WP4: AI-assisted communications	Machine learning together with SDN and NFV is considered one of the main enablers of 5G networks. For instance, the Network Data Analytics Function (NWDAF) defined in 3GPP TR 23.791 may be used for analytics by collecting data from OAM and the Application Function (AF) in the Core network to potentially enhance mobility management, session management, QoS management, security management and NF life cycle management of the network. Many of the ML solutions proposed in WP4 could potentially be used to provide new methods to optimize the network resource utilization or may also replace existing traditional algorithms. Therefore, this work will primarily impact the actual deployment solutions that are available to the network operators. In the longer term, however, these new deployment solutions may also impact the network architecture, leading to new standard solutions which can leverage from the capabilities afforded by the machine learning capabilities in the network.

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[21] https://www.3gpp.org/DynaReport/WiCr--830032.htm

[22] https://www.3gpp.org/DynaReport/WiCr--830034.htm

3.1.2 *Early project activities with standards impact*

Early activities by certain partners that have direct or indirect impact to standards development is noted in Table 16.

Table 16 M1-M18 early activities per partner related to standards

Partner	M1-M18 early activities per partner related to standards
EAB	Ericsson has reviewed the PriMO-5G D1.1 use case scenarios and other PriMO-5G deliverables as part of the back office work for standardization. PriMO-5G D1.1 use case scenarios is pointing out a shift from voice centric to data centric public safety solutions. New public safety capabilities is added, e.g. drone traffic and advanced video services but also requirements on mm wave radio. Ericsson has used the D1.1 use case scenarios to impact the tactics for Ericsson public safety 3GPP standardization. The overall context and direction as well as detailed impacts for public safety have been reviewed for RELEASE 17. In 3GPP there are certain TSs/TRs focused on mission critical communication: 3GPP TS 23.280: " Common functional architecture to support mission critical services ", 3GPP TR 23.379: " Functional architecture and information flows to support Mission Critical Push To Talk (MCPTT)", 3GPP TR 23.281: " Functional architecture and information flows to support Mission Critical Video (MCVideo)", 3GPP TR 23.282: " Functional architecture and information flows to support Mission Critical Data (MCData)", 3GPP TR 23.283: " Mission Critical Communication Interworking with Land Mobile Radio Systems ", TS 23.180 Mission Critical (MC) services support in the Isolated Operation for Public Safety (IOPS) mode of operation, TR 23.783 study on mission critical services support over 5G system but the PriMO-5G points out to many more potential TSs to address, e.g. regarding non terrestrial networks. Ericsson has looked upon this larger context of potential impacted TSs in the analysis of 3GPP public safety. Ericsson will use potential results from PriMO-5G to further influence subsequent releases after RELEASE 17.
NI	NI is active in the 3GPP standardization body with focus on RAN WG1 and WG2 as well as WG4. NI will provide updates from the 3GPP standardization meetings including information relevant for the project. In 3GPP RAN WG1, the focus is on monitoring specification progress on initial access and MIMO. In 3GPP RAN WG2, the focus is on monitoring specification progress on initial access, beam management and L1 control. In 3GPP RAN WG4, the focus is on monitoring specification progress on RF performance on below as well as above 6 GHz. If aligned with internal strategies NI can contribute to joint 3GPP standardization activities with other partners highlighting project results.

3.2 New or enhanced products/ services

Use of project results for enhancing the features of partners existing products or services, or development of completely new products/news. This exploitation action is more relevant for industry partners in the consortium.

Table 17 M1-M18 achievements or developments per partner in terms of new or enhanced products/services

Partner	M1-M18 achievements or developments in terms new or enhanced products/services
CMC	A new interface xMB defined recently in 3GPP has been added to the eMBMS system which makes the system user-friendly from operator or broadcaster point of view. This results in a more compact system, which is now operational and used in few pilots and demos e.g. EuCNC 2019, and also delivered to customer which used for H2020 5G-XCAST project.

Partner	M1-M18 achievements or developments in terms new or enhanced products/services
NI	The measurements and assessment of the mmWave Beam Forming solution investigated in Primo-5G are baseline and input for potential future products in the range of NIs 5G NR product portfolio
EUCAST	Eucast supplied Korean government with PS-LTE portable NIB system composed of EPC, MCPTT and eNB. The prototype of this system with 5G backhaul was used at field trial of YU.

3.3   Patents, licenses or technology transfer agreements

For some partners (both industry and academic) these activities enables transforming their research results into protected intellectual property with commercialization potential.

Table 18 M1-M18 achievements or developments per partner in terms of patents, licenses or technology transfer agreements

Partner	M1-M18 achievements or developments in terms of patents, licenses or technology transfer agreements
EUCAST	Applied a patent for "Method and Apparatus for Obtaining TDD Synchronization at Relay" on February 2019.
YU	YU has registered SW programs to implement, evaluate, and verify the DoA estimation required for 5G mmWave MIMO (Multiple Input Multiple Output) communication. Within this program, a measure of assessing lateral performance is RMSE (Root Mean Squared Error) and NMSE (Normalized Mean Squared Error). At the same time, YU has been preparing a few patents, which are mostly based on machine learning-based task offloading and cooperative UAV flight techniques or mmWave communications including the techniques for lens antenna and hybrid beamforming.

3.4   Contributions to open source projects/communities

Some of the key 5G-related developments are also taking place in community-drive open source projects [5GAmericas2019]. The openness of these initiatives creates opportunities for contributions from both academic and industry partners in PriMO-5G.

Table 19 M1-M18 achievements or developments per partner in terms of contributions to open source projects/communities

Partner	M1-M18 achievements or developments in terms of contributions to open source projects/communities
NI	A proof of concept for porting the Open Air Interface 4G stack to the NI Linux RT platform was investigated in the context of the PriMO-5G project. This enables the usage of Open Air Interface (OAI) on a wider range of hardware platforms such as the USRP-2974. The contribution to the OAI alliance is under discussion.
KAIST	KAIST developed AirNet, a joint network and drone simulator built on AirSim and OMNet++, and AirNet-gym, a framework for implementing multi-agent reinforcement learning environments for multi-drone systems. This work is featured in D4.1.

3.5   Contributions for regulation or policy making processes

The PriMO-5G research results may have insights that could potential inform decisions of regulators or

policy makers in areas of spectrum, drones and public safety.

Table 20 M1-M18 achievements or developments per partner in terms of contributions to regulation or policy making processes

Partner	M1-M18 achievements or developments in terms of contributions to regulation or policy making processes
KTH	No update yet. However, results on regulatory and policy issues will be created mostly in year 2.

3.6 Demonstrators and prototypes

The PriMO-5G activities have a strong experimentation focus with contributed testbed and experimental platforms from different partners. The PriMO-5G project provides opportunity enhancing these assets or even creating new ones. The detailed monitoring and reporting on the demo platforms and prototypes is provided in WP5 deliverables, which include *D5.1 Demonstration plan* submitted in [M12] and the *D5.2 Intermediate report – Component demonstrations & System integration plan* which is currently under preparation for submission in [M23].

3.7 Education and researcher development

Exploitation activities in this context include use of the project work as part of thesis works (masters or doctoral level) for some of the researchers participating in project implementation phase. The project results exploited by academic project partners for implementing intensive courses, lectures and so on.

Table 21 M1-M18 achievements or developments per partner in terms of education and researcher development

Partner	M1-M18 achievements or developments in terms of education and researcher development
AALTO	The research carried out by doctoral candidates in the PriMO-5G has generated a number of scientific publications to support thesis works of the candidates. This includes doctoral research in areas of cell free architectures (by Nicolas Malm and Estifanos Menta), fog computing (by Zhu Chao) and network slicing (by Hamed Hellaoui and Oussama Bekkouche).
CMC	MSc instruction under supervision at Aalto University for thesis titled "*Optimizing mobile backhaul using machine learning*" by Abdulkadir Mohammedadem. The thesis was completed a paper published and presented in poster session at EuCNC 2019 with the results of the thesis.
EAB	Supervision of MSc Thesis student from KTH Ali Symeri who worked on PriMO-5G topic "Application Server Mobility and 5G Core Network"[23] completed July 2019.
KTH	KTH has offered a post-doc position and several Master thesis projects within the framework of PriMO-5G. The post-doc has collaborated with YU and will collaborate with EAB as well. Master thesis projects will be mainly in collaboration with EAB.
YU	To cultivating their engineering abilities, more than 10 students are studying and developing AI and 5G-related demonstrations with the PriMO-5G project. Among them, four doctoral students and four master students having contribution in PriMO-5G plan to graduate during the project

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[23] http://kth.diva-portal.org/smash/record.jsf?pid=diva2%3A1334568&dswid=-6147

Partner	M1-M18 achievements or developments in terms of education and researcher development
	duration, and their thesis will cover a part of PriMO-5G project's achievements. Two doctoral students (Hyesung Kim and Jinho Choi) graduated with the topic of "Distributed Control for Resource Utilization in Wireless Ultra Dense Networks" and "Sharing and Offloading for Resource Utilization in Wireless Networks" in this year.
CAU (now KU)	Four master students are graduated during the project duration and two master students participate newly. Their thesis will cover a part of PriMO-5G project's achievement.
KAIST	Three research outputs from KAIST are acknowledged as part of the PriMO-5G project. These works are implemented by eight graduate students during their graduate studies. All three works are highlighted in D4.1.

3.8 Follow-up research projects

The PriMO-5G project results also open new research questions or challenges, which could be pursued by partners in follow-up projects national or international calls.

Table 22 M1-M18 achievements or developments per partner in terms of follow-up research projects

Partner	M1-M18 achievements or developments in terms of follow-up research projects
AALTO	AALTO has managed to leverage the research and insights from the PriMO-5G to actively and gain new projects, particularly those related to the focus area on drones. Notably, this includes the following two Horizon 2020 projects: • Unmanned Aerial Vehicle Vertical Applications' Trials Leveraging Advanced 5G Facilities (5G!Drones)[24] which runs from July 2019 to June 2022 • Terahertz technology for ultra-broadband and ultra-wideband operation of backhaul and fronthaul links in systems with SDN management of network and radio resources (TERAWAY)[25] which runs from November 2019 to October 2022
KTH	KTH has utilized the knowledge and insight obtained by PriMO-5G for new project applications. Particularly, from spring 2020, KTH will coordinate a EUREKA Celtic-Plus project, Communication and Computation in the Sky (Com2Sky), which aims at solutions to enable reliable connectivity and efficient computation capabilities in the sky with novel radio technology solutions, resource allocation schemes and cloud technologies.
CMC	CMC is partner in H2020 TERAWAY project which runs from November 2019 to October 2022
YU	YU has conducted research about distributed learning via wireless communication and got a huge insight from PriMO-5G. It helped us to gain a new project including the following information: Research on B5G Joint Mobile-Communication/Machine-Learning Technology for Collaborative/Distributed Machine-Learning among Fast-Moving Objects which runs from March 2019 to February 2023.
CAU (now KU)	KU (CAU) has studied super resolution algorithm with new participants and researched about a developed SR algorithm, which has better performance than the algorithm used at first demonstration. We plan to keep focusing on research, which has a remarkable result using the algorithm.
KAIST	KAIST is currently participating in two drone-related projects:

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[24] 5G!Drones website https://5gdrones.eu/

[25] TERAWAY website http://ict-teraway.eu/

Partner	M1-M18 achievements or developments in terms of follow-up research projects
	• A Study on AI-based Collaboration Control of Cluster Unmanned CPS which is funded by the Agency for Defense Development and will run from 2019-2024 • Drone-network-based dynamic system for real-time wide-area multi-altitude PM measurement and data collection/analysis which is funded by the Global Singularity Research Funds – Fine Dust Research Group KAIST and will run from 2019-2023

3.9   Start-ups/Joint ventures

The IPR generated from the project could also be a basis creation of start-up companies or joint ventures from the existing consortium members. This is an option is a commercialization path that could be considered by some academic partners in the project. However, at the current reporting period there is no concrete plans noted in terms of spinoffs from research organisations or joint ventures.

3.10 Exploitation KPIs and initial objectives

In D6.2 [PRIMO-5G_D6.3] it was noted that most of the exploitation actions will occur during the societal impact and exploitation enhancement phase in the final third of project lifetime. Therefore, the KPI targets for the exploitation activities are mostly considered over the lifetime of the project. The KPIs for the exploitation activities (reported in Sections 3.1-3.9) as of M18 is shown in Table 23. The review of the exploitation KPIs (see Table 23) follows similar approach as described previously in Table 10. The target KPIs for exploitation activities was set to the end of the project, mostly due to fact that majority of the activities where envisioned for the societal impact and exploitation Impact enhancement phase (M25-M36). However, some significant exploitation actions are already noted as of M18. Some activities, such as, standards contributions, will be reviewed once again in M24 as the project enters its final year.

Table 23 Exploitation KPIs as of M18

Exploitation actions	KPI	KPI ID	Success criteria	Realised as of M18	Comment
New or enhanced products/ services	Number of new or enhanced products or services	EXP_1	≥ 3 within project lifetime	Enhancements reported by 3 partners (see Section 3.2)	Good progress
Patents, licenses or technology transfer agreements	Number of patents, licenses or technology transfer agreements	EXP_2	≥ 1 within project lifetime	1 patent applied and few in preparation (see Section 3.3)	Overachievement →Need to revise KPI target
Contributions to standards	Number of contributions to standards	EXP_3	≥ 1 within project lifetime	No direct contribution	Situation to be reviewed again in M24
Contributions to open source projects/ communities	Number of contributions to open source projects/communities	EXP_4	≥ 1 within project lifetime	2 open access initiatives (see Section 3.4)	Overachievement →Need to revise KPI target
Regulatory/policy change or proposal	Number of regulatory/policy recommendations (e.g.	EXP_5	≥ 1 within project lifetime	None reported	Work on this area ongoing in WP1

Exploitation actions	KPI	KPI ID	Success criteria	Realised as of M18	Comment
	policy brief from project)				
Demonstrators and prototypes	Number of component/system demonstrations and prototypes	EXP_6	*To be elaborated, monitored and reported in WP5 deliverables*	Reported in WP5 deliverables	*n/a*
Education and researcher development	Number of (bachelor, master or PhD theses) thesis works supported by research from the project	EXP_7	≥ 4 within project lifetime	> 20 theses works ongoing or completed	Overachievement →Need to revise KPI target
	Number of intensive course, summer school etc.	EXP_8	≥ 1 within project lifetime	None reported	Need for intervention to be reviewed in M24
Follow-up research	Number of follow-up research projects	EXP_9	≥ 1 within project lifetime	> 6 new research projects reported (see Section)	Overachievement →Need to revise KPI target
Start-ups/Joint ventures	Number of startups/joint ventures	EXP_10	*Optional*	*None*	n/a

Otherwise, it was noted that even as of M18 a few of the KPI targets were surpassed. Therefore, as was the case with communications and dissemination KPIs, there surpassed targets are revised setting new exploitation KPI targets for M19-M36 (Table 24).

Table 24 Revised exploitation KPIs success criteria for M19-M36

Exploitation actions	KPI	KPI ID	Success criteria for M1-M18	Success criteria for M19-M36
New or enhanced products/ services	Number of new or enhanced products or services	EXP_1	≥ 3 within project lifetime	Same
Patents, licenses or technology transfer agreements	Number of patents, licenses or technology transfer agreements	EXP_2	≥ 1 within project lifetime	≥ 4 within project lifetime
Contributions to standards	Number of contributions to standards	EXP_3	≥ 1 within project lifetime	Same
Contributions to open source projects/ communities	Number of contributions to open source projects/communities	EXP_4	≥ 1 within project lifetime	≥ 3 within project lifetime
Regulatory/policy change or proposal	Number of regulatory/policy recommendations (e.g.	EXP_5	≥ 1 within project lifetime	Same

Exploitation actions	KPI	KPI ID	Success criteria for M1-M18	Success criteria for M19-M36
	policy brief from project)			
Demonstrators and prototypes	Number of component/system demonstrations and prototypes	EXP_6	*To be elaborated, monitored and reported in WP5 deliverables*	Same
Education and researcher development	Number of (bachelor, master or PhD theses) thesis works supported by research from the project	EXP_7	≥ 4 within project lifetime	≥ 30 within project lifetime
	Number of intensive course, summer school etc.	EXP_8	≥ 1 within project lifetime	Same
Follow-up research	Number of follow-up research projects	EXP_9	≥ 1 within project lifetime	≥ 8 within project lifetime
Start-ups/Joint ventures	Number of startups/joint ventures	EXP_10	*Optional*	Same

4   Conclusions and Next Steps

This deliverable reviewed the communications, dissemination and exploitation activities in the first half of the project M1-M18. In case of communications and dissemination activities, it was essential to scrutinise how effective have those activities been in ensuring that PriMO-5G project results reached the right external stakeholders in an accessible and timely manner. To that end, four focus areas were considered, namely communications (5G), drones, machine learning/AI and public safety, and the respective stakeholders active in each focus area. In the case of exploitation activities, although majority of them are envisioned in the final year of the project (M25-M36), it was useful to review some of the early exploitation actions and ensure previous plans outlined in D6.2 remain valid.

In all cases, the review of the performance of dissemination, communications and exploitation activities is underpinned by measurable objectives (KPI values) and success criteria previously specified in D6.2 [PRIMO-5G_D6.3]. In the cases where the activities overachieved (achieved KPI far exceeded the success criteria), the KPI values have been revised to ensure that the ambition remains high. Whereas, in the cases were the activities fell short, specific interventions have been proposed and will be reviewed in subsequent periodic checkpoints. Specifically, the following future checkpoints envisioned for review of communications, dissemination and exploitation activities:

- Period 2 project report and second technical review meeting [around M25-M26]
- D6.4 Final dissemination and exploitation report [M36]
- Period 3 project report and third review meeting [1-2 month after project ending]

In addition to the formal reporting points above, an internal interim checkpoint for all the KPIs is added midway in the third year of the project (around M30-M31) to ensure timely interventions before the project ends.

References

[5GAmericas2019] 5G Americas white paper, "The Status of Open Source for 5G", February 2019.

http://www.5gamericas.org/files/6915/5070/2509/5G_Americas_White_Paper_The_Status_of_Open_Source_for_5G_Feb_2018.pdf

[5GPPP2019]   5G-PPP report, "Phase 3 (Part 2) Pre-structuring Model Version 2.0", November 2019.

https://5g-ppp.eu/wp-content/uploads/2019/09/190712_5GInfraPPP_PSM-Phase3.II_V2.0_Final.pdf

[EU2018]   European IPR Helpdesk. Making the Most of Your H2020 Project. Boosting the impact of your project through effective communication, dissemination and exploitation. March 2018. https://iprhelpdesk.eu/sites/default/files/EU-IPR-Brochure-Boosting-Impact-C-D-E.pdf

[PriMO-5G_D6.3] PriMO-5G D6.2 Dissemination and Exploitation Plan. September 2019 version. https://primo-5g.eu/download/415/