"5G for Drone-based Vertical Applications"

D6.2 – Annual report, year 1

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Approvals

	Name	Organization	Date
Coordinator	Jussi Haapola	UO	31.5.2020
Technical Committee	Pascal Bisson	THA	21.5.2020
Management Committee	Project Management Team, UMS, and NCSRD personnel	FRQ, AU, THA, UMS, AIR, UO, NCSRD (reviewer)	15.5.2020

Document History

Version	Contribution	Authors	Date
V1	**Integration of all Quarterly Management Reports QMR#1 to QMR#3, overall introduction**	**Jussi Haapola (UO), All Beneficiaries**	**27.4.2020**
V2	**Integration of QMR#4 to the report**	**Jussi Haapola (UO), All Beneficiaries**	**4.5.2020**
V3	**TM, WPL summaries and requested additions. Revision based on PMT comments. WP3 progress report.**	**Jussi Haapola (UO), TM, WPLs, and Reviewers (NCSRD, UMS)**	**15.5.2020**
V4	**Final inputs from Partners, TM review**	**All**	**27.5.2020**
V5	**Final refinement, preliminary D3.1 draft inclusion**	**Jussi Haapola (UO)**	**31.5.2020**

Executive Summary

The aim of this Annual report, year 1 is to report on the progress of 5G!Drones achieved during the 1st year of the project (June 1st, 2019 – May 31st, 2020). This Deliverable describes the state of 5G!Drones project at the Milestone MS2. It conducts a description of the overall activities of the project spanning up to M12 and subsequently describes the technical activities conducted at each Work Package, going down to individual Task level and contribution of each Beneficiary of the project.

This report takes a look at the main achievements of the project during the first year and the significant changes in the project Consortium occurred during the period. This report does not provide financial estimations statements of use of resources use it, but it provides an estimate of personnel resources expended in term of person months at project overall and Work Package levels. From the technical point of view, the summary of submitted deliverables along with remarks are described and the achieved Milestones of the project are captured, with remarks. The report captures the activities taken by the various project internal bodies and their contributions towards the objectives of the project.

The actual work carried out in Work Packages is described in detail. The description starts, in each Work Package and Task, with recapturing on what has been stated in the Description of Action (or Work, as used henceforth) followed with the main achievements of each Work Package, significant results obtained, and deviations from Description of Work. Subsequently the report addresses each Task of the Work Packages and each Beneficiary's specific contributions to the Tasks. The report also details the dissemination and exploitation activities taken by the project Beneficiaries during the period. The report further details the 5G!Drones project's achievements at 5G-PPP Programme level through participation to various bodies including Working Groups of interest where project has appointed representatives.

This report is intended mainly, as the summary of the 5G!Drones project activities during its first year of implementation for the EC to review. It also serves for the interested reader to gain an overview of the state of the project at M12 of its implementation.

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List of Beneficiaries

Participant No.	Part. Short name	Participant organisation name	Country
1 (Admin. Coordinator)	UO	OULUN YLIOPISTO	Finland
2 (Tech. Coordinator)	THA	THALES SIX GTS FRANCE SAS	France
3	ALE	ALERION	France
4	INV	ONESKY SARL (INVOLI)	Switzerland
5	HEP	Hepta Group Airborne OÜ	Estonia
6	NCSRD	NATIONAL CENTER FOR SCIENTIFIC RESEARCH “DEMOKRITOS"	Greece
7	AU	AALTO KORKEAKOULUSAATIO SR	Finland
8	COS	COSMOTE KINITES TILEPIKOINONIES AE	Greece
9	AIR	AIRBUS DS SLC	France
10	UMS	UNMANNED SYSTEMS LIMITED	United Kingdom
11	INF	INFOLYSIS P.C.	Greece
12	NOK	NOKIA SOLUTIONS AND NETWORKS OY	Finland
13	RXB	ROBOTS EXPERT FINLAND Ltd	Finland
14	EUR	EURECOM	France
15	DRR	DRONERADAR Sp z o.o.	Poland
16	CAF	CAFA TECH OÜ	Estonia
17	FRQ	FREQUENTIS AG	Austria
18	OPL	ORANGE POLSKA SPOLKA AKCYJNA	Poland
19	MOE	MUNICIPALITY OF EGALEO	Greece
20	ORA	ORANGE SA	France

List of Abbreviations and Definitions

ADS-B Automatic Dependent Surveillance – Broadcast

ANSP Air Navigation Service Provider

API	Application Interface
AppD	Application Descriptor
ASTM	American Society for Testing and Materials (Nowadays, ASTM International)
B2B	Business-to-Business
C2	Command and Control
CA	Consortium Agreement
CAA	Civil Aviation Authority
DASMO	Distributed Autonomous Slice Management and Orchestration
DL	Downlink
DoW	Description of Work
EAB	External Advisory Board.
EASA	European Union Aviation Safety Agency
ELK	Elasticsearch, Logstash, and Kibana
FBS	Functional Breakdown Structure
FIMS	Flight Information Management System
GCS	Ground Control Station
GUTMA	Global UTM Association
ICAO	International Civil Aviation Organization
IP	Intellectual Property
ITS	Intelligent Transport Systems
KPI	Key Performance Indicator
LL-MEC	Low Latency MEC
LTE-M	Long-Term Evolution Machine Type Communications
M#	Month of the implementation of the project action since June 1st, 2019
MEC	Multi-access Edge Computing
MEP	MEC Platform
NFV	Network Functions Virtualisation
NG-RAN	Next-Generation Radio Access Network
NSD	Network Service Descriptor
NSI	Network Slice Instance
NST	Network Slice Template

OAI	OpenAirInterface
PC	Project Coordinator
PM	Person Month
PMT	Project Management Team
RACI	Responsible, Accountable, Consulted, Informed (responsibility assignment matrix)
ROS	Robot Operating System
SDL	Scenario Description Language
SDN	Software-Defined Networking
SDO	Standards Development Organisation
TM	Technical Manager
U2U	UAV-to-UAV
UAS	Unmanned Aerial Systems
UAV	Unmanned Aerial Vehicle
UTM	UAS Traffic Management
UC	Use Case
UCxScy	Use Case Number x Scenario y
UL	Uplink
V2X	Vehicle-to-Everything
VIM	Virtualised Infrastructure Manager
VM	Virtual Machine
VNF	Virtualised Network Function
VNFD	VNF Descriptor
WF	Workforce
WP	Work Package
WPL	Work Package Leader
WS	Windows Script
WUI	Web User Interface

Definitions:

U-Space: U-space is a set of new services relying on a high level of digitalisation and automation of functions and specific procedures designed to support safe, efficient and secure access to airspace for large numbers of drones.

1. INTRODUCTION

This Deliverable summarises the key topics addressed, achievements and open issues for the first year of the 5G!Drones project from June 1st, 2019 to May 31st, 2020.

1.1. Main achievements

The main achievements of the project since its beginning are described in chronological order. The 5G!Drones project had its kick-off of the activities in June, 2019 organised at Thales SIX GTS France premises in Paris, France. During the meeting majority of the project operational mechanisms were established followed by a more formal documentation of them internally. Many of those procedures are reported in the Deliverable D6.1 – Data Management Plan and quality, and risk management plan. Work Package (WP) 1 activities were also initiated during the kick-off meeting. Negotiations of the Consortium Agreement (CA) were carried out and finalised during the first quarter year of the project. The Consortium submitted its first Amendment in August (M3) making adjustments on Partner level planned resources between WPs. The WP5 leadership was also changed from Partner NOK to Partner AIR with an amount of resource shifting from NOK to AIR reflecting the change of responsibilities.

The Work Packages 2 and 3 were started in September (M4), one month late from the original timeline mainly due to the holiday period disrupting efficient coordination of the activities. Since then these WPs did manage to catch up on time to deliver as expected . The Consortium held its second face-to-face meeting at Cosmote's facilities during October in Athens, Greece, where WP2 and WP3 had a good opportunity to organise the work and the internal Workforces within them. The second quarter of the project was mainly focused in producing Deliverables D1.1 – "Use case specifications and requirements" and D1.2 – "Initial description of the 5G trial facilities" that serve as foundations for the work of other WPs. Both D1.1 and D1.2 were finalised and submitted in December (M7), completing the project Milestone MS1. The Deliverable D5.1 - Communication, showcasing, dissemination and exploitation plan and standardization roadmap was already submitted in November (M6). During this period the 5G!Drones representation at 5G-PPP and 5G IA WGs level was finalised and the project started contributing to the activities, which included also needed contributions from e.g. 5G TB Workshop held with ICT-17, ICT-18 & ICT-19 Projects in October. The communication and dissemination activities continued along as planned. Internally the means of effective and efficient monitoring of progress at both project and programme level (with Quarterly Management Reports put in support) were agreed on.

The Consortium held a very successful third face-to-face meeting at Eurecom facilities in Sophia-Antipolis, France in January 2020. One of the main outcomes of the meeting was the shared and agreed overall system architecture for the project, addressing critical issues in Deliverables D4.1 – Integration Plan and D1.3 – 5G!Drones system architecture initial design finalization. The D4.1 and D1.3 were both submitted in February (M8) of the project. During the meeting the project also held meetings transcending WP boundaries to enable efficient transition of work from design to implementations and trials. The project continued to have a good level of involvement at 5G-PPP Programme level.

Overall the WPs performed as expected. WP2 and WP3 could not start on August (M3) as originally planned due to the holiday period and were thus delayed by 1 month, staring in M4. The work in both WPs has been expedited to such extent that both WPs are on time and there is no impact on reaching project or WP Objectives. WP4 also started one month late, in M7, mainly due to the efforts put into WP1 activities and especially completing deliverables D1.1 and D1.2 which function as the basis for WP4 work. As a consequence, D4.1 completion also suffered similar delay, partly also due to WP2 and WP3 delayed starting. At the Project Management Team (PMT) level, the delays in deliverables have been recognised. New measures have been put in place to be ready to engage and more closely monitor progress also to deal with inherent risks (e.g. risks now addressed at each of the PMT and on a per WP basis).

1.1.1. Changes in the Consortium

During the first quarter year of the project the WP5 leadership was changed from NOK to AIR. The change has been reflected in Amendment 1 of the project. Amendment 2 is currently under preparation and its main justification is to address the impacts that the covid-19 outbreak is causing to the implementation of the work.

1.1.1.1. Amendment 1

The main changes of Amendment 1 with respect to the original Description of Work (DoW) are as follows.

1. Beneficiary 11 (INF) shifted 6 PM from its WP2 resources to its WP1 resources. The reason for the change is that INF identified it requires to put significantly more effort to T1.1 as it is responsible for its final deliverable.
2. WP5 Leadership change from Beneficiary 12 (NOK) to 9 (AIR). The personnel working at NOK in the project are more technically oriented and do not have the experience in WP Leadership. AIR accepted the WP leadership as they have the experience and they are also involved in standardisation. The impacts are as follows
    a. 6 PM resource shift from NOK to AIR in WP5. At personnel cost rates 6 Person Months (PMs) from NOK translates to 5.08 PM for AIR.
    b. WP5 total PM decreases from 155 PM to 154.08 PM.
    c. Project total PM decreases from 1,369 PM to 1,368.08 PM.
    d. NOK total PMs changes from 92 PM to 86 PM.
    e. AIR total PMs changes from 67 PM to 72,08 PM.
3. Deliverable D6.1 delivery date is changed from M3 to M4. The Data Management Plan requirement is to be submitted at latest M6, hence there is no breach of that obligation. The delay is due to the holiday period disrupting execution of the action.
4. Changed all instances of Beneficiary 6 DEMOKRITOS short name from DEM to NCSRD. This was a request from NCSRD as their administration requires the use of NCSRD as short name.
5. The Administrative coordinator is changed from Prof. Ari Pouttu to Dr. Jussi Haapola along with the contact details.
6. For INFOLYSIS the Financial section, the personnel cost need to be split between the two categories "Direct personnel costs declared as actual costs" and "Direct personnel costs declared as unit costs". As an SME, INFOLYSIS has to fill in the field "Number of Units" at the SME owner/Natural person cost with 4000 units. This field had been filled in at the preparation level of GA but it was lost when it was finalised. Hence, here we correct a mistake made.
7. Fixed a few typographical errors.

1.1.1.2. Amendment 2

The procedure for Amendment 2 is open at M12. The Amendment 2 addresses mainly changes in project timeline due to the covid-19 outbreak delaying project implementation. The Amendment requests project extension by 6 months, to December 31st, 2022. The timeline shifts include changes in duration of the project, durations of Work Packages, durations of Tasks within WPs, deliverables submission deadlines' adjustment, project's Milestone achievement shifts, and addition of a WP6 deliverable at the end of the third year of the project to compensate for shifting of the project Final Report deadline.

2. RESOURCE UTILISATION

The resource utilisation figures provided here are estimates of the Beneficiaries. Real figures are only given in the context of periodic reports at M18 and M36 in Deliverables D6.3 and D6.5, respectively.

2.1. Estimated overall resource use

The estimated resource use graph of the overall project in terms of PMs is illustrated in Figure 1. The figure shows declared resources used per quarter year of the project, cumulative PM use, and an illustrative linear resource use accumulation for understanding the trends in use of resources. As can be seen from the figure, the resource use was quite low overall during the first quarter year. This is mainly due to only WP1, 5, and 6 being active. WP2 and 3 started activities during the second quarter year of the project and the resource use began to increase. Quarter year four shows slightly less resource use increment than expected due to challenges in conducting implementation and trials related work due to covid-19 pandemic caused restrictions.

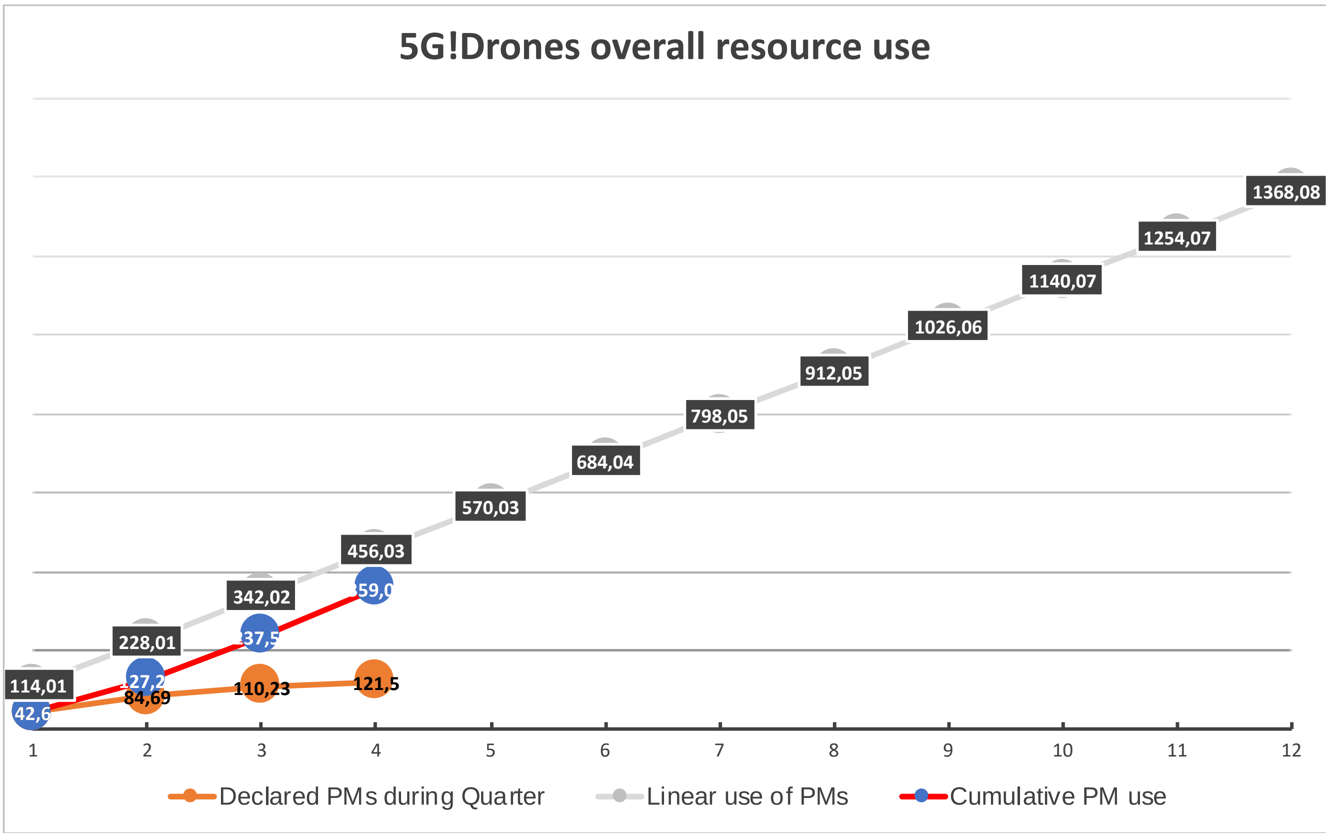

Figure 1: 5G!Drones project overall 1st year resource use.

2.2. Work Package level resource use

Next the estimated project resource use is shown at WP level. The presented illustrative linear resource use accumulation should be only used for understanding the trends in use of resources, and not as a target for resource use.

2.2.1. Work Package 1 resource use

The estimated resource use of WP1 is illustrated in Figure 2. As can be observed the resource use during the first year has been relatively high, as expected. The WP1 provides significant groundwork for the project and there has been in total five deliverables produced by the WP during year one. After year one, only two of the WP1 tasks remain active, hence less resources are expected to be used in the following periods.

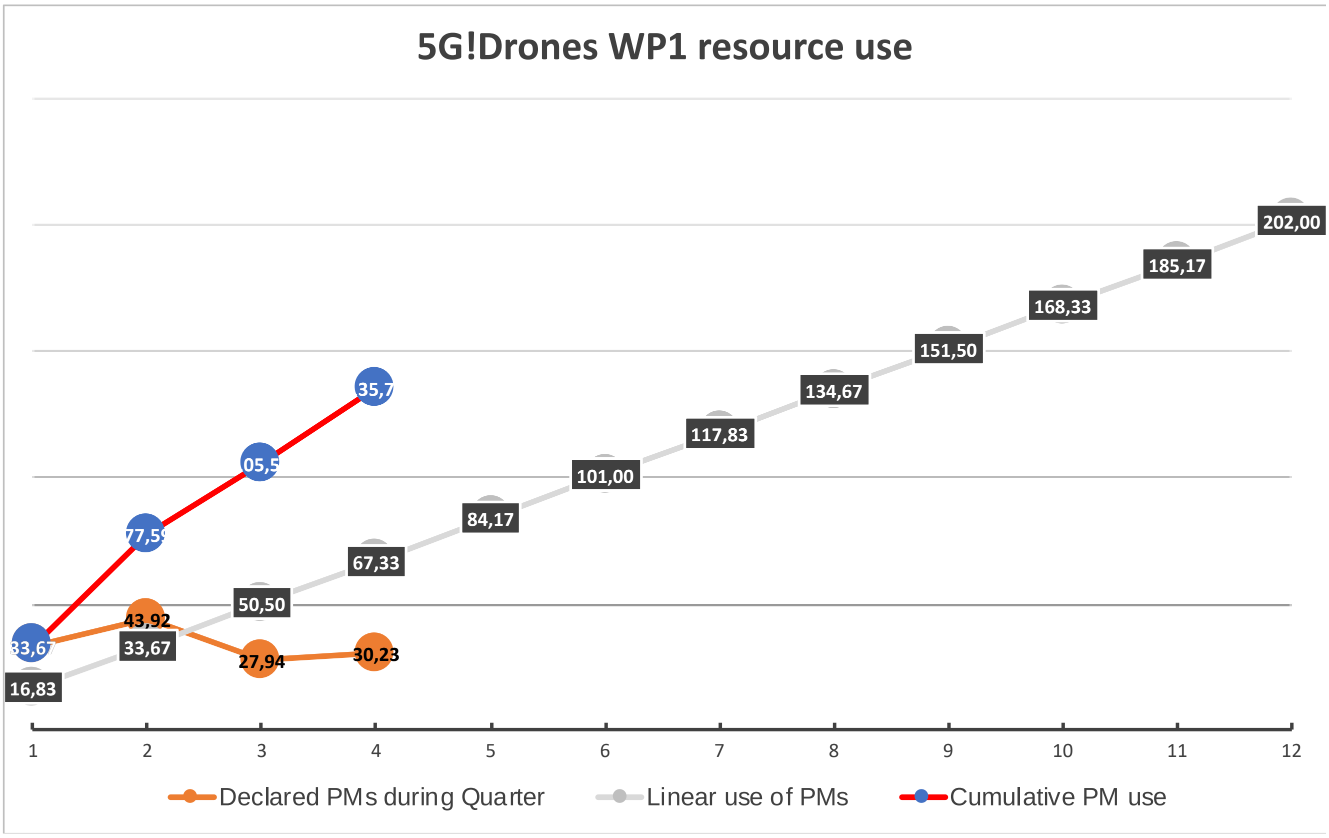

Figure 2: 5G!Drones project Work Package 1, 1st year resource use.

2.2.2. Work Package 2 resource use

The estimated resource use of WP2 is illustrated in Figure 3. As can be seen from the figure, work did not start during the first quarter year of the project. Since then the resource use has picked up, but the WP1 efforts limit WP2 use to some extent. Majority of WP2 effort is expected to be used during year 2 of the project and it is reflected in the number of Deliverables scheduled for WP2 during the second year.

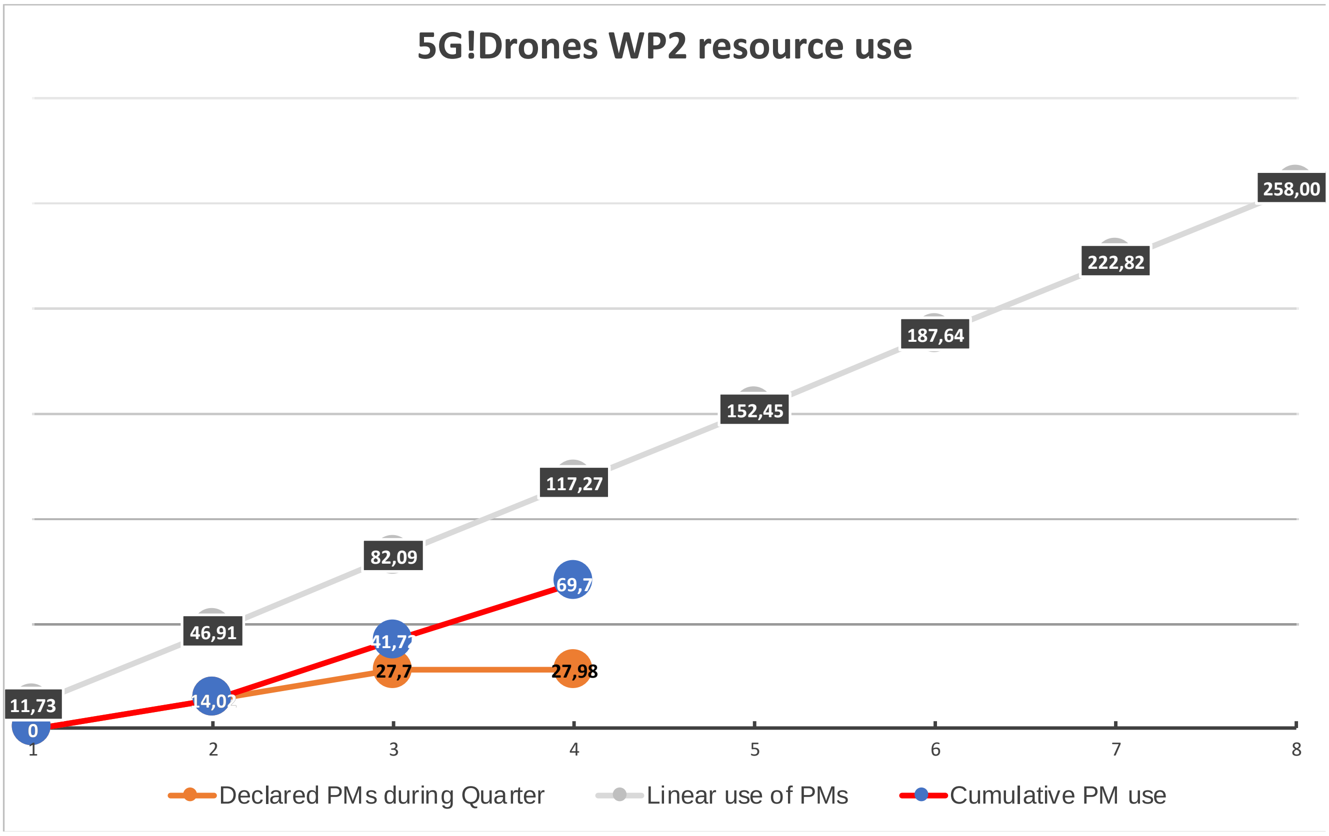

Figure 3: 5G!Drones project Work Package 2, 1st year resource use.

2.2.3. Work Package 3 resource use

The estimated resource use of WP3 is illustrated in Figure 4. As can be seen from the figure, work did not start during the first quarter year of the project. Since then the resource use has picked up, but the WP1 efforts limit WP3 use to some extent. Majority of WP3 effort is expected to be used during year 2 of the project and the first quarter of year 3, as the work is dependent on WP1 work and to some extent WP2 work.

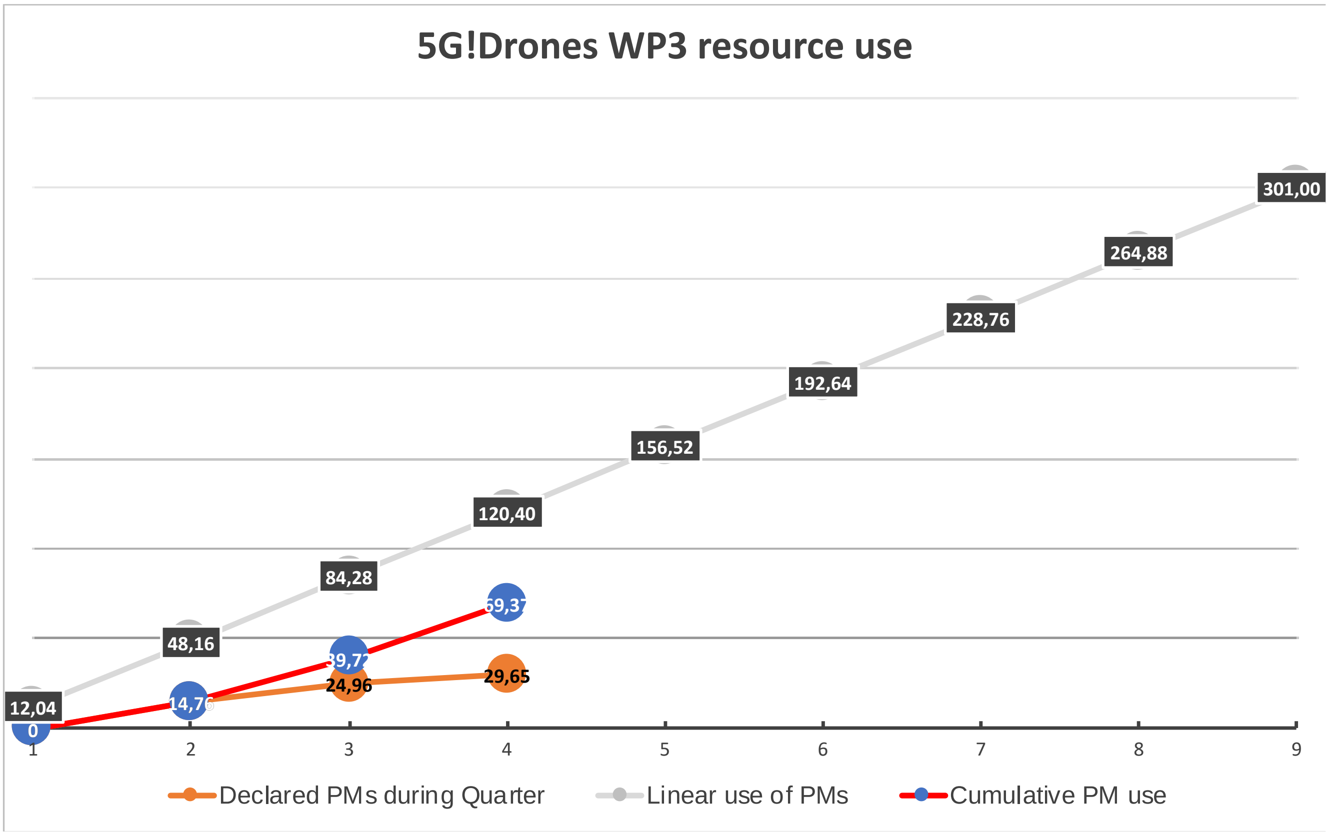

Figure 4: 5G!Drones project Work Package 3, 1st year resource use.

2.2.4. Work Package 4 resource use

The estimated resource use of WP4 is illustrated in Figure 5. As can be seen from the figure, work did start at M6 of the project. Only the Task 4.1 was significantly active during the first year of the project, Task 4.2 starting at M12. Considering only one Task of the WP4 was active most of the year, the WP4 resource use has been as expected. The covid-19 pandemic impact on this integration and trial validation WP is starting to show during the fourth quarter year of the project. Originally, trial feasibility tests were planned during the fourth quarter, but those have been delayed due to restrictions in travel, access to facilities, and ability to work in groups.

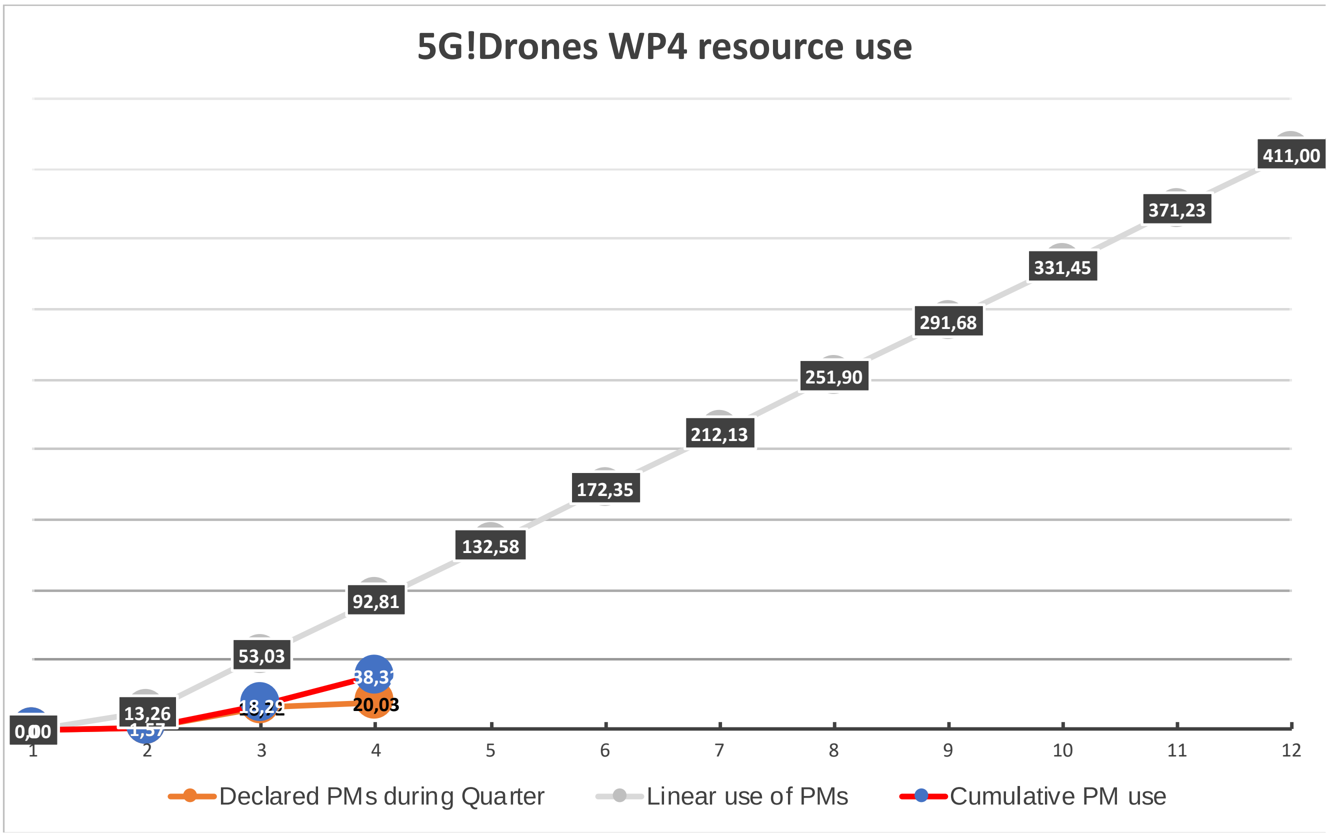

Figure 5: 5G!Drones project Work Package 4, 1st year resource use.

2.2.5. Work Package 5 resource use

The estimated resource use of WP5 is illustrated in Figure 6. As can be seen from the figure, WP5 activities have been picking up as more and more material of the project becomes available. The fourth quarter year of the project saw equal amount of dissemination work to third quarter year as the covid-19 pandemic is affecting all forms of events starting first with dissemination but also standardisation, and exploitation.

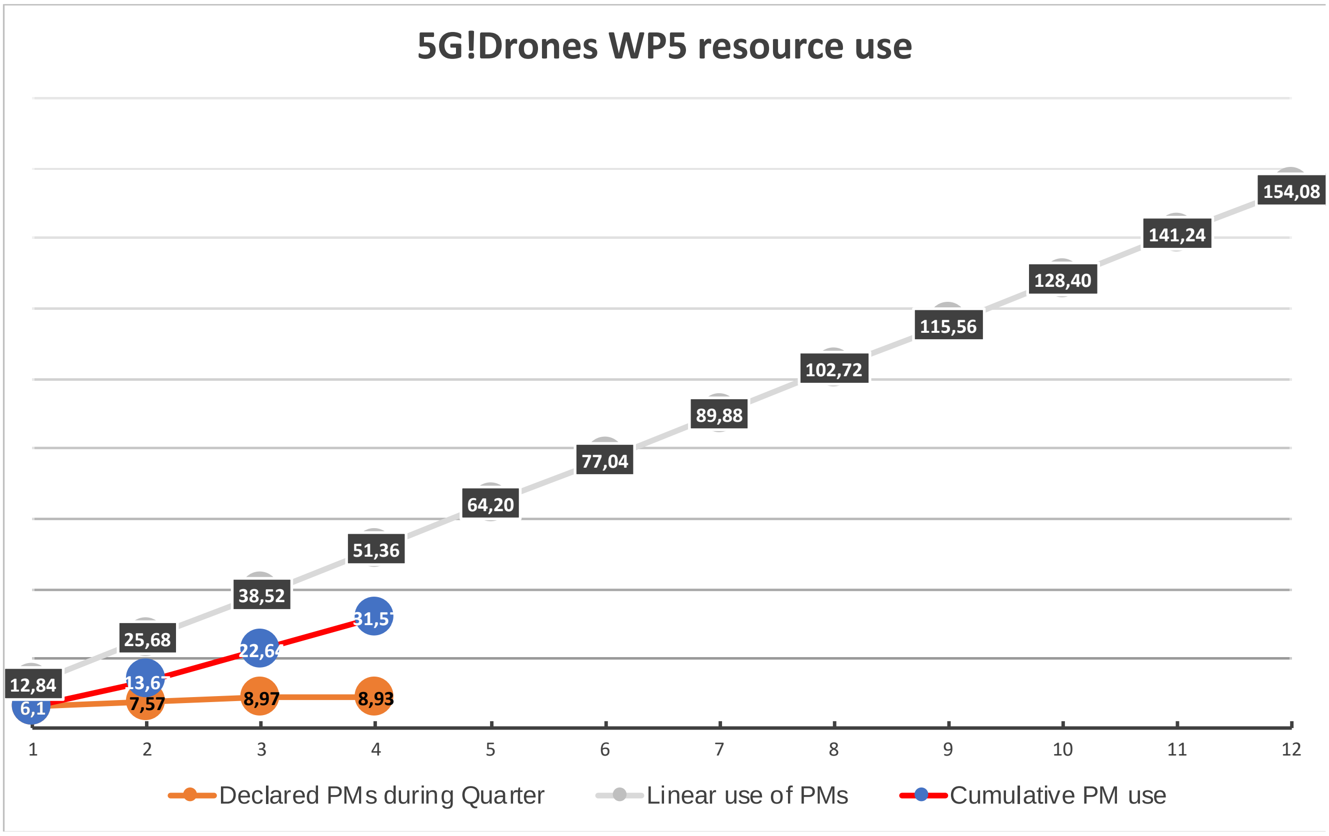

Figure 6: 5G!Drones project Work Package 5, 1st year resource use.

2.2.6. Work Package 6 resource use

The estimated resource use of WP6 is illustrated in Figure 7. As can be seen from the figure, the project management WP has had fairly stable resource use, increasing slightly as new WPs and project collaborations, e.g. 5G-PPP activities begun.

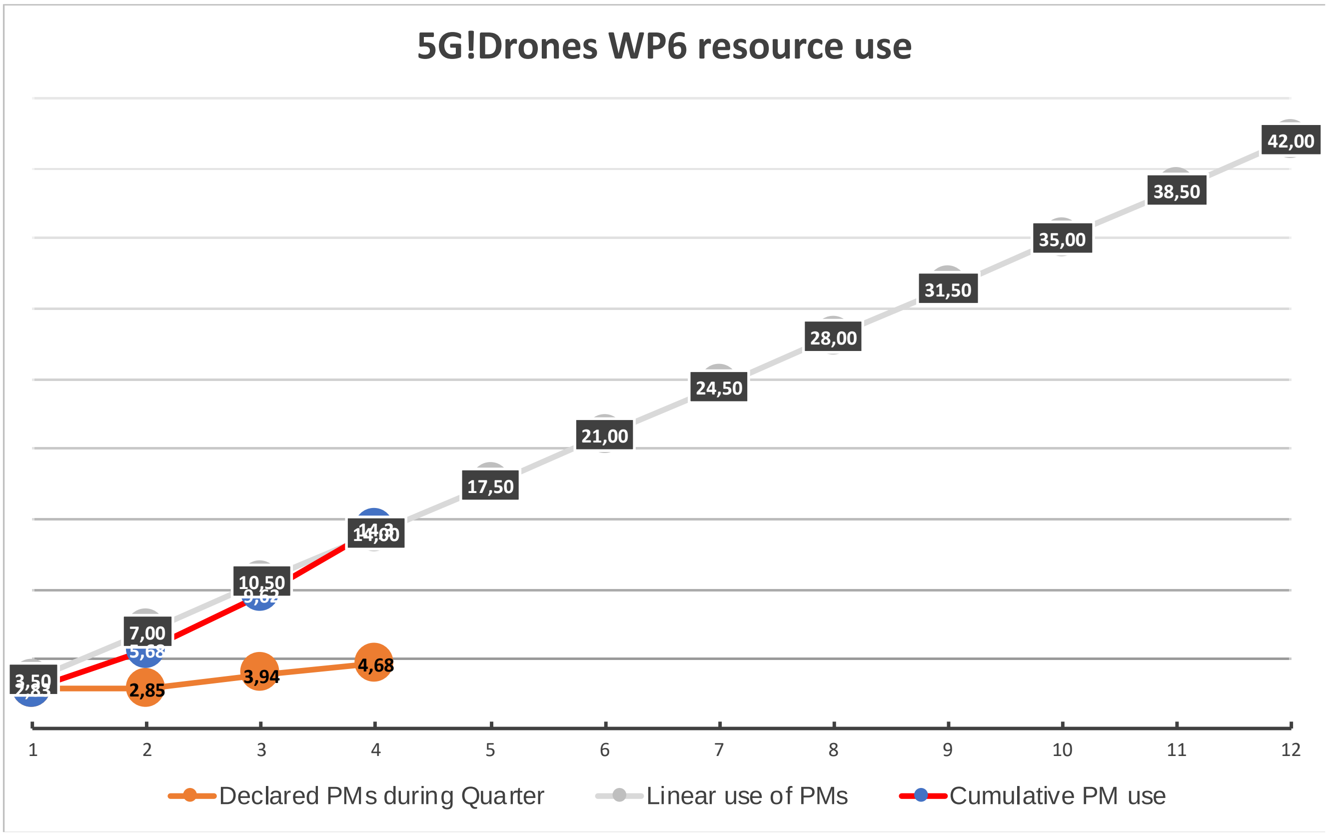

Figure 7: 5G!Drones project Work Package 6, 1st year resource use.

3. DELIVERABLES

The Table 1 contains the list of the deliverables that were due in the reporting period. The table describes the Deliverable number, the name of the Deliverable, its associated WP, responsible beneficiary, Deliverable type, its dissemination level, its due delivery month from DoW, and its actual submission date to the Commission.

Table 1: Deliverables due during the reporting period

Del. #	Name of Deliverable	WP #	Lead Benefi-ciary	Type	Dissem-ination level	Contr-actual delivery	Actual Delivery date
D6.1	Data Management Plan and quality and risk management plan	6	UO	ORDP	Public	M4 (Amend-ment 1)	30.9.2019 (M4)

D1.1	Use case specifications and requirements	1	UMS	Report	Public	M6	23.12.2019 (M7)
D1.2	Initial description of the 5G trial facilities	1	UO	Report	Public	M6	19.12.2019 (M7)
D5.1	Communication, showcasing, dissemination and exploitation plan and standardization roadmap	5	INF	Report	Public	M6	30.11.2019 (M6)
D4.1	Integration Plan	4	DRR	Report	Public	M7	08.02.2020 (early M9)
D1.3	5G!Drones system architecture initial design	1	ORA	Report	Public	M8	28.02.2020 (M9)
D1.4	Report on UAV business and regulatory ecosystem and the role of 5G	1	CAF	Report	Public	M12	31.05.2020 (M12)
D1.5	Description of the 5G trial facilities and use case mapping	1	UO	Report	Public	M12	29.05.2020 (M12)
D2.1	Initial definition of the trial controller architecture, mechanisms, and APIs	2	AU	Report	Public	M12	31.05.2020 (M12)
D6.2	Annual report, year 1	6	UO	Report	Public	M12	31.05.2020 (M12)

3.1. Remarks on Deliverables

In the original Description of Work, the Deliverable D6.1 was scheduled for M3. The delivery date was changed to M4 in Amendment 1 to factor in the holiday periods, which took place during the first three months of the project. During the reported period, 4 deliverables have been delivered late, namely: D1.1, D1.2 due M6 but delivered M7; D4.1 due M7 but delivered M9; and D1.3 due M8 but delivered M9. The reasons for Deliverable delays are as follows.

The D1.2 submission to Commission portal was discussed during the monthly Project Management Team meeting at end of November. During the discussion the PMT decided to carry out one final round of review to root out any inconsistencies that we found out in the deliverable. The 5G!Drones project desires to produce deliverables of high quality, so instead of meeting the deadline, the Consortium conducted one more internal review of the deliverable and decided to submit the deliverable in December. The D1.2 was submitted on 19.12.2019.

The goal of task T1.2 is to re-evaluate the use cases and trial scenarios that were defined at a high level in the proposal submitted to the EC. Based on the current state of the vertical market, the availability of commercial 5G technology, and the status of the trial facilities, potential necessary adjustments and additions needed to be identified for the trial scenarios. The results of this study formed the basis of the D1.1 where a detailed definition of the use case scenarios were provided. The D1.1 was due in M6 and marked the completion of the task T1.2. D1.1 has an important role in 5G!Drones, since its outcomes drive the activities in T1.4, T2.4, T3.1, T3.4, T4.2, and T4.3. The objective of D1.1 is to introduce the reader to both the 5G and the Unmanned Aerial Vehicle (UAV) ecosystem and their various components. Furthermore, D1.1 assists the reader in understanding the scenarios in detail by providing context for the following topics:

1. Description of the scenario,
2. UAV service components,
3. Workflow of the scenario,
4. Information on the UAVs being used for the trial,
5. Application performance requirements and vertical-service-level key performance indicators (KPIs),
6. 5G and infrastructure requirements, and
7. 5G KPIs.

Summary of D1.1 delay: Work on this deliverable began after the kick-off meeting of WP1 in mid-June with the intention to have the deliverable submitted for an internal review by the end of October. An initial table of contents (ToC) was produced to structure content and scenario leaders were assigned, responsible for producing the content, manage their respective scenarios in collaboration with interested partners. Given that this was the first time a relatively large number of partners from the 5G and UAV ecosystem were working together the time taken to establish working relationships as well as overcoming the steep learning curve of understanding each other's ecosystems has taken longer than anticipated. This combined with the summer holiday period, the earliest time to get all partners on the same platform to progress and accelerate this process of relationship building, increase understanding of each other's ecosystems and use case scenarios was the Athens face-to-face meeting in mid-October. After the fruitful face-to-face discussions in Athens, work on this deliverable was accelerated with partners from COS, NCSRD, FRQ, DRR, CAF, HEP, and UMS working collaboratively to work on the background section of the deliverable as well as the UC4:SC1 in line with the 3GPP TR 22.829 v17.1.0 report. Once the background section had reached an acceptable level of maturity, it was circulated to the other scenario leaders who were requested to organize their existing content according to the new structure.

UMS as the D1.1 responsible beneficiary proposed the following action plan to deliver the D1.1 within the December timeline.

1. UMS anticipated that the new structure will be ready to circulate by Monday, December 2nd.
2. The use case scenario leaders provided their updated content by Monday, December 9th.
3. UMS compiled the document and made it ready for an internal review by Friday, December 13th.
4. With a timeline of 1 week allocated for internal review, UMS anticipated making final changes to the document and made it ready for submission to the Commission Portal by Monday, December 23rd.

Unfortunately, the late submission of Deliverables D1.1 and D1.2 had a cascading effect to D4.1 and caused to have it also delayed. As the decisions and outcomes of WP1, WP2, and WP3 formed the basis of D4.1, it was important that an initial consensus was a reached on the architecture and use case component elements within these WPs before an initial integration plan was devised and proposed. The fact that WP2 and WP3 have begun with a slight delay has had an impact on the delivery of D4.1. The D4.1 submission to Commission portal was discussed during the General Assembly and monthly Project Management Team meeting at end of January in conjunction with the face-to-face meeting in Sophia-Antipolis. The General Assembly decided significant changes were required in the deliverable in light of the consensus reached on the 5G!Drones overall architecture and the submission of D4.1 was further delayed by one week. The submission of D4.1 was done on February 8th, 2020.

The Consortium decided to make significant changes to the initial system architecture and the depth with which the project aimed to present it during the face-to-face meeting in Sophia-Antipolis at the end of January. This decision had an effect on the delivery of D1.3. The deliverable had a submission deadline of January, but the change in the system architecture needed revision work. The updated plan was to have the D1.3 in project internal review on February 14th and the deliverable was submitted on February 28th, 2020.

Work Package 3 did not have any deliverables due during the first year of the project implementation. As a consequence, the Consortium has decided to provide a separate WP3 progress report of its activities and a preliminary draft of Deliverable D3.1 – Report on infrastructure-level enablers for 5G!Drones as appendices (Appendix 1 – Work Package 3 – 1st year progress report and Appendix 2 – Preliminary Draft of D3.1 – Initial Report on infrastructure-level enablers for 5G!Drones) of this Annual report, year 1. The WP3 activities at task level have further been described in Section 7.3.

4. MILESTONES

The Table 2 presents the milestones of the project due during the first year of the project. The two milestones are verified by the delivery of deliverables associated with them from the DoW. The table describes the Milestone identified, the actions related to it, the method of validation for the milestones, related WPs to validation, responsible Beneficiary, completion of Milestone from DoW, and actual submission dates of validation documents.

Table 2: Milestones during the reporting period

No	Name	Validation	WP #	Lead Beneficiary	Contr-actual completion	Actual completion
MS1	Use cases defined	D1.1 (UMS)	1	THA	M6	23.12.2019
	Communication, showcasing, dissemination and exploitation plan and standardization roadmap defined.	D5.1 (INF)	5	THA		30.11.2019
MS2	Initial version of the 5G!Drones architecture ready	D1.3 (ORA)	1	FRQ	M12	28.02.2020
	Detailed description of facilities available and use cases mapped to facilities	D1.5 (UO)	1	FRQ		29.05.2020
	Additional required functionality at the facility level identified	D1.3 (ORA), D1.4 (CAF), D1.5 (UO)		FRQ		31.5.2020

4.1. Remarks on Milestones

During the reporting period two MSs were in scope (i.e. MS1 and MS2). Significant work has been done to meet the milestones and all deliverables attached to them have been delivered. Nevertheless, Milestone MS1 due M6 was fully completed during M7, one month late for reasons explained in Section 3.1.

At Milestone MS2 a very significant deliverable, D2.1 - Initial definition of the trial controller architecture, mechanisms, and APIs has also been delivered as can be seen from Table 1. In the DoW is has not been included as MS2 means of validation, but it serves an important role towards attaining the Objectives of the project.

5. PROJECT BODIES AND MEETINGS

5.1. General Assembly / Plenary meeting

The 5G!Drones project officially started on June 1st. The kick-off meeting and first GA took place respectively on June 10th to 12th, 2019 hosted by Thales at SIX GTS France in Gennevilliers. Minutes have been produced, accepted, and uploaded on the project document repository together with material presented and discussed.

The 2nd General Assembly was hosted by Cosmote in Athens, Greece on October 15th – 17th, 2019. Minutes have been produced, accepted, and uploaded on the project document repository together with material presented and discussed.

The 3rd General Assembly was hosted by Eurecom in Sophia-Antipolis, France on January 28th – 30th, 2020. Minutes have been produced, accepted, and uploaded on the project document repository together with material presented and discussed.

The planned 4th physical General assembly to be hosted by Frequentis in Vienna, Austria on May 25th – 26th was cancelled due to the covid-19 outbreak making travel and convening not possible. Instead a virtual General Assembly was held at the same dates using the projects established teleconferencing channels in Microsoft Teams. Minutes have been produced and uploaded on the project document repository together with material presented and discussed.

5.2. Project Management Team

The Project Management Team consisting of the Project Coordinator (PC), Technical Manager (TM), and Work Package Leaders (WPLs) had regular meetings (28/06, 02/08, 30/08, 04/10, 29/11, 29/01, 28/02, 28/03, 24/04) over the reported period where progress towards objectives was reviewed and discussed to further drive the project according to work plan defined. For each of these meetings minutes were produced and uploaded on workspace. It has become customary that all partners of the project may partake and contribute to PMT activities, but it is the core PMT, which drives the activities leading to General Assembly matters.

5.3. Facility Coordination Team

During the period, work was initiated to further interact with the facilities of concern (namely 5GENESIS and 5G-EVE). This work was performed by partners involved in those platforms and supported by the TM and others. The work mainly consists of aligning on the topics to be discussed/covered (5G!Drones Use Case (UC) requirements) and also gaining insights in platform offerings to date versus to come through planned upgrades/releases. 5G!Drones project followed here the approach coming from each of the platforms (e.g. 5G-EVE questionnaire requested to get filled in in by each and every ICT-19 projects). In addition, work has been conducted on gaining insights of facilities' offering, ranging from trials to service going through underlying architecture in order to come up with shared and agreed overall architecture for the 5G!Drones project.

5.4. External Advisory board

No External Advisory Board (EAB) meeting was organised during the reported period. The main reason comes from a decision made by the Consortium to wait for enough content to be there prior to engage with the EAB. Further to this, the objective was to have early results to discuss with them such as the ones from trial feasibility tests. Unfortunately, due to covid-19 feasibility tests have been delayed. In any case, reaching the project Milestone MS2 provides sufficient material to engage the EAB. Plans have been set for this to happen by this Fall, 2020.

5.5. Innovation Management Team

At project kick-off the Consortium started to exchange views on Innovation Management Team (IMT) with an objective to agree on it in order to have it setup in the coming months and to be ready when needed. Objective remains to have IMT operational to advise the PMT on the results as soon as they will come. The IMT composition was re-discussed based on proposals made and it was finally setup at GA held in Sophia-Antipolis. An initial set of action items on which to engage was defined and progressed since there. TM demanded for IMT to report on activities performed at regular PMT meetings in order to monitor and assess their progress. During the first year of the project the IMT has identified the following topics the 5G!Drones could bring added value to.

Innovation related to the regulation
Problem: Currently it is not allowed to use modems and mobile phones on board an UAV in Finland mainly based on unsolved interference issues. Also, restrictions apply in France as well.

Innovation: EPT ECC conducted a research in 2018-2020 to evaluate the use of Mobile Fixed Communication Networks for the communication links of Unmanned Aircrafts (UAs). The Report nr 309 (final draft published 23.04.2020). ECC Report nr 309 studies in its ANNEX 3 and ANNEX 17 **show that the interference from aerial UEs in adjacent channel is negligible** compared to the case of adjacent interference caused by ground UEs.

Use of drones in the frequency bands 700 MHz, 800 MHz, 900 MHz, 1800 MHz, 2 GHz, 2.6 GHz and 3.5 GHz open promising prospects for applications using modems or mobile phones. The constraints remain moderate and linked to the protection of certain uses in the adjacent strip:

- In the 700 MHz band, drones will have to fly more than 30 meters from the ground in order to avoid interference to TV broadcasting receivers.
- National conditions will have to be established to protect earth stations in the 3.4-4.2 GHz bands (based on minimum radius of UAV or antenna ERP).

Innovation related to UAV-to-UAV (U2U) real time position sharing

Position broadcast (Telemetry) is used in aviation primarily to provide information about aircraft's identification and location. The main worldwide standards for such are:

- Interrogation transponders working in A, A&C, S modes (require Interrogator),
- ADS-B (Automatic Dependent Surveillance – Broadcast) system,
- FLARM, and
- OGN.

The main issues on the topic are:

- The International Civil Aviation Organization (ICAO) 24-bits address issue: only 16,777,214 codes are available, which will not sufficient when including UAVs.
- Privacy concerns: ADS-B are publicly available with connection to the Identification repository.
- Possibility of sending additional information: intensions (HDG change), Battery condition, etc.

The problem is direct two-way Vehicle-to-Everything (V2X) communication using telecommunications networks and potential redistribution of the information to manned aviation. The cellular V2X definitions over the ETSI Intelligent Transport Systems (ITS) currently do exist and there is an ongoing activity to produce such standard for the 5G New Radio Cellular-V2X. The ETSI ITS has made communications specifications[1], which could suit also U2U communications. The IMT will continue to analyse the topic and map innovation in the field of U2U.

6. PROGRESS OF TECHNICAL WORK AND ACHIEVEMENTS

This section reports on major work performed and achievements obtained for each of the 5G!Drones project objectives.

6.1. Summary and progress towards project objectives

Objective 1 "Analysis of the performance requirements of UAV verticals": A deep analysis of the UAV use case requirements in terms of the needed network functionalities and the required application performance to validate. Business models will be also derived.

5G!Drones UAV use cases as stated in DoW have been revisited, complemented, and confirmed in terms of both feasibility and market relevance perspective. Within each of the four broad UAV-based Use Case categories identified to benefit from the large-scale deployment of 5G networks, twelve scenarios (including three sub-scenarios) have been identified as candidates to be trialled over the available 5G testing facilities to test and validate 5G KPIs. D1.1 *Use case specifications and requirements* provides a description of each of the use case scenarios detailing hardware and software enabling components for the UAV trial to take place. It also provides information on the 5G network and drone requirements required to deploy the trials as well as lists the application performance requirements and vertical-service-level KPIs that are critical to be measured during the trials.

Further to this an initial analysis of the UAV market, the regulation and legislation to date vs. to come, as well as the role 5G technology could play was also performed. This has been fully documented in D1.4 "UAV business and regulatory ecosystem and the role of 5G". This is used to ensure proper alignment of the whole (development & trial) work towards useful and usable results. This is also in favour to have results widely adopted and generate new business opportunities through provision of

[1] ETSI TS 102 637-1 V1.1.1 (2010-09) and ETSI EN 302 637-3 V1.2.1 (2014-09)
https://www.etsi.org/deliver/etsi_ts/102600_102699/10263701/01.01.01_60/ts_10263701v010101p.pdf
https://www.etsi.org/deliver/etsi_en/302600_302699/30263702/01.03.01_30/en_30263702v010301v.pdf

newly enabled UAV services.

Objective 1 has been worked out by WP1 mainly through task 1.1 “Analysis of the UAV business and regulatory ecosystem and the role of 5G technology” and task 1.2 “Use case assessment and refinement” which have respectively delivered D1.4 and D1.1.

Objective 2 “Design and implementation of the 5G!Drones software layer (or system) to execute UAV trial”: Design and implement the 5G!Drones trial system, which will be in charge of running the UAV trials using the ICT-17 facility components and 5G!Drones enablers developed during the project. The envisioned 5G!Drones system abstracts the low-level details on the usage of 5G facilities resources, by providing a high-level API to describe, run and obtain results on the specific KPIs.

Several significant progress steps have also been reported by key technical deliverables.

- **High-level design of 5G!Drones overall architecture** to support the UAV use cases over a federated, multi-domain 5G infrastructure, as well as to manage successful execution of their trials. This architecture fully documented in D1.3 has been produced by WP1 but most importantly has been shared and agreed by other WPs since made actionable from their side. Indeed the overall 5G!Drones architecture, while stressing structuring environmental concepts (e.g. 5G network slice, MEC as well as UTM & U-Space) and embracing relevant standardisation work, depicts the major building blocks needed to get it realised namely the Portal, the Trial Controller, the Abstraction Layer, the 5G Facility Infrastructure Monitoring, the U-Space entity and the U-Space Adapter. It also presents in detail the cornerstone of the envisaged architecture, the 5G!Drones Trial Controller its components and their interaction , as well as the UAV verticals and the 5G Facilities, in order to enforce the relevant UAV service logic. Last but not least it also stress some of the identified gaps at first supporting 5G Facilities level (i.e. X-Network, 5GEVE, 5GTN and 5GENESIS) and second, enablers level to cover the UAV use case requirements.
- **5G trial Facilities description:** description of 5G Facilities was provided initial on M6 through deliverable D1.2 with insights on each of the 5G trail facilities, namely: the 5GENESIS, Athens 5G site, the 5G-EVE, Sophia Antipolis 5G site, Aalto university X-network, and the University of Oulu 5G Test Network (5GTN). Initial description of 5G facilities was further refined and extended in the context of D1.5 (M12) that extensively describes each of the 5G facilities required to carry out trial experiments in the 5G!Drones adding some of the details which were missing in previous deliverables (e.g. radio and core network capabilities, edge computing technologies supported, interactions with the trial controller) while considering features upgrades as well as security mechanisms in place. Furthermore, the mapping of use case scenarios and facilities. The initial mapping of use-case scenarios and facilities (in D1.2) was advanced and made actionable since now expressed (in D1.5) as a set of functional components that will permit the deployment of a given scenario. These components are first mapped within architecture proper to each scenario deployment, and then categorized into UAV components, UAV operator components, UTM components, and 5G components.
- **Trial controller**: an initial version of the Trial Controller architecture, its mechanisms and APIs has been worked out by WP2 and fully documented in D2.1. This work leverages on overall design of 5G!Drones architecture from D1.3 and further details trial controller, its components (Trial Scenario Execution Engine, Trial Architecture Management Plane, KPI Assessment, Data Gathering) their interaction as well as supporting mechanisms and/or algorithms. Further to this D2.1 also emphasizes on references points derived and that are key towards the definition of the Trial Controller APIs. Apart from paving the way towards the next release of the trial controller architecture, mechanisms and APIs (aka D2.4), D2.1 was also made actionable to other WP and more specifically WP4 to figure components to integrate, test and validate from Trial Controller perspective.

Objective 3 "Design a high-level scenario descriptor language to run and analyse the results of the UAV trials": Design a high-level (or Northbound) API to allow a UAV vertical to configure a trial and run the test.

This objective in scope of WP2 was mainly covered during the period by worked performed on T2.1 **"**Trial execution APIs for verticals and experimenters**"** and T2.3 **"**Trial architecture management plan**"**. Results achieved have been detailed and reflected in D2.1. With focus put on the provision of high-level scenario description languages and APIs, as well as mechanisms to translate scenarios to deployments using the APIs provided by facilities and the 5G!Drones enablers, a Functional Breakdown Structure (FBS) for Web Portals describing all the functions, required to be performed by the experimenter to specify his test was defined. From this FBS a Scenario Description Language was defined, with all the details and information elements, which are required to work with Web Portals 1 and 2, and to define the experiment. Based on this, the prototype APIs were designed. This initial work which has delivered will be continued and further detailed and documented in the context of implementations of the web portals.

Objective 4 "Design and implementation of 5G!Drones enablers for UAV trials and operations": 5G!Drones will use the 5G facilities provided by i) EURECOM (5G EVE– Sophia Antipolis, France), ii) NCSR Demokritos and the Municipality of Egaleo (5GENESIS, Athens, Greece), in addition to iii) the 5GTN platform available at the University of Oulu, Finland and iv) the X-Network facility available at the Aalto University, Finland. Based on the analysis of the target UAV use cases, 5G features of these platforms will be used, and, when deemed appropriate, additional software will be developed by the project, and additional UAV-relevant hardware will be acquired. These new components represent the 5G!Drones enablers. Particularly, 5G!Drones will focus on improving Network Slicing functionalities, as UAVs require at least two running network slices; one for command and control (type uRLLC) and one for the data plane (type eMBB or mMTC). The security of each of these network slices will be also investigated and duly addressed. Moreover, a UAV traffic management service based on virtual reality allowing control and/or supervision of multiple UAVs operating in the same area will be studied.

Objective 4 has been worked out by WP2, WP3, and WP4 following technical progress achieved by WP1 ranging from the Use Cases detailed (D1.1), the High-level design of 5G!Drones overall architecture (i.e. D1.3), initial (M6/D1.2) and refined description of the 5G facilities (M12/D1.5). This has been performed while taking into consideration additional work performed in the context of D1.4. This has framed the work of WP2 and WP3. The former has delivered initial description of Trial Controller seen as one of the core enabler despite coarse-grained. The later has been working on initial list of enablers (see WP3 appendices for details form Section 9 to Section 14) under work (specification / development).

Based on information coming from the work performed by WP1, WP2, and WP3, WP4 has specified an initial integration plan which has been reported in D4.1. A 4-phased iterative process of Build-Deploy-Cycles per facility has been devised and the basic steps and involved interactions for each integration activity have been defined. This initial integration plan has been shared and agreed with other WPs and more specifically WP2 and WP4 that will deliver components/enablers to be tested integrated in the context of the test cases to be trialled.

Objective 5 "Validate 5G KPIs that demonstrate execution of UAV use cases": According to the envisioned UAV use cases and scenarios, several 5G KPIs need to be

demonstrated and tested to validate UAV application requirements. As per the ambitious requirements of 5G, the most critical ones are: • End-to-end latency of < 1ms, (URLLC use cases) • 1000 times higher mobile data volume per geographical area, (eMBB use cases) • 10 to 100 times more connected devices (mMTC use cases)

This objective is in scope of two tasks of WP4 which have either barely started or not started at all, namely T4.2 “Preparation and execution of trials” (M12-M36) and T4.3 “Evaluation of trial results (M20-M36). As such there is no progress to report yet except preliminary discussions in view of 5G KPIs to validate coming from UAV use cases description as stated in D1.1.

Objective 6 “Validate UAV KPIs using 5G”: Many UAV applications, and particularly Unmanned Aerial Systems (UAS) traffic management (UTM), require very challenging KPIs such as low latency, security, coverage, high data rates, all of which are hard to attain in current networks. One advantage of 5G is its ability to ensure the aforementioned KPIs. Therefore, 5G!Drones will focus on validating the UAV use case application KPIs, carefully taking care of the UTM use case, as it is the main enabler of all other envisioned UAV use cases..

This objective is in scope of two tasks of WP4 which have either barely started or not started at all, namely T4.2 “Preparation and execution of trials” (M12-M36) and T4.3 “Evaluation of trial results (M20-M36). As such there is no progress to report yet except preliminary discussions in view of UAV KPIs to validate coming from UAV use cases description as stated in D1.1.

Objective 7 “Advanced data analytics tools to visualise and deeply analyse the trial results, and provide feedback to the 5G and UAV ecosystem”: By using data analytics tools, each use case scenario will be carefully studied in terms of performance, aiming at drawing conclusions and recommendations to the 5G and UAV ecosystems. The feedback can be used as input to standardisation bodies, such as 3GPP or ETSI MEC, in order to optimise or update 5G standards for UAV

This objective is mainly in scope of WP2 task T2.4 “Tools for experiment data analysis and visualization” and WP4 task T4.3. Due to the fact T4.3 from WP4 has not yet started, the progress comes mainly from WP2 and Task 2.4.

During the period several investigations, leading to some experimentations, of available tools for data aggregation, analysis and visualisation (e.g. Elasticsearch, Logstash, and Kibana) have been performed by partners and a survey was conducted. All results have been delivered and discussed in order to further converge towards selection of the most appropriate data analysis and visualisation tools to cover Use Cases requirements. Integration of those tools was also looked at and further progressed under overall trial architecture perspective (e.g. relation between the trial enforcement module and the data extraction and visualisation/analytics) in view of the refined 5G!Drones architecture.

Objective 8 “Dissemination, standardisation and exploitation of 5G!Drones Description Dissemination, standardisation and exploitation of all concepts and**” :** Dissemination, standardisation and exploitation of all concepts and technologies developed in the 5G!Drones project. A special focus is given to showcasing components of the project in UAV- and 5G-related events.

Initial plans for what concerns dissemination, showcasing, exploitation and standardisation have been started and reported in D5.1 “Communication, showcasing, dissemination, exploitation plan and standardization roadmap”. The project has performed and delivered according the plans despite it has to adapt to situation caused by covid-19 (some dissemination events were cancelled or went virtual). 5G!Drones has been presented within private and public events on numerous occasions and has had very active online presence through website, social media, and updated newsletters issued. 5G!Drones has been very active at the 5G-PPP Programme through various bodies ranging from Steering Board and Technology Board but also Working Groups of interest for which the project had appointed representatives (see 5G-PPP devoted section for the details in Section 8).

7. PROGRESS AND ACHIEVEMENTS OF THE WORK PACKAGES

The following sections provide a detailed description of the work carried out in the Work Packages of the project. Each Work Package first describes its overall summary. The summary is followed by the Work Package objectives, respective to those found in the Description of Work and, subsequently, the description highlights the main achievements and progress over the reporting period. The work carried out in each of the tasks of the respective Work Package are described in detail along with the individual Beneficiary contributions to those tasks.

7.1. WP1 Use case requirements and system architecture

7.1.1. Progress towards objectives and details for each task [FRQ]

WP1 Objectives

- Objective 1: **“Analysis of the performance requirements of UAV verticals’ applications and business models in 5G”**
- Objective 2: **“Design and implementation of the 5G!Drones software layer (or system) to execute UAV trials”**
- Objective 3: **“Design a high-level scenario descriptor language to run and analyse the results of the UAV trials”**
- Objective 4: **“Design and implementation of 5G!Drones enablers for UAV trial and operations”**.

WP tasks and interrelations:

- T1.1: Analysis of the UAV business and regulatory ecosystem and the role of 5G technology (M01-M36)
- T1.2: Use case assessment and refinement (M01-M06)
- T1.3: Detailed description of 5G facilities and mapping with the vertical use cases (M1-M12)
- T1.4: System architecture for the support of the vertical use cases (M1-M18)

Main Progress in the period:

Starting from kick-off meeting in June 2019, WP1 leader, has set up a series of regular bi-weekly meetings to monitor and control the project activities and achieving the WP1 goals, giving the task leaders the opportunity to report the progress of work performed during the period. All partners have

been comprehensively exploiting the bi-weekly meetings for ex-change of ideas and administrative and technical discussions. At the first meeting on July 1st, 2019, the efforts in tasks T1.1, T1.2, T1.3, and T1.4 were assigned to the partners based on their capabilities and interests, achieving a good basis for the further development. WP1 has successfully submitted the Deliverables D1.1, D1.2, and D1.3 with a delay of 1 month compared to the project schedule, contingent on prerequisite initial harmonising efforts among the UAV verticals and 5G stakeholders. It has also submitted the Deliverables D1.4 and D1.5. The work package's first year has been very deliverable intensive, producing in total five deliverables.

Significant results

After the WP kick-off meeting use case scenarios have been assigned for Beneficiaries. The most significant results of WP1 during the first year are:

- D1.1 – Use case specifications and requirements,
- D1.2 – Initial description of the 5G trial facilities,
- D1.3 – 5G!Drones system architecture initial design,
- D1.4 – Report on UAV business and regulatory ecosystem and the role of 5G, and
- D1.5 – Description of the 5G trial facilities and use case mapping

The results published in deliverables include selection and finalisation of use case scenarios in D1.1, specifications of trial facilities in D1.2 and their evolved description mapping use cases to facilities in D1.5, elaboration of regulations regarding 5G!Drones implementation in Finland, Greece, and France in D1.4, and reaching a Consortium consensus on the 5G!Drones overall architecture in D1.3.

Deviations from Annex I and impact on other tasks, available resources and planning

The deliverable D1.1, D1.2, and D1.3 experienced a one-month delay in submission. The delay of D1.1. has led to extension of task T1.2 work by three weeks, which ended on M7 instead of M6.

Reasoning for failing to achieve critical objectives and/or not being on schedule

The one-month delay in submission of D1.1, D1.2, and D1.3 were mainly due to additional effort needed for complexity of harmonisation of UAV and 5G requirements and their respective ecosystems. The reasons for deliverable delays have been further elaborated in Section 3.1.

7.1.2. Task 1.1 Analysis of the UAV business and regulatory ecosystem and the role of 5G technology (M01-M36) [CAF]

Task Objectives:
A basic premise of the 5G!Drones project is that 5G technology will provide the technical means and thus provide new opportunities for the provision of enhanced UAV services. The purpose of this task is thus to provide a detailed analysis of the current state of the UAV market with a particular focus on the role of 5G technology in it. This analysis will identify key application areas where 5G technology can help provide new or enhanced services, and how each stakeholder in the UAV-service-related value chain (UAV equipment vendors, vendors of telecommunications equipment, network operators, UAV service providers, regulatory bodies), and the society at large, can benefit from these developments. At the same time, this task will pay particular attention to regulatory aspects, since the related legislation to perform UAV flight operations is currently subject to significant changes and may have impact on both how UAV vertical services should operate (e.g., necessitating UAS Traffic Management modules onboard), and how the 5G!Drones trials will be executed. The activities of this task and their outcomes, which will be reported in **D1.4**, will provide input to T1.2 for the refinement and detailed descriptions of the target use case scenarios. Before the end of the project, and after the

trial results get evaluated, the analyses of this task will be reassessed, taking into account also the changes in the market, regulatory and technological landscape that will have taken place after the delivery of D1.4. This study will deliver an updated version of D1.4, using insight from the results of the trials to provide recommendations and study market perspectives (deliverable **D1.7**).

Task Activities during the period: In June 2019, the team was formed and work was organised. First, the source materials were collected and then the updating of the D1.4 document was started on an ongoing basis. As there have been many developments in the field of UAVs over the past year in both the UAV Business and Regulatory areas, partners have continuously contributed the latest information to the D1.4 document. All partners have been actively involved in compiling D1.4 UAV Businesses Regulatory Ecosystem and 5G role.

Partners from countries where trials are planned - Finland, France, and Greece - are especially helpful. This ensures a very good overview of local regulations (both in the field of UAVs and radio communication rules). In May 2020, the compilation of D1.4 has been completed. D1.4 – "Report on UAV business and regulatory ecosystem and the role of 5G" provides a comprehensive overview of both UAV verticals in both commercial and government (civilian drone use). EU regulation is also thoroughly discussed, as well as separate regulations in Finland, France, and Greece, both for UAV flights and radio communication equipment. It also analyses how 5G technology can be used for drone services. Task 1.1 has provided input to Taskforce in the planning and design of T1.2 Use Cases, with both UAV business and regulation inputs. Task 1.1 has provided inputs to Taskforce for T4.2 Trials, what are the regulatory requirements and recent changes. The D1.4 report also provide inputs to the 5G!Drones project on what activities to start towards Standardisation Organisations to initiate improvements to technical recommendations and regulations for the use of 5G technology. Improvements are needed to support the deployment of 5G technology in UAV based services.

The breakdown of the contribution, results, deviation and proposed corrective action of each partner in this task are described next. Regular partner activities, such as participation to teleconferences and face-to-face meetings will not be reported independently as they are considered the default a Beneficiary partaking a task would do.

1-UO does not participate in this Task.

2-THA has followed up the Task activities in order to identify and anticipate future needs for enabling primarily the Use Cases identified for the project. THA reviewed D1.4 and provided comments. There has been no deviation from the expected contributions.

3-ALE has focused on the French UAV and 5G-related regulations providing input to the Task activities and D1.4. There has been no deviation from the expected contributions in the first two quarters of the project. ALE had no activity in the third quarter as no update on the regulation was needed. ALE made contributions to D1.4 regarding the Role of 5G technology related to 5G!Drones Use Cases and it reviewed D1.4.

4-INV has contributed to the discussion and provided inputs on drone markets, business, and regulatory aspects. It has participated to specific alignment calls and discussions and it has engaged in exchanges with the members of the Consortium on the regulatory aspects. INV has further conducted a review of drone market related materials. INV contributed to D1.4 document by writing the description of the legacy Radio Control methods used by DJI in comparison to 5G communication. INV was also triggering the discussion to re-arrange the chapter 4 of D1.4 and an author of the first draft of the table summarising the advantages of 5G over the legacy UAS connectivity solutions. At the end we have also proposed our product called KIVU tracker as the Remote ID solution to be used during the tests. There has been no deviation from the expected contributions.

5-HEP does not participate in this Task.

6-NCSRD has made contributions to the role of 5G in the UAV industry and identified and provided 3GPP relevant references for use case definitions. Furthermore, NCSRD has made contributions on Deliverable D1.4, especially concerning the Athens site (regulations and Use Case). NCSRD participated in the investigation of the business-related aspects of the use case planned to take place in Athens/5GENESIS platform, considering also the various components that formulate the scenario (e.g. multiple UAS traffic management (UTM) etc). NCSRD reviewed D1.4 and provided comments. There has been no deviation from the expected contributions.

7-AU did not start on this Task until the second quarter of the project. AU has both analysed and investigated UAV business aspects for the scenario ‘UAV-based IoT data collection’. AU has been contributing to the deliverable D1.4 and providing inputs related to the role of 5G in the scenario "UAV-based IoT data collection". It has reviewed the deliverable D1.4, especially the sections assigned for AU to review. There has been no deviation from the expected contributions.

8-COS did not start on this Task until the second quarter of the project. Since then, COS has provided support for the analysis of the 5G and UAV regulatory ecosystem. It has contributed as an author in Deliverable 1.4, Sections 3 and 4. It made a revision of Deliverable D1.4 in Sections 3 & 4 and editorial and formatting changes. There has been no deviation from the expected contributions.

9-AIR does not participate in this Task.

10-UMS did not start on this Task until the third quarter of the project. It had provided input to D1.4 in Sections 2.3.2, 2.3.5, and 4.2 and made a review of Deliverable D1.4. There has been no deviation from the expected contributions.

11-INF has participated in refinement of Task and D1.4 objectives as per DoW. It has made contributions to excel file summarising on drone markets, business and 5G aspects. INF has initiated the communication of business aspects of the project through 5G!Drones social media channels. The partner has been very actively involved in D1.4 from the creation of table of contents to contributions in sections 1, 2 and 4 concerning the defined use cases (business and market analysis, statistics, impact, models), etc. including also subsections 2.4 and 4.5. INF has further participated in review and editing of the D1.4 including the latest working versions plus additional sections related to list of tables, list of figures, abbreviations, captions, and references throughout the document as well as sections 1.1, 1.2, 1.3, and Section 5. INF has considered and performed communication of business and market aspects of the project through 5G!Drones social media channels and website throughout year 1 period. There has been no deviation from the expected contributions.

12-NOK has contributed in this Task with specification of 5G requirements and it has shared information about 5G. It made contributions to D1.4 working versions, sections 3.3.2, 4.1, 4.2.2. NOK made a review and commented D1.4 working versions. There has been no deviation from the expected contributions.

13-RXB did not start on this Task until the second quarter of the project. Since then RXB has contributed on D1.4 in sections 4.3, 4.4, 2.2.6, 2.2.4, 2.3.5. RXB has further participated in multi-lateral discussions related to business cases and business models with partners from OPL, FRQ and CAF. There has been no deviation from the expected contributions.

14-EUR has contributed to the discussion on the impact of 5G on UAV use-cases and it has made contributions to the Deliverable D1.4. There has been no deviation from the expected contributions.

15-DRR has contributed to discussions by meeting with Polish civil aviation authority (CAA) and air navigation service provider (ANSP) on further legislation development. It has contributed to D1.4 and

carried out legal framework tracking (European Union Aviation Safety Agency, EASA). It made clarifications to UC4Sc1 UTM related requirements (application of dedicated UTM and telemetry link) and updated D1.4 sections 2.4.1 and 2.2.4 (8). There has been no deviation from the expected contributions.

***16*-CAF** as Task leader and D1.4 responsible beneficiary has led the D1.4 workforce. It has driven the D1.4 activities, analysed EASA and European and national regulations regarding UAV flights and radio communications, organised work in the Task, made UAV Market and regulation analyses, and made contributions to D1.4. UAVs business sectors analysis. CAF made UAV related radio communication regulation analysis and had discussions with partners regarding contributions. CAF finalised D1.4. There has been no deviation from the expected contributions.

17-FRQ is the WP1 leader and has contributed to the task by leading the WP1 bi-weekly meetings performing preparation, distribution and tracking of agenda, Minutes of Meetings, and Action Points. It has initiated and monitored the drafting of Table of Contents (ToC) for D1.4 and proposed addition of section "Market Analysis" per Use Case basis. FRQ has made comprehensive contribution and constructive discussion by bringing Deliverable D1.1 use cases actively to D1.4. FRQ further proposed to study the Madrid declaration for potential impacts on D1.4. FRQ proposed to monitor and to report the EASA opinion on U-space regulation on a regular basis. There has been no deviation from the expected contributions.

18-OPL has conducted study and analysis of regulatory ecosystem (bodies, projects, concepts, rules, requirements, procedures etc.) in unmanned aerial systems (UAS) domain. It has made analysis of regulatory aspect of RF for 5G (band-plan for 5G) and provided a 5G/slicing tutorial in the second face-to-face meeting in Athens. OPL has conducted a review of D1.4 draft version and prepared remarks on 5G bands issue. It has further participated in multilateral discussions, led by EUR after the third face-to-face meeting in Sophia-Antipolis about the aviation-telco business ecosystem and mutual interactions between the domains within business processes. There has been no deviation from the expected contributions.

19-MOE does not participate in this Task.

20-ORA does not participate in this Task.

7.1.3. Task 1.2 Use case assessment and refinement (M01-M06) [UMS]

Task Objectives:
The 5G!Drones project has already defined a set of use cases aiming to cover a wide range of UAV services. For each use case, a number of trial scenarios have been defined at a high level, along with the requirements in terms of 5G system functionality (e.g. types of network slices), 5G KPIs and vertical-related KPIs that will be measured. However, as new developments emerge both at the vertical-service level and the 5G system level, these use cases need to be reassessed. The main purpose of this task is to re-evaluate the decided use cases and the trial scenarios, in order to ensure their feasibility and market relevance, and identify potential necessary adjustments following the current state of the vertical market, the availability of commercial 5G technology and the status of trial facilities. This study will lead to a detailed definition of the target use case scenarios, which will be reported in **D1.1**. The definition of the use cases will include the following information:

- UAV service components that will be included as software and/or hardware onboard the UAVs and at remote infrastructures, as well as the role of each partner in providing or realizing them.
- Detailed workflows for each application scenario, including the intra-component communication, timing, and information flows.

- Types, technical specifications, and numbers of UAVs that will be used for trialing the use case scenario.
- Application performance requirements and vertical-service-level KPIs that are critical to be measured during the trials.
- 5G and other infrastructure support requirements, which will be the basis for the design and implementation of the overall system architecture (T1.3) and the 5G!Drones enablers (WP3).
- 5G KPIs that are relevant with the use case scenarios and that will be monitored during the trials.

This is a critical task, since its outcome will drive many other activities, and in particular those of

- T1.4, to ensure that the 5G!Drones architecture design support the target use cases,
- T2.4, to select the appropriate data analysis and visualization tools to cover the important aspects of each use case,
- T3.1, so that the network slice management enablers can support the performance, isolation, and other requirements (e.g. security) of each use case,
- T3.4, for the development of the necessary UAV service components that each use case entails,
- T4.2, for the preparation and execution of trials,
- T4.3, to appropriately interpret the results of the trials.

Task Activities during the period:

Since the duration of T1.2: "Use case assessment and refinement" was quite brief, majority of the efforts spent on this task were in understanding the exact use case scenarios that could be trialled over the 5G test facilities. To this effect, use case scenario leaders were identified who were responsible for identifying and assessing the scenarios. As part of the assessment the scenario leaders collaborated with the partners involved in the task to conduct the following activities:

1. Description of the scenario;
2. Architecture of the trials;
3. Identification and description of UAVs, service components, and 5G network capabilities;
4. A high-level workflow of the scenario;
5. Target KPIs and;
6. Use case requirements.

These activities were documented and submitted as part of D1.1: Use case specifications and requirements.

The breakdown of the contribution, results, deviation and proposed corrective action of each partner in this task are described next. Regular partner activities, such as participation to teleconferences and face-to-face meetings will not be reported independently as they are considered the default a Beneficiary partaking a task would do. The Task completed its work at Submission of Deliverable D1.1.

1-UO has collaborated with NOK in preparing and refining the 3D Mapping Use Case and it has provided an updated description of the Use Case. It has contributed to the discussions and updates of the table of contents and UAV service components. Evaluation has been conducted with Use Case leaders of 5GTN capabilities to be designated for several scenarios to be trialled. UO has provided inputs to D1.1 on the 3D mapping Use Case with refinement of the Use Case requirements. In December, UO provided additional contributions to finalize deliverable D1.1 for submission to the Commission. After submission of D1.1 work has been carried out to assess the implications of the deliverable on 5GTN facility. There has been no deviation from the expected contributions.

2-THA has participated to discussion engaged on refinement of UC definition (with focus on Public Safety & UTM) with focus on deliverable D1.1. It has carried out discussion with THA Business line of concern in order to shape contribution to Use Cases of concern. THA has proposed and provided three Use Case scenarios to D1.1 and participation to the discussion related to the refinement of the Use Cases. Further, it has participated to the editing of the deliverable D1.1 especially for UC it has proposed, but also others and with specific focus (e.g. 5G requirements incl. security). THA conducted a Consortium internal review of the deliverable D1.1.

Deviation and corrective action: less effort than initially expected could be devoted during the first quarter of the project because, firstly, of the holiday season and secondly, because it took more time than expected to interface and exchange with the THA Business Line. More effort was dedicated to the Task during the second quarter of the project. As for successive quarters, normal effort was put forth.

3-ALE has proposed various scenarios to trial and it started the discussion between the partners involved in Use Case 3 Scenario 1 (UC3Sc1). ALE suggested the idea to have several sub-scenarios under UC3Sc1 in order to give every partner the chance to trial their scenario. ALE provided a draft and complete description of its sub-scenario for UC3Sc1 along with the UAV service components requirements. Contributions to the D1.1 were made following sections assigned to ALE. There has been no deviation from the expected contributions.

4-INV has provided inputs to UAV service components excel sheets and subsequent discussions around the components. It has participated to the ToC discussion, reviewing, providing inputs, and revision of the D1.1. INV provided scenario description skeleton for UC1Sc1 (UTM command & control). Further, it edited sections and chapters of D1.1 and provided the description of and revised UC1Sc1 based on project partner feedback. INV also made comments and proposed edits for D1.1 document related to contributions from other partners. There has been no deviation from the expected contributions.

5-HEP proposed UC3Sc1 sub-scenario 2 (Power Line Inspection beyond visual line-of-sight (BVLOS)) formulation and championed it for D1.1. HEP also participated in D1.1 UC4Sc1 discussion and helped to develop its description to be used as a template for other scenarios. It also made other contributions to D1.1. Further contributions were made after submission of D1.1 on the feasibility of the use cases. Also inputs for other WPs were given about the use cases. HEP has been supporting other tasks in WP1: giving input to D1.4 and D1.5.

Deviation and corrective action: HEP did not participate in teleconferences during the summer holiday period and internal communication errors but recovered later on with additional resources.

6-NCSRD proposed initial design of UC4Sc1 and contributed the scenario to D1.1. It defined different variants of the UC4Sc1 suitable for trialling taking into account safety concerns of the risk assessment. In addition to UC4Sc1 contributions to D1.1 NCSRD also contributed to sections 1., 2.1, 2.2, 2.3.1, 3.1, 2.1, and 3.4.4. There has been no deviation from the expected contributions.

7-AU assumed the leadership of the scenario UC3Sc2 and provided evaluation and assessment of the scenario against the facility of Aalto University. It provided inputs on the scenario and in addition to the section 'NB-IoT' in D1.1. Moreover, AU addressed the sections assigned to it in the deliverable D1.1 and re-edited UC3Sc2 scenario as per the common template provided agreed on later. There has been no deviation from the expected contributions.

8-COS contributed with identification of the target 5G ecosystem, related requirements and KPIs framework. It further contributed to the evaluation of the initial Use Cases and related descriptions. COS provided support for the description of the UC4Sc1 to be run on 5GENESIS facility and supported the formulation of the expected Deliverable D1.1 content with proposed templates and descriptions.

COS contributed to the definition of the common experimentation requirements and to the 3GPP UAV KPIs and requirements summary. COS was a contributing author in Deliverable D1.1 Sections 1, 2.1, 2.2, 2.3.1, 3.1, 2.1, 3.4.4, and Annexes. There has been no deviation from the expected contributions.

9-AIR led 'public safety' use case, 'monitoring a wildfire' scenario and coordinated partners' effort and contribution to refine this use case. In particular, AIR provided the backbone for building a strong and relevant scenario based on their expertise on fire fighters' communication knowledge. AIR integrated the mission critical services aspects mandatory in this type of use cases. AIR provided services components, 5G infrastructure requirements, and non-5G infrastructures requirements as well as 5G KPIs to be measured. AIR made revision of the scenarios as new requirements emerged and the 5G!Drones architecture had been detailed. AIR has converted use case functional requirements to architectural and technical requirements for feeding WP3 with inputs. It has lead monitoring wildfire use case to map the use case description to components available on 5GEVE platform and provided the fundamental architecture on which the trial will base on. There has been no deviation from the expected contributions.

10-UMS led the work on delivering D1.1. It prepared a draft ToC and requested feedback from all partners, defined use case scenario leaders in collaboration with partners, provided input on UAV service components excel, and organised dedicated calls on D1.1. As T1.2 leader, UMS collected inputs from partners, aligned them within the structure of D1.1 and reviewed the entire document. UMS contributed to UC2Sc1, UC2Sc2, and UC4Sc1. It compiled inputs from all partners to finalise the D1.1 and managed the project internal review process. There has been no deviation from the expected contributions, although D1.1 was submitted on M7 due to previously detailed reasons.

11-INF conducted an overview of the Task and D1.1 objectives as per DoW and participated in refinement of the proposed UCs definition as per DoW. INF identified the required 5G and business ecosystem characteristics and related requirements framework for the UCs and made contributions to the evaluation and definition of the initial use cases and related descriptions (as per DoW). INF has monitored all the activities for communicating the results through social media and website. INF made contributions to D1.1 on use case compliance with DoW and grouping of them and provided text on deliverable objectives, scope and target audience sections. It made high level contributions to D1.1 on use cases description and scenarios, and also reviewed the working documents of D1.1 providing comments. It made detailed analysis of the content of D1.1 (Use Cases) for updating the project website and creating content for the social media channels. In specific, INF conducted a detailed analysis of the content of D1.1 (Use Cases) for linking them to D1.4 (business and market perspective) and creating content for T5.1 activities. There has been no deviation from the expected contributions.

12-NOK has collaborated with UO on UC1Sc2 and UC3Sc3 content and contributed to scenarios requirements for test facilities and collaborated with UO, UMS, and CAF on the scenarios review. NOK created the first draft of UC3Sc3. NOK has further contributed to D1.1 for several scenarios. In December, NOK did content review and check of material for deliverable D1.1. There has been no deviation from the expected contributions.

13-RXB did not start on the task in the first quarter of the project. It has participated in multilateral discussions related to business cases and business models with partners from OPL, FRQ, and CAF.

14-EUR has prepared a presentation of the 5GEVE EURECOM facility, covering its features and its limitations regarding the envisioned Use Cases to run on the facility. It has been a contributor and reviewer of D1.1. There has been no deviation from the expected contributions.

15-DRR has collaborated with OPL on contributions to UAV/5G requirements. It developed and contributed to 5G features vs. Use Case scenarios worksheet and developed, submitted and reviewed the Wildfire scenario UC2Sc1 for D1.1. DRR has made further refinement of UC2Sc2 and further overall Use Case development. There has been no deviation from the expected contributions.

16-CAF has made updates on D1.1 UC3Sc1 Sub-Scenario2 description. It has participated in D1.1 UC4S1 discussion and helping to develop its description to be used as a template for other scenarios. CAF made contributions to D1.1 ToC and prepared, submitted, and refined UC1Sc3, UC2Sc3, UC3Sc3, and it made contributions to UC1Sc2, UC2Sc1, UC2Sc2, UC3Sc1, UC3Sc2, and UC4Sc1. In addition, CAF analysed and provided for all scenarios their regulation aspect sub-sections. There has been no deviation from the expected contributions. *17*-FRQ led the WP1 bi-weekly meetings performing preparation, distribution and tracking of agenda, MoM and AP. It Initiated and monitored the drafting of Table of Content (ToC) for D1.1 and organised telco voting to identify the interested partners for each of the 12 use case scenarios. FRQ has made comprehensive contribution and constructive discussion on the specification of use cases in D1.1. It has also organised and performed an internal review process on D1.1. FRQ has also participated in intensive discussions on the role of mobility management and promoted the answers to the questions to WP1 on D1.1 (by WP3). There has been no deviation from the expected contributions. *18-OPL* has participated in the development and contribution of 5G features vs. Use Case scenarios worksheet and collaborated with DRR on contribution for UAV/5G requirements. Also, in collaboration with DRR, OPL prepared a detailed reference description of the Wildfire scenario for D1.1. OPL has made an analysis of D1.1 in terms of required 5G enablers and features and has searched for tools on 3D RF coverage estimation. There has been no deviation from the expected contributions. *19-MOE* has contributed to the evaluation of the initial use cases and related descriptions. It has supported the description of the UC4Sc1 to be run in 5GENESIS facility (Municipality of Egaleo premises). MOE had contributed to the design and description of UC4Sc1 for D1.1. There has been no deviation from the expected contributions. *20*-ORA has made contributions to D1.1 for UC4/ Long-Term Evolution Machine Type Communications (LTE-M). It has reviewed D1.1 for consistency check of D1.3, regarding use cases. ORA has contributed to D1.1 regarding architecture summary. There has been no deviation from the expected contributions.

7.1.4. Task 1.3 Detailed description of 5G facilities and mapping with the vertical use cases (M1-M12) [UO]

Task Objectives: The goal of this task is to provide a detailed description of the supported functionality of each trial facility, including the 5G features that are available, as well as existing interfaces to access the platforms. Since the ICT-17 trial facilities that will be used by 5G!Drones (5G EVE, Sophia Antipolis, France, and 5GENESIS, Athens, Greece) and the complementary X-Network (Aalto, Espoo, Finland) and 5GTN (Oulu, Finland) testbeds will be evolving in parallel with 5G!Drones, it is critical to maintain an up to date view of their development status. T1.3 will work in close coordination with T1.2 to map vertical use case features to facility components. An initial mapping of high-level use case scenarios to facilities has already been carried out. This task will deliver a fine-grained mapping at the UAV service component level. This will be based on the capabilities of each facility and the features each use case aims to showcase, also taking into account other criteria such as regulation and logistics (e.g., in case it is only possible or more efficient from an administrative/licensing/logistics perspective to fly drones with specific characteristics provided by a

partner near a specific trial site, while hosting other management components of the UAV service at another).

Finally, this task will identify critical missing components of the 5G facilities for the support of the selected use cases, provide feedback to facility operators, and provide input to T1.4 for the design of the 5G!Drones enablers. T1.3 will deliver an initial 5G facility description at M06 (**D1.2**), which will be updated together with the final use case mapping (**D1.5**) at M12 in order to be used for the preparation and execution of trials (T4.2).

Task Activities during the period: During the first year of the 5G!Drones project, Task 1.3 which is focused on the description of 5G trial facilities and their mapping to use-case scenarios, has produced D1.2, a deliverable that describes the initial technical assets, technologies and roadmap of the facilities involved in the project, namely ICT 17 facilities 5G-EVE and 5GENESIS, and supporting sites X-Network and 5GTN. It also listed the use-case scenarios KPIs as a first assessment of their mapping to the facilities. Another deliverable D1.5 is has also been completed and submitted. The deliverable extends the roadmap provided in D1.2 to offer a complete list of 5G assets (e.g., RAN, Core network, orchestration, etc.), interactions with the trial controller (e.g., web portal) and MEC capabilities. An architectural perspective on the deployment of scenarios in their respective facilities has been provided, with the list of software and hardware UAV, UAV operator, UTM, and 5G functional components that are necessary to their trial.

The breakdown of the contribution, results, deviation and proposed corrective action of each partner in this task are described next. Regular partner activities, such as participation to teleconferences and face-to-face meetings will not be reported independently as they are considered the default a Beneficiary partaking a task would do.

*1-**UO*** has, as the Task leader, setup the bi-weekly meetings and it has prepared the first steps to work on the task. It has prepared the first version of ToC of D1.2. Solicitation of feedback and comments from partners, which led to a compact version of the ToC. UO has gathered the initial inputs from facility partners and it has coordinated and participated in all activities related to the. It has provided the initial inputs to D1.2 on UO's 5GTN facility. UO has had internal discussions with 5GTN team on the capabilities of 5GTN, with its limitations and updated UO's inputs to D1.2 accordingly. Coordination with the scenario leaders to bring new insights and feedback on the current version of D1.2 has been carried out. UO has monitored partners' contribution to D1.2 and contacted partners about the remaining inputs on the limitations and roadmap, and updated contribution on 5GTN. UO has had discussions with 5G facility partners and made refinement of 5G KPIs and technical assets. UO has been the lead Beneficiary of D1.2. In addition, UO presented a white paper for the extensive explanation of the difference and similarities of applications deployment in ETSI multi-access edge computing (MEC) against applications deployment in an ordinary edge server. UO initiated the start of deliverable D1.5, in which it is the lead Beneficiary. It added inputs about application deployment in ETSI MEC and edge server to D1.5 and presented the MEC description in the 5GTN facility. UO introduced the components tables in D1.5. It has collected inputs, edited, revised, consolidated, and submitted D1.5.

Deviation and corrective action: Delivery of D1.2 was delayed due to late revisions of the document and PMT decision to conduct an additional review of the deliverable. Justifications for the late delivery were drafted and sent for Project Officer approval. D1.2 was delivered to the Commission portal on December 19th. The late delivery further affected achieving the Milestone MS1 of the project, which was achieved at the submission of deliverable D1.1 on December 23rd.

2-THA is not partaking T1.3. Nevertheless, it has participated to all conference calls and editing D1.2, and it has reviewed D1.2. THA has also had internal discussions about mapping of Use Case scenarios proposed in T1.2 and its mapping with 5G facilities. THA reviewed and commented D1.5.

3-ALE did not start work on the task during the first quarter of the project. Since, ALE has started internal work on an overview of mapping of service components in line with T3.4. It has made contribution to D1.5 by providing details regarding the mapping between ALE Use Cases' components and facilities. ALE made review and editing of the latest working version for D1.5 documents.

4-INV has had exchanges with EUR to understand the 5G facility requirements to map it with the UAV needs. It has conducted a review of the provided descriptions of 5G facilities within D1.2. INV has had discussions with 5G facilities representatives on the technical integration aspects and alignment with respect to 5G KPIs and it has had exchanges with members of the Consortium on the 5G requirements for the drone trials. INV has studied the UO document about differences between edge and ETSI MEC implementation to understand what is required for UC1Sc1 and it has made a review and commented on the D1.2 document. Lately, INV reviewed and suggested changes for the part of D1.5 document for 5G-EVE, as well as contributed to D1.5 regarding the description, providing details and mapping the components for UC1Sc1. This was done in the close cooperation with EUR. There has been no deviation from the expected contributions.

5-HEP is not partaking the Task 1.3.

6-NCSRD has drafted an initial design of the 5GENESIS trial facility and made initial mapping of the trial facility to UC4Sc1. NCSRD has made contributions in D1.2 related to 5GENESIS facility and specifically in Section 1.2, 2.2, and 4.1. Subsequently, it has, reviewed, refined D1.2 descriptions. Contributions have been made to D1.2 related to the Athens/5GENESIS facility along with mapping of the UC4Sc1 scenario to the facility. NCSRD made contribution in D1.5, concerning 5GENESIS trial site, emphasising on the complementarity of 5G!Drones and 5GENESIS architectures. It made analysis of the Use Case planned for 5GENESIS site, listing the relevant functional components and the integration of them. NCSRD contributed on the security aspects of the Athens trial site. There has been no deviation from the expected contributions.

7-AU has reviewed the first ToC draft of D1.2 and it has provided initial inputs on its 5G facility (X-Network). AU has conducted exchanges and meetings with their facility manager (and also with our industrial partners) to understand the current setup and evaluate the roadmap. AU has made contribution to D1.2 for the trial facility of Aalto University and addressed reviewers' comments related to the X-network facility. It has further mapped the Use Case to AU facility and it has addressed the reviewers' comments related to our trial facility in the deliverable D1.2. AU made contributions to D1.5: provided update information about its trial site and provided inputs on the mapping of the Use Case "UAV-based IoT data collection" to its facility. AU held discussiond with CAF on the scenario led by CAF that will be trialled in AU premises. There has been no deviation from the expected contributions.

8-COS has made contributions to the 5GENESIS platform description and it has contributed to the finalisation of the D1.2 ToC. COS has been a contributing author in Deliverable D1.2 Section 2.2 and 4.1, and it has conducted an internal review of D1.2. COS has been a contributor in D1.5. There has been no deviation from the expected contributions.

9-AIR is not partaking the Task 1.3.

10-UMS is not partaking the Task 1.3. Nevertheless, UMS organised dedicated telcos to gather inputs from participating partners for UC2Sc2 and it provided input to D1.5 regarding UC2Sc2 and input to D1.5 as participating partner for UC4Sc1.

11-INF has carried out refinement of D1.2 objectives as per DoW. It has monitored all T1.3 activities for communicating the results through social media and website. INF has made refinement on D1.2 ToC. INF made contributions to D1.2 concerning the deliverable scope, objectives, target audience (Section 1 and 2). In addition, INF made an overview of the structure of D1.5, reviewed two times and

it has monitored and analysed T1.3 activities for linking them to T1.1 (business impact). INF contributed also to the second deliverable of this tasks, the D1.5, with focus on sections 1.1, 1.2 and 1.3, template fixing, tables/figures captions. It conducted two rounds of full review with comments and updates in latest working D1.5 versions. There has been no deviation from the expected contributions.

12-NOK is not partaking the Task 1.3.

13-RXB is not partaking the Task 1.3.

14-EUR has made major contributions to D1.2 by providing a detailed description of the 5GEVE Eurecom facility and its components. EUR has participated to the discussion on how the facility can support the UC1 and UC2 and it has provided information and details on the facility's new features. EUR has worked as a liaison with 5GEVE partners to describe the needs of 5G!Drones. EUR made contribution to D1.5 by providing details on 5GEVE-SA and Use Cases mapping. EUR contribution was taken as model for all the other facilities. There has been no deviation from the expected contributions.

15-DRR has contributed to 5G requirements and 5G deep dive discussions at the second face-to-face meeting in Athens. It has made 5G features vs. UAV service component analysis and contributed to UAV service components sheet contribution for D1.2. It has contributed to D1.5 and made a review of the U-Space diagram from EUR and the MEC and edge server White Paper. DRR made a UC2Sc2 scenario review for D1.5. There has been no deviation from the expected contributions.

16-CAF has made contributions to identify critical missing components of the 5G facilities for the support of the use cases which are led by CAF. It has made contributions to D1.2. regarding use-case requirements. Contribution to D1.5 by providing details regarding the mapping between scenarios which are leaded by CAF (UC1Sc3, UC2Sc3, UC3Sc1) and scenarios where CAF participates: UC1Sc1, UC2Sc1, UC4Sc1). There has been no deviation from the expected contributions.

17-FRQ leads the WP1 bi-weekly meetings performing preparation, distribution and tracking of agenda, MoM, and AP. It has initiated and monitored the drafting of ToC for D1.2 and provided a review and feedback on D1.2 draft. FRQ has made comprehensive contribution and constructive discussions on the content of D1.2 and it has performed an internal review process on D1.2. FRQ suggested to include security in the D1.5 and to have a dedicated section on ETSI MEC versus legacy edge computing. FRQ has performed a comprehensive review of internal report on D1.5 and distributed the results to partners for resolving the comments with residual issues on security and missing KPI values. There has been no deviation from the expected contributions.

18-OPL does not contribute to this task. Nevertheless, it has made a review of functional description of selected test beds and found them as useful for better comprehension of their impact on T3.1 (especially review of draft version of D1.2). There has been no deviation from the expected contributions.

19-MOE has contributed to the 5GENESIS platform description, to the initial design of the trial facility, and to the initial mapping of the trial facility to UC4Sc1. MOE has contributed to the deliverables D1.2 and D1.5 related to the Athens/5GENESIS facility. There has been no deviation from the expected contributions.

20-ORA followed the progress of D1.2, thereby ensuring consistency with the T1.4/D1.3 inputs regarding the four 5G ICT-17 trial Facilities. ORA reviewed D1.2 for consistency check with D1.3 regarding 5G Facility gap analysis. It followed the T1.3 activities during the period in preparation of D1.6 and the required consistency with the outcomes of D1.5, use-case and facility-wise. There has been no deviation from the expected contributions.

7.1.5. Task 1.4 System architecture for the support of the vertical use cases (M1-M18) [ORA]

Task Objectives:
This task will provide the overall system architecture design (i) to support the selected use cases over a federated, multi-domain 5G infrastructure and (ii) to execute large-scale UAV trials. It will identify and design at a high level the architectural components to provide the necessary infrastructure support for the selected use cases (5G!Drones enablers), which will be elaborated in WP3. Furthermore, it will define the underlying 5G architecture on top of which the vertical services will be deployed. This includes all the necessary 5G system components, as well as the specific 5G!Drones enablers. At the same time, it will provide a high-level design of the management plane for the execution of the trials, which will be the basis for the detailed design and implementation of the 5G!Drones trial controller (WP2). T1.4 will deliver an initial architecture design (**D1.3**) at the end of M08, marking partially **MS2** (due M12) of the project. An updated version of the architecture (**D1.6**) will be delivered at M18 based on feedback from implementation and integration activities of WP2-WP4.

Task Activities during the period: The first 3 months of the period were mainly focused on the identification of a comprehensive Table of Contents for delivery D1.3 "System architecture initial design", with many discussions within WP1 and with the other work packages to bootstrap the architectural discussions and structure the deliverable accordingly. This was consolidated during month 4 along with the first initial contributions for D1.3, which were thoroughly analysed during the Athens Face-to-Face meeting in October, and subsequently during four dedicated T1.4/D1.3 meetings and the regular WP1 bi-weekly meetings to complete the contributions in every section of the deliverable. D1.3 was stabilised for the Nice Face-to-Face meeting in January 2020, and on this basis was finalised and internally reviewed and submitted to the EC at Month 8. For the rest of the period, Task 1.4 continued its architectural discussions within WP1 and other work packages and started completing the Table of Content for the second deliverable of the Task, D1.6, due at Month 18.

The breakdown of the contribution, results, deviation and proposed corrective action of each partner in this task are described next. Regular partner activities, such as participation to teleconferences and face-to-face meetings will not be reported independently as they are considered the default a Beneficiary partaking a task would do.

1-UO has reviewed D1.3 ToC and provided feedback. It has reviewed the draft versions of D1.3 and contributed to section on enablers, KPIs, and facility limitations. Further, UO has contributed extensively to the ToC and subject matter of deliverable D1.3. UO has been identifying the components of the 5G!Drones architecture that need revision based the work done for D1.5 development. The use case mapping to facilities has helped in identifying needs for updating the overall architecture. There has been no deviation from the expected contributions.

2-THA has followed-up on the activities of this Task. It has made contribution to D1.3 table of content definition, participated to the edition of D1.3 with security aspects contribution, made a review of D1.3, and contributed to the design of the overall architecture and its adoption. THA has participated to the identification of the security aspects of 5G!Drones system. THA has made plans regarding architecture update and deliverable related to it (i.e. D1.6) in terms of both ToC and delivery plan. There has been no deviation from the expected contributions.

3-ALE reviewed the initial ToC for D1.3 and proposed ideas for the structuration of the "UAV Use Case service components" section. ALE contributed to D1.3 section 6.2 "UAV Service Enablers", especially by making a template for the service components of all scenarios, contacting and compiling all the service components for all the scenarios from the partners, checking if there are no obvious missing components. It will start to investigate the UAV Services Enablers update needs for D1.6 from D1.3. There has been no deviation from the expected contributions.

4-INV participated to discussion on the D1.3 ToC and its main architecture elements. INV reviewed and provided input to draft D1.3 and made exchanges with the Task leader on the preparation of D1.3. It conducted reviewing, editing, and suggesting changes for D1.3 document. INV contributed also to the first draft version of ToC for the next deliverable D1.6. There has been no deviation from the expected contributions.

5-HEP does not partake the Task 1.4.

6-NCSRD contributed to the initial Design of 5G!Drones architecture and carried out initial mapping of 5GENESIS architecture to 5G!Drones. It compiled the initial gap analysis for 5GENESIS and 5G!Drones architectures and contributed to D1.3 by analysing the components of the 5G!Drones architecture from the 5G technology perspective. NCSRD participated to the description and definition of the architecture. It has been planning for the revised 5G!Drones architecture in view of D1.5 and made identification of architectural revisions. There has been no deviation from the expected contributions.

7-AU has been working on the trial controller architecture. It is related to WP2 led by AU. AU has been working on detailing and breaking down the trial controller architecture (to be reflected in D1.3). AU has contributed to D1.3 for the assigned sections (gap analysis of the 5G facility & abstraction of the 5G facilities). AU has been appointed as a reviewer of D1.3 and has done this accordingly. It has made identification of the revisions of the overall architecture based on the work already achieved in both WP2 and WP3. There has been no deviation from the expected contributions.

8-COS made a preliminary analysis of the intended contributions for the target 5G!Drones architecture and supported the appropriate formulation of Deliverable D1.3 content. COS has supported the analysis of the 5G!Drones architecture components in focus for D1.3. It has further studied the gap analysis for the 5GENESIS platform and has been a contributing author in D1.3, Sections 3.1.5, 3.2. COS has also reviewed Deliverable D1.3. COS performed an analysis together with NCSRD on the revised architecture of 5GENESIS Facility and Use Case mapping (UC4Sc1). It is a contributing author to relevant Section 2.1 on Deliverable 1.5 There has been no deviation from the expected contributions.

9-AIR has contributed to architecture design and provided inputs for D1.3 structure. AIR has specifically contributed providing a draft for network functions virtualisation (NFV) and software-defined networking (SDN) sections. AIR has also contributed describing micro core system (MCS) platform architecture as UAV service enabler as well as corresponding application interface (API) specifications that will be implemented during the course of the project. AIR has contributed to security chapter on the multimedia critical collaboration platform topic. It has completed the sections related to NFV and SDN. AIR has completed MCS platform section and its contribution to cyber security section. AIR has further contributed to D1.3 first version of architecture detailing more the MCS component. Nonetheless, AIR made specific contribution to disseminate MCS architecture among T1.4 partners for synchronization and alignment. AIR has defined the architecture on which will be based 5G EVE 5G!Drones Use Case. There has been no deviation from the expected contributions.

10-UMS has reviewed D1.3 initial ToC and provided feedback. In addition, as the lead beneficiary of D1.1, it has provided relevant content for Section 2.4 which describe at a high-level the target use cases and trial scenarios. UMS has also reviewed the first D1.6 draft ToC. There has been no deviation from the expected contributions.

11-INF conducted overview of Task and D1.3 objectives as per DoW and participated on the discussion on the D1.3 ToC and sections definition. INF monitored core T1.4 activities for communicating the results through social media and website. INF has contributed to and commented on D1.3 by reviewing working draft versions and proposed updates to D1.3 initial structure. INF has

made contributions to D1.3 concerning the deliverable scope, objectives, target audience (Section 1) and liaison with the DoW objectives. It has made comments to D1.3 by reviewing three working draft versions. It has linked results to T1.1 (business impact). INF initiated internal processes for exploiting D1.3 content for posting material. There has been no deviation from the expected contributions.

12-NOK provided feedback to D1.3 initial ToC proposal: NOK suggested additional paragraphs under subsection 4.1 (Specification of the 5G architecture), related to beamforming, spectrum & spectrum efficiency. NOK also proposed a subsection focusing on the efforts of the 5G!Drones project regarding data analysis and intuitive representation of trial. Another proposal was the insertion of a paragraph describing components "for available spectrum usage, physical limitations and possibilities (RF block walls and space for 1 to 100 drones to fly at same time)". Further, NOK proposed a paragraph on new 5G release opportunities (i.e. to anticipate upcoming 3GPP releases e.g. R17+). NOK has provided contribution to D1.3 on the chapters: next-generation radio access network (NG-RAN), 5G Core, Beamforming, Spectrum and spectrum efficiency, and further enhancements with next 3GPP Releases. There has been no deviation from the expected contributions.

13-RXB did not start working on the Task during the first quarter year of the project. Since then, RXB has actively participated in the discussions with partners related to the architecture and supported partners FRQ, CAF, UMS and HEP. RXB also actively participated in integrating U-space architecture into the 5G!Drones project.

14-EUR contributed on and reviewed the ToC of D1.3 and provided the definition of the role of the 5GEVE facility in the 5G!Drones architecture. EUR further had two calls with Orange to discuss on D1.3. It has contributed to D1.3 and initiated a draft describing a gap analysis of 5GEVE and 5G!Drones, which were provided to the other facilities as a model. In addition, EUR has participated and contributed to the description of an architecture that integrates 5G into U-Space. It made contribution to the 5G!Drones architecture that maps the 5G!Drones components to 5G and U-Space. There has been no deviation from the expected contributions.

15-DRR contributed to architecture design discussion and provided UTM system requirements contribution. It has reviewed architecture drafts for D1.3 and has completed all task assigned to it by the WPL. DRR provided an update on U-space regulation EASA update. There has been no deviation from the expected contributions.

16-CAF has contributed to D1.3 on the chapters: 2.4 Target use cases, 3.1.5 MEC, 4. Overall architecture, and 6.3 Cyber security. For D1.6 it initiated table of security needs for mapping necessary security requirements. There has been no deviation from the expected contributions.

17-FRQ leads the WP1 bi-weekly meetings performing preparation, distribution and tracking of agenda, MoM and AP. It has initiated and monitored the drafting of ToC for D1.3. FRQ has made comprehensive contribution and constructive discussion on specification of high-level architecture, particularly regarding UTM interface towards ToC in D1.3. Exchanges among partners were made on a weekly basis. FRQ has performed an internal review process on D1.3. It has suggested the detailed architecture of Trial Controller (from WP2) is not in scope of D1.3, because the design of Trial Controller is a fast-evolving process and capturing the latest updates in D1.3 is not feasible and not useful. FRQ on a regular basis is monitors the progress of D1.6 Table of Content and pushing for the drafting of first draft version.

Deviation and corrective action: FRQ reports a late start of the Task due to change in ORA on the designated task leader. ORA has assigned a task leader, who has managed to pick up on the schedule.

18-OPL has made contribution to architecture design discussion and its initial design. It has also had bilateral exchanges with D1.3 leader on the architecture. OPL has delivered the expected

contributions to D1.3 and it has made intermediate reviews of D1.3 and preparation of feedback for the T1.4 leader. Further on, OPL has contributed to D1.3 and made review and editing of D1.3, and preparation of remarks for the lead-editor. There has been no deviation from the expected contributions.

19-MOE has contributed to the initial design of 5G!Drones architecture. The contributions relate to the initial mapping of 5GENESIS architecture to 5G!Drones and compilation of the initial gap analysis for 5GENESIS and 5G!Drones architectures. It has also contributed to D1.3. MOE conducted an analysis together with NCSRD and COS on the architecture of 5GENESIS Facility and Use Case (UC4Sc1). There has been no deviation from the expected contributions.

20-ORA is the leader of the Task and lead beneficiary of the D1.3 deliverable. It has initiated and monitored the ToC for D1.3 and has made bilateral exchanges with partners contributing to D1.3. It has reported the periodic progress of task T1.4 as task leader and D1.3 as deliverable editor. And organised the D1.3 specific meetings over the period. ORA has edited D1.3, had contact with all other D1.3 contributors to ensure participation to D1.3 with the expected level of quality and in the expected timeline, and made contributions to D1.3. ORA edited D1.3 finalisation over the period, gathered the different contributions of the partners and maintained a centralised, working document to prepare for i) document stabilisation, ii) internal reviews, iii) technical coordinator review, iv) consortium coordinator review. ORA coordinated with NCSRD to define a timetable toward D1.6 delivery, and in the short term agreed on a methodology regarding D1.6 ToC.

Deviation and corrective action: A late start of the Task due to change in the designated Task leader. ORA has assigned a task leader, who has managed to pick up on the schedule.

7.2. WP2 Trial controller

7.2.1. Progress towards objectives and details for each task

WP2 Objectives

This WP will work towards the following high-level project objectives:

- Objective 2: **"Design and implementation of the 5G!Drones software layer (or system) to execute UAV trials"**
- Objective 3: **"Design a high-level scenario descriptor language to run and analyze the results of the UAV trials"**
- Objective 7: **"Advanced data analytics tools to visualize and deeply analyze the trial results, and provide feedback to the 5G and UAV ecosystem"**

WP tasks and interrelations:

- Task 2.1: Trial execution APIs for verticals and experimenters (M3-M24)
- Task 2.2 Trial scenario execution engine (M3-M24)
- Task 2.3: Trial architecture management plane (M6-M24)
- Task 2.4: Tools for experiment data analysis and visualization (M3-M24)

Main Progress in the period:

During the first year of the project, WP2 introduced an initial definition of the trial controller architecture. The latter is a revision of the architecture proposed in the DoW. It details the different modules of the trial controller and proposes interconnecting 5G and U-space domains. In order to tackle the definition of this architecture, WP2 partners have been organised into Workforces (WFs) to better address architecture submodules and functions. In specific, each WF focuses on a specific submodule and is composed of the relevant partners from the concerned domains and operations. The current definition of the trial controller architecture is reported in D2.1, which is a deliverable that spans across the three first tasks of WP2.

Significant results

- Revision of the trial controller architecture**.**
- Creation and submission of Deliverable D2.1.
- Advancing in the definition of the trial controller architecture.
- Initial proposal of the module owners for the implementation of the trial controller architecture.

Deviations from Annex I and impact on other tasks, available resources and planning
WP2 did not start on M3 (August) as planned, it started in M4 instead. The WP2 has managed to catch up on the original timeline.

Reasoning for failing to achieve critical objectives and/or not being on schedule
The late start of the WP is mainly due to the holiday period that caused insufficient participant presentation to get the WP2 and attached tasks to be decently kicked-off. The WP2 leader decided to get this WP to be kicked-off in September. So, delayed by 1 month but with no incidence on the work to be done since WP2 promised to catch up on time with full support of his team.

7.2.2. Task 2.1 Trial execution APIs for verticals and experimenters (M3-M24) [INV]

Task Objectives:
This task will provide a high-level language and API for describing and executing trial scenarios. This language will allow the composition of UAV services, the definition of the KPIs to monitor, the specific requirements of the service in terms of 5G functionality (e.g., number and types of slices), and the selection of a mapping between service components and facilities where these should be deployed and executed. Moreover, it will allow to specify the trial duration and infrastructure resources to be leased per facility/region and per service component, using an abstracted view of the underlying facility infrastructure. Receiving early feedback from WP1, the activities of T2.1 will begin at M03 by creating an API model which will be representing all the entities that are relevant with the execution of the experiments (scenario, service component, KPI, network capability, physical/virtual compute/network/storage resource abstraction, etc.). The API model will be expressed following the OpenAPI Specification using a yaml or json syntax, which will facilitate the development of RESTful services for trial execution.

Task Activities during the period: Task 2.1 tackles the definition of the APIs for verticals. It deals with the specifications of the experimenters and exposes the functionalities of the system. For this end, Task 2.1 has identified the different variables that need to be specified during the planning of an experiment. These variables are in accordance with the specifications of the use cases reported in D1.1 and they consider both UAV and 5G related variables. The planning of an experiment will therefore be performed using two web portals (two views), whereas the first one serves for the UAV vertical to provide the flight plan and the second web portal is used for configuration of telecommunications network serving the mission. Furthermore, Task 2.1 has defined an initial Scenario Description Language (SDL) (c.f. D2.1 for more details) that can be used to assist the

description of the trial by an experimenter.

The breakdown of the contribution, results, deviation and proposed corrective action of each partner in this task are described next. Regular partner activities, such as participation to teleconferences and face-to-face meetings will not be reported independently as they are considered the default a Beneficiary partaking a task would do.

1-UO made a presentation assessing the initial API, KPI, and technical requirements for the components of the trial controller. An application example took into consideration the scenario on 3D mapping and 5GTN site. UO has contributed to the discussions on the trial controller architecture and its modules. UO made contributions to D2.1 based on the agreed table of contents and it has contributed extensively to the trial architecture design and also to the development of the trial engine. UO has made contribution with a list of KPIs and their assessment, as well as the definition of the main northbound API components for the creation of network slices and services. It has also made contribution with the trial repository data model, and detailed attributes. There has been no deviation from the expected contributions.

2-THA has had discussion with partners about technical aspects and it has followed-up activities in Task 2.1. THA has made contributions to D2.1 according to Table of Contents shared and agreed. It has further made specific contributions to D2.1 for what concerns security aspects. There has been no deviation from the expected contributions.

3-ALE does not partake the WP2.

4-INV as the Task leader has had exchanges with consortium partners on the creation of trial planning module. It has made a presentation on INV involvement in the task, and it has reviewed and provided input on the high-level architecture documents. INV also leads the sub-task “Experiment planning” part and has organised meetings for it. It has been preparing Functional Breakdown Structure (FBS) for Web Portal, consulting it with partners and identifying missing components. It has further been researching for solution for 3D radio coverage predictions; a discussion with OPL and external partners. INV has studied document “SESAR 2020 GOF USPACE WP2 D5 FIMS Interface Description – Flightplans – Notifications” for work related to the “Experiment planning” module. INV has reviewed and provided feedback to AU about ToC for D2.1 document and it had had further discussions with AU, who is developing a web portal for the planning of the trials. INV is author of several chapters of D2.1 document: Experiment Planning, Dashboard, Interfaces for Web Portal and reviewed and commented the remaining parts of D2.1. INV also created the document describing the Scenario Descriptionn Language (SDL), which has been used by AU to model the SDL in Swagger. This work also required various discussion with different partners. There has been no deviation from the expected contributions.

5-HEP does not partake in the Task 2.1.

6-NCSRD has addressed all requested tasks from it and it has described the 5GENESIS architecture, which supports an OpenAPI for the vertical trials. In addition to follow-up of activities, NCSRD has made contributions to D2.1 and it has provided analysis on the 5GENESIS approach and the respective API. Further details will follow with a detailed handbook for experimenters. NCSRD provided contribution in D2.1 “Initial definition of the trial controller architecture, mechanisms, and APIs”, emphasising on the components related to the trial enforcement. It also contributed related to 5G-repository design. There has been no deviation from the expected contributions.

7-AU has, as the WPL managed all the conference calls. It proposed the initial architecture of the trial controller and it has presented and discussed the proposed architecture with the partners. AU also made the proposition of work forces for the trial controller for which it has planned the work. AU proposed the initial ToC for D2.1 and it has also consolidated and reflected the partners’ comments

on the ToC. In addition, AU has worked on assigned sections to partners. AU has worked on the definition of the interfaces for the experimenters, allowing the planning of the trials. It has also developed a web portal for the planning of the trials. AU has been editing, contributing, and reviewing the deliverable D2.1. It has been working with INV on the definition of the scenario description language and made a Swagger implementation of the SDL. AU has been implementing a web portal and collaborating / discussing with INV on its functions. There has been no deviation from the expected contributions.

8-COS does not partake in WP2.

9-AIR has presented the initial API, KPI, and technical requirements for the components of the trial controller in order to integrating MCS services. It has participated to the discussions on the trial controller architecture and interfaces. AIR has started the developments allowing to evolve their MCS critical collaboration platform to be interfaced with drones and profit by potential of 5G. The first step was implementing a proof of concept demonstrating the possibility to containerise an MCS server and corresponding client to be embedded in a drone. AIR has continued the development of evolved version of MCS. A first prototype with a much-reduced set of functionalities (mainly registration) can now be run. AIR is also contributing to workforce on LCM with specific interest managing lifecycle for future critical platform VNF component. There has been no deviation from the expected contributions.

10-UMS has discussed the impact of vertical APIs on UAV operations. It has contributed to working group discussions regarding experiment planning in the Web Portal. It has made contributions to D2.1 and reviewed the deliverable. There has been no deviation from the expected contributions.

11-INF does not partake in Task 2.1.

12-NOK has had discussions with partners about technical aspects of Task 2.1. It has made contribution to the Web Portal design and identifying possible missing components. NOK contributed to the Web Portal design by shared experience and screenshots on of Nokia's in-house tools for 3D coverage measurements. NOK contributed also by clarifying planning dashboard and lifecycle manager responsibilities during planning and trial phases. It reviewed D2.1. There has been no deviation from the expected contributions.

13-RXB did not start on the Task during the first half a year of the project. Since then it has contributed to trial architecture and it has been coordinating and contributing to Workforce Trial Validator. It has participated in U-space adapter discussion with partners and contributed to the responsibility assignment RACI (responsible, accountable, consulted, informed) matrix.

14-EUR has made a proposal presentation of its activity related to WP2. EUR is leading the activities on the Trial Engine and it has described each block composing the Trial Engine. EUR has implemented a Trial translator for 5GEVE Sophia-Antipolis location and it has implemented in its Web Portal features specifics to 5G!Drones, such as KPIs to selects, etc. EUR has proposed a new architecture for the Trial Engine by dividing the portal into two entities, one for the planification and one for the enforcement. Also, it has removed the trial validator from the Trial Translator. This also impacts T2.1. EUR made contribution and new architecture of the Web portal. It proposed to divide it into two: Web Portal 1 and Web Portal 2. EUR made development of a prototype of Web Portal 2 adapted to the 5GEVE-SA facility It has had a bilateral meeting with INVOLI (leader T2.1) to discuss the new proposition. There has been no deviation from the expected contributions.

15-DRR has made API definition for trial controller contribution related to D1.1 and made API definition payload proposal. It has contributed to the D2.1 and it has defined Flight Planning Mechanism and developed initial Flight Plan protocol for it. DRR made U-Space adapter specification analysis and Open API interface description. It made U-Space interfaces common denominator definition for U-Space adapters and has conducted U-space adapter protocol development. There has been no

deviation from the expected contributions.

16-CAF has done reviewing and providing input on the high-level architecture documents. It has participated in Web Portal and Dashboard discussion, and in developing web portal for the planning of the trials. CAF has participated in U-Space Adapter workgroup and had bi-lateral discussions with INV. Contribution to D2.1. There has been no deviation from the expected contributions.

17-FRQ has made comprehensive contribution and constructive discussion on specification of high-level architecture, particularly regarding UTM interface towards D2.1. It has participated in numerous architecture meetings for clarification of the basis for architecture. FRQ has been contributing in WP2 architecture and respective deliverables, coordinating and contributing to Workforce Trial Validator, coordinating and contributing to Workforce U-space Adapter, and it has made contribution to RACI matrix. FRQ has performed Contribution to D2.1 KPI, Trial Validator, Overall Architecture, UTM chapters. FRQ has reviewed D2.1. Furthermore, FRQ contributed to EUROCOM paper. There has been no deviation from the expected contributions.

18-OPL does not partake in WP2.

19-MOE does not partake in Task 2.1.

20-ORA has ensured liaison between WP2 and WP1 D1.3 regarding architectural consistency. It has participated in the activities on the Trial Controller about data monitoring. It contributed to D2.1 on data monitoring. There has been no deviation from the expected contributions.
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7.2.3. Task 2.2 Trial scenario execution engine (M3-M24) [EUR]

Task Objectives:
Requests for the execution of trial scenarios that are received over the northbound API of the trial controller need to be translated to an actual UAV service deployment on top of one or more trial sites, and the appropriate functionality should be in place to manage the execution of the trial. This is the purpose of T2.2. The trial execution engine needs to interface with the different facilities that will be used in the project using APIs exposed by the facilities, as well as the interfaces of the enablers that will be designed and implemented in WP3. Regarding the latter, particularly important is the work in T3.3, which provides an infrastructure abstraction offering the trial controller a unified view of the resources and the capabilities available across facilities. The execution engine is responsible for extracting the requirements of each UAV trial in terms of 5G (and other) features and (i) establishing end-to-end network slices with the required performance, security and isolation characteristics using the APIs provided by the slicing enablers (see T3.1), (ii) if necessary, onboarding and instantiating application components at edge data centers by interfacing with Mobile Edge Application Orchestrators (see T3.2), (iii) configuring and launching UAV-service and connectivity-related components onboard the UAVs. The trial scenario execution engine thus manages the full "lifecycle" of a trial, from deployment to termination and result collection

Task Activities during the period: Task 2.2 tackles the execution engine of the trial controller. It uses the scenario description produced by the planning module (Task 2.1). In order to enable safe and secure execution of the trial, Task 2.2 has proposed submodules allowing to interface with the U-space and validate the planned experiments. In addition, Task 2.2 has also proposed submodules and processes allowing to translate the described scenario into network components to run on the top of the target facilities. Furthermore, a dedicated submodule is proposed to manage the lifecycle of the trials.

The breakdown of the contribution, results, deviation and proposed corrective action of each partner in this task are described next. Regular partner activities, such as participation to teleconferences and face-to-face meetings will not be reported independently as they are considered the default a Beneficiary partaking a task would do.

1-UO made a presentation assessing the initial API, KPI, and technical requirements for the components of the trial controller. An application example took into consideration the scenario on 3D mapping and 5GTN site. UO contributed to the discussions on the trial controller architecture and its module, while its main contributions focus on the trial translator and the lifecycle manager. It has also made contribution to the 5G infrastructure manager and orchestrator section of D2.1. There has been no deviation from the expected contributions.

2-THA has participated to technical discussions of Task 2.2. It has had internal discussions regarding integration of security aspects in the Trial Controller, and about the requirements, interfaces, and services of 5G facilities. It has also discussed these with the members of the Consortium. THA has participated to edition of D2.1 (security sections and lead of data analysis section). There has been no deviation from the expected contributions.

3-ALE does not partake in WP2.

4-INV is not partaking Task 2.2, but it has had internal discussion about role of different components, their coexistence and interfacing. INV added inputs related to UAV telemetry and INV's redundancy solution (KIVU) and discussed with EUR the role of Trial Translator and Trial Validator.

5-HEP is not partaking Task 2.2.

6-NCSRD has addressed all requested tasks from it. NCSRD proposed OpenTAP as a reference module for building the execution engine. It made a GAP analysis and mapping between 5GENESIS Coordination Layer and 5G!Drones Trial controller. NCSRD participated in all the discussions and teleconferences for the definition of the internal architecture of the trial controller and provided clarification of the role of each component. It has made contributions in the trial enforcement component. NCSRD made contributions to D2.1 and participated in the discussions of a refined version of the 5G!Drones trial architecture. It further participated in the discussions on the level of automation concerning drones' flights. There has been no deviation from the expected contributions.

7-AU has managed all the conference calls. It has proposed initial architecture of the trial controller. It has been presenting and discussing the proposed architecture with the partners and proposed work forces for the trial controller. AU proposed the initial ToC for D2.1. AU has also consolidated and reflected the partners' comments on the ToC. In addition, AU has worked on assigned sections to partners. AU has worked on the definition of the lifecycle manager and it has worked on defining VNF repository and presented the outcome of this work force in a bi-weekly meeting. AU has discussed/coordinated with EUR on the revision of the trial execution engine. AU has been editing, contributing, and reviewing the Deliverable D2.1. There has been no deviation from the expected contributions.

8-COS does not partake WP2.

9-AIR does not partake Task 2.2.

10-UMS presented the dependencies and requirements for UAV operators to interface with WP2 trial controller. It has been reviewing and providing input on the trial controller execution engine. UMS led and contributed to UAV Repository workforce, contributed to VNF Repository workforce, and analysed and discussed the scope of responsibilities of trial engine. UMS leads UAV Telemetry workforce and has made contributions to D2.1 regarding UAV Telemetry. It has done research and preparation for

‘Scope of Mission Planning’ Discussion and reviewed legislation for pilot-in-command role. There has been no deviation from the expected contributions.

11-INF does not partake Task 2.2.

12-NOK has had discussions with partners about technical aspects. It started the lifecycle manager task force work and analysed and discussed with partners about trial engine components and architecture. NOK is leading Lifecycle manager task force and it delivered lifecycle manager related chapter to D2.1. NOK reviewed and commented different D2.1 working versions. There has been no deviation from the expected contributions.

13-RXB RXB supported various partners including UMS, FRQ, CAF, HEP, DRR, and HEP in laying out the various dependencies and requirements for UAV integration, operation and safety aspects. RXB also actively supported in defining the role of Pilot in Command and how the software would play a vital role in the integration.

*14-**EUR*** is the Task leader. It is also the leader of the activity on the trial translator. EUR made proposal of a refined version of the 5G!Drones trial architecture. EUR made contribution and was a section leader in D2.1, and it reviewed D2.1. EUR developed a new API to check the facility availability for a trial. There has been no deviation from the expected contributions.

15-DRR proposed 3GPP recommendation development for trial engine synergy. It has made Trial Controller architecture contribution and 3GPP compliance recommendation contribution. DRR made contributions to U-Space adapter module concept development. It has reviewed and updated proposal to D2.1 ToC (Data model and process flows) and elaborated the Mission planning module. DRR has contributed to concept of content and approach to D2.1 Ch. 2.2.2, 2.2.3. DRR made D2.1 Data model and process flows content preparation - use case research, and process analysis. It updated D2.1 sections 2.2.2 and 4.2 and prepared pre-flight and inflight procedures flow and description for section 4.2 of D2.1. It has been aligning 5G!Drones process to updated U-space regulation and made Diagrams (pre-flight procedure, in flight procedure, drone states) - detailed content for section 4.2.1 and 4.2.2 of D2.1. DRR made content crosscheck, review/update/corrections to content and diagrams according to received remarks, added section 3.4, updates to section 2.2.3, and process definition for U-space related actions. There has been no deviation from the expected contributions.

16-CAF has made recommendations to architecture. It has participated in Lifecycle Manager discussions and in analysing the requirements and possible interfaces for trial engine. It made contributions to D2.1 and participated in the discussions of automated flights, trial controller architecture. There has been no deviation from the expected contributions.

17-FRQ has made comprehensive contribution and constructive discussion on specification of high-level architecture, particularly regarding UTM interface towards D2.1. It has participated in numerous architecture meetings for clarification of the basis architecture. FRQ made contributions in WP2 architecture and respective deliverables. FRQ is coordinating and contributing to Workforce Trial Validator and to Workforce U-space Adapter. FRQ is contributing in preparation of validation system – setup and initial product software deployment. There has been no deviation from the expected contributions.

18-OPL does not partake WP2

19-MOE does not partake Task 2.2.

20-ORA does not partake Task 2.2.

7.2.4. Task 2.3 Trial architecture management plan (M6-M24) [NCSRD]

Task Objectives:
The activities in this task will focus on trial execution monitoring and management aspects. Different management interfaces will be provided to cover the needs of the different roles (verticals and experimenters, facility owners). In particular, T2.3 will design APIs for runtime monitoring of a trial and the collection of results. This interface is used by verticals/experimenters. This management component also uses the APIs provided by the 5G facilities and 5G!Drones enablers (WP3). The verticals will also be provided with a management interface to control the UAV applications at the vertical-service level and retrieve application-level KPIs, as the latter have been defined in the scenario description. Finally, the trial architecture management plan will provide interfaces to facility owners to enable the monitoring of the infrastructure during the execution of a trial and the collection of 5G KPIs. It should be noted that different facilities may have different mechanisms and interfaces to monitor their infrastructures, and there will be trial scenarios which will be spanning across different facility domains. The purpose of this task is to unify these interfaces providing a common entry point for monitoring and management. This will also reduce the complexity of the data analysis and visualization mechanisms of T4.2, since the latter will not have to deal with the particularities of each underlying facility and each heterogeneous UAV service.

Task Activities during the period: Task 2.3 is about management plane of the trial architecture. A number of interfaces are identified to enable the management and the monitoring of the trial for experimenters. This includes interfaces to the facility as well as interfaces to the UAV operator to manage the UAV applications. Furthermore, Task 2.3 has identified different types of data that can be collected from the trials. In addition to data captured from monitoring the facilities, T2.3 has also considered UAV related data which are reflected in telemetry data.

The breakdown of the contribution, results, deviation and proposed corrective action of each partner in this task are described next. Regular partner activities, such as participation to teleconferences and face-to-face meetings will not be reported independently as they are considered the default a Beneficiary partaking a task would do.

1-UO made a presentation assessing the initial API, KPI, and technical requirements for the components of the trial controller. An application example took into consideration the scenario on 3D mapping and 5GTN site. UO has made contribution to the discussions on the trial controller architecture and its module. It has worked on assigned sections of D2.1. It also made contribution to the configuration and deployment of network slices within the trial enforcement module as part of D2.1 inputs. The software in the UAVs have been implemented in the ROS (Robot Operating System), which allows remote monitoring and control of the UAVs. The UAVs can be controlled using orientation, position, and velocity commands. The UAVs onboard computer’s software node for navigation will handle collision avoidance and data fusion between the onboard sensors and external tracking information. Any internal data from the UAV can be accessed and monitored through the ROS services and transmitted over any network. There has been no deviation from the expected contributions.

2-THA has had technical discussion with partners about the trial controller architecture and its API. It has done follow-up of activities of Task 2.3. There has been no deviation from the expected contributions.

3-ALE does not partake WP2.

4-INV does not partake in Task 2.3. INV, as the owner of Web Portal workforce, worked with CAF on functions and description of Dashboard for trial’s monitoring and visualisation.

5-HEP does not partake in Task 2.3.

6- ***NCSRD*** is the Task leader. It has compiled its initial draft of the activities in WP2 and presented it. NCSRD proposed an infrastructure monitoring system based on Grafana and Prometheus bundled with InfluxDB for keeping historical data. NCSRD has provided an initial design of the trial architecture management plane, which automates the experimental process step-by-step, but also provides a unique northbound interface to the experimenter. NCSRD made contribution in D2.1. It also did work on definition of the trial architecture management plane, clarifying the borderlines between the states monitoring and the data monitoring. There has been no deviation from the expected contributions.

7-AU has been managing all the conference calls. It has proposed an initial architecture of the trial controller and presented and discussed the proposed architecture with the partners. AU proposed work forces for the trial controller. AU proposed the initial ToC for D2.1. AU has also consolidated and reflected the partners' comments on the ToC. In addition, AU has worked on assigned sections to partners. AU has been editing, contributing, and reviewing the Deliverable D2.1. There has been no deviation from the expected contributions.

8-COS does not partake in WP2.

9-AIR does not partake in Task 2.3.

10-UMS has done reviewing and providing input on the proposed architecture. It has led and contributed to Interfaces to UAV Operators workforce. UMS performed internal research on future integrations of UMS platform with trial controller interfaces. It made contributions to D2.1 regarding Interfaces to UAV Operators. There has been no deviation from the expected contributions.

11-INF does not partake in Task 2.3.

12-NOK has had discussion with partners about technical aspects of Task 2.3. it has made D2.1 ToC review and follow-up of activities. NOK has made analysis and defining interfaces from Lifecycle management point of view monitoring and management aspects. There has been no deviation from the expected contributions.

13-RXB does not partake Task 2.3.

14-EUR developed an API (facility) to update resource dedicated to the VNF running at the Edge. It also developed an API to have access directly (not through a web portal) to the measured KPI of a trial. There has been no deviation from the expected contributions.

15-DRR has conducted mapping of trial architecture management plane into U-Space (GOF project concept). It has made D2.1 ToC review and worked on assigned sections for it. DRR made an update to D2.1 section 2.2.2 - define domain model of solution architecture. There has been no deviation from the expected contributions.

16-CAF has made recommendations for architecture. It has contributed to Trial Architecture discussions and participated in technical discussions. CAF conducted D2.1 internal review and carried out research about state of the art of the trial execution solutions. There has been no deviation from the expected contributions.

17-FRQ has made comprehensive contribution and constructive discussion on specification of high-level architecture, particularly regarding UTM interface towards D2.1. It has participated in numerous architecture meetings for clarification of the basis architecture. FRQ has reviewed the deliverable D2.1 and it has participated in technical discussions and business-to-business (B2B) Architecture definition. FRQ is contributing in preparation of validation system – setup and initial product software

deployment. There has been no deviation from the expected contributions.

18-OPL does not partake WP2.

19-MOE has addressed all requested tasks from it and made contribution to the deliverable D2.1. There has been no deviation from the expected contributions.

20-ORA does not partake Task 2.3.

7.2.5. Task 2.4 Tools for experiment data analysis and visualization (M3-M24) [FRQ]

Task Objectives:
The goal of this task is to provide sophisticated mechanisms for the management and analysis of the data that will be generated during the trials. These mechanisms will be applied in WP4. This task will face important challenges. First, very large volumes of experimental data will be generated during the trials; these data pertain to both the UAV-service level (e.g., video traces, sensor readings, etc.) and the 5G facility level (e.g., packet-level measurements, signal coverage reports, latency measurements, etc.). Second, these data are often unstructured, have multiple dimensions, and involve multiple KPIs to measure. The expected challenges pertain particularly to the management, analysis, and the visualization of the experimental data and call for (i) big data management techniques, (ii) the application of data analytics and/or machine learning techniques for the analysis of trial results, (iii) development of visualization tools which will be used both at trial execution time and for the post-trial evaluation of the results.

The work in this task place efforts on data analysis and the intuitive representation of trials results. This feature is becoming essential to process and understand the volumes of data generated by automated trial systems. This task will use and extend open-source tools (such as Elasticsearch, Logstash, Kibana, collectively known as the ELK stack [ELK18]) for real-time actionable insights on any type of unstructured data. Notably, partners in 5G!Drones already have significant experience applying this solution and plan to extend these tools with new features, such as new visualisation plugins relevant to 5G parameters and advanced statistical data analysis, correlation techniques, and machine learning algorithms. The algorithms, mechanisms and tools developed in T2.4 will be reported in **D2.3**, while the related software will be released in **D2.6**.

Task Activities during the period: Task 2.4 is about tools for data analysis and visualisation. This task considers the data specified in the previous task (T2.3). A number of tools have been identified for data analytics, such as Elasticsearch, Logstash, Kibana (ELK stack). This task will rely on the different data captured from the trials.

The breakdown of the contribution, results, deviation and proposed corrective action of each partner in this task are described next. Regular partner activities, such as participation to teleconferences and face-to-face meetings will not be reported independently as they are considered the default a Beneficiary partaking a task would do.

1-UO made a presentation assessing the initial API, KPI, and technical requirements for the components of the trial controller. An application example took into consideration the scenario on 3D mapping and 5GTN site. UO contributed to the discussions on the trial controller architecture and its modules. UO has made provision of log traces captured on 5GTN needed for T2.4 preparation. Exchange and discussions were made on it with FRQ. UO has carried out investigations on the tradeoffs between visualisation of mapping data computed on board a drone and data communicated wirelessly to a dedicated GPU visualisation processing server. The UAV's onboard localisation, point cloud data, and video streams processed within ROS can be remotely accessed over network for

implementing remote visualisations in MEC environments. The UAVs onboard sparse point cloud currently is an OctoMap 3D occupancy mapping output, which is primarily used in collision avoidance. Raw point clouds from onboard RGBD camera and 3D LiDAR can be read as well. There has been no deviation from the expected contributions.

2-THA made a presentation about data analysis tools survey. THA leads data analysis task force and leads data analysis tools survey document. THA has conducted an analysis of available data analysis tools that can be used and has had discussion on data analysis tools and integration with Consortium partners. There has been no deviation from the expected contributions.

3-ALE does not partake WP2.

4-INV has conducted internal investigations regarding how our data storage solution can be used for the project. INV reviewed and commented this task related content in D2.1. There has been no deviation from the expected contributions.

5-HEP has made a presentation of its planned work and addressed relevant action points directed to it. HEP is leading UAV telemetry task force activities and is holding separate meetings and discussions to plan a test for gathering UAV telemetry data. It has contributed to the D2.1 with information about UAV telemetry data.

Deviation and corrective action: Some delays have occurred organising agreed tests. HEP has allocated more resources in the company for project activities.

6-NCSRD has addressed all requested tasks from it. It has compiled an initial draft of its activities in WP2. NCSRD contributed in the monitoring tools survey by proposing Graphana and Prometheus as two candidate technologies. NCSRD has contributed in the definition and clarification of the relation between the trial enforcement module and the data extraction and visualisation/analytics. NCSRD contributed the NCSRD available monitoring tools and made clarification of the management plane from the monitoring tool. There has been no deviation from the expected contributions.

7-AU has been managing all the conference calls. It proposed an initial architecture of the trial controller. AU has been presenting and discussing the proposed architecture with the partners. It made proposition of work forces for the trial controller. AU proposed the initial ToC for D2.1. AU has also consolidated and reflected the partners' comments on the ToC. In addition, AU has worked on assigned sections to partners. AU has worked on defining cloud data and presented the outcome of this work force. AU has been Editing, contributing, and reviewing the Deliverable D2.1. There has been no deviation from the expected contributions.

8-COS does not partake WP2.

9-AIR does not partake Task 2.4.

10-UMS has participated to UAV telemetry working group. It has conducted internal research on available telemetry data and its associated formatting. It made contributions and review of D2.1. There has been no deviation from the expected contributions.

11-INF has participated in setup and refinement of task forces. It has conducted an initial business-related analysis and participates to analytics task force where contributions were made. INF activities in Task 2.4 have been set up linking them to Task 1.1. and Task 5.1. INF monitors all T2.4 activities for communicating the results through social media and website. INF has made contribution and refinement of task forces and made a presentation of INF plan and activities for T2.4. It has reviewed D2.1 ToC and structure. INF is monitoring and analysing T2.4 activities from a business perspective, communicating the results through social media and website, linking T2.4 activities to T1.1 and T5.1.

INF contributed in D2.1: Sections 1.1, 1.2, 1.3, 2.6.4 and 2.6.4.5. It made a full review of working D2.1 0.6 version: comments, additions, corrections in all sections and fixing formatting issues and captions. There has been no deviation from the expected contributions.

12-NOK has had discussions with partners about technical aspects of Task 2.4. It has conducted internal analysis of available data analysis tools for data aggregation and analysis. NOK made contribution details to analytics task force and collected, for academic analysis, proposed KPI and counter logs from 5G gNBs. NOK did ELK stack setup for MEM/CPU load to analyse and visualise network equipment performance. There has been no deviation from the expected contributions.

13-RXB has participated in multilateral conference calls supporting partners and actively contributing to D2.1 in different sections, and also actively reviewing the architectures and text. There has been no deviation from the expected contributions.

14-EUR has started to study the different tools for monitoring, such as Grafana, Promotheus and Elastic Search. There has been no deviation from the expected contributions, as more efforts will be dedicated to this task in the next period, where clearer information on the needed KPI of each scenario will be available.

15-DRR made analysis of overall trial architecture. It conducted research on possible data analysis and visualisation tools. Data type extraction for UTM system interfaces research. There has been no deviation from the expected contributions.

16-CAF has made recommendations for architecture and discussed it with partners. It has done internal research for tools for experiment data analysis and visualisation. CAF did development of network QoS data visualisation solution and development of operational map for visualising UAV route. There has been no deviation from the expected contributions.

17-FRQ is the task leader and it has made contribution to the overall trial architecture with respect to virtual machine (VM) set up, installation of Elasticsearch, Logstash, and Kibana (ELK) stack, and preliminary data aggregation in Windows script (WS) format. It implemented ELK stack as analysis and visualisation Tool, and made a presentation on it for the Consortium. FRQ is also performing VM and ELK maintenance, and it provides VPN setup for partners regarding access rights to VM / ELK. Since partners have reported some difficulties to connect to VM, FRQ is continuing the discussion on utilization of the ELK or alternative solutions. There has been no deviation from the expected contributions.

18-OPL does not partake WP2.

19-MOE does not partake Task 2.4.

20-ORA does not partake Task 2.4.

7.3. WP3 Enabling mechanisms and tools to support UAV use cases

7.3.1. Progress towards objectives and details for each task

WP Objectives:
WP3 aims to accomplish Objective 4: **"Design and implementation of 5G!Drones enablers for UAV trials and operations."**

Based on the outcome of T1.3, which will identify which enabling mechanisms are necessary for the support of the use cases defined in T1.2 and for the execution of the respective trials, this WP, which will be carried out in parallel with WP2, has the following sub-objectives:

- Design and implementation of mechanisms for end-to-end orchestration, management and security of coexisting UAV slices, with a particular focus on scalability and performance isolation.
- Development of the necessary components for MEC support.
- Implementation of software tools and APIs for facility infrastructure abstraction and to enable the federation of 5G facilities.

WP tasks and interrelations:
WP tasks and interrelations: Breakdown structure of WP3 reflects the structuration of the work according the 5 thematic areas in scope. As such it is made of the following 5 tasks:

- T3.1: Scalable end-to-end slice orchestration, management and security mechanisms (M3-M27)
- T3.2: MEC capabilities for the support of 5G!Drones trials (M3-M27)
- T3.3: Infrastructure abstraction and federation of 5G facilities (M3-M27)
- T3.4: Development of UAV use case service components (M3-M27)

Main Progress in the period:
Discussions took place about slice mechanisms and their integration in the overall architecture. NOK and UO started implementing an enabler for indoor position system for UO 5GTN test facility. Work was carried out in identification of how partners plan to use MEC. The WP has made progress on slicing architecture and identification of the different interfaces between the abstraction layer and the different facilities. The WP has reached an agreement on the use of an abstraction layer. The WP has made good progress regarding end-to-end slicing architecture and clarification regarding how MEC will be used in the project Use Cases. It has also made identification of enablers at project level and progress on the identification of module owners and release dates. The WP has made preliminary architectural studies on the orchestration of end-to-end secure slices in 5GCore. First version of D3.1, Report on infrastructure-level enablers for 5G!Drones, due at M18, has been submitted to reviewers. At a Work Package level, a document used as a backlog for enablers has been provided. It contains information regarding the identification of enablers, their technical progress status, identification of maintainers, and release dates. The WP has also considered the security aspects. The WP has applied the following methodology to track progress: bi-weekly meetings are held during which technical discussions are addressed.

Significant results
The partners agreed on their understanding of the use of the MEC. There has been good progress in slicing, MEC, and abstraction layer work. Security aspects have been addressed.

Deviations from Annex I and impact on other tasks, available resources and planning
WP3 did not start on M3 (August) as planned, instead it was started on M4 (September).

Reasoning for failing to achieve critical objectives and/or not being on schedule
The delay in starting was mainly due to the holiday period that caused insufficient participation to get this WP and attached tasks be decently kicked-off. WP3 Leader decided to get this WP kicked-off in September. Hence, the start was delayed by 1 month but with no incidence on the work to be done since WP3 made measures to catch up on time with full support of WP participants.

7.3.2. Task 3.1 Scalable end-to-end slice orchestration, management and security mechanisms (M3-M27) [OPL]

Task Objectives:
Task T3.1 will address challenges for network slicing to support emerging UAV-related use cases. It should be noted that the successful execution of the targeted use case trials depends on the capabilities of the underlying facilities to maintain different types of services (uRLLC, mMTC, eMBB), including the provision of performance isolation and resource sharing at the RAN, core, transport and compute levels. Following the identification of missing components for slicing support in the selected 5G facilities (T1.3) and the architecture design provided by T1.4, this task will provide the slicing-related enablers.

In particular, it will develop components for end-to-end secure slice deployment and orchestration, with the support for managing slice components across administrative domains. This is necessary for the cases where the functionality of an end-to-end slice spans across facilities (e.g., one facility is providing RAN and MEC functionality, while UAV control functions are split between the trial site and the vertical's premises; UAVs are restricted to a single facility due to regulatory requirements, while core network components and other functions of the UAV slice are executed as virtual instances at another trial site/facility). Activities in this task will be in close synergy with T3.3, where the necessary infrastructure abstractions will be developed to facilitate federation and multi-domain operation
The selected 5G!Drones use cases have as a typical feature the *coexistence of multiple network slices* with different performance requirements for the provision of a *single drone service*. For example, for a public safety scenario, apart from operation of UTM modules, which require a uRLLC slice to meet the strict timing and reliability requirements for safe and secure flight operations, video has to be streamed from the drones necessitating the deployment of an eMBB slice to support it. Taking into consideration that

- multiple slices for other services/"tenants" would be deployed simultaneously over the shared 5G infrastructure, and
- end-to-end slices may cross administrative domains,

raises significant concerns regarding *scalable slice management*.

Furthermore, critical services such as UTM and public safety related have important *security and performance isolation* requirements. For UAV services in general, *safety is linked with security*. For example, without appropriate protection mechanisms at various levels, a malicious actor might aim to disrupt the operation of UTM or tamper with the control of a UAV, bringing significant risks. Security aspects in network slicing are generally overlooked. T3.1 will put particular focus in this direction, studying network slicing security extensions and integrating them with the selected trial facilities. T3.1 will enable each of the network slices needed to achieve the UC trials to be adequately secured. To cope with specific security requirements from each of the network slices, software defined security (SD-Sec) and security as a service (SECaas) will be promoted. The advanced slicing mechanisms that will be contributed by this task will be reported in **D3.1**, while the software components that will be implemented will be released with the whole 5G!Drones Enablers Software Suite (**D3.3**).

Task Activities during the period: Work on end-to-end slicing and design of the corresponding architecture. Preliminary architectural studies on the orchestration of end-to-end secure slices in 5GCore have been conducted and many technical discussions took place. The slice mechanisms and their integration in the overall architecture have been addressed.

The breakdown of the contribution, results, deviation and proposed corrective action of each partner in this task are described next. Regular partner activities, such as participation to teleconferences and face-to-face meetings will not be reported independently as they are considered the default a Beneficiary partaking a task would do.

1-UO is working on achieving network slice service type enforcement using VNF placement. UO is

testing network slice deployment across multiple domains in the 5GTN based on open source tools. It has made contribution to network slice management and orchestration in the 5GTN. There has been no deviation from the expected contributions.

2-THA is the WPL and it has organised all the conference calls. THA has participated to discussion about slicing and it has had internal technical meetings and discussion regarding slicing. THA is working on integrating slicing capabilities on 5G network. It is also working on a scheduling algorithm that will allow slicing in upload traffic. It has participation to the preparation of a preliminary version of D3.1. THA has made a design of a RAN slicing solution for 5G and made preliminary architectural studies on the orchestration of end-to-end secure slices in the 5G Core. It conducted a study of Slice Manager / Policy Manager solutions used on 5GENESIS. There has been no deviation from the expected contributions.

3-ALE does not partake in Task 3.1.

4-INV does not partake in Task 3.1.

5-HEP does not partake in Task 3.1.

6-NCSRD has participated in the work regarding the slice manager operations and functionalities. It has made an internal gap analysis based on the functionalities that are foreseen for the slice manager in relevance with the functionalities that are supported by 5GENESIS in order to reassure compatibility and appropriate support of the trials. NCSRD presented the work to be done based on the Katana slice manager (open source developed by NCSRD) in order to support slicing in the NFV part. NCSRD participated in the discussion of the slice manager API towards the abstraction layer. It made a presentation of Katana Slice Manager for NFV-space and enhancements needed for 5G!Drones considering Policy Manager solutions. It further participated in the discussions towards the end-to-end secure slices in the 5G domain. There has been no deviation from the expected contributions.

7-AU has conducted initial tests of a virtualised and distributed 5G core. It has made a design and implementation of new web user interface (WUI) for network slice management. AU has further investigated on new network cores that can be used for service type enforcement via VNF placement (3GPP control and user plane separation compliant). They also investigated on new network cores (OpenAirInterface, srsLTE, OMEC) that can be used for service type enforcement via VNF placement (3GPP CUPS compliant). Their work on network slices orchestrator based on Kubernetes is ongoing. There has been no deviation from the expected contributions.

8-COS does not partake WP3.

9-AIR does not partake WP3.

10-UMS's focus in T3.1 to date has been as a future application developer integrating with 5G slicing mechanisms. UMS has initiated research on application-level vs. network-level security requirements for the UMS platform with a view to understanding how the UMS platform will integrate with 5G slicing security mechanisms. UMS additionally aided in defining slicing requirements for autonomous UAV deployments, in line with the expectations and requirements detailed in other work packages (i.e. D1.1, D1.5). There has been no deviation from the expected contributions.

11-INF does not partake WP3.

12-NOK does not partake Task 3.1.

13-RXB does not partake Task 3.1.

14-EUR is working on a solution to segregate intra-slice traffic to support command and control (C2) link and another traffic that belongs to the same Network Slice. EUR is also working on implementing on OpenAirInterface (OAI) 4G, an algorithm that allows to separate UAV slice into uplink (UL) and downlink (DL), where UL is dominated by video traffic, while DL is dominated by C2 link traffic. EUR made development of an end-to-end Network Slice solution integrating the RAN for the 5GEVE-SA facility. It made a design of a RAN slicing solution for 5G. There has been no deviation from the expected contributions.

15-DRR provided advise and consulting to the proposed architecture considerations. The main goal was to assure, that such an architecture would meet service SLA required to maintain appropriate QoS for drone service. This was achieved by active participation in working group meetings as well as reviewing provided documents and deliverables. There has been no deviation from the expected contributions.

16-CAF has analysed WP3 documents and made an internal research on CAFA platform integration with slicing mechanisms. It has also made an internal research on CAFA Videolyzer integration with slicing mechanism and also on how to develop CAFA Tech software applications CAFA Analyzer and CAFA VideoLyzer and 3D map, which will be used in 5G!Drones project, compatible in 5G MEC. CAF is working on a cyber security solution draft. It has participated in T3.1 discussions and conducted internal research about end-to-end security requirements. There has been no deviation from the expected contributions.

17-FRQ has made contribution to the overall architecture with respect to research on Flight Information Management System (FIMS) for integration with UTM system. There has been no deviation from the expected contributions.

18-OPL as the task leader coordinated the task activities and actively participated and contributed to all periodic conference calls and F2F meetings. First, they presented the task T3.1 vision and goals during the F2F meeting in Athens. Additionally, the tutorial “5G and network slicing: Intro to techno and business aspects” was prepared and presented during the same F2F meeting, and further developed, as a stand-alone (self-commenting) version for the FRQ team. The draft (working) versions of WP1 documents analysis in terms of necessary inputs for T3.1 was performed. Based on the outcome of this review, the system level-analysis of 5G!Drones scenarios was done for validation of requirements against needed 5G system functionalities and identification of 5G System-level enablers. In consequence a detailed questions sheet was prepared for scenario-owners and facilities owners. During periodic conference calls the presentation about network slicing issues for the WP3 and the presentation of the In-Slice Management concept design and implementation was done. The initial vision of D3.1 and allocation of responsibilities has been provided. There has been no deviation from the expected contributions.

19-MOE does not partake in Task 3.1.

20-ORA does not partake in Task 3.1.

7.3.3. Task 3.2 MEC capabilities for the support of 5G!Drones trials (M3-M27) [EUR]

Task Objectives:
Edge computing comes with the promise of low latency, and this is critical for the delay-sensitive components that many of the 5G!Drones use case scenarios involve. This task will focus on the integration of Multi-access Edge Computing in the 5G!Drones architecture and in the trial facilities. As described in Section 1.3, the ICT-17 and other facilities where the use cases will be trialled feature to

some extent MEC features. However, these capabilities are heterogeneous. Therefore, following the requirements analysis of T1.2, this task will ensure that a common subset of MEC capabilities necessary for the support of the defined use cases is present at all facilities that will be used in the trials, and will fill potential gaps by developing the missing components critical MEC components.

Building on existing MEC components provided by the partners, T3.2 will create the necessary support for the inclusion of MEC application instances and related network and compute resources into an end-to-end UAV slice. However, an overview of the current status of the standards in slicing and edge computing reveals that *slicing support for MEC is still at a very early stage*. Given that 5G!Drones makes heavy use of slicing in conjunction with edge computing, it is necessary to extend current MEC implementations for slice awareness so that the appropriate level of (performance and other) isolation among coexisting slices is also enforced at the MEC level. This task will thus provide interface extensions and mechanisms for improved slicing awareness, resource isolation and security in a multitenant MEC environment for new UAV vertical use cases.

Finally, the research activities of this task will address the challenges of UAV mobility by introducing a *mobility management component*, which will ensure that UAV service components that are deployed at the edge are appropriately migrated across edge clouds following UAV mobility in order to maintain the latency constraints of the respective slices. The contributions of this task will be reported in deliverable **D3.1**, and the related software components will be released with the 5G!Drones Enablers Software Suite (**D3.3**).

Task Activities during the period: Extraction of list of challenges regarding MEC. Long discussions to clarify the differences between ETSI MEC and edge computing have taken place during bi-weekly meetings. After the partners agreed on their understanding of the use of the MEC, the Task participants worked on the identification of how partners plan to use MEC in the scope of the project.

The breakdown of the contribution, results, deviation and proposed corrective action of each partner in this task are described next. Regular partner activities, such as participation to teleconferences and face-to-face meetings will not be reported independently as they are considered the default a Beneficiary partaking a task would do.

1-UO made contribution with a report on MEC slicing state-of-the-art. UO is working on a solution for service migration between edge servers and planned the integration into the ETSI MEC in 5GTN. UO is working on the integration of the Oulu 5GTN MEC for support of multiple use cases. It presented an extensive description of the ETSI MEC in the 5GTN and it presented a white paper on the extensive explanation of the difference and similarities of applications deployment in ETSI MEC against applications deployment in edge servers. UO made a presentation on the MEC capabilities in 5GTN. It is currently upgrading from MEC 17 to MEC 19, and provisioning of inputs on the research work that can be carried out related to MEC, its slicing, orchestration, etc. Onboard YoloV3 based object detection has been tested, combined with object localization with respect to the UAV frame, but the object recognition can be run off board the UAV as well. It is even recommended because of the high computational requirements for object detection and classification. Integration to a cloud environment will be considered, depending on the MEC environment capabilities and services. MEC computational resources could also be used to form a real time updating model of the environment shared between UAVs, that control applications can use in the decision-making process when controlling the UAVs. There has been no deviation from the expected contributions.

2-THA has participated to discussion about MEC and its challenges. It has had internal technical discussions on the topic and it is working on MEC application that can be used in a public safety scenario. THA provided the ETSI Application Descriptors of its MEC application. THA has had internal discussions regarding research challenges about slicing in MEC. It made a state-of-the-art review on 5G MEC security at 3GPP and ETSI level and conducted preliminary architectural studies on security orchestration in the MEC. There has been no deviation from the expected contributions.

3-ALE does not partake in Task 3.2.

4-INV does not partake in Task 3.2.

5-HEP does not partake in Task 3.2.

6-NCSRD has been monitoring of the activities related to MEC functionality in 5G!Drones in order to reassure compliance of the 5GENESIS facility with the requirements and needs of the planned trials. NCSRD described the edge computing solution of Athens platform and discussed towards the necessary add-ons and modifications to support the planned Use Cases. NCSRD discussed on challenges in an access part, ETSI-MEC compliant solution is not currently supported. It has collaborated with partner COS on integrating the MEC solution available at COS premises with the 5G core located in NCSRD and extend the Use Cases at both sites. NCSRD had discussion on installing UAS at edge-computing of Athens site for supporting the trial. There has been no deviation from the expected contributions.

7-AU is working on a solution that allows the migration of containers-based flight control services between edge servers. It has conducted investigation of the possible solutions for the integration of edge servers in Aalto’s X-network. There has been no deviation from the expected contributions.

8-COS does not partake WP3.

9-AIR does not partake WP3.

10-UMS has made internal research regarding MEC requirements for UMS platform. It has conducted research on the required network service architecture for UMS deployments and it has participated in focused calls on network requirements for Use Cases. UMS has done research and development of a tentative application descriptor (AppD) for UMS software pilot. UMS made updates to required network service descriptor for UC2Sc2 and internal improvements to containerisation of UMS platform. There has been no deviation from the expected contributions.

11-INF does not partake in WP3.

12-NOK has made active participation in discussions and review of the respective paper regarding the role of MEC versus legacy edge computing. It has conducted Research on Positioning Services demands integration for MEC systems. NOK has had collaboration and workshops with partner UO on project needs for the MEC solution, particularly related to UC1Sc2 and UC3Sc3. It has further studied MEC architecture from Use Case perspective. There has been no deviation from the expected contributions.

13-RXB does not partake in Task 3.2.

14-EUR is the Task leader. It has led the discussion, presented the objectives of T3.2 during the face-to-face meeting in Athens, proposed a description of the work for T3.2, and organised the task of T3.2 into sub-tasks and assigned partners to those sub-tasks. EUR has worked on a solution to include in a network service descriptor (NSD) AppD in addition to VNF descriptor (VNFD). EUR has updated the facility with a new release of EURECOM MEC platform (MEP) and virtualised infrastructure manager (VIM) that support Docker container for MEC. EUR prepared a document to track the activity of T3.2 and wrote Task 3.2 report (WP3 progress report appendix) for the first review meeting. EUR did development of a new format of NSD integrating AppD for MEC application. There has been no deviation from the expected contributions.

15-DRR has made mapping of MEC to UTM and a MEC capabilities proposal and presentation. It has

investigated MEC usage in trial scenarios. It made further work on drone flight plan mapping into MEC provisioning. There has been no deviation from the expected contributions.

16-CAF has worked on MEC applications that can be used in a UC1Sc3, US2Sc3, UC3Sc1, UC4Sc1. It has done research on CAFA platform requirements for MEC and CAFA Video analyzer and 5G QoS mapping requirements for MEC. There has been no deviation from the expected contributions.

17-FRQ has made contribution to the overall architecture with respect to MEC and contribution to asking for ETSI standard Application service Descriptor in JSON. FRQ has had active participation in discussions and review of the respective paper regarding the role of MEC versus legacy edge computing. It has conducted research on FIMS for integration with UTM systems. FRQ contibuted to the technical discussions on feasibility test preparation and interface specification preparation. There has been no deviation from the expected contributions.

18-OPL has made an analysis of MEC standardisation documents, especially in terms of dependencies with network slicing concept, analysis of low latency MEC (LL-MEC) solution by EUR. OPL has further made analyses of ETSI MEC documents on Applications services exposed by MEP and their impact on underlying 5GS. OPL has worked on integration of MEC with the generic network slicing framework and Distributed Autonomous Slice Management and Orchestration (DASMO). There has been no deviation from the expected contributions.

19-MOE does not partake in Task 3.2.

20-ORA does not partake in Task 3.2.

7.3.4. Task 3.3 Infrastructure abstraction and federation of 5G facilities (M3-M27) [AU]

Task Objectives:

Given that 5G!Drones will trial services over heterogeneous 5G facilities, T3.3 is focused on providing a unified interface to expose facility capabilities and to deploy functions there. This interface will provide a single abstraction for network (e.g., RAN) and compute resources (e.g., those provided from a central or MEC datacenter). The API will be accessed by the trial controller to deploy and manage components of the vertical service and to orchestrate the execution of a trial. The abstraction layer that will be provided by this activity will in turn rely on the 5G facility interfaces. From a software design perspective, it can be seen as a plugin framework, where for each facility a plugin will be implemented, thus contributing to the system's extensibility.

Furthermore, this task will ensure the necessary level of connectivity across facilities and, in turn, among the components of a vertical service deployed at different sites, as well as between the trial controller and the management and orchestration components of each facility. This activity involves all relevant authentication, authorization and access control issues (AAA), and will further enable features such as the interconnection of a partner site to a facility and the dynamic relocation of service components at trial runtime. It shall be noted that these AAA issues are relevant with access to the management planes of facilities and, although having implications to the slicing security issues studied in T3.1, are distinctly different. The activities of this task will contribute towards achieving multi-domain orchestration of UAV slices, a topic also related with T3.1.

As a final note, since ICT-17 (and other complementary infrastructures that will be used by the project) will be still evolving during the course of 5G!Drones, this can significantly impact the activities in this task. We will adopt an incremental design and development approach, which will follow closely the output of task T1.3 (detailed description of 5G facilities). The abstraction and federation interfaces and mechanisms provided in this task will be reported in **D3.1** and the produced software will also be released as part of the 5G!Drones Enablers Software Suite in **D3.3**.

Task Activities during the period: The Task partners have identified the different interfaces between the abstraction layer and the different 5G facilities and they agreed on a common vision of the abstraction layer.

The breakdown of the contribution, results, deviation and proposed corrective action of each partner in this task are described next. Regular partner activities, such as participation to teleconferences and face-to-face meetings will not be reported independently as they are considered the default a Beneficiary partaking a task would do.

1-UO has contributed to the extensive description of the abstraction capabilities in the 5GTN. It contributed to the definition of network slice management interfaces 5GTN, defining all required interfaces for network slice feasibility check, network slice creation, activation, deactivation, and network slice instance modification. There has been no deviation from the expected contributions.

2-THA, 3-ALE, 4-INV, and 5-HEP do not partake in Task 3.3.

6-NCSRD presented 5GENESIS facility open API reference point as the way to perform abstraction and federation of the 5GENESIS facility. NCSRD discussed and provided feedback on the Northbound interface of Slice Manager for integrating it with the abstraction layer and had a discussion on the federation research of the different facilities NCSRD expressed concerns on integrating ICT-17 trial facilities with non-ICT-17 ones. NCSRD participated in discussions on Open-API of ICT-17 facilities. It provided a YouTube demo video, showing the functionality of 5GENESIS portal. There has been no deviation from the expected contributions.

7-AU is the Task leader. It has presented and led discussion related to T3.3. AU performed a detailed study of the interfaces and APIs to abstract and expose to the trial controller. The exhaustive list of interfaces and the related standards can be found in project repository. AU contributed to the initial ToC of D3.1 (Section 4). It provided the high-level architecture of the abstraction layer and discussed it with the involved partners. There has been no deviation from the expected contributions.

8-COS and *9-AIR* do not partake in WP3.

10-UMS participated to the various meetings but has not been actively involved in the task.

11-INF does not partake in WP3.

12-NOK, and *13-RXB* do not partake in Task 3.3.

14-EUR has started updating EURECOM slice orchestrator to interface with the 5G!Drones. EUR organises the API of the 5GEVE Sophia Site to be compliant with the project. It participated and contributed to the abstraction layer discussion. There has been no deviation from the expected contributions.

15-DRR made a recommendation for 3GPP standard infrastructure compliance development. It has conducted research on Operational Support Systems Service Configuration and Activation available solutions for facility enabler adapter implementation. There has been no deviation from the expected contributions.

16-CAF has analysed 3GPP and WP3 documents and made internal research regarding 5G infrastructure requirements. CAF did research regarding security related aspects and requirements. There has been no deviation from the expected contributions.

17-FRQ has contributed to the overall architecture with respect to discussion on specific Plugins for each facility and research on FIMS for integration with UTM systems. There has been no deviation from the expected contributions.

18-OPL does not partake in Task 3.3

19-MOE has made no specific contributions on the Task. There has been no deviation from the expected contributions.

20-ORA has ensured liaison between WP3 and WP1/D1.3 regarding architectural aspects. Otherwise, it has not made any specific contribution on the Task. There has been no deviation from the expected contributions.

7.3.5. Task 3.4 Development of UAV use case service components (M3-M27) [ALE]

Task Objectives:
Based on the detailed specification of the use cases of T1.2, the goal of this task is to enhance the existing UAV software or develop new software to support the use cases. This pertains both to onboard units and to software to be run remotely (e.g., as virtual instances on edge or remote clouds), and includes both control functionality and application level one. With the completion of the activities of this task, all *target use case scenarios will be fully implemented*. Also, in another line of activities in this task, the necessary software and hardware components for the integration of 5G technology on UAVs will be provided (e.g., installation and integration of UE equipment onboard). Deliverable **D3.2** is dedicated to the description of the activities of this task, while the full software suite including all use case scenarios to be trialed is delivered in **D3.4**

Task Activities during the period: This task has started later than the others because of the lack of 5G modems that can be embedded on the drones. However, questions on the identification of the hardware and software enablers, related to the drones have been addressed and allowed a clearer identification of the associated enablers.

The breakdown of the contribution, results, deviation and proposed corrective action of each partner in this task are described next. Regular partner activities, such as participation to teleconferences and face-to-face meetings will not be reported independently as they are considered the default a Beneficiary partaking a task would do.

1-UO as the owner of UC1Sc2 has developed the setup for cable drone used in tests, designs for indoor and outdoor drone testing in Oulu, and participated in the gathering of required service components for the deployment of use cases in 5GTN. It has been designing and developing of localisation references for UC3Sc3 for the 5GTN test site. UO participated in the gathering of required service components for the deployment of use cases in 5GTN. An example of service components considered include the mobile phone and camera holder for drone by Nokia. The UAV is implemented the necessary remote-control environment to enable simplification of the command interfaces on the UAV, using the onboard navigation and collision avoidance as much as possible. The UAV uses onboard tracking and measurements to prevent accidents and will implement fail safes for flying to safe locations and landing, in case the control application issues dangerous or invalid commands. The onboard ROS environment will be implemented data pre-processing and database nodes, to synchronise internal data used in navigation and task execution over 5G. There has been no deviation from the expected contributions.

2-THA has participated to the discussions regarding the implementation of 5G terminals on-board of

UAVs. It has organised and participated to all audio calls and followed-up of activities. THA followed-up of activities in view of service components of concern. There has been no deviation from the expected contributions.

3-ALE is the leader of T3.4 on the development of UAV use case service components/enablers. It has initiated talks with partners to have a first list of enablers that are required for the use case scenario to be realised. This list was highlighting the functions or enablers required for each scenario, and where each of the enablers would be running, such as the UAV, the edge, or the operator. This helped having an overview of the enablers needed for each use case scenario and was a first step to help identify missing components to adapt these scenarios to a 5G system and particularly to the global 5G!Drones architecture. This work was reported in D1.3.

Discussions have also been initiated to have an understanding of the 5G UE and modems existing at the moment on the market, the one currently owned by the partners, and which one are known to be compatible with the 5G!Drones facilities, but also the constraints of a 5G modems linked to drones. Following this work, and relying on the work performed in D1.3 in which the first system architecture was described, but also on the WP4 integration plan which provides the framework of the implementation, ALE has produced and distributed a more comprehensive set of documents on the service components for each use case scenario for each partner having enablers to fill. This document aims to have a more detailed description of each enablers and functionalities needed for the use case to be realised, in order to have a current status of them, and to follow the evolution of the development and implementation of each enabler.

In the meantime, partners have started to work on the implementation and development of their enablers and functionalities for the use case scenarios they are owning or participating, but also participated to the general talks within this WP3, and with WP1 and WP4, alongside the participation of calls. Finally, ALE, as owner of UC3Sc1 Sub-Scenario 3, has discussed on 5G modems, and worked on its own services components for the scenario . It has especially worked on the interface with the autopilot and the GCS. It has also worked on planning and beginning to implement strategies in order to adapt its drone, the Hydradrone, to be able to fly with 5G UE, even though not knowing this device makes it more difficult for the process.

Deviation and corrective action: The WPL has reported low activity of ALE until February, 2020. Since then the activity of ALE has risen to expected levels.

4-INV has carried out an internal analysis of technical requirements. It has done investigation on what phones or data USB sticks are available on the market. As the owner of UC1Sc1 INV has performed an internal analysis of the requirement, investigated on the 5G UE and asked partners about the possibility to use Nemo Handy; UO has one which can be used. There has been no deviation from the expected contributions.

5-HEP has, as owner of UC3Sc1 Sub-Scenario 2 participated in the discussion about 5G dongle options. It is mapping technical requirements for connecting FX-20 UAV to 5G. HEP has participated and contributed in the discussions and followed-up activities. HEP has done work on supporting service components of Use Cases. It has done preparation of tethering system for the purpose of the Use Cases and writing software to send autopilot sensor data to Kibana. There has been no deviation from the expected contributions.

6-NCSRD does not partake in Task 3.4.

7-AU did not start activities in the Task in the first half a year of the project. As the owner of UC3Sc2, AU has worked on the implementation of the different service components related to US3Sc2, mainly on the interface with the autopilot, the virtual flight controller, and the streamer. There has been no deviation from the expected contributions.

8-COS and *9-AIR* do not partake in WP3.

10-UMS has done research and planning on development required to prepare UMS platform as a UAV enabler for feasibility tests and future trials. It has consolidated required UAV Use Case service enablers for UC2Sc2. UMS is developing the UMS platform as a service enabler for feasibility tests. There has been no deviation from the expected contributions.

11-INF does not partake in WP3

12-NOK has discussed with UO and AU related to UAV software for UC3Sc3. It has started implementing enabler for indoor position system for UO test facility. NOK has established a UWB based indoor position system that enables sending real world object location to the VR world. The position system can also be used for drone indoor navigation. Nokia designed and created mechanics to add 5G UE + GoPro/360 camera holder to Mavic 2 Pro. This design is available to partners. NOK is designing and developing a UWB based positioning system to UO facilities. There has been no deviation from the expected contributions.

13-RXB has supported the partners and reviewing the scope of mission planning in the Trial Controller. RXB played a key role in defining the automation capabilities and scope by supporting UMS on several conference calls. There has been no deviation from the expected contributions.

14-EUR did not start activities in the task during the first half a year of the project. EUR has conducted investigation with UC leaders on the missing components for the UCs to be deployed on 5GEVE facility. It has participated to initial discussion on the UAV enabler.

15-DRR made an assessment of the Scope of Mission planning in Trial Controller architecture. It reviewed and updated of UC Service Components sheets. DRR made UC service component development for UTM interface (telemetry, Drone Flight Plan support, 112 mission prioritisation, Controller-Drone Data Link Communication). There has been no deviation from the expected contributions.

16-CAF has, as the owner of UC1Sc3; UC2Sc3; UC3Sc1 Sub-Scenario 1, engaged in discussion and analysing about 5G connection for Lidar technology. CAF is working on development of CAFA flight planning platform and CAFA Analyzer. It is also working on a DJI Mavic delivery solution to carry 5G smartphone and medicine. There has been no deviation from the expected contributions.

17-FRQ has made contribution to the overall architecture with respect to research on FIMS for integration with UTM systems. There has been no deviation from the expected contributions.

18-OPL is not partaking the Task 3.4.

19-MOE has made no specific contributions on the Task. There has been no deviation from the expected contributions.

20-ORA has ensured liaison between WP3/Task 3.4 and WP1/D1.3 (Section 6.2 regarding architectural aspects and UAV use case service component first description). Otherwise, it has made no specific contributions on the Task. There has been no deviation from the expected contributions.

7.4. WP4 Integration and trial validation

7.4.1. Progress towards objectives and details for each task [UMS]

WP4 Objectives

- Objective 5: **“Validate 5G KPIs that demonstrate execution of UAV use cases”**
- Objective 6: “**Validate UAV KPIs using 5G”**
- Objective 7: **“Advanced data analytics tools to visualise and deeply analyse the trial results, and provide feedback to the 5G and UAV ecosystem”**

To this end, the following specific objectives will be pursued:

- Integration of the developments of WP2 (trial controller) and WP3 (5G!Drones enablers) towards a full 5G!Drones architecture on top of the selected 5G trial facilities.
- Detailed design of trials.
- Execution of trials for the 5G!Drones use cases on the selected trial sites.
- Validation of the vertical service and 5G related KPIs.
- Evaluation of the performance of the use cases.

Identification of necessary enhancements in the used 5G facilities, and the 5G system in general and provision of recommendations.

WP tasks and interrelations:

- T4.1: Software integration and 5G!Drones architecture validation (M6-M24) [DRR]
- T4.2: Preparation and execution of trials (M12-M36) [CAF]
- T4.3: Evaluation of trial results (M20-M36) [COS]

Description of work

This is the work package where most of the efforts of the project will be put. It involves all aspects that have to do with the execution of trials. T4.1 is responsible for the integration of the software and hardware components that will be developed in WP2 and WP3, leading to a fully functional 5G!Drones trial architecture on top of the selected 5G facilities. Task T4.2 is where the use case scenarios, defined in detail in T1.2, will be trialled, after a careful design of a trial plan and a preparation phase. T4.3 will use advanced data analysis tools produced in T2.4 to evaluate the results of the trials from the perspectives of both the UAV industry and the 5G system. These results will be fed back to T1.1 to re-evaluate the role of 5G technology in the UAV ecosystem and provide recommendations to the appropriate bodies and stakeholders.

Main Progress in the period:

The WP was officially kicked-off WP4 during December (M7). The high-level objectives that WP4 – Integration and Trial Validation is aiming to achieve are: validation of 5G & UAV KPIs and visualising & analysing trial results to provide feedback to the 5G and UAV ecosystem. The WP initiated and completed work on D4.1, and initiated work on integration planning within Task 4.1. Preparatory work was initiated on Task 4.2 and the task officially began at M12. Consensus on integration planning responsibilities and test planning strategy was achieved and the WP initiated discussion with WP2 and WP3 module owners to align on development cycle. The activities also include preparation to conduct feasibility tests in all four 5G test facilities.

Significant results

Deliverable D4.1 was completed and submitted.

Deviations from Annex I and impact on other tasks, available resources and planning

The WP was kicked off in December (M7) instead of M6, as in the DoW. Also, the Deliverable D4.1 was submitted late, on February 8th, 2020.

Reasoning for failing to achieve critical objectives and/or not being on schedule

The late submission of Deliverables D1.1 and D1.2 had a cascading effect to D4.1 which will was also delayed. As the decisions and outcomes of WP1, WP2, and WP3 formed the basis of D4.1, it was important that an initial consensus was a reached on the architecture and use case component elements within these WPs before an initial integration plan was proposed. The fact that WP2 and WP3 have begun with a slight delay has had an impact on the delivery of D4.1. The D4.1 submission to Commission portal was discussed during the General Assembly and monthly Project Management Team meeting at end of January in conjunction with the face-to-face meeting in Sophia-Antipolis. The General Assembly decided significant changes were required in the deliverable in light of the consensus reached on the 5G!Drones overall architecture and the submission of D4.1 was further delayed by one week.

7.4.2. Task 4.1 Software integration and 5G!Drones architecture validation (M6-M24) [DRR]

Task Objectives:
The role of T4.1 is to deliver *a fully-fledged trial system* including all the necessary components at the UAV service and the infrastructure levels for the execution of the selected trials over 5G facilities. It will *integrate the 5G!Drones trial controller and 5G!Drones enablers, including UAV-service-related software and hardware*. Given the *size and complexity* of the project, with lots of heterogeneous components that are to be implemented and integrated with existing ones in a manner compatible with the trial facilities, a detailed *integration plan* will be created early in the course of the task, which will drive all integration activities in the project. This plan will define the integration and testing procedures and environment (including development and testing methodologies, tools, interfaces, and validation criteria) which will manage how the software and/or hardware modules that will be progressively delivered by WP2 and WP3 are *incrementally deployed and tested in the trial facilities*. Following the plan, the following activities will take place within this task:

- Incremental deployment and unit tests in a laboratory environment.
- Deployment and individual component testing on the 5G facilities.
- Functional tests for the validation of the 5G!Drones architecture.
- Integration and testing of the UAV hardware in the target ICT-17 facilities and other supporting 5G facilities.
- Functional tests of the selected scenarios over the selected facilities.

This task will work in close synergy with WP2 and WP3, providing continuous feedback from the integration activities for the refinement of the designed trial architecture and enablers. The integration plan will be reported in **D4.1** at M07 and refined in **D4.2** at M18.

Task Activities during the period: According to the DoW, this task has been charged with the responsibility of delivering a trial system. To fulfil this responsibility, the Integration Plan deliverable (D4.1) was prepared and submitted by DRR, the deliverable owners in collaboration with all task partners. This initial integration deliverable provided the integration methodology, key definitions and processes that would govern the integration activities. This integration plan would be updated as the project progressed. In addition, the following supporting documents were also created to assist in the integration:

a. Integration Management Plan,
b. Global Test Strategy,
c. Change Management,
d. RACI matrix.

Post the submission of this deliverable, work was done to align and agree on the steps to be followed for integration planning and testing strategy and consensus has been reached. Allocation of responsibilities for the release and testing cycle for the modules developed in WP2 and WP3 has been discussed. As a next step, DRR, the task leader will continuously align with the WP2 and WP3

module owners to align on the development cycle. Preparations to conduct feasibility tests in all four 5G test facilities have been made.

The breakdown of the contribution, results, deviation and proposed corrective action of each partner in this task are described next. Regular partner activities, such as participation to teleconferences and face-to-face meetings will not be reported independently as they are considered the default a Beneficiary partaking a task would do.

1-UO has made contribution to D4.1 in various sections as a facility owner. It has contributed in the integration plan and planned the trial of use cases at the 5GTN facility. UO also provided contribution to Gap analysis (requirements vs available capabilities) database useful for the integration plan. The UAV ROS environment has a Gazebo simulator support, where the simulation is being run on the UAV's onboard computer, with the real networking hardware. All the sensor measurements, and the flying environment can be simulated for the purposes of developing and testing control applications for the UAV, where the data is being transmitted over the real 5G hardware mounted on the UAV, as if in the actual real use case. From the control perspective, it is made as indistinguishable as possible, whether the UAV is operating in the simulated or the real environment. The data streams are made to be as similar as possible between the real and simulated environments; although the UAV's limited computational capacity will set bounds to the realism achievable in simulated environments. Later, when the 5G related software and hardware is tested this way, it should be easily transferrable over to the real testing facilities. There has been no deviation from the expected contributions.

Deviation and corrective action: Use Case feasibility tests were planned to take place in May, 2020. Those tests are currently postponed to June due to the covid-19 restrictions on Use Cases' participants for travel to Oulu. Should the restrictions apply also during June timeframe, the feasiblity tests need to be postponed further on. The Consortium has initiated a project Amendment process to mitigate the delays caused by covid-19 pandemic.

2-THA has followed-up activities of Task 4.1. It has participated to the edition of D4.1 and it has delivered reviews and contributions based on expertise/experienced. In addition, THA participated to activities setup as per integration plan defined (e.g. release and testing approach). There has been no deviation from the expected contributions.

3-ALE has held internal discussions about the proposed integration plan and testing plan and checking if it agrees. ALE made no objections submitting D4.1. It has also worked on the compatibility of the release plan sheet and Task 3.4 service components tables. There has been no deviation from the expected contributions.

4-INV conducted review of the D4.1 v2.5 and submitted comments back to the deliverable lead beneficiary. INV made contributions to the RACI table. It has conducted UC1Sc1 pre-test (feasibility) preparation (discussion with CAF, writing document). INV reviewed and added the inputs to the deliverables excel list prepared by THA. INV asked to designate Solution Architect for Web Portal role to partner competent in this area – UAS part was given to DRR and network part to AU. INV reviewed the testing plan proposal prepared by DRR. There has been no deviation from the expected contributions.

5- HEP has been reviewing and providing feedback to D4.1. It has been planning and preparing for feasibility tests in May (Oulu, Athens) and providing input for integration plans. HEP is providing necessary hardware (A3 flight controller and M600 drone) to UMS for their software integration with HEP drone. Due to the covid-19 situation those feasibility tests are currently planned to be carried out at end of June, early July. There has been no deviation from the expected contributions.

6-NCSRD has commented on initial D4.1 content and it has contributed in the integration plan and methodology along with various other parts of D4.1. It has made definition of the components for the

feasibility trial of May. NCSRD made a contingency plan due to covid-19 crisis on making the feasibility trial based on the integration of the components but emulating the flight of the UAV. It has had discussions on clarifying the role of using two web portals, one that of the facility and the other one dedicated to the drone flight, exposing UTM and UAS capabilities. NCSRD provided detailed figures demonstrating the complementarity of 5GENESIS platform with 5G!Drones experimentation / automation layer, showing which components will be integrated in ICT-17 facility from 5G!Drones architecture in order to support the experimentation.

Deviation and corrective action: The feasibility trial of year 1 planned for end of May in order to perform a first integration of all the necessary components on top of the Athens platform was originally scheduled in May 2020. Due to the covid19 crisis, travelling of the involved partners cannot take place and therefore the integration meeting and feasibility trial in Athens site has been postponed for June. Since, travelling restrictions will be still valid in June (at least for reaching Athens), a contingency plan to perform the integration remotely and emulate the flight has started to be discussed and planned. NCSRD as use case leader of Athens trials coordinates this activity. This shift of integration activity/feasibility trial after year 1 will affect the consumed PMs, since initially M11/12 was planned for integration effort that has not been performed at full scale.

7-AU made contribution to D4.1 by providing inputs on which components are available and planned to be considered to the Aalto trial site. It followed the discussions on the integration plan and it is planning the trials at AU facility. AU has made contributions to the preparation of the feasibility test planned for June and contributions about the trial that will be held in Aalto University trial site, and providing information related to its facility. AU is working on the dependencies between WP2 and T4.1 in terms of providing module owners of the trial controller in order to start discussing the implementation / integration. There has been no deviation from the expected contributions.

8-COS is a contributing author in D4.1 in various parts of Section 3 - Appendix A, Executive Summary, Introduction, and overall editorial changes. COS provided support for the formulation of the integration plan activities for the Athens demonstrations (UC4Sc1 in 5GENESIS Athens). COS participated to integration planning discussion and it provides support of the analysis of integration and validation environment and tooling specification. There has been no deviation from the expected contributions.

9-AIR contributed to the discussions around integration. AIR also brought the requirements from MCS point of view for demonstrating corresponding use case and also took into account external constraints to orient WP2 developments in order to be sure integration will be possible to implement in future steps. AIR has contributed with UC2Sc1 partners as Use Case leader to prepare integration of hardware and software components. Unfortunately, 5G-EVE platform is now blocked until September 2020 due to covid-19. There has been no deviation from the expected contributions.

10-UMS made contribution and review of D4.1. It also contributed and reviewed the RACI matrix. UMS has had coordinating efforts across Task 4.1 and WP2 and WP3. It has done initial preparation work for Task 4.2 – Athens and Eurecom feasibility tests. UMS participated to integration planning discussion. It has conducted a review of test planning strategy and aligning with task leaders on impact of covid-19 to task activities. It has further been aligning with task leaders on extension of tasks with extension of project duration. There has been no deviation from the expected contributions.

11-INF has made an internal overview of Task objectives as per DoW. It provided a definition of INF communication and business role in the RACI matrix. INF contributed to D4.1 in executive summary and section 1. It made a review and comments on the final draft version of D4.1. INF is monitoring and analysing Task 4.1 activities from a business perspective, communicating the results through social media and website, linking Task 4.1 activities to Task 1.1 and Task 5.1. INF defined its communication and business role in the RACI matrix and it has initiated internally processes for using D4.1 content for future media postings. There has been no deviation from the expected contributions.

12-NOK made a contribution and review effort to the RACI matrix. It is participating to June 2020 Feasibility Tests preparations. NOK prepared and built a drone container system for Nokia side pre-integration activities related to UAVs and 5G co-operations. There has been no deviation from the expected contributions.

13-RXB does not partake in Task 4.1.

14-EUR has proposed a new integration plan, by separating the trial tests and the components validation. It was accepted by all the partners. Due to the covid-19 issue, EUR is not able since the 14th of March to have physically access to the facility. EUR is not able to start the test of the UC as initially planned. The situation in France is still not clear, so every physical meeting is postponed to the beginning of September.

Deviation and corrective action: This has been solved by the extension of six months of the Task and the project.

*15-**DRR*** is the Task leader and D4.1 lead Beneficiary. It made D4.1 development, produced the initial version of D4.1 deliverable (Main document and attachments: D4.1 Integration plan, Integration Management Plan, Global Test Strategy, Change Management, RACI matrix, amendments to Risk Management). DRR prepared the first version of D4.1 Integration plan for review and made updates, and review updates. DRR made a Task 4.1 status presentation during the face-to-face meeting in Sophia-Antipolis and chaired workshops during the F2F meeting. It made the second release of D4.1, review of the updates' development, and preparation of the final release of D4.1. DRR finalised D4.1 and prepared it for official submission. DRR has been preparing agendas and content for integration working group meetings. DRR has done preparation of release planning and testing approach materials and provided release testing approach presentation. It has prepared initial version of Release Plan sheet - combining and verifying existing inputs (more specifically WP3 enablers list, WP2 modules owners, Task 3.4 Service components). There has been no deviation from the expected contributions.

Timeline deviation and corrective action: D4.1 was delivered late due to dependency on other WPs and due to reasons described before.

16-CAF has been contributing to D4.1, to the RACI matrix, and made a review of D4.1. Also participated in pre-trials integration discussions. There has been no deviation from the expected contributions.

17-FRQ has been contributing in the integration working group as responsible for enterprise architect. It performed an internal review on D4.1 and contributed to the RACI matrix. FRQ is involved in preparation of Athens Feasibility test and in coordination activities for integration of DRR and UMS systems. There has been no deviation from the expected contributions.

18-OPL has followed-up of the activities. Otherwise there has been no specific contribution.

19-MOE has been contributing in D4.1. It has provided support for the planned activities for the Athens demonstrations (UC4Sc1 in 5GENESIS Athens). MOE made preparation of infrastructure and supplied necessary materials of municipal stadium "Stavros Mavrothalasitis" for a feasibility test in May 2020. Due to covid-19 situation, the feasibility test is currently planned to occur in June. MOE has made contribution to the definition of the components for the feasibility trial and supported the planned activities for the Athens demonstration (UC4Sc1 in 5GENESIS Athens).

Deviation and corrective action: Due to the covid-19 crisis, travelling of the involved partners cannot take place and therefore the integration meeting and feasibility trial in Athens site has been postponed for June.

20- ORA did not start activity in this task during the first quarter year but followed carefully activities in order to adapt our components to follow the project integration requirements.

7.4.3. Task 4.2 Preparation and execution of trials (M12-M36) [CAF]

Task Objectives:
In this task, the scenarios defined in T1.2 will be trialled over the 5G!Drones architecture which integrates the different 5G trial facilities. The activities of this task are split in two phases:

- **Preparation phase:** Following an evaluation of the evolution and status of the available ICT-17 and other 5G facilities to which use cases have been mapped in T1.3, and the requirements of the use cases, as identified in T1.2, a detailed *trial plan* will be drafted for all use cases, including the 5G facilities for the execution of the trials, the interconnection of the trial sites, the KPIs to extract and the partners responsible for managing the trials. The trial plan will include *experiments of varying scales*, ranging from *small-scale, single-site trials* focusing on studying particular use case features which do not necessitate extensive deployments and lots of resources to *large-scale showcasing events*. The preparation phase also includes full *functional tests* of the selected scenarios over the selected facilities and preparations for showcasing trials. A critical aspect of trial preparation is planning the timing of trials: *Trial scheduling* should take into account the availability of facilities (and the amount of resources thereof for the execution of experiments) and the expected trial duration.
- **Trial plan execution and collection of trial results:** This is the main phase of the experiments, where the trial plan is executed. The orchestration of this activity and the collection of its results will take place using the interface of the trial controller. We remark that depending on the decisions that will be taken during the specification of the trial plan, multiple trials may take place simultaneously, potentially on top of a shared facility. Trials will commence after the delivery of the trial plan, marking **MS3** (M20).

An activity that will take place in parallel with trial execution is *trial demonstration*. Part of the trials specified in the trial plan will be on live showcasing events. For example, the plan will include showcasing the use case scenario that demonstrates enhanced connectivity during crowded events at the trial facility of the Municipality of Egaleo (municipal stadium). This is linked with specific communication and dissemination activities of WP5 and has as its focus not only to demonstrate the UAV-related use case scenarios, but also to demonstrate the operation and capabilities of the overall trial architecture and experimental methodologies. The trial plan (deliverable **D4.3**) will be delivered in M20. The trial results will be directly channelled to T4.3 as they become available.

Task Activities during the period: The goal of this task is to prepare and execute trials of use case scenarios identified in D1.1. To achieve this goal, work has been initiated to conduct feasibility tests in all the 5G trial facilities within the 5G!Drones project. These feasibility tests will test existing technologies that partners within the Consortium possess as well as early developments done within this project towards the achievement of the eventual use case scenario trials. The results of these feasibility tests will be fed to WP2 and WP3 as well as T4.1 to assist in development and integration processes.

The breakdown of the contribution, results, deviation and proposed corrective action of each partner in this task are described next. Regular partner activities, such as participation to teleconferences and face-to-face meetings will not be reported independently as they are considered the default a Beneficiary partaking a task would do.

1-UO has set up discussions on the feasibility tests and preparation of the pre-trials in 5GTN. UO has been developing drone software, installed sensors onboard and over the indoor positioning infrastructure, and preparing UAVs for testing. There has been no deviation from the expected contributions.

2- THA has joined discussions regarding feasibility tests as well as the preparatory work induced at facility level wrt. to Use Case / scenarios of concern. There has been no deviation from the expected contributions.

3- ALE worked to investigate feasibility tests session for the scenario UC3Sc1 Sub-Scenario 3. There has been no deviation from the expected contributions.

4- INV participated in the planning of the pre-test feasibility tests as the owner of UC1Sc1. Required inputs were given to CAF. Unfortunately, due to covid-19 the EUR facilities cannot be accessed at the moment and tests are now shifted from June till September 2020.

5- HEP has been preparing for the feasibility test at Oulu and Athens.

Deviation and corrective action: HEP has had to deviate from the original agreed feasibility test plans and made new ones due to covid-19 situation.

6- NCSRD has started activities for performing the trial with drone emulation (as a response to covid-19 crisis). There has been no deviation from the expected contributions.

7- AU is working on the preparation of the environment of the trials by getting remote access to the gNB/core in order to cope with the restrictions due to covid-19.

Deviation and corrective action: Activity of this task has been slowed down because of difficulty of getting physical access to the university due to covid-19.

8-COS did not start activities in this Task during M12.

9-AIR activities related to Task 4.2 will start in M13.

10-UMS has participated in feasibility test preparations in Athens and Eurecom. It is aligning with task leaders on impact of covid-19 to task activities on extension of tasks with extension of project duration. UMS carries out preparation for bi-weekly teleconferences as WP4 leader. There has been no deviation from the expected contributions.

11- INF has initiated internal processes for monitoring and analysing upcoming trials activities as communication and business liaison of WP4. INF monitors and analyses T4.2 activities from a business perspective, communicating the results through social media and website, linking T4.2 activities to T1.1 and T5.1. There has been no deviation from the expected contributions.

12-NOK did not start activities in this Task during M12.

13- RXB has participated and actively contributed to the Athens trial preparation, Aalto University and Oulu feasibility testing conference calls. There has been no deviation from the expected contributions.

14- EUR reports the same issue as in Task 4.1.

Deviation and corrective action: Same solution as in Task 4.1.

15- DRR Initial assessment of test principles. Contribution to Athens feasibility tests. There has been no deviation from the expected contribution.

16- ***CAF*** Initiating and leading Task 4.2 work and feasibility tests planning. Preparations for applying permits for feasibility tests. Coordination of teleconferences related Athens, Oulu and Aalto feasibility tests. Deviation and proposed corrective action: Due to covid-19 situation feasibility tests in Eurecom postponed to September.

17- FRQ is involved in preparation of Athens Feasibility test and in coordination activities for integration of DRR and UMS systems. Deviation and proposed corrective action: Due to covid-19 situation feasibility tests postponed to September.

18- OPL did not start activities in this Task during M12.

19- MOE has done contribution for the initial performing trials with drone emulation (as a response to covid-19 crisis).

Deviation and corrective action: Due to the covid-19 crisis, travelling of the involved partners cannot take place and therefore the integration meeting and feasibility trial in Athens site has been postponed for June.

20 – ORA has not stated yet activities in T4.2.

7.5. WP5 Dissemination, standardization and exploitation

7.5.1. Progress towards objectives and details for each task

WP Objectives

This WP contributes towards the following high-level project Objectives

- Objective 8: **"Dissemination, standardization and exploitation of 5G!Drones"**

For these to be attained, the following specific objectives will be pursued within this WP:

- Communicate project outcomes to a wide audience
- Showcase the activities and results of the project in large events
- Disseminate results to industrial and academic communities, as well as standardization and regulatory bodies
- Cross-fertilize within 5G-PPP and beyond
- Exploit the results of the project by various means: Improve 5G facilities, provide recommendations for the 5G system, improve UAV products to take full advantage of the 5G potential, etc.
- Produce and manage intellectual property and perform activities towards commercialization.

WP tasks and interrelations:

- T5.1: Communication activities (M1-M36)
- T5.2: Standardization, exploitation and IPR management (M1-M36)
- T5.3: Showcasing and dissemination activities (M1-M36)

Main Progress in the period:

The cross task deliverable D5.1 encompassing the three tasks of this WP has been released on time. 5G!Drones social media and sites are up and running. Project newsletters have been released has expected. Posters and other dissemination material that will be regularly updated are already available for dissemination purposes. Statistical dashboards are regularly updated to measure project impacts. Processes have been established to allow partners to document the activities they are achieving within the activities of this WP.

With regards to standardisation, in spite of low budget for this task and in spite of the fact that few partners declared SDO involvement, main SDOs relative to 5G!Drones shall be covered, especially ETSI, 3GPP, ASTM, GUTMA, and others (see specific Section 7.5.5.3).

5G!Drones has identified Working Groups of interest at 5G-PPP Programme level and consequently has appointed project's representatives to these WGs that have joined and contributed under supervision and support of TM and whole PMT. A number of activities have been undertaken (see dedicated Section 8 for details).

In addition, and in spite of covid-19 difficulties and cancelled physical meetings, dissemination tasks produced results as expected. The list of the diverse 5G!Drones dissemination activities can be found in a dedicated Table 3. Last but not least, 5G!Drones established during this first year some bridges to other European projects, not only ICT-17 projects as mandatory but also with PriMo-5G trying to find synergies.

5G!Drones jointly submitted a workshop proposal (AERCOMM) with PriMo-5G for WCNC 2020 conference. The workshop was accepted. The entire WCNC 2020 was later changed to a virtual one due to the covid-19 pandemic and the AERCOMM was virtually organised on May 25th, 2020. The 5G!Drones has been presented within private and public events on numerous occasions, including events such as the 21st Infocom World (in collaboration with ICT-17 5GENESIS project) and COSMOTE "Innovation Forum 2019". The project has had very active online presence through website, social media, and updated newsletters issued.

Significant results

The Deliverable D5.1 – Communication, showcasing, dissemination and exploitation plan and standardization roadmap was submitted on M6 of the project. 5G!Drones has been very active in presentations at various events of 5G and UAV fora.

Deviations from Annex I and impact on other tasks, available resources and planning

NOK has withdrawn from WP5 leadership and AIR has taken over this leadership at the beginning of the project this with no incidence at WP5 level. This change rather than deviation has been reflected in the submitted and accepted Amendment 1 of the project.

The ongoing covid-19 pandemic has affected a number of events the project had made plans to partake. As a consequence, some dissemination and exploitation have been outright cancelled, made to occur in closed doors, or made virtual making presentation of the project challenging. Otherwise, there have been no deviations with regards to progress towards WP objectives.

7.5.2. Task 5.1 Communication activities (M1-M36) [INF]

Task Objectives:

The main objective of this task is to devise and deploy a sound communication strategy plan, required to make the project achieve maximum visibility and to maximize the impact within the business and scientific communities, so to guarantee a fast dissemination and adoption of the project outputs. Planned activities will be monitored throughout the project lifetime and periodically amended, so to ensure long-term effectiveness and attainability. Communication activities will target related markets and industries with the objective of fully exploiting the novel business opportunities that are raised from related market activities and business functions. To this task belong activities such as setup of a

public website, file sharing and collaboration tool, keep social channels/networks updated, and communicate project achievements to the broadest possible audience through events, conferences, etc. This task will also rely on facilities offered at 5G PPP programme level to communicate (e.g. 5G PPP newsletter).

Task Activities during the period: Task 5.1 was set up and initiated from the beginning of the project with all the 5G!Drones communication channels namely: the 5G!Drones website (www.5gdrones.eu), social media channels (in Twitter, LinkedIn, Facebook, Instagram, YouTube), quarterly newsletters, leaflets, posters, and stickers. As per the 5G!Drones communication plan/strategy, all channels are intensively used on a regular basis for communicating project's activities and achievements to the project's audience and the general public. In parallel, monitoring mechanisms for evaluating the channels performance are used on a monthly basis (Monthly Data Studio Statistical dashboards are issued for the website and social media channels, refer to Section 7.5.5.1 for more details). Also tracking processes have been established that allow partners to formally document their performed activities which are then used as communication content for the 5G!Drones posts and website news.

The breakdown of the contribution, results, deviation and proposed corrective action of each partner in this task are:

1-UO assumed establishment of the project internal collaboration environment, Microsoft Teams. It has been managing access to the Teams environment. UO has been coordinating from 5G!Drones side and submission of a workshop proposal Aerial Communications in 5G and Beyond Networks (AERCOMM) for WCNC 2020 conference. The workshop is Co-organised with PriMO-5G project and it was accepted. UO has positions as general co-chair, technical program co-chair, publication co-chair, and technical program committee of the workshop. The WCNC conference and its respective AERCOMM workshop was first postponed due to covid-19 and second, turned as a virtual event. AERCOMM was held on May 25th, 2020. UO made preparations of roll-up for Nokia-hosted booth at 6G Summit in Levi, Finland and planning and preparation of participation in the event. The event was made virtual due to covid-19 and hence, the preparation work was done in vain. Similar situation occurred to Race of Drones event in Oulu, Finland. UO has addressed some email contact redirection issues on 5G!Drones 5G-PPP website and it has managed the project email lists. UO coordinated 5G!Drones contribution to Full-5G Annual report, with deadline March 9th, 2020.

Deviation: Planned roll-up poster participation at NOK booth in March 6G Summit, Levi, Finland was cancelled due to covid-19. Planned stand exhibition in March at Race of Drones, Oulu, Finland was cancelled due to covid-19.

2-THA has followed-up task activities and provided support based on demands issued. It has provided support to D5.1 ToC definition, made contribution to D5.1 and reviewed it. THA provided support to 5G!Drones project communication at Fraunhofer Focus Fuseco Forum 7-8 November 2019 event in Berlin and has followed-up Task 5.1 progress through meeting minutes. THA performed several internal communications on 5G!Drones project (within own global business unit as well as others). It has communicated on 5G!Drones through various instruments (e.g. 5G IA Security WG, …). THA submitted a joint (5G IA & ECSO) EuCNC Workshop proposal. Unfortunately due to covid-19 situation that did occur, EuCNC organizers informed the Conference will be held virtual this Year and that the Workshops had been cancelled. Apart from this, there has been no deviation from the expected contributions.

3-ALE did not start activities on this task during this first year to have enough material on its side. It will use its PMs during the following 2 years. There has been no deviation from the expected contributions.

4-INV made the design of the 5G!Drones poster and various exchanges and updates based on partners' remarks. It has had discussions on leaflet/flyer and made a review of the D5.1 ToC and

provided contribution. INV made a presentation of 5G!Drones project within private and public presentations, including within face-to-face private meetings with representatives of French and Swiss authorities. It has had various exchanges and discussions with the Consortium partners on the communication strategy, and followed-up and supported social media efforts. INV has had collaboration with RXB and CAF on proposing the topics, review, and edition of the article for European 5G Annual Journal. INV collaborated with RXB on the organisation of Commercial UAV Expo participation of Consortium members. INV participated in the interview with Commercial UAV News about 5G!Drones project and had different exchanges on the participation to Commercial UAV Europe Amsterdam. Apart of that INV as usual kept sending updates about the project in social medias. There has been no deviation from the expected contributions.

5-HEP does not partake in WP5.

6-NCSRD has followed-up of task activities and provided support based on demands issued. It made a presentation of 5G!Drones project in collaboration with 5GENESIS in the 21st Infocom World Conference 2019[2]. NCSRD planned to participate in Mobile World Congress to communicate the project activities. Unfortunately, the event was cancelled due to covid-19 crisis. There has been no deviation from the expected contributions. PI of partner NCSRD, Dr. Harilaos Koumaras contributed in two white papers of 6G Flagship initiative towards the UAV vertical industry in 2030. The papers submitted preprints to ARXIV and will be also submitted for publication is a Magazine or Journal.

7-AU did not start on this Task during the first half a year of the project. AU has participated to GLOBECOM (December 2019) and presented two accepted papers acknowledging 5G!Drones. There has been no deviation from the expected contributions.

8-COS has updated COSMOTE web portal with 5G!Drones presentation in Greek and in English[3]. It presented 5G!Drones project in the "Innovation Forum 2019", Workshop "IT–Telecommunications, "OTE Group Research Activities on 5G". https://griechenland.ahk.de/gr/ekdiloseis/plirofories-ekdilosis/foroym-kainotomias-h-kainotomia-os-mochlos-anaptyxis/ and in the 21st Infocom World Conference 2019[4]. There has been no deviation from the expected contributions.

9-AIR has taken over WP5 leadership from NOK and supervised this task as Work Package leader. AIR has contributed to D5.1 section corresponding to this task especially concerning topics relative to mission critical communication. AIR has had internal presentations of 5G!Drones project to raise interest of diverse business lines within Airbus Defence and Space (AIR stands in fact for Secure land Communications SLC which is a subsidiary of Airbus Defence and Space). AIR raised MINARM interest around 5G!Drones plans for future recourse in the context of the crisis submitted due to covid-19 pandemic. AIR has updated internal communication through prototype issued from WP2 and from discussions and contributions to 3GPP UAS. There has been no deviation from the expected contributions.

10-UMS made preparations and presented 5G!Drones in an interview with Commercial UAV News.

11-INF is the Task leader. It has coordinated all Task 5.1 related activities, set up and maintenance of 5G!Drones website, set up, running, and maintenance of social media accounts (Twitter, LinkedIn, Facebool, Instagram, YouTube), is in charge of issuing on a quarterly basis 5G!Drones newsletter issues and developing statistical dashboards (live/dynamic web based dashboards) for monitoring the performance of web site and social media on a monthly basis. INF was the lead editor of D5.1. INF led, edited, coordinated and finalised the D5.1 with core contributions in all sections related to communication, exploitation, 5GPPP and dissemination. INF has issued all the three newsletters of

[2] https://www.infocomworld.gr/21o-infocom-world-2019/5g-epistimoniki-synantisi-aithoysa-makedonia/
[3] https://www.cosmote.gr/cs/otegroup/en/5g_drones.html, https://www.cosmote.gr/cs/otegroup/gr/5g_drones.html
[4] https://www.infocomworld.gr/21o-infocom-world-2019/5g-epistimoniki-synantisi-aithoysa-makedonia/

the project and is preparing the fourth one, scheduled for release in the first quarter of June. Within the project INF maintains the communication activities repository in MS Teams. It supported the call for papers initiatives at WCNC2020 AERCOMM (publicity and promotion plan, setup of dedicated page at the website, dedicated posts through the social media). INF has updated the project leaflet. INF made communication of 5G-PPP activities including newsletter and newsflash issues. It has prepared year 1 statistical dashboards of communication channels, and T5.1 reporting for year 1 review. There has been no deviation from the expected contributions.

12-NOK has reviewed D5.1 (v1.0). It has promoted 5G!Drones at PRINSE'20 (29/01/2020, OULU, FINLAND) Juha Hannula (NOKIA) presented 5G!Drones at Session 1: Opening and Keynotes at Prinse'20, 29/01/2020, Oulu, Finland; and FINNISH SATELLITE WORKSHOP AND REMOTE SENSING DAYS (20- 22/01/20, HELSINKI, FINLAND) Mika Jarvenpaa (Nokia) participated at the Finnish Satellite Workshop and Remote Sensing Days 2020(20-22/01/20, Helsinki, Finland) with a 5G!Drones project poster and a panel participation. NOK has done preparation for interview with Commercial UAV News. There has been no deviation from the expected contributions.

13-RXB did not start activities on the Task during the first quarter year of the project. Since then RXB has actively led dissemination activities and has gotten 1000s of views on social media on each post. In total, the posts from RXB had 20,461 views, 276 reactions, and 64 comments. The geographic spread of the post ranges from San Francisco, to Tokyo.

14-EUR has two scientific publications related to the project activities, and acknowledging 5G!Drones, accepted in IEEE ICC 2020 conference. An interview of Adlen Ksentini on 5G!Drones has been published in Institut Mines Telecom (IMT) blog. There has been no deviation from the expected contributions.

15-DRR does not partake in WP5.

16-CAF conducted a test flight in Tallinn November 1st, 2019 and published a story and photos related to this showcase. The story and photos were also published in a presentation related to 5G!Drones Project in Focus Fuseco Forum 7-8 November 2019 in Berlin. CAF provided inputs and recommendations for D5.1. In collaboration with RBX and INV, CAF proposed the topics, review, and edition of the article for European 5G Annual Journal. CAF has been analysing dissemination possibilities in Estonia. CAF partook in preparation and interview with Commercial UAV News and it made contributions to 5G network and U-Space article. There has been no deviation from the expected contributions.

17-FRQ has made social media postings with a link to the latest 5G!Drones newsletter in Twitter, LinkedIn, and Facebook. It has contributed to D5.1 on exploitation plan and made a review of the deliverable D5.1 and provided comments. FRQ has made re-distribution of project Newsletters on social media. FRQ has performed preparation for interview with Commercial UAV News, conducted by RBX. There has been no deviation from the expected contributions.

18-OPL and *19-MOE* do not partake in Task 5.1.

20-ORA did not start activities on the Task during the first quarter year of the project. It has made contributions to a project Newsletter. Orange has published research works IFIP Networking 2020 related to the project activities on controlled mobility.

7.5.3. Task 5.2 Standardisation, exploitation and IPR management (M1-M36) [AIR]

Task Objectives:

This task is mainly focusing on three activities:

- Contribution to standards bodies,
- IPR management, and
- Commercialisation activities

First, this task will contribute to various standardization bodies. The contributions to standardization will ensure that the research outcome of 5G!Drones will obtain broader recognition and also its results are utilized by a wide industry community. The consortium members have long history of standardization experience in various standardization bodies including ITU-T, IETF, IRTF, ETSI and 3GPP. For instance, **AIR, ORA, NOK, and THA** are contributing to ITU-T, IETF ETSI and 3GPP working groups. These partners will disseminate the results of 5G!Drones within these standards development bodies and support the translation of key results into potential recommendations. Partners representing the UAV ecosystem will be contributing to UAV-relevant standards bodies (e.g., ISO/TC 20/SC 16 Unmanned aircraft Systems, NASA's Unmanned Aircraft System (UAS) Traffic Management (UTM) ecosystem, EUROCAE Working Groups on Unmanned Aircraft Systems (UAS), and RTCA). **AU and UO** will also determine standardization opportunities for the findings of the 5G!Drones project and launch pre-standardization research groups, study groups and/or working groups in the areas of the project under IEEE Standards Association and IEEE IoT Community. Standards' relevant results of the project will be also promoted within the IEEE Conference on Standards for Communications and Networking, founded by **AU**. **FRQ** is a member of several relevant international fora, which focus on bringing industry, research and end-users together. Examples are the PSCE (Public Safety Communications Europe), the EENA (European Emergency Number Association), the British APCO, and the TCCA Tetra and Critical Communications Association. In several of these fora, **FRQ** is providing an official role such as chairing a workgroup. In addition, the active involvement of consortium members in the standardization process will bring their knowledge of standardization to the project and make the consortium aware of any standardization results that can be applied to the project. WP Leaders will monitor the respective R&D activities in 5G!Drones and stimulate the standardization of their outcomes. This task involves a continuous awareness of possible standardization opportunities and development within relevant standards identified during proposal preparation. This task will also take advantage of the 5G-PPP Pre-standardization Working Groups active at 5G IA level and so liaise with it.

Second, this task will be focusing on management of IPRs. Intellectual property (IP) management is important to safeguard investment from the partners but also to maximize commercial exploitation the potential of the resources invested in the project. ***IPR will be protected by an agreement, in alignment with the policies and context for EU funded projects***, that specifies how and under which conditions partners get access to existing and created IP owned and generated by other partners and specifies the conditions of access to such IP in the case of exploitation beyond the scope and duration of the project. The agreement will cover specification and handling of the types of intellectual properties, mechanisms to identify and to brand them and definition of the roles of the partners and the individual usage rights of the intellectual properties. A Consortium Agreement (CA) based on the EICTA (European Information, Communications and Consumer Electronics Technology Industry Association) model will be signed between all partners before the start of the project, specifying among other things the internal organization of the consortium reflecting rules for dissemination, internal disputes settlement and IPR arrangements.

Third, this task will be also focusing on the exploitation of project results. It will be focusing on three primary goals:

- **Sustainability.** The project's efforts will be made sustainable in the immediate term beyond the project's lifetime. This will ensure that exploitation of the project's results can be made smoothly towards the end of the project and will continue after the project's funding period ends.
- **Exploitation of results.** The project's results, particularly those that fulfill the objectives as described in Section 1.1, will be directly exploited by the consortium and individual partners.

- **Long-term viability.** Long-term exploitation of objectives will be explicitly considered in view of the market. For this purpose, this task will be focusing on the creation of both partner-level and consortium-level exploitation plans. Moreover, it will include an impact assessment that prioritizes the highest-impact exploitation methods. Based on these results, post-project business plans will be generated. In addition, this task will organize workshops inviting a range of target stakeholders that will provide feedback and assist in exploiting the project results in the best possible way.

Task Activities during the period: During this first year period, the Consortium has identified relevant standardisation bodies and analysed current situation with regards to support drones services on 5G infrastructures. Partners have followed up and contributed to diverse work streams giving inputs from and to 5G!Drones project (See details below). The project has established link and contributed to 5G-PPP Pre-standardization WG effort. IPR issue has been solved in an agreement in alignment with the policies and context for EU funded projects. Exploitation tasks have just begun. This activity has not suffered significantly from covid-19 situation. Main standardisation activities have continued converting physical meetings into virtual ones.

The breakdown of the contribution, results, deviation and proposed corrective action of each partner in this task are as follows.

1-UO did not start activity in this task during the first quarter year of the project. It made a proposal to ETSI SmartBAN standardization, which was accepted, to enable inter-BAN connectivity. UO also made a proposal, which was accepted, for ensuring BAN connectivity using intra-BAN relays on-demand. The SmartBAN standardization could be relevant in drone swarms as inter- and intra-BAN coordination technology. There has been no deviation from the expected contributions.

2-THA has followed-up of task activities and provided support based on demands issued. With main focus on standards development organisations (SDOs) of concern and alignment with respect to actions engaged at Programme level. THA initiated some work to engage on 5G IP material. It has had internal coordination performed as well as provided support. THA has been monitoring of SDOs of interest and work on identification of standards to use for components/enablers of concern. More specifically THA has closely followed the 5G standardization efforts in the 3GPP with particular focus on the radio standardization activities (RAN) and System Aspects (SA). THA has put under scrutiny the work on RAN slicing in the release 17 of 3GPP. In this context, the Study items on RAN slicing (RP-193254) in RAN2 has been identified as of a high interest.

There has been no deviation from the expected contributions.

THA is closely following the 5G standardization efforts in the 3GPP. In particular, internal working groups have been investigating how the new releases (Rel17 and beyond) will impact THALES products and businesses. A particular focus is drawn of the radio standardization activities (RAN) and System Aspects (SA). With a direct impact on our contributions in 5G!Drones, THA is putting under scrutiny the work on RAN slicing in the release 17 of 3GPP. In this context, the Study items on RAN slicing (RP-193254) in RAN2 that will be starting in Q2-2020 is of a highly interesting. As a matter of fact, we will continue following on the Work Item (WI) that will be the outcome of this study and is expected to start in 2021.

3-ALE did not start activities on this task during this first period to have enough material on its side. It will use its PM during the following 2 years. There has been no deviation from the expected contributions.

4-INV has done a full review of project Data Management Plan and has had discussions on it with UO regarding exploitation through open and FAIR data. INV has joined ASTM (International Standards Body) and attended ASTM F38 (UAS chapter) Committee meeting. INV filled and submitted the list of

previous participation in SDO WG activities and its plans for 2020. INV once per week participated in in ASTM standards working committee on the topic of SSDPs (supplemental service data providers). INV participated in GUTMA Connected Skies Webinars (in April as a presenter, and in May as a participant) on the topic of using cellular networks for surveillance data and participated in Remote ID activities, including the development of drone compatible trackers. There has been no deviation from the expected contributions.

5-HEP does not partake in WP5.

6-NCSRD does not partake in Task 5.2.

7-AU has not done any specific activity on the Task during the first year of the project.

8-COS has started the Task activity during the first year of the project, as planned, aiming at supporting the exploitation methodology and its respective deliverable (M18).

9-AIR is the Task Leader. AIR has taken over WP5 leadership from NOK and supervised this task as WPL (in addition to be task leader for Task 5.2). AIR has contributed to D5.1 section corresponding to this task especially concerning topics relative to mission critical communication. AIR has established a framework allowing involved partners to contribute. AIR has established a list of SDOs of interest for 5G!Drones. AIR has monitored 3GPP activities. AIR has established a preliminary exploitation plan of 5G!Drones results. AIR established a global SDO cartography relevant for 5G!Drones project and proposed a global exploitation plan for the project. AIR has raised consortium awareness about 3GPP TR 23.754(SA2) and 23.755(SA6). AIR has collected standardisation actions and plans from consortium partners. AIR has Contributed to 3GPP UAS e-meetings. AIR has achieved specific work for defining objectives related to SA6 discussions. AIR has submitted 2CR in response to SA6 LS. AIR has attended and made liaison between 5G!Drones and 5G-PPP WG Pre standardization. There has been no deviation from the expected contributions.

10-UMS did not start activities on the Task during the first half a year of project. It has provided inputs to WPL on standardisation activities.

11-INF is not partaking in Task 5.2.

12-NOK has had internal discussion related standardisation groups. NOK had an internal workshop, where 5G!Drones information was shared to Nokia 3GPP delegates and pointed out project findings, for example, from deliverables D1.1 and D1.3. It has participated, followed, and contributed via telco, webinars, internal workshops etc. to several standardisation groups ETSI, GUTMA, ECC SE21, IETF DRIP, CCSA ST9 WG3#10: Navigation and Location service (Positioning), FAA, 3GPP and GSMA. There has been no deviation from the expected contributions.

13-RXB has participated in NASA Advanced Air Mobility (Urban Air Mobility) Technical working group and has actively contributed to certification standards for drone operations, communication standards, architecture and U-space adaption. Besides that, RXB has also actively participated in African Drone Forum in assisting the UAV Payload Delivery Working Group and contributed on several topics.

14-EUR has not done any specific activity on the Task during the first year of the project. There has been no deviation from the expected contributions.

15-DRR does not partake in WP5.

16-CAF has contributed to the identification of relevant standards for 5G!Drones Use Case trials. It has analysed radio communication standards related UAVs. There has been no deviation from the expected contributions.

17-FRQ does not partake in Task 5.2.

18-OPL has made an analysis of the current documents of 3GPP on UAV support within 5G and earlier generations (especially requirements). It has had no standardisation activities at this stage of the project. It has only followed-up of standardisation “state of the art” during WP1 and WP3 activities (including gaps identification). There has been no deviation from the expected contributions.

19-MOE does not partake in Task 5.2.

20- ORA has followed standardization activities at CEPT about ECC report 309, 3GPP on supporting UAV in 5G architectures, IETF about Drone Remote ID protocol, and GSMA about Remote ID project but didn’t identified valuable information to report in the project until now.

7.5.4. Task 5.3 Showcasing and dissemination activities (M1-M36) [RXB]

Task Objectives:
During the runtime of this task, the consortium partners will establish a showcasing and dissemination plan for presentation of the project results to stakeholders and public. First, we plan to set up an initial plan for showcasing and dissemination. The plan will be refined at M18. Results that seem to be relevant for the European industry will be advertised and made public for a deeper analysis of their commercial and sociological potential. Designated “public use” results will be shared with the public and made open source wherever it is possible. All partners will contribute to a frequent update of the project’s dissemination channels: Website (to come online in M03), community forming platforms (Facebook, Twitter, YouTube, blogs), scientific publications, open access publications, conferences, topic-related community, open-source software, general media publications, exhibitions, etc.

The consortium partners will participate in large showcasing events related to both UAV (i.e. Amsterdam Drone Week, UAS TAAC Conference etc.) and 5G (i.e. 5G Summits, MWC etc.) to demonstrate the results of the project and the acquired 5G knowhow. Moreover, 5G!Drones targets publication in selected and high-impact journals and magazines on communications/networking (e.g. IEEE Communication Magazine, IEEE JSAC, IEEE Network, IEEE Internet of Things), and reputed international conferences (e.g. Globecom, ICC, WCNC, Infocom, EuCNC) as well as vertical-oriented publications (Journal of Unmanned Aerial Systems, International Journal of Intelligent Unmanned Systems). Finally, this task will be focusing on organization, presentation and participation in the organization of events (e.g., panels, targeted workshops, workshops co-located with relevant conferences, special sessions) and participation in these same kind of sessions as keynote speakers, panelists, etc.

Furthermore, 5G!Drones will take advantage of 5G-PPP Programme to liaise and disseminate results to 5G-PPP or 5G-IA Working Groups of interest among which, (already mentioned) Pre-standardization, Architecture WG and Security WG.

Task Activities during the period: Dissemination activities were conducted at Amsterdam Drone Week 2019 in Amsterdam with partners from RXB, FRQ & INV. The preparation for dissemination and showcase activities at ADW 2020, MWC 2020 and InterDrone 2020 were undergoing, and RXB had several calls with organizers and partners to organize an exhibit. But due to the COVID-19 situation, the conferences were either cancelled, or were moved to virtual. Currently, ADW 2020 has gone virtual, but discussions are ongoing with the organizers to plan for dissemination activities, speaking (presentation) opportunities, etc. Besides that, an international journalist from commercial UAV News interviewed 5G!Drones partners and an article about the project is under preparation. The first draft for the article will be presented to the partners during the 1st week of June, and the article is due for publishing mid-June. This article will have a sequel, meaning, the journalist is interested in following

the activities of the project, and publish multiple articles highlighting the results and the efforts. Numerous presentation activities were conducted, representing 5G!Drones project from various partners, including research publications.

The breakdown of the contribution, results, deviation and proposed corrective action of each partner in this task are:

1-UO has done project promotion at EuCNC, Valencia, June 2019 and at EC Digital Transport Days, Helsinki, October 2019. It gave an invited speech at EC Digital Transport Days 2019 in Helsinki on what 5G can bring to drones. UO gave a 5G!Drones poster presentation at 5GTNF Results and Demo Seminar in Helsinki. UO planned participation and roll-up stand at Race of Drones Oulu event for March 13th. The event was held at closed doors due to covid-19 pandemic. UO is the 5G-PPP Steering Board member of the project. UO has provided project feedback, for example on Use Cases for 5G document. It has also contributed to the 5G-PPP COMMS WG by collecting input from project partners and adding 5G!Drones inputs to the Target Stakeholder Identification work. There has been no deviation from the expected contributions.

2-THA has done internal dissemination of the project. It provided support to external event participation (e.g. Focus Fuseco Forum 7-8 November 2019 in Berlin. THA is making continuous dissemination in various context starting first with 5G PPP through TB participation (e.g. at TB Workshops).as well as through 5G IA SEC WG as one of the co-chair. THA was also active in organizing 5GDrones representation at WGs of interest and as provided support to project's representatives appointed. THA also started to initiate liaison with other projects on the field as well as towards interested Business lines. THA contributed to D5.1 and sections it was more specifically in charge of. There has been no deviation from the expected contributions.

3-ALE did not start activities on this task during this first period to have enough material on its side. It will use its PM during the following 2 years. There has been no deviation from the expected contributions.

4-INV made a presentation of the project during Salon International de l'aèronautiqe et de l'espace le Bourget and during various public and private presentations. It has followed-up on social media, made social media communications, and it has provided input to the dissemination plan. INV has made exchanges with Consortium members on the communication and dissemination strategy. INV has put info about 5G!Drones into its commercial presentations and offers. Presentation of the 5G!Drones project during GUTMA Connected Skies Webinar "Using Cellular Networks for surveillance data". Presentation replaced the in-person participation to the GUTMA Connected Skies Conference within MWC which was cancelled due to covid-19 crisis.

5-HEP does not partake in WP5.

6-NCSRD presented 5G!Drones at the Infocom 2019 conference. Harilaos Koumaras has participated in various workshop proposals on behalf of 5G!Drones for the forthcoming EuCNC event, related to 5G and vertical industries. There has been no deviation from the expected contributions. The booth planned for MWC has been cancelled due to covid-19 crisis. A commitment for MWC2021 has been made with the organisers, paying a reduced price for the booth of the next year.

Deviation and corrective action: The booth for the MWC has been postponed for 2021, because MWC2020 cancelled due to covid-19 crisis.

7-AU has made publication of three papers acknowledging 5G!Drones: one magazine and two conference papers. It is working on different scientific papers in relations with 5G!Drones activities.

8-COS has not started the Task activity during the first year of the project, as planned.

9-AIR has taken over WP5 leadership from NOK and supervised this task as WPL. AIR has contributed to D5.1 section corresponding to this task especially concerning topics relative to mission critical communication. AIR made a roadmap for MCS API evolutions to allow 3rd party developers to reuse projects results. AIR as WP leader ensured with INF (T5.1 leader) for RXB to well understand the role of task leadership in T5.3. AIR has ensured liaison between 5G!Drones and 5G-PPP WG Pre standardization There has been no deviation from the expected contributions.

10-UMS has ongoing discussion with RXB on participating in ADW2020. It has also promoted 5G!Drones through its social media handles.

11-INF has made an overview of T5.3 as per DoW. It has performed communication of dissemination activities via website and social media. INF made contributions to D5.1 - Section 3 and has reviewed and edited D5.1 - Dissemination section. INF has made content creation in the form of news and posts in the news section of the project website, posting dissemination activities in all social media accounts (Twitter, LinkedIn, Facebook, Instagram, YouTube). INF ran the call for papers details at WCNC2020 for AERCOMM workshop and it has printed leaflets and stickers for MWC2020, EuCNC and future events. INF is maintaining within the project repository the dissemination activities excel tracking file and is preparing annual reporting of such activities. Concerning 5G-PPP WGs, INF is participating in the 5G-PPP SME WG activities, participating in teleconferences, contributing to the new SME web page and SMEs brochure, info on upcoming 5G-PPP ICT activities (events, booths etc.), and reporting to 5G!Drones Consortium. There has been no deviation from the expected contributions in T5.3.

12-NOK created two different one slide PowerPoint Ads for Nokia 5G slide deck which is used as advertisement material. NOK participates to 5G PPP WG Test, Measurement and KPIs Validation. NOK planned participation and to have a demo stand in Race of Drones Oulu event for March 13th. Due to covid-19, there was no Nokia participation. NOK also planned participation and preparation to have a 5G Drone demo for 6GSummit in Levi with moving 5G RAN network, 5G UE, flying drones and cameras. Due to covid-19, there was no Nokia demo in 6Gsummit, which was organised virtually due to covid-19. There has been no deviation from the expected contributions.

13-RXB is the Task leader. RXB did not start its Task activities during the first half a year of the project. Since then RXB has led activities and related to Amsterdam Drone Week (ADW) exhibit. It has further led the Task work and actively contributed to Full-5G article highlighting the use cases of 5G!Drones project. RXB also arranged for an international journalist to interview various partners of the 5G!Drones project. The article will be published during Q2 2020. RXB presented in 2 conferences highlighting the work done in the 5G!Drones project. RXB has coordinated with INF in reporting dissemination activities. There has been no deviation from the expected contributions.

14-EUR made a publication of a scientific paper “Dynamic slicing of RAN resources for heterogeneous coexisting 5G services” acknowledging 5G!Drones in IEEE Globecom 2019, Hawaii, USA 2019. It has also made publication of two new journal papers acknowledging 5G!Drones. EUR has led the writing of a paper on the 5G integration in U-Space. There has been no deviation from the expected contributions.

15-DRR does not partake WP5.

16-CAF made a presentation of 5G!Drones Project at Focus Fuseco Forum 7-8 November 2019 in Berlin with L. Tomaszewski (OPL) with presentation “5G!Drones trials – how to match UAV business cases, drone capabilities and 5G test facilities”. It has provided recommendations for D5.1 showcasing and analysing the dissemination plan regarding Estonia. CAF is participating 5G-PPP SEC WG and introducing 5G!Drones activities. CAF has had interaction with RXB on participating in ADW2020 and planning for this showcasing. Participating 5GPPP Security WG.
Preparations for regulation article. .

17-FRQ did not start activities in this task during the first half a year of the project. Since then, it has had interaction with RXB on participating in ADW2020 (finally, no go due to the covid-19 situation). FRQ has been participating in 5G-PPP Software Network WG Telcos. There has been deviation from the expected contributions due to COVID-19, as FRQ participation in potential events has been cancelled.

18-OPL did not start activities in this task during the first quarter year of the project. It gave an invited speech: “5G!Drones trials – how to match UAV business cases, drone capabilities and 5G test facilities” at FOKUS FUSECO Forum, Berlin, November 2019, and an invited speech: “Advancements in network management - Implementation of the In-Slice Management concept” at FOKUS FUSECO Forum, Berlin, November 2019.

- Preparation of the conference paper: *Sławomir Kukliński (OLP), Lechosław Tomaszewski (OLP), Paweł Korzec (DroneRadar, Poland), Robert Kołakowski (OLP): 5G-UASP: 5G-based multi-provider UAV platform architecture – accepted at 2020 IEEE Conference on Network Softwarization, Ghent, BE.*
- Preparation of the conference paper: *Lechosław Tomaszewski (OLP), Robert Kołakowski (OLP), Paweł Korzec (DroneRadar, Poland): On 5G support of cross-border UAV operations – accepted at 2020 IEEE International Conference on Communications, Workshop on Integrating UAVs into 5G and Beyond, Dublin, IE.*
- Preparation of the conference paper: *Lechosław Tomaszewski (OLP), Sławomir Kukliński (OLP), Robert Kołakowski (OLP): A new approach to 5G and MEC integration – accepted at the 5th Workshop on “5G – Putting Intelligence to the Network Edge” (5G-PINE 2020) – collocated with the 16th International Conference on Artificial Intelligence Applications and Innovations – AIAI 2020, Porto Carras, GR.*

19-MOE has not conducted any specific work on the Task during the first year of the project. There has been no deviation from the expected contributions.

20-ORA does not partake in Task 5.3.

7.5.5. Exhaustive list of dissemination, exploitation, and standardisation activities performed over Year 1

7.5.5.1. Social Media

The 5G!Drones project tracks its social media impact on a monthly basis. The project social media links have been defined in Deliverable D5.1. In the following, an overview of the various social media channels is shown during the period from June 2019 to April 2020. The overviews are in a form of dashboard reports. They are live data updated regularly. The Website, Twitter, Facebook, LinkedIn, and Instagram use statistics are illustrated in Figure 8, Figure 9, Figure 10, Figure 11, and Figure 12, respectively.

The 5G!Drones project has established its official website available at **www.5gdrones.eu,** serving as a portal where informative details and relevant 5G and drone data are published, sustaining the ICT-19 project’s scope across multiple vertical industries. The Website dashboard data regarding Figure 8 can be found at **https://datastudio.google.com/reporting/84bcdd4f-20f5-4216-ae26-952e7f679393**.

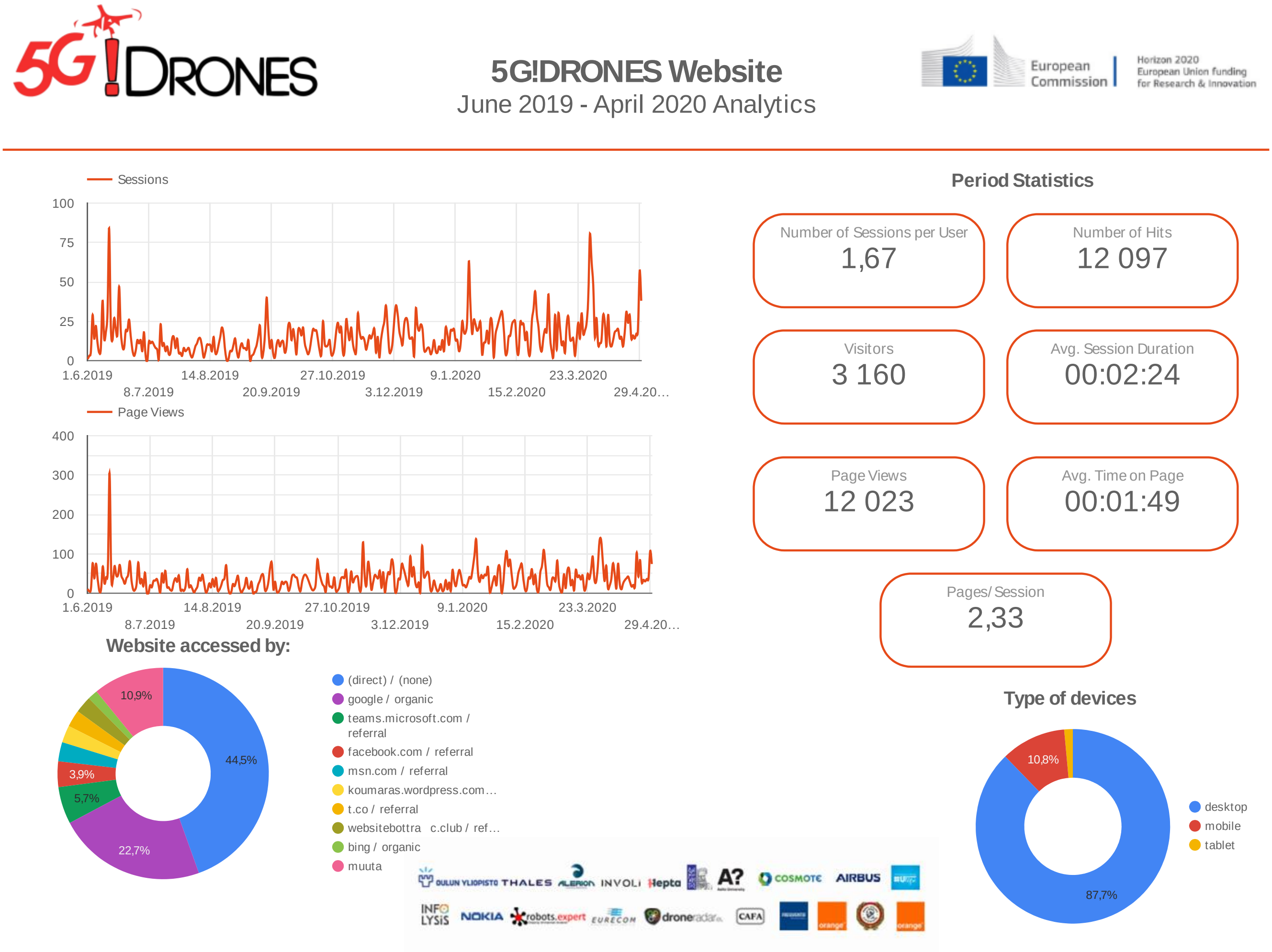

Figure 8: 5G!Drones Website Statistics/Dashboards, June 2019 - April 2020.

5G!Drones is present in all popular social media networks. In specific, the following 5G!Drones social media accounts are open and have been actively used since the beginning of May 2019: Twitter, LinkedIn, Facebook, Instagram, and YouTube and their access links are the following:

Twitter: https://twitter.com/5gdrones

LinkedIn: https://www.linkedin.com/in/5gdrones/

Facebook: www.facebook.com/5gdrones

Instagram: https://www.instagram.com/5gdrones_project/

YouTube: https://www.youtube.com/channel/UChPj4gQ5P5go7Fer6NJxGOQ

5G!Drones social media posts are oriented towards promoting the project's news as well as the dissemination activities in which the partners participate. Dissemination activities cover a wide spectrum of events, publications, presentations, workshops, demonstrations, call for papers and other relative activities communicated via the social media accounts. The Twitter dashboard data regarding Figure 9 can be found at https://datastudio.google.com/reporting/5e1e13c8-3666-458e-b84d-894609a047ae.

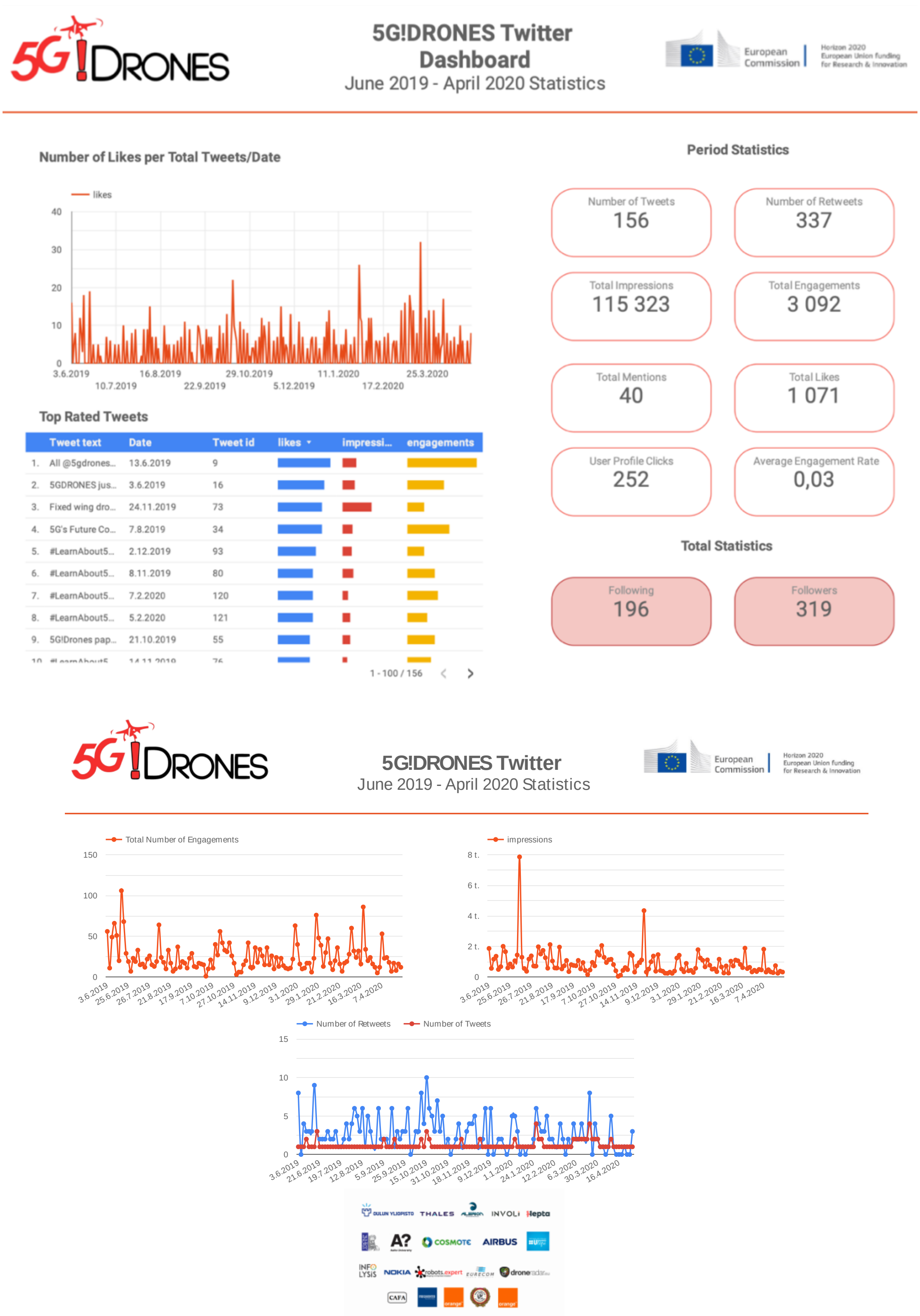

Figure 9: 5G!Drones Twitter Statistics/Dashboards, June 2019 - April 2020.

In the 5G!Drones Facebook profile page users can find the latest 5G!Drones posts, get informed on the latest news of the project and send an immediate message to the 5G!Drones team. The Facebook dashboard data regarding Figure 10 can be found at https://datastudio.google.com/reporting/60415255-f5ad-4e1b-8156-977026e9cf82.

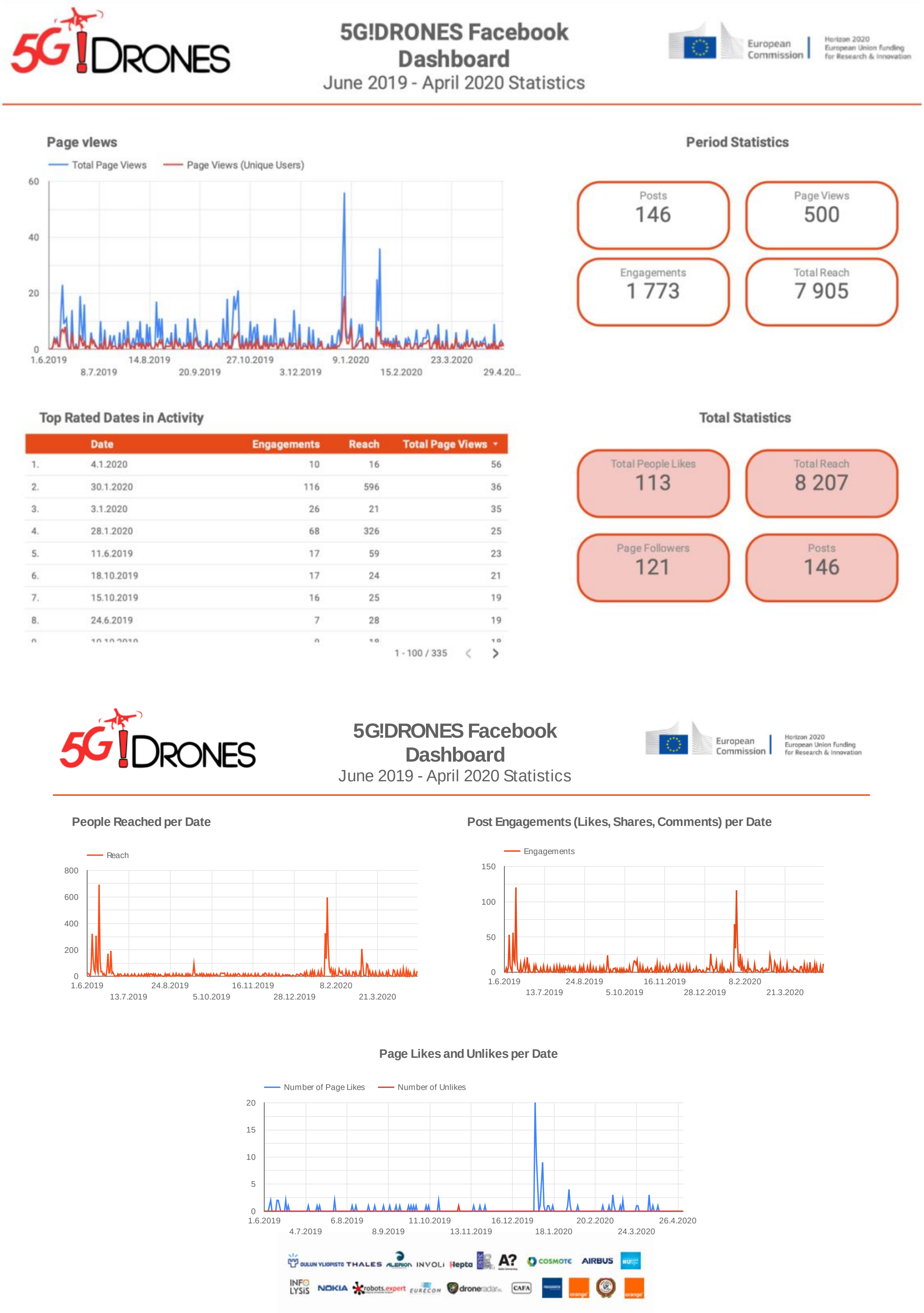

Figure 10: 5G!Drones Facebook Statistics/Dashboards, June 2019 - April 2020.

There is a short bio of the project including its objectives and quantitative details in the official 5G!Drones LinkedIn profile. The audience can easily check the latest project posts and communicate directly with the 5G!Drones team in case of any queries. The Linkedin dashboard data regarding Figure

11 can be found at https://datastudio.google.com/reporting/e2b8204a-88fa-4897-b09d-a1f74b14fece.

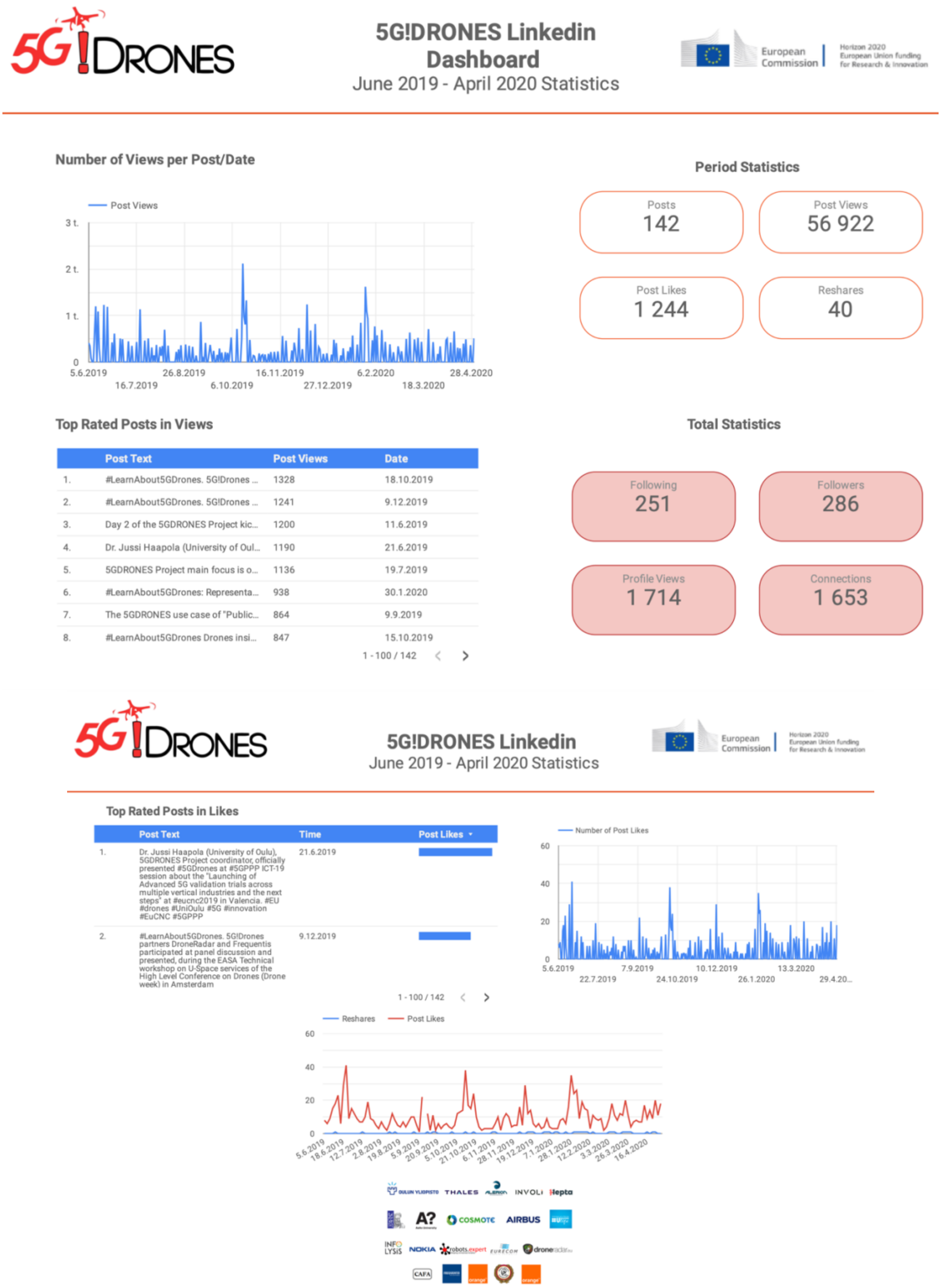

Figure 11: 5G!Drones Linkedin Statistics/Dashboards, June 2019 - April 2020.

In the official 5G!Drones Instagram profile and posts/pictures, users can be also redirected to the official 5G!Drones website when clicking on the relevant link included in the profile page. The Instagram

dashboard data regarding Figure 12 can be found at **https://datastudio.google.com/reporting/75d2992c-ff23-4813-a23f-fb2ff15e897a**.

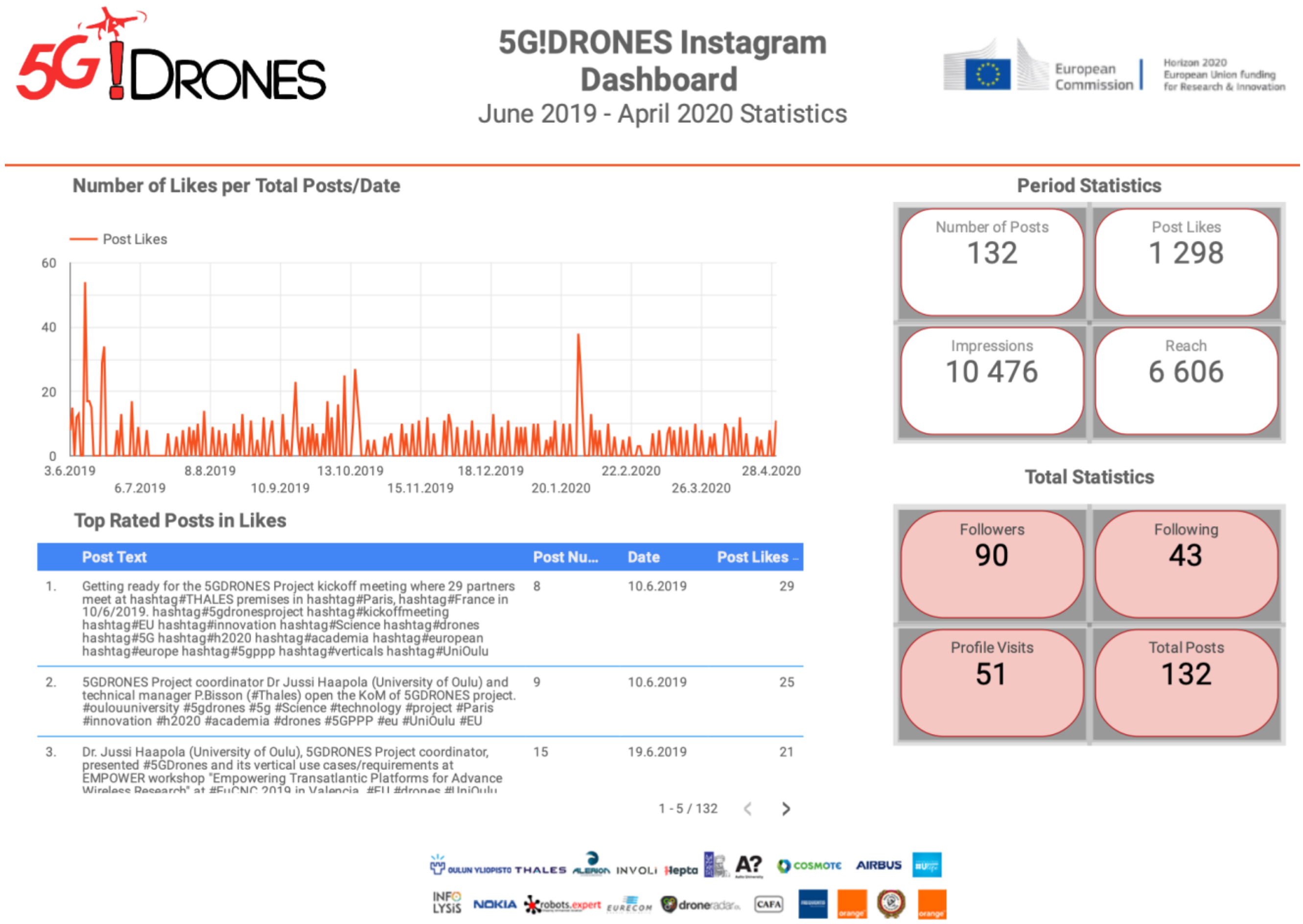

Figure 12: 5G!Drones Instagram Statistics/Dashboards, June 2019 - April 2020.

The project also published newsletters. During the first year of the project, three newsletters have been published and they are available on the project website at **https://5gdrones.eu/newsletter/**. The fourth newsletter is in preparation with a planned timeline of June 2020.

7.5.5.2. Dissemination and exploitation activities

The specific WP5 dissemination and exploitation activities are listed in more detail in Table 3. The table describes the authors and Partners involved, the title of the activity, the target of the activity, and a brief description of the activity. It needs to be noted the Table 3 does not list some of the planned activities as the covid-19 pandemic has caused events to be cancelled, postponed, changed as virtual events, or changed form in such a fashion that dissemination and exploitation is not feasible. An example is the 6G Summit in Levi, Finland, during March, which was changed as a virtual event. UO prepared a roll-up for the NOK stand in the conference venue. The covid-19 pandemic restrictions first, made it not possible for NOK, due to their internal policies, to hold the stand. Further, making the event virtual made

having the roll-up and presentation of it not feasible. As a consequence, significant preparations were made both by NOK and UO, but the dissemination and exploitation activity could not take place.

Table 3: 5G!Drones table of dissemination and exploitation activities

#	Authors / Partners	Activity Title	Target (Event, Location, Date)	Description
1	Dr. Jussi Haapola (UO)	5G!Drones and its vertical use cases/requirements	EMPOWER Empowering Transatlantic Platforms for Advance Wireless Research workshop on June 18th 2019 at EuCNC in Valencia	Dr. Jussi Haapola (University of Oulu), 5G!Drones project coordinator, presented 5G!Drones and its vertical use cases/requirements at EMPOWER Empowering Transatlantic Platforms for Advance Wireless Research workshop on June 18th at EuCNC in Valencia
2	Dr. Jussi Haapola (UO)	5G!Drones presentation	ICT-19 project session at EuCNC 2019 in Valencia (21 June 2019)	Dr. Jussi Haapola (University of Oulu), 5G!Drones project coordinator, officially presented 5G!Drones at 5G PPP ICT-19 session about the "Launching of Advanced 5G validation trials across multiple vertical industries and the next steps" at Eucnc 2019 in Valencia (20 June 2019)
3	Mélanie Guittet (INV)	INVOLI presentation and involvment in 5G!Drones project	Salon du Bourget, Paris Air Lab, 21.06.2019	Presentation about the company INVOLI and some of its involvement into European projects such as 5G!Drones
4	Tero Vuorenmaa (RXB)	RXB presentation about requirements of Urban Air Mobility	ITS World Congress Singapore, 24 Oct	Presentation about UAM requirements, where mobile network and 5G are one key player. In presentation few slides about 5G!Drones project
5	Adlen Ksentini (EUR)	presentation of 5G!Drones to 5G EVE	5G EVE meeting, Tuesday 3rd of September in Pisa	Presentation for collaboration with 5G EVE project. ICT-17 collaboration with ICT-19 & ICT-22 projects.
6	Dr. Jussi Haapola (UO)	What can 5G bring to Drones?	Digital Transport Days, October 9th, 2019 - What can 5G bring to each mode of transport?	Dr. Jussi Haapola (University of Oulu), 5G!Drones project coordinator, presented 5G!Drones project and the opportunities 5G can bring to UAV transport sector.
7	EUR	Dynamic slicing of RAN resources for heterogeneous	IEEE Global Communications Conference (IEEE GLOBECOM 2019)	A conference paper on IEEE Globecom 2019

		coexisting 5G services	will be held in Waikoloa, Hawaii, USA, from 9 -13 December 2019.	
8	Prof. Ari Pouttu (UO)	5G!Drones general presentation - porter session	5GTNF Results and Demo Seminar, Helsinki, Finland, 1 November 2019	Prof. Ari Pouttu (UO) presented the 5G!Drones at the poster session of 5GTNF Results and Demo Seminar in Helsinki, Finland, on 1st of November 2019 at http://5gtnf.fi/5gtnf-results-and-demo-seminar/ for approximately 100 attendees.
9	CAF, AU	Tests/Trials	Aalto University, Helsinki, Finland (24 Oct 2019)	CAFA Tech conducted first initial tests with DJI Mavic Pro drone and 5G smartphones. 24th October 2019 we tested in Aalto University, Helsinki, Finland, with Hamed, 5G smartphone OnePlus 7Pro. Stream upload was: 21 Mbps Ping: 11 ms
10	CAF	Tests/Trials	November 1, 2019 Place: Tallinn, Estonia.	CAFA Tech conducted first 5G drone test flight in Estonia, November 1, 2019 Drone: DJI Mavic Pro Place: Tallinn, Estonia. Test network: Elisa (telecom operator) 5G NSA test network 5G smartphone: Huawei Mate 20X 4K video streaming application: Larix Broadcaster Upstream throughput: 25-47 Mbps Ping: 8-10 ms
11	Tero Vuoren maa (RXB)	Is UAM ready for business	11/8/2019, Helsinki, Finland (FRUCT 19)	Drone related Conference, where Tero presented challenges of the Urban Air Mobility where drone connectivity is one major issues. 5G is a promising solution and presented 5G!Drones as an example of activity towards 5G connected drones.
12	OPL, CAF, THA	5G!Drones trials – how to match UAV business cases, drone capabilities and 5G test facilities	FOKUS FUSECO 2019 Forum - Berlin, Germany, 7-8/11/2019	On 7-8 November 2019 Dr. Lechosław Tomaszewski (Orange Labs, Poland) and Tanel Järvet (CAFA Tech, Estonia) participated in the 10th FOKUS FUSECO 2019 Forum - Berlin, Germany with the presentation “5G!Drones trials – how to match UAV business cases, drone capabilities and 5G test facilities“, which was prepared together with Pascal Bisson (Thales Group, France).
13	Oussam a Bekkouc he, Miloud	Toward a UTM-based Service Orchestration for UAVs in	IEEE Globecom 2019, 9-13 December 2019 // Waikoloa, HI, USA	A conference paper on IEEE Globecom 2019

	Bagaa, and Tarik Taleb (AU)	MEC-NFV Environment		
14	Hellaoui et al (AU)	Efficient Steering Mechanism for Mobile Network-enabled UAVs	IEEE Globecom 2019, 9-13 December 2019 // Waikoloa, HI, USA	A conference paper on IEEE Globecom 2019
15	Mariem Maiouak and Tarik Taleb (AU)	Dynamic Maps for Automated Driving and UAV Geofencing	IEEE wireless Communications Magazine 2019 (Volume: 26 , Issue: 4 , August 2019)	A journal paper in the IEEE Wireless Communications Magazine
16	Pascal Bisson (THA)	Technical Workshop on key enablers for 5G Experimentatio n	10/10/2019, University of Malaga	Pascal Bisson (Thales), Technical manager of 5G!Drones Project, represented the at the 5G-TB Workshop hosted by the University of Malaga.
17	COS	5G!Drones: Unmanned Aerial Vehicle Vertical Applications' Trials Leveraging Advanced 5G Facilities	INFOCOM WORLD CONFERENCE 2019 "Economy 4.0: Connected Future", 26/11/2019 Athens Greece	Cosmote partner presented 5G!Drones at INFOCOM WORLD CONFERENCE 2019 - "Economy 4.0: Connected Future" on Tuesday 26 November 2019 in Athens, Greece
18	DRR and FRQ	EASA technical workshops: Technical workshop on U-Space services	EASA High Level Conference on Drones during Amsterdam Drone Week 2019	During EASA High Level Conference on Drones in Amsterdam on 5-6 of December 2019, Pawel Korzec (DroneRadar) presented during Technical workshop on U-Space services innovative ideas which came out of the synergy between UTM and 5G network. The integration of UTM and 5G facilities was raised and the need to fulfil various SLA requirements for C2 link, Bandwidth for media and FPV.
19	ORA	Tests/Trials	French championships of Windsurf in Saint-Pierre-Quiberon France, 1-3 Nov 2019	Orange France conducted an experiment of a tethered drone embedding a cellular base station based on Open Air Interface, acting as a connectivity bubble, at French championships of Windsurf in Saint-Pierre-Quiberon France, from 1st to 3rd of

				November, as part of 5G!Drones use case #4 (UC4) initial tests.
20	NCSRD	Presentation of 5G!Drones to 5GENESIS GA Meeting	5GENESIS GA Meeting in Berlin, 28 Nov 2019	Harilaos Koumaras (NCSR Demokritos) during the 6th 5GENESIS GA meeting at Fraunhofer FOKUS in Berlin, explaining how #5GDrones will use the #5GENESIS Athens platform for the connectivity during crowded events drones use case!
21	EUR	Towards Slicing-Enabled Multi-Access Edge	Accepted paper in IEEE Network (additional information to be added soon)	A paper accepted in IEEE Network Magazine
22	Mika Jarvenpaa (NOK)	Panel discussion: low earth orbit telecommunication constellations and a project poster	Finnish Satellite Workshop and Remote Sensing Days 2020(20-22/01/20, Helsinki,Finland)	Mika Jarvenpaa (Nokia) participated at the Finnish Satellite Workshop and Remote Sensing Days 2020(20-22/01/20, Helsinki,Finland) with a 5G!Drones project poster and a panel participation. Read more at: **https://spaceworkshop.fi**
23	(RXB) Gokul Krishna Srinivasan	Wildfire detection using 5G & Drones	AIX & FCAI Event	Robots Expert had the opportunity to present the use case of detection of wildfire using 5G network and drones. During the presentation, RXB talked about 5G!Drones project in the slide deck
24	Juha Hannula (NOK)	Session 1: Opening and Keynotes	Prinse’20, 29/01/2020, Oulu Finland	Juha had a presentation at Session 1: Opening and Keynotes at Prinse’20, 29/01/2020, Oulu, Finland. Additional information can be found at: **https://www.printocent.net/tapahtumat/prinse20-printocent-industry-seminar/#areas**
25	adlen Ksentini (EUR)	Interview on Drones (in French)	interview to Institut Mines Telecom (IMT), 19-02-2020	Adlen Ksentini (Eurecom) was interviewed by IMT (Institut Mines Telecom) and talked about drones in the interview entitled "Les drones à l’épreuve de la 5G." The interview can be found at **https://blogrecherche.wp.imt.fr/2020/02/19/les-drones-a-lepreuve-de-la-5g/**
26	EUR	Federated Learning for UAVs-Enabled Wireless Networks: Use Cases,	IEEE Access journal	The 5G!Drones EURECOM Paper entitled "Federated Learning for UAVs-Enabled Wireless Networks: Use Cases, Challenges, and Open Problems" was accepted in IEEE Access Journal. Read the paper online via this link:

		Challenges, and Open Problems		https://5gdrones.eu/wp-content/uploads/2020/03/Paper_IEEE_Access.pdf
27	AU	A Service-Based Architecture for enabling UAV enhanced Network Services	IEEE Network Magazine	The 5G!Drones Paper entitled "A Service-Based Architecture for enabling UAV enhanced Network Services" was accepted in IEEE Network Magazine. Read the paper online at: https://5gdrones.eu/wp-content/uploads/2020/03/Enabling_UAV_based_enhanced__Network_Services.pdf
28	DRR	How Poland built and introduced an operational, integrated national UTM/ATM system	Unmanned Airspace, March 25th 2020	An 5G!Dones article interview in Unmanned Airspace website. Read more at: https://www.unmannedairspace.info/news-first/how-poland-built-and-introduced-an-operational-integrated-national-utm-atm-system/
29	adlen Ksentini (EUR)	Putting drones to the 5G test	ITM, April 1st 2020	A 5G!Drones article interview by Adlen Ksentini (Eurecom) in IMT website. Read more at: https://blogrecherche.wp.imt.fr/en/2020/04/01/putting-drones-to-the-5g-test/
30	OPL and DRR	5G-UASP: 5G-based multi-provider UAV platform architecture	IEEE Conference on Network Softwarization, 29 June – 3 July 2020 (Virtual Conference)	A 5G!Droned Project related conference paper entitled 5G UASPP: 5G-based multi-provider UAV platform architecture", has been accepted at IEEE Conference on Network Softwarization, 29 June – 3 July 2020 (Virtual Conference). Read the paper at: https://5gdrones.eu/wp-content/uploads/2020/05/Multi-provider.pdf
31	OPL and DRR	On 5G support of cross-border UAV operations	Workshop on Integrating UAVs into 5G and Beyond in IEEE International Conference on Communications, 7-11 June 2020 (Virtual Conference)	A 5G!Drones Project related conference paper entitled "On 5G support of cross-border UAV operations" has been accepted at Workshop on Integrating UAVs into 5G and Beyond in IEEE International Conference on Communications, 7-11 June 2020 (Virtual Conference) . Read the paper at: https://5gdrones.eu/wp-content/uploads/2020/05/Cross-border.pdf

32	OPL	A new approach to 5G and MEC integration	5th Workshop on "5G – Putting Intelligence to the Network Edge" (5G-PINE 2020) in AIAI 2020, 16th International Conference on Artificial Intelligence Applications and Innovations, 5–7 June, 2020 (Virtual Conference)	A 5G!Drones Project related conference paper entitled "A new approach to 5G and MEC integration" has accepted at 5th Workshop on "5G – Putting Intelligence to the Network Edge" (5G-PINE 2020) in AIAI 2020, 16th International Conference on Artificial Intelligence Applications and Innovations, 5–7 June, 2020 (Virtual Conference). Read the paper at: **https://5gdrones.eu/wp-content/uploads/2020/05/5G-MEC.pdf**
33	AU	Spectrum Sharing for Secrecy Performance Enhancement in D2D-Enabled UAV Networks	IEEE Network Magazine	A 5G!Drones Project journal paper entitled "Spectrum Sharing for Secrecy Performance Enhancement in D2D-Enabled UAV Networks" has been accepted in IEEE Network Magazine. Read the paper at: **https://5gdrones.eu/wp-content/uploads/2020/05/Spectrum-Sharing-for-Secrecy-Performance-Enhancement-in-D2D-Enabled-UAV-Networks.pdf**
34	AU	Energy-aware Collision Avoidance stochastic Optimizer for a UAVs set	IEEE IWCMC	A 5G!Drones conference paper entitled "Energy-aware Collision Avoidance stochastic Optimizer for a UAVs set" has been accepted in IEEE IWCMC (Virtual Event) in 15-19/06/2020. Read the paper online at: **https://5gdrones.eu/wp-content/uploads/2020/05/Energy-aware-Collision-Avoidance-stochastic-Optimizer-for-a-UAVs-set.pdf**
35	AU	UAV Communication Strategies in the Next Generation of Mobile Networks	IEEE IWCMC	A 5G!Drones conference paper entitled "UAV Communication Strategies in the Next Generation of Mobile Networks" has been accepted in IEEE IWCMC (Virtual Event) in 15-19/06/2020. Read the paper online at **https://5gdrones.eu/wp-content/uploads/2020/05/UAV-Communication-Strategies-in-the-Next-Generation-of-Mobile-Networks.pdf**
36	OPL	Integration of U-space and 5GS for UAV services	IFIP Networking 2020 – Workshop on Network Slicing 2020, 22-25/06/20	A 5G!Drones Project journal paper entitled "Integration of U-space and 5GS for UAV services" has been accepted in IFIP Networking 2020 – Workshop on Network Slicing 2020, 22-25/06/20.

37	RXB, Gokul Krishna Srinivasan	Challenges & Benefits of 5G in Urban Air Mobility	IEEE AERIAL COMMUNICATIONS IN 5G AND BEYOND NETWORKS (AERCOMM) WORKSHOP	Invited keynote speech highlighting the 5G!Drones project use cases, current status and challenges.

7.5.5.3. Standardisation activities

The first year of the project has included some standardisation activities. Those activities are described next in alphabetical order of SDOs and in order of project Beneficiaries.

3GPPP

2-THA is closely following the 5G standardization efforts in the 3GPP. In particular, internal working groups have been investigating how the new releases (Rel17 and beyond) will impact THA products and businesses. A particular focus is drawn to the radio standardisation activities (RAN) and System Aspects (SA). With a direct impact on our contributions in 5G!Drones, THA is putting under scrutiny the work on RAN slicing in the release 17 of 3GPP. In this context, the Study items on RAN slicing (RP-193254) in RAN2 that will be starting in Q2-2020 is highly interesting. As a matter of fact, we will continue following on the Work Item (WI) that will be the outcome of this study and is expected to start in 2021."

9-AIR has been particularly active in 3GPP SA6. The SDO suffered from covid-19 with cancelation of all 3GPP face-to-face meetings now conducted as e-meeting and with less but still stable and high-quality output. The work is mainly focused on completion of Rel-16. More and more new vertical industry service proposals are brought to 3GPP and among them drone services. 3GPP aims at avoiding past experience with specific features developed for niche markets and now privileges global approaches. Drone chapter is two-fold: eMBB with regards to data captured by drones and URLLC with regards to their remote control. FS_UASAPP corresponds to Study on application layer support for Unmanned Aerial System. Active companies in the discussions are Interdigital, Tencent, Airbus, China Unicom, Huawei, DT, Vodafone, Samsung, Qualcomm, KRRI, Ericsson, and CATT. Two outgoing LSs approved, both to SA1 asking clarifications. The first one (544) is asking whether SA1 defined a 1-to-1 or 1-to-N relation between a UAV-controller and UAV(s). TS22.125 has some internal misalignments on this issue. The second LS is a trickier one, asking clarifications on SA1 requirements that list a bunch of parameters delivered between UAV and UTM, most of them being out-of-3GPP-scope. AIR has written two CR to SA1 referring to the above LS clarifying that these parameters are not visible to the 3GPP system.

12-NOK has participated, followed, and contributed via teleconferences, webinars, internal workshops etc.

ASTM: (a globally recognized leader in the development and delivery of voluntary consensus standards)

4-INV participated to meetings of F38 UAS Committee, in charge with issues related to design, performance, quality acceptance tests, and safety monitoring for unmanned air vehicle systems.

Particularly, INV is involved in the standardisation regarding supplemental data providers. In such capacity, it participated in the last meeting in November, in Raleigh, North Carolina, USA, where various UAS related aspects were discussed, including connectivity and how to ensure its continuity and redundancy. Related standards preparation is ongoing and INVOLI is closely following the matter.

INV will continue its involvement in the ASTM, by participating to the future meetings and reviewing the related technical documentation, focusing on the standards and position of supplemental data providers and how connectivity trials should be taken into account when preparing relevant standards. Particularly, next meetings will take place as follows:

- ASTM F38 Committee: Syracuse, New York, USA, 7-9 April 2020.

ETSI

1-UO is continuously contributing to ETSI SmartBAN Technical Committee development activities. UO is the Rapporteur (leader) of the Work Item for the medium access control technical specifications standards development (currently, ETSI TS 103 325 − SmartBAN-005r1). The latest SmartBAN meeting took place on February 20th in Sophia-Antipolis, where UO proposed a relay mechanism to maintain connectivity in an established SmartBAN when associated nodes venture in areas of poor connectivity. The proposal was accepted to be adopted to the TS. While this is not strictly relevant to drone operations trialled in 5G!Drones, such connectivity assurance critical with drone swarms and the ETSI SmartBAN specifications also suit for such machine type close-proximity networks. UO continues to actively contribute to TC ETSI SmartBAN with the intention of extending it to cover multiple types of machine body area networks. Drone swarms can be an example of such machine type BANs.

12-NOK has participated, followed, and contributed via teleconferences, webinars, internal workshops etc.

GUTMA (Global UTM Association)

4-INV participated to various events organised by the association, including Connected Skies conferences where telecommunication companies and the drone industry gather to exchange on the topic of connectivity and how the two industries need each other in order to progress. It was largely understood that drone flights are going to be one essential point to be made by the telecommunication industry in order to prove the benefits and advancements brought by the new 5G technology.

INV is also involved in the reviewing of various technical documentation prepared by GUTMA in their capacity as industry representative and answering requests from various bodies (such as the European Aviation Safety Agency, during relevant phases of the regulatory process). While details are mostly reserved for the members, INV's contributions to these documents always underlines the importance of 5G for Drones and of the tests envisaged by 5G!Drones project whose results may become relevant for the standardisation activities undertaken by the industry.

INV will continue its involvement in GUTMA by participating to the future meetings and reviewing the related technical documentation, focusing on the standards and position of supplemental data providers and how connectivity trials should be taken into account when preparing relevant standards. Particularly, next meetings will take place as follows:

- GUTMA Harmonised Skies, Singapore, 2-4 June 2020.
- While the physical Connected Skies conference as part of MWC 2020 in Barcelona has been cancelled, GUTMA will aim to organise a series of short public virtual Connected Skies Webinars until the 2nd of June when Harmonized Skies Singapore event takes place.

12-NOK has participated, followed, and contributed via telco, webinars, internal workshops etc. to several standardisation groups GUTMA, ECC SE21, IETF DRIP, CCSA ST9 WG3#10: Navigation and Location service (Positioning), FAA, and GSMA.

7.6. WP6 Project Management

WP6 is responsible for the overall administrative and technical management of the project. The project had its kick-off of the activities, including the kick-off meeting in Paris, France in June. One of the first tasks was establishing tools and methodologies for project execution including project repository, email list, templates, meeting principles, etc. Creation of the first complete version of Deliverable D6.1 followed and establishment of project liaison activities, including participation in 5G-PPP working groups was started. Amendment 1 of the project was completed during the first quarter year of the project resulting in a number of changes at WP and Task level. In the same period of time the project quality and risk management plans were finalised in Deliverable D6.1. The first version of the project Data Management Plan was published in D6.1. The Consortium agreement was finalised and signed by all Partners during the second quarter year of the project. Progress at project and programme level has been monitored and assessed. The Consortium had its second face-to-face meeting during October in Athens, Greece. PMT meetings occurred regularly to help to review progress and adjust work plan whenever needed and justified. The project has been represented at both 5G SB & TB levels and work on specific actions have been engaged. The appointed representatives of the project for 5G-PPP or IA WGs of interest started to join and contribute to on behalf of the project.

Further steps have been taken to learn from 5G platform project (facilities) and provide them with requirements for them to consider. Milestone MS1 was achieved at the submission of D1.1. The MS1 completion was delayed from the original plan due to reasons communicated with the Project Officer and he accepted the delay. The reasons have been explained in Section 3.1. The Consortium held a successful face-to-face meeting in Sophia-Antipolis between January 28th and 30th, 2020. During the meeting open matters of D4.1 and D1.3 were discussed and concrete time schedule for completion of the deliverables was made. The Innovation Management Team members and initial agenda were established. Members are DRR, CAF, FRQ, and ORA. At the Consortium level, it was perceived, WP4 Task 1 requires to be extended and a Consortium-wide vote was conducted to reach a consensus on the extension duration. The Project officer was consulted on the possibility of extension and he had no objections for it. Dates for the 1st year review were decided and review team establishment was initiated. Due to the covid-19 pandemic the first-year review has been changed to remote review enabling all Beneficiaries to join the review. The PMT drafted the agenda for review and it was communicated to the project officer and reviewers. With the escalation of the covid-19 pandemic restrictions, a Consortium-wide vote was conducted to identify if project extension is required. The Consortium was unanimous in this and preparations for Amendment 2 have been started. The main changes in Amendment 2 relate to Task and WP durations, Deliverable deadlines, and attaining project's DoW described Milestones. The fourth Consortium face-to-face meeting was organised virtually from May 25th to 26th instead of the cancelled physical meeting in Vienna, Austria. M12 of the project has been very intensive with the finalisation and review of four project Deliverables in addition to normal project work.

7.6.1. Progress towards objectives and details for each task

WP Objectives

This work package is responsible for coordinating the overall project aiming towards achieving effective operation of the project as well as timely delivery of quality results. The management structure and tools described within will be instrumental to the achievement of the following objectives:

- Implement management procedures, produce reports, carry out project meetings, conflict resolution mechanisms, knowledge management, and others.
- To steer the project to ensure the success of the UAV use case trials within the ICT-17 and other facilities.
- To liaise with the EC and share with the EU the status of project progress.
- To establish appropriate quality management procedures within the project.
- Planning, monitoring, and controlling project progress and outputs as well as anticipating and taking corrective actions.
- Administer the project funds in the interest of the success of the project, in accordance with the consortium, and according to individual partner performance.
- Management of the relationship with the ICT-17 5G facilities.
- Management of the relationship at 5G-PPP Programme level.

WP tasks and interrelations:

- T6.1: Administrative, financial and contractual management (M1-M36)
- T6.2: Risk and quality management (M1-M36)
- T6.3: Technical coordination and innovation management (M1-M36)
- T6.4: 5G facility relationship management (M1-M36)

Main Progress in the period:

The project had its kick-off of the activities, including the kick-off meeting in Paris, France in June. Establishing tools and methodologies for project execution including project repository, email list, templates, meeting principles, etc. was completed soon after. Submission of the project Data Management Plan and quality and risk management plan with Deliverable D6.1. Establishment of project liaison activities, including participation in 5G-PPP working groups was started. Amendment 1 of the project was completed during the first quarter year of the project. The Consortium agreement was finalised and signed by all Partners during the second quarter year of the project. PMT meetings occurred regularly to help to review progress and adjust work plan whenever needed and justified. Milestone MS1 was achieved at the submission of D1.1. The Innovation Management Team members and initial agenda were established during the third quarter year of the project. A Consortium-wide vote was conducted to identify if project extension is required. The Consortium was unanimous in this and preparations for Amendment 2 have been started. Completion of project Milestone MS2 at M12 by submission of four project Deliverables.

7.6.2. Task 6.1 Administrative, financial and contractual management (M1-M36) [UO]

Task Objectives:

This task is related with the overall project management from an organisational, administrative, and financial point of view. This task is in the hands of the Project Coordinator. It covers the following activities:

- Ensuring knowledge sharing and communication within the consortium: the project management must receive from each consortium member periodic reports to present accurately and briefly the work performed during the period, problems encountered, expected impact, and resources consumed.
- Administration and contract management: the UO will ensure this activity. It will deal with the proper management of the Contract, the proper management of the decision process within the Consortium, and the liaison with the EC Office.

- Financial management: It will monitor that the project budget and resources are distributed in a timely manner, including the preparation of cost statements and of the supporting justification by the project partners and ensure that these are produced at dates according to the contract, and context meeting the EU financial procedures and guidelines.

Task Activities during the period:
Only the Coordinator – UO is partaking this Task.

1-UO was responsible for the establishment of project tools. It carried out negotiations and drove forward the Consortium Agreement. UO coordinated project ramp up phase and prepared the project Amendment 1, including the change of WP5 leadership, shift of D6.1 delivery date to M4, shift of resources, etc. UO coordinated, edited, and submitted Amendment 1 of the project to the Commission. UO further coordinated the Consortium Agreement negotiations, which were finalised during the second quarter year of the project and the CA was signed by all partners. UO distributed the pre-financing based on the CA clauses. UO prepared templates in coordination with THA for quarterly technical management reports and approximate resources use of partners were collected for the all the quarters of the project. During the period UO coordinated the submission of all deliverables. UO created and coordinated agendas for the face-to-face meetings, Project Management Team meetings and other out-of-the-ordinary Consortium-general meetings. UO also acted as the chairperson and secretary in such meetings keeping minutes and assigning action points. During the period UO further initiated 1st year review organisation and initiated the Innovation Management Team activities. UO initiated the Amendment 2 process.

Deviation and corrective action:
All deviations from the original project plan have been reflected in the submitted project Amendment 1. D6.1 was submitted to the Commission portal on time based on the Amendment 1 timeline, which was one month later than in the original Description of Action.

7.6.3. Task 6.2 Risk and quality management (M1-M36) [UO]

Task Objectives:
This task focuses on establishing risk and quality management procedures, monitoring and identification potential problems, and developing plans to mitigate the impact of such events, should one arise. Managing technical risks or quality deviations handled closely with the technical coordinator THA. The task covers the following activities:

- Quality management: It will define quality assessment guidelines and monitor their implementation in the project on the different deliverables (e.g. reports, code, etc.).
- Risk management: It will define risk assessment guidelines, identify potential risks, and minimize their impact on the project implementation.

Task Activities during the period:
Only the Coordinator – UO is partaking this Task. The quality and risk management are, on the other hand, closely tied with project technical management. As a consequence, there is significant collaboration with the Technical Manager – THA on the topic.

*1-**UO*** drafted, edited, and submitted the Deliverable D6.1 Data Management Plan and quality and risk management plan. It established the tools and procedures recorded in D6.1 for managing quality and risks of the project. UO has done organisation and coordination of monthly Project Management Team teleconferences for effective management of the project and to understand project progress towards its objectives and drive the project.

During drafting of D4.1 it was identified the Task 4.1 requires to be extended. UO organised a consortium-wide vote on the task extension and communicated with the PO on the implications of

such an extension. During the end of M9 UO started administrative coordination of addressing the implications covid-19 will have on the project. Project Beneficiaries have one by one started identifying the impacts of covid-19 to the implementation of the project, especially with relation to conducting trials and developing facility components. UO organised a Consortium-wide vote on applying for extension of the project by 6 months, which was approved unanimously. UO is currently preparing, with the PMT, the second Amendment for the project to manage the risk identified based on covid-19 pandemic.

Deviation and corrective action:
Deliverable D6.1 delivery date was shifted to M4 and the shift is reflected in submitted Amendment 1. Work Packages 2 and 3 were kicked of one month late due to summer holiday period disrupting the first quarter activities. WP4 was kicked of one month late due to WP1, 2, and 3 delays. The covid-19 pandemic is expected to affect 5G!Drones project implementation. UO will coordinate mitigating the effects of this unforeseen risk for the project implementation.

Although Beneficiaries COS and AIR are not a part of WP6, they conducted a review and provided comments on D6.1 in addition to THA. Correspondingly, NCSRD and UMS conducted a review and provided comments on D6.2 in addition to THA.

7.6.4. Task 6.3 Technical coordination and innovation management (M1-M36) [THA]

Task Objectives:
This task will be led by THA as Technical Manager of 5G!Drones in coordination with the Project Coordinator. This task will ensure that all technical outcomes comply with the project work plan, and results fulfil the technical requirements set by the consortium for effective progresses toward the achievement of the project goals. It covers the following activities:

- Project planning and control: assessment of project progress and subsequent recommendations for work packages implementation.
- prepare proposals for the Project Management Team (PMT) on technical concepts, principles and architectural view.
- control the accomplishment of technical objectives and implementation of decisions and monitor WPs and overall project progress.
- approve deliverables for submission to the PMT and to ensure technical consistency within the project,
- verify milestones.
- manage communication with external liaison and External Advisory Board,
- control exploitation activities,
- identify potential major technical problems and propose solutions and actions to the PMT,
- coordinate the final report and technical audit, and
- contribute to the 5G-PPP program activities like the Technology Board and coordination with other 5G-PPP projects. Also organize and monitor project's representation at 5G PPP or IA WG of interest.

Task Activities during the period:
Only the Technical Manager – THA is partaking this Task.

2-THA monitored and assessed progress towards project's objectives (incl. Milestones, deliverables) on a regular basis at Project level going down each and every WP but also at Programme level. THA participated and contributed actively to all consortium meetings (kick-off, GA, PMT) performing preparatory actions as well as contributing to the minutes of these meetings. THA interacting with PMT members (so WP leads) and others, providing necessary guidance and support in view of topics of concerns (e.g. overall architecture, integration, security …). THA contributed to shared and agreed

overall architectural model and carried out overall technical coordination among the various WPs joining some of the WP meetings whenever needed. THA produced the initial draft of Quarterly Management Report in support of effective and efficient technical reporting. It also contributed to overall assembly and check of QMRs produced over the period and used to support also ease production of this Annual Report. THA carried out extensive reviews of all deliverables and approve them once ready for submission to the PMT. THA constantly checked overall consistency of the work. THA did follow both Milestones and Deliverables and verified attainment for the former and quality for THA made proposal (at Kick-off) regarding IMT and contributed to have it setup and now ready to engage with at PMT level.

THA did revive work on EAB on Q3 (at GA Sophia-Antipolis) nevertheless it was decided by the consortium to wait from MS2 to be passed prior to engagement with EAB. In the meantime THA did work on plan to engage with EAB by this Fall.

THA organised the 5G!Drones representation at 5G Programme level through (5G-PPP & 5G IA) WGs of interest and it participated to 5G-PPP Technology Board as 5G!Drones TM and also 5G SB as 5G SEC WG co-chair.

Deviation and proposed corrective action: None.

7.6.5. Task 6.4 5G facility relationship management (M1-M36) [NCSRD]

Task Objectives:
This task is dedicated for coordination of 5G facilities of the project. The task contains frequent and timely communications between the facility owners, planning for common component adoption, such as UTM deployment, managing agreements, and managing permissions for the execution of trials. The task covers the activities:

- Management of the communication between facility owners
- Manage agreements between facility owners
- Manage permissions for the execution of trials

Task Activities during the period:
The breakdown of the contribution, results, deviation and proposed corrective action of each partner in this task are as follows. Only facilities and the TM are partaking this Task.

1-UO is following ICT-17 facilities activities for catering ICT-19 projects. The facility coordination was mainly conducted in WP1 in developing Deliverables D1.2 and D1.5. Therefore, no significant efforts were needed in WP6 during the period for this. UO has been an observer of ICT-17 facilities portal and validation framework presentations. Within the project coordination has taken place in the technical WPs. There has been no deviation from the expected contributions.

2-THA has done investigation of activities engaged by ICT-17 project platforms to learn from ICT-19 and more specifically their requirements. It has initiated interaction within project Consortium to answer specific demands issues (either platform level vs via the 5G TB). THA joined discussion between ICT-17 and ICT-19 projects during TB workshop organised in Malaga (October 8-10, 2019). It represented 5G!Drones project at this workshop. THA provided early input on 5G!Drones Use Cases, requirements, and targeted platforms (ICT-17 and others brought within the consortium). THA supported 5G!Drones project to deliver information requested to ICT-17 platforms projects in order for them to figure UC requirements and answer them. It further supported information on APIs considered by ICT-17 projects to be shared with ICT-19 Projects. THA has worked to raise awareness of work engaged with ICT-17 facilities (including converged work). This with focus of the ones of concern (5G-EVE, 5GENESIS). THA also has encouraged the ICT-17 Facilities to raise awareness on work to date vs. work to come (in terms of releases, documentation, etc.). THA raised a number of questions

regarding security on the basis of 5G!Drones specific concerns and it has follow-up the discussions initiated on the topic. It invited other facilities to do the same and position wrt. to ICT-17 in terms of features offered vs. targeted to meet 5G!Drones UC requirements. THA also shared information from activities performed within 5G-PPP. There has been no deviation from the expected contributions.

6-NCSRD has done investigation of activities engaged by ICT-17 project 5GENESIS platforms to learn from ICT-19 and more specifically their requirements. It addressed the gap analysis request between ICT-17 and ICT-19 project architectures. NCSRD clarified the intention of the 5GENESIS facility participating in the project to use the 5GENESIS coordination layer for the execution of the 5G!Drones experiments and trials, since the facility participates in the project bringing the whole facility and the tools developed. NCSRD considers potential extensions and additions needed for the execution of the 5G!Drones trials on top of Athens 5GENESIS facility. Discussions were raised by NCSRD and within 5G-PPP groups about the role of ICT-17 in relation to ICT-19 projects. Collaborating with Prof. Alex Kaloxynos (5G-PPP Technical Board director) this issue was raised as top priority and informative material in order to clarify the interaction of ICT-17 platforms with non-ICT-17 platforms have been prepared and released. More specifically, the manual of how to onboard functions (e.g. UAS) in ICT-17 platforms has been released facilitating the discussion how similar procedures should be followed and materials should be prepared by the rest platforms of the project. There has been no deviation from the expected contributions.

14-EUR made a presentation of the 5G!Drones use-cases that rely on 5GEVE Eurecom facility to the 5GEVE consortium in Pisa, September 3rd, 2019. EUR contributed to the excel file provided by 5GEVE to express the needed components of 5G!Drones Use Cases. EUR made a contribution to the deliverable “D2.6: Participating vertical industries planning” of the 5GEVE project. The contribution details the envisioned 5G!Drones Use Cases on the 5GEVE facility and a forecast of the timeline. EUR has participated to a meeting with 5GEVE partners to explain the UCs of 5G!Drones. It has also had one meeting with 5GEVE consortium to discuss the evolution of 5G!Drones. It has informed Orange, leader of French cluster, about the development of a new portal to use 5GEVE Sophia. There has been no deviation from the expected contributions.

19-MOE has managed permissions for the execution of trials in Egaleo stadium. It has been discussing the potential extensions and additions needed for the execution of the 5G!Drones trials on top of Athens 5GENESIS facility (in Egaleo). There has been no deviation from the expected contributions.

8. 5G-PPP CROSS-PROJECT CO-OPERATION

During the reported period, 5G!Drones has been also deeply involved at 5G-PPP Programme level. First through representation of Project Manager and Technical Manager at respectively 5G-PPP Steering Board and Technology Board and second, through participation to 5G-PPP & IA WGs of interest for the project. 5G!Drones representation at 5G-PPP Programme level, which is shown in Table 4 shows this level of involvement together with names of appointed representatives.

Table 4: 5G!Drones project 5G PPP & IA representatives

5G-PPP SB	5G-PPP	Jussi Haapola	jussi.haapola@oulu.fi
5G-PPP TB	5G-PPP	Pascal Bisson	pascal.bisson@thalesgroup.com
SME WG		Vaios KOUMARAS	vkoumaras@infolysis.gr
SEC WG	5G-IA	Tanel Järvet	tanel.jarvet@cafatech.com
ARCH WG	*5G-PPP*		*pascal.bisson@thalesgroup.com*
PRE-STAND WG	5G-IA	Serge Delmas	serge.delmas@airbus.com
SOFT NET	5G-PPP	Wolfgang Kampichler	Wolfgang.KAMPICHLER@frequentis.com
NET WMG & QOS			*Wg stopped*
Spectrum	5G-IA		NA
Vision & societal Challenges	5G-IA		pascal.bisson@thalesgroup.com
Trials WG	5G-IA	Tanel Järvet	tanel.jarvet@cafatech.com
IMT 2020 Evaluation Group		Fotis Lazarakis	flaz@iit.demokritos.gr
Test, measurement & KPIs validation	5G-PPP	Ilkka Känsälä	Ilkka.kansala@nokia.com

In what follows we detail the activities which have been performed.

8.1. 5G-PPP Steering Board

Activityname	5G-PPP SB
Main interface	Jussi Haapola (UO)
Activities	The overall management of the 5G-PPP and cross-project co-operation
5G!Drones contributions	• Provided Use Cases for 5G questionnaire responses from 5G!Drones project. • Active participation in the regular 5G-PPP SB meetings and conference calls. • Attendance to 5G SB virtual meetings as well as Physical Meeting held on 21/01 in Brussels • Maintaining 5G-PPP BSCW repository up to date with 5G!Drones specific documentation. • Attendance to 5G SB virtual face-to-face, full-day meeting on May 28th.

8.2. 5G-PPP Technology Board

Activity name	5G-PPP TB
Main interface	Pascal Bisson (THA)
Activities	Overlooking the aspects related to the technology work of the projects and respective implementation of the initiative.
5G!Drones contributions	Active participation in the regular 5G-PPP TB meetings and conference calls. As well as participation to 5G-PPP TB workshops: • 5G TB Workshop held in Malaga (8-10/10/2019) together with ICT-17, ICT-18 and other ICT-19 projects. • 5G TB Workshop (virtual) in May (*25*-26/05) together with ICT-17, ICT-18 and ICT-19 projects and ICT20 projects. Active participation in the regular 5G-PPP TB meetings and conference calls in order to represent the project and work the needed contributions from 5G!Drones with respect to especially : • the Cartography for Platforms Capability Table; • the Cartography for Platforms KPI Table; • the project information wrt. Plans and Priorities document; and • the information for the top 20 technical documents. This while informing and engaging with the team. During the period the following initiatives were also investigated and later joined: 1) the 5G TMV Task Force and 2) the Edge Computing Whitepaper.

8.3. 5G IA Security WG

Activity name	5G-PPP SEC
Main interface	Tanel Järvet (CAF)
Activities	Join 5G IA SEC WG activities and contribute input on behalf of the 5G!Drones project. This according to SEC WG ToR and Work plan for Y2020 also in view of action items set for ALL.

5G!Drones contributions	5G!Drones project is represented in 5G IA SECURITY WG by Tanel Järvet (CAF) seconded by Pascal Bisson (THA) since also co-chair of the 5G IA SEC WG.
	During the reported period, a total of four plenary meetings were held on the following topics:
	
	• 27-09-2019 telco meeting. Focus was on 5G Security outcomes.5G!Drones inputs was given related to security objectives.
	• 22-11-2019 physical meeting in France, Orange Chatillon, FR. Participating in discussions EC plan and Sec WG actions and represented 5G!Drones statements and needs for whitepapers:
	  o "Access Control Mechanisms to Verticals" (slice oriented),
	  o "SDN/NFV virtualisation, 5G Slicing and Security Considerations",
	  o "5G Attack Referential", and
	  o "Vertical security needs".
	• 14-02-2020 telco meeting. Reviewed first drafts and teams building for compiling aforementioned whitepapers.
	• 21-05-2020 telco meeting. Review of first drafts of whitepapers and ToR specification aforementioned whitepapers.

	• Pascal also joined 5G-SB meetings (Physical Meeting e.g. January 21st in Brussels, and virtual meeting e.g. May 28th) as 5G IA SEC WG co-chair to inform and report. • 5G!Drones contributions to SEC WG short Whitepapers is on-going. Further to this 5G!Drones is also now engaged to contribute to the 5G-PPP Whitepaper on Edge Computing (contribute to Security section).

8.4. SME WG

Activityname	SME WG
Main interface	Vaios Koumaras (INF)
Activities	The SME Working Group represents the NetWorld2020 SME community, and provides the networking place for the NetWorld2020 SME community related to EC and 5G-PPP research projects and activities.
5G!Drones contributions	5G!Drones is represented at 5G PPP/Networld2020 SME WG by INFOLYSIS. During the period June 2019-May 2020 the SME WG has organized 4 telcos in which INFOLYSIS has participated and contributed. Below is a list of activities that were performed by SME WG in which INFOLYSIS, on behalf of 5G!Drones, has participated and contributed: • INFOLYSIS introduced 5G!Drones project and that it will be its representative at September SME WG telco. • SME brochure released **https://www.networld2020.eu/wp-content/uploads/2019/06/2019-sme-brochure-final-web.pdf** . INFOLYSIS contributed and 5G!Drones project has been reported. • Updates performed at the "**NetWorld2020" web page** (**https://www.networld2020.eu)** and "**Find your SME**" page (**https://www.networld2020.eu/find-the-sme-you-need-new-page/**). INFOLYSIS representing 5G!Drones made related contributions and suggestions on its content. • Plans for SME WG presence together with the 3 ICT-17 projects, 5G IA and 5G PPP at MWC 2020 in Barcelona, Spain, on 24-27 February 2020 were made. INFOLYSiS made arrangements to attend the booth (stand in Hall 7 -7K39) and communicate 5G!Drones project. Leaflets and stickers of 5G!Drones were produced for making them available at the booth. However, MWC2020 was cancelled due to COVID-19. • EuCNC 2020 Dubrovnik, Croatia, June 15-18, 2020. Call for papers, workshops and specific sessions were discussed. Dedicated SME booth was planned for EuCNC. "5G business opportunities for SMEs" follow-up workshop was also planned by SME WG with support from Full5G. INFOLYSIS planned to attend and communicate 5G!Drones through SME booth and workshop. However, EuCNC 2020 turned into a virtual event due to COVID-19. • The SME WG, with support from Full5G, plan to develop a "European Strategy" for SMEs developing 5G-related products and solutions, which would take advantage of the EU SME strategy currently being initiated. Initial discussion was made during February telco and INFOLYSIS participated representing 5G!Drones. This activity is still in progress. • Martel, member of SME WG, ran a survey at the beginning of the COVID-19 confinement period and published the results of the COVID-19 impact.

	156 responses were received including INFOLYSIS one that participated representing 5G!Drones project. (https://www.martel-innovate.com/remote-collaboration-survey/)

8.5. 5G Architecture WG

Activityname	5G-PPP Architecture WG
Main interface	WG monitored by TM (pascal.bisson@thalesgroup.com)
Activities	Follow up evolvement of overall 5G architecture and contribute
5G!Drones contributions	No contribution to report during the period since waiting for this WG to be revived.

8.6. PRE-STAND WG

Activityname	Pre-stand. WG
Main interface	Serge Delmas (AIR)
Activities	Identify standardization and regulatory bodies to align with e.g. ETSI, 3GPP, IEEE and other relevant standards bodies, & ITU-R (incl. WPs) and WRC (including e.g. ECC PT1). Develop a roadmap of relevant standardization and regulatory topics for 5G: Evaluate existing roadmaps at international level; Propose own roadmap for 5G being aligned at international level. Influencing pre-standardization on 5G and related R&D: Potentially propose where topics should be standardized; Influence timing on R&D work programs (e.g. EC WPs)
5G!Drones contributions	This working group had a strong focus on working with Verticals as input to 3GPP. The WG updated and published the action Plan from the 2nd 5G Vertical User Workshop: https://www.global5g.org/sites/default/files/Action%20Plan%20from%202nd%20vertical%20user%20workshop.pdf. 5G!Drones has actively contributed and especially to these following items: • Report on the achieved SDO impact. • Shared with the WG about the intended/planned impact to be achieved by 5G!Drones on standards. • Suggestions to the WG to facilitate the 5G!Drones impact to SDO.

8.7. SOFT-NET WG

Activity name	Soft Net WG
Main interface	Wolfgang Kampichler (FRQ)
Activities	Join 5G Automotive activities and participation in all telcos. EDGE Computing White Paper.
5G!Drones contributions	• Active participation in the regular 5G-PPP SOFT NET conference calls. • 5G!Drones presentation was requested by 5G-PPP, the request was brought up at PMT to decide and prepare a standard presentation. • FRQ has already received the formal 5GDrones presentation to be brought up at next SOFT-NET WG Telco.

8.8. IMT 2020 Evaluation WG

Activity name	IMT 2020 Evaluation WG
Main interface	Fotis Lazarakis (NCSRD)
Activities	IMT-2020 5G IA Evaluation Group is an independent Evaluation Group that officially initiated their work in January 2018. The scope of the Group is the evaluation of candidate Radio Interface Technologies (RITs) submitted by standardization organizations.
5G!Drones contributions	During the last year, the Group continued the work in order to complete the Interim Evaluation Report which was submitted to ITU-R at the end of November 2019. During 10 – 11 December 2019 the 5G IA IMT-2020 Evaluation Group attended, with a small number of representatives, the ITU-R WP5D Evaluation Workshop: "Workshop on IMT-2020 terrestrial radio interfaces evaluation", organized in Geneva where the independent evaluation groups (IEGs) presented a summary of their results. The Final Evaluation Report was submitted in February 2020 as a regular input to ITU-R WP5D meeting #34, organized in Geneva from February 19 to February 26, 2020. WP 5D announced the availability of the final evaluation reports from the registered IEGs and the reports were posted at ITU's web site. During this period, NCSRD contributed to the evaluation of Control Plane and Use Plane Latency of the 3GPP submission NR (New Radio) and LTE Rel.15. After the submission of the Final Report the Group interacts with ITU-R for various clarifications and provision of additional information supporting the next W5D meeting in June 2020.

8.9. Test, measurement & KPIs validation

Activity name	Test, measurement & KPIs validation
Main interface	Ilkka Känsälä (NOK)
Activities	The Test, Measurement, and KPIs Validation (TMV) Working Group was founded as part of the 5G PPP effort to promote commonalities across projects that have strong interest in the T&M methodologies needed to provide support to the vertical use cases in the 5G Trial Networks
5G!Drones contributions	5G!Drones joined in March 2020 this WG and have defined to 5G-PPP TMV TF two most important KPIs from UAV (Unmanned Aerial Vehicles) points of view. Those are related to C2 (Command and Control). PPP Trials & Pilots (T&Ps) Summary Table updated with 5G!Drones trial sites information."

Appendix 1 – Work Package 3 – 1st year progress report

PURPOSE OF THE DOCUMENT

The purpose of this document is to describe the work carried out within the framework of WP3 during the first year of the 5G!Drones project. It will consist of two parts: the first describes the major work undertaken during this first year and the second part concerns a description of the tasks carried out by each partner.

9. WORK PACKAGE 3 MAIN ACHIEVEMENTS

9.1. 5G!Drones MEC

9.1.1. ETSI MEC

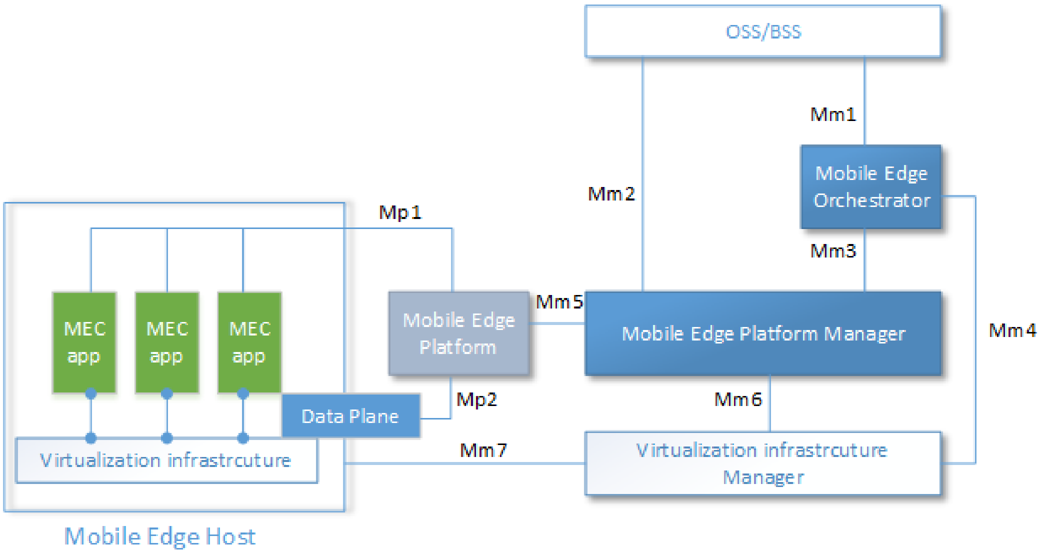

Figure 13. High-level view of the MEC architecture.

Since its creation in 2013, the ETSI ISG MEC group has been working on the development of standardization activities around MEC. The first released document of the group covers the reference architecture [MEC003], which aims to specify the different necessary components; a high-level representation of the architecture is shown in Figure 13. It introduces three main entities:

- The MEC host, which provides the virtualization environment to run MEC applications, while interacting with mobile network entities via the MEC platform (MEP) to provide MEC services and data offload to MEC applications. Two MEC hosts can communicate via the Mp3 interface aiming at managing user mobility via the migration of MEC applications among MEC hosts.
- The MEC platform (MEP), which acts as an interface between the mobile network and the MEC applications. It has an interface (Mp1) with MEC applications, so that the latter can expose and consume MEC services, and another interface (Mp2) to interact with the mobile network. The latter is used to obtain statistics from the RAN on UEs and eNBs, e.g. in order to provide the Radio Network Information Service (RNIS) and the Location Service, and to appropriately steer user-plane traffic to MEC applications.
- MEC applications that run on top of a virtualized platform.

Another concept introduced by ETSI MEC is the MEC service, which is either a service provided natively by the MEC platform, such as the RNIS and traffic control, or a service provided by a MEC application, e.g. video transcoding. MEC services provided by third-party MEC applications should be registered with the MEP and made available over the Mp1 reference point. Once registered, a service may be discovered and consumed by other MEC applications. Regarding the management plane, ETSI MEC introduced the Mobile Edge Orchestrator (MEO), which is in charge of the life-cycle of MEC applications (instantiation, orchestration and management), and acts as the interface between the MEC host and the Operation/Business Support System (OSS/BSS).

Several interfaces have been specified for the MEC management plane. The Mm1 interface is used to communicate with the OSS/BSS, allowing the latter to onboard MEC application packages and request application instantiation and termination. The MEO uses the Mm3 reference point to interface with the MEP Manager (MEPM) for application lifecycle management and configuration, and Mm4 to manage application images at the edge Virtual Infrastructure Manager (VIM), which is in charge of launching application instances on the MEC host. The MEPM element is in charge of the life-cycle management of the deployed MEC applications, and the configuration of the MEC platform, via the Mm5 interface. This includes MEC application authorization, specification of the type of the traffic that needs to be offloaded to a MEC application, Domain Name Service (DNS) management, etc.

The Mm6 interface is used by the MEPM to obtain information on the virtual resources used by a MEC application from the VIM and implement their life-cycle management. Such information can be passed on via Mm3 to the MEO to check the MEC application resource status, and, if deemed appropriate, add more resources to it. This information is also exposed to the OSS/BSS over the Mm2 reference point. It should be noted that MEC allows the migration of MEC applications among MEC hosts, using the mp3 interfaces; i.e. the Mp3 is used to implement the migration processes.

9.1.2. MEC in NFV

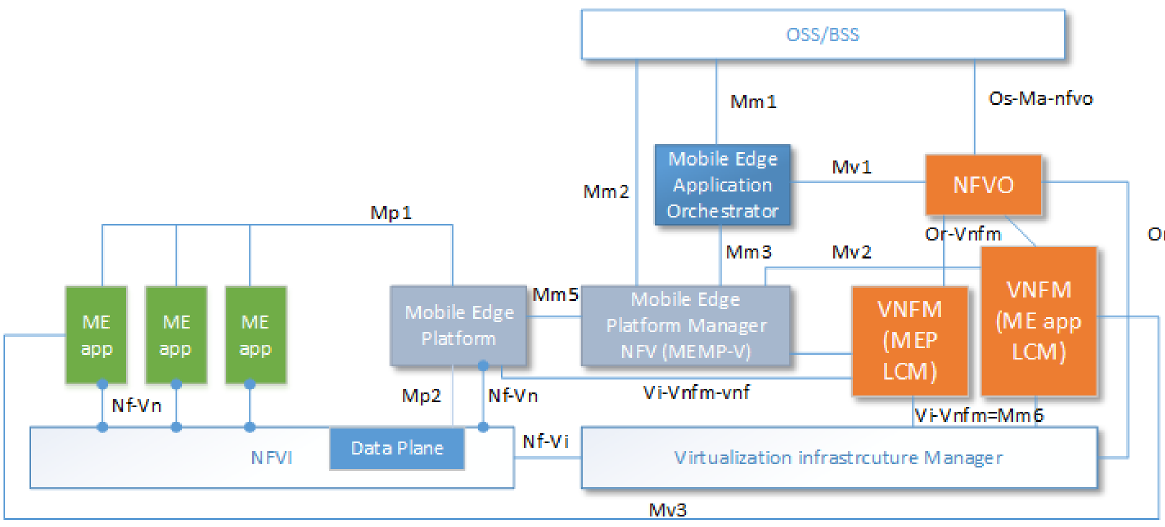

Figure 14. Updated version of the MEC architecture featuring MEC in NFV.

As described in the precedent section, the MEC architecture is defined to run independently from the NFV environment. However, the advantage brought by NFV, and aiming to integrate and run all MEC entities in a common NFV environment, has led the MEC ETSI group to update the reference architecture. The proposed document [MEC017] updates the reference architecture as shown in Figure 14. As it could be noticed, the MEC platform and the MEPM are run as a VNF. The MEO became the

MEAO (Mobile Edge Application Orchestrator); it keeps the main functions described before, excepting that it should use the NFVO to instantiate the virtual resources for the MEC applications as well as for the MEP. Consequently, all the process of instantiation and management of resources will follow the NFV well-defined interfaces. By doing so, the edge resources can be seen as classical computation and storage resources, and managed by the same VIM software. Note that Table 5 summarises the difference between the MEO and MEAO, in term of functionality.

Table 5. Differences between MEO and MEAO

Function	MEO	MEAO
Maintaining an overview of the MEC, available resources, available MEC hosts, topology	Yes	Yes
Selecting appropriate MEC host based on constraints (latency, available resources and available services)	Yes	Yes
Triggering application instantiation and termination	Yes	Via the NFVO
Triggering application relocation as needed when supported (migration due to mobility)	Yes	Yes

The MEC architecture is defined to run independently from the NFV environment. However, considering the advantages brought by NFV, and aiming to integrate and run all MEC entities in a common NFV environment, has led the ETSI MEC group to update the reference architecture. The ETSI MEC 017 working group drafted a document [MEC017] to update the reference architecture, as shown in Figure 14. These updates have also been included as an NFV-oriented variant in the most recent version of the MEC framework and reference architecture [MEC003]. As it could be noticed, the MEP and MEPM are run as VNFs. The MEO was renamed to MEAO (Mobile Edge Application Orchestrator), keeping the main MEO functionality as described before, except that it should use the NFVO to instantiate MEC applications as well as the MEP and MEPM. Consequently, all the processes of instantiation and management of resources will follow the well-defined NFV interfaces. By doing so, edge resources can be seen as classical computation and storage ones, and can be managed by the same Virtual Infrastructure Manager (VIM) software.

In addition to MEC applications, the VNF Manager (VNFM) is also in charge of the life-cycle management of MEP and MEPM. Finally, another important extension is the appearance of new interfaces (Mv1, Mv2, and Mv3), which allow communication between MEC and NFV components, in addition to the usage of the interfaces defined by the ETSI NFV.

9.1.3. MEC in 5G

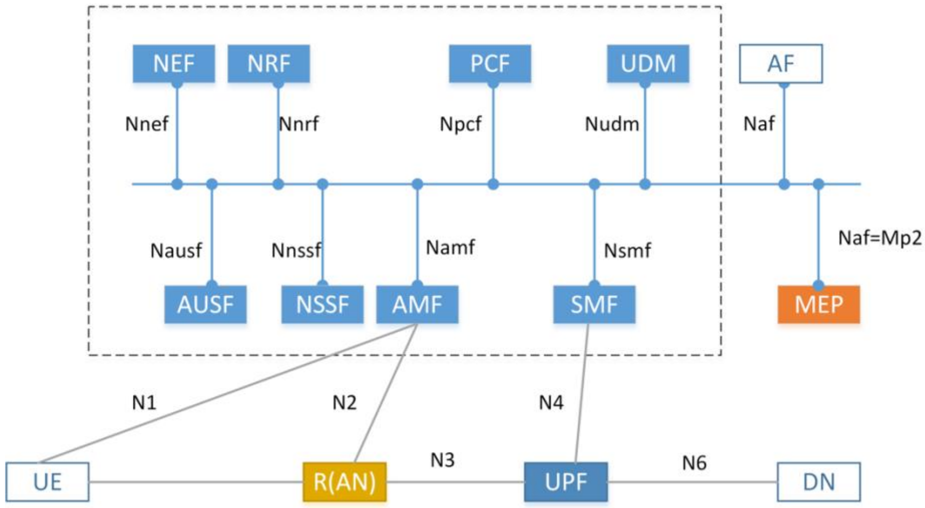

Figure 15. MEC vision in 5G.

The new 5G reference architecture introduces several NFs. The most prominent are Access and Mobility Management Function (AMF), Session Management Function (SMF), User Plane Function (UPF), User Data Management (UDM), Network Slice Selection Function (NSSF), Network capability Exposure Function (NEF), Policy Control Function (PCF), and Application Function (AF). All the NFs expose APIs to provide one or more services to other NFs, following the producer-consumer concept. Regarding the support for Network Slicing, we notice the appearance of the NSSF, which allows the RAN to select the appropriate AMF (slice-specific or common to all slices), when a UE indicates in the first attach request its S-NSSAI.

In this work, we focus on user-plane functions (SMF, PCF and UPF), as MEC requires the definition of traffic policies to redirect traffic to the appropriate MEC applications. More details on the other 5G functions can be found in [TS23501]. The UPF is the function in charge of routing the user plane traffic to the appropriate Data Network (DN). It gets its configuration from the SMF. The latter is considered as one of the key elements for user-plane traffic management. Among the various functions of the SMF, such as IP address allocation and management, and session management, is the control of the UPF by configuring traffic rules. The SMF exposes service operations to allow another function or 5G AF to use policy and traffic rules to reconfigure the UPF, via (i) the PCF, if the 5G AF is a trusted application, or (ii) the NEF, for untrusted AFs.

In the 5G architecture, the MEP will be integrated as a 5G AF (Figure 15), trusted or not, depending on the use-case; this will be discussed later. The MEP requests traffic redirection for a MEC application as per the request of the MEAO via the MEPM. Therefore, if MEP is a trusted 5G AF, it can use directly the PCF to generate a policy to offload traffic towards the MEC application. If it is not considered as a trusted 5G AF, it uses the NEF to access the SMF, via its traffic filter policy exposed API, and requests the traffic redirection.

9.1.4. MEC and Network Slicing

Currently very few research papers are available regarding slicing in MEC or MEC support for slicing. Meanwhile, there is a study group from ETSI that is focused on MEC support for Network slicing. First group report came out on the 28-11-2019 as ETSI GR MEC 024 v2.1.1 (2019-11). Report focused on identifying MEC functionalities in order to support slicing. Basically, it described relevant use cases based on identified network slicing concept in the context of MEC. It identified gaps within the current MEC defined functionalities that might affect slicing deployment. The document also present new MEC

functionalities and extended interfaces definitions to support slicing, and future works. New architecture was proposed for NSI creation and termination with integration based on the existing reference architecture for MEC in NFV.

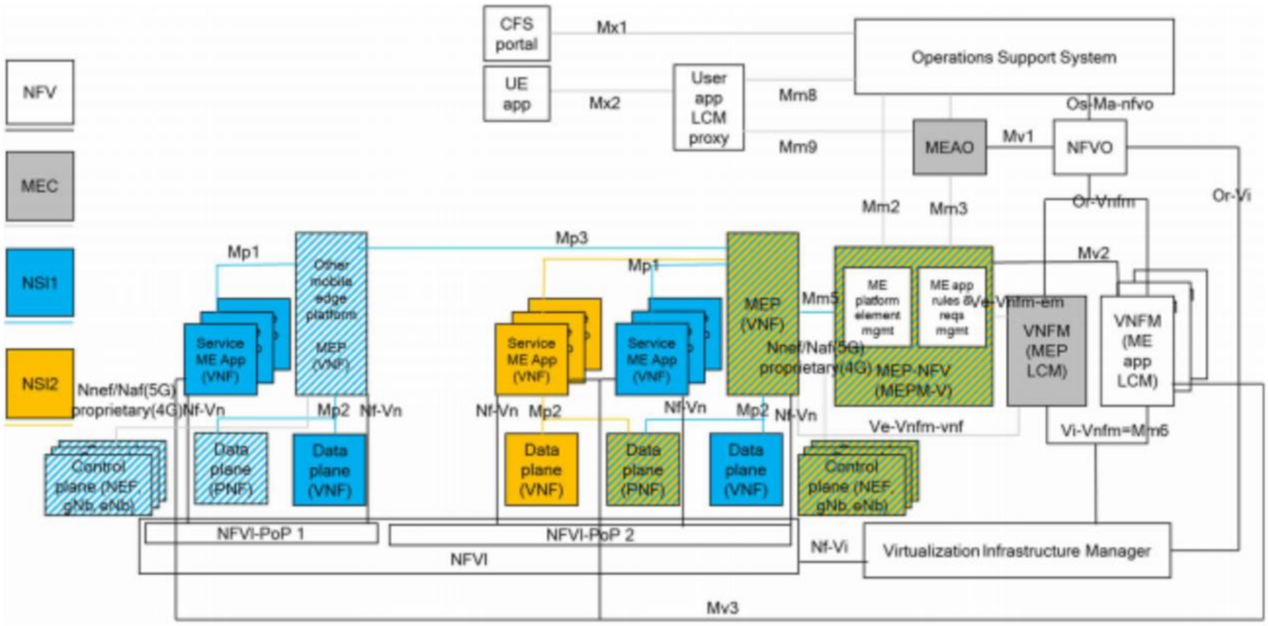

Figure 16: Example of MEC in NFV supporting network slicing.

Key points in the architecture

a) MEC Platform (MEP) and MEC services are treated as separate VNF -> NSD and thus separate NSSI, however their VNF architecture will be based on the MEC reference architecture in VNF with MEAO, MEPM-V.
b) MEAO should be made slice aware (Very important point) to support service availability to single or multiple NSI.
c) MEPM-V should be tenant aware to support operation distinction amidst different tenants
d) A MEP can be dedicated to a single NSI or Multiple NSI.
e) MEP uses the same VNFD and NSD as normal NSSIs, however MEP VNFD has extra fields the AppD field which include the app traffic rule and the app service required.
f) in terms of latency, 5 Steps is proposed to realize NSI latency assurance, from specifying latency requirement in NSD, to UPF deployment, the MEC platform latency and finally calculating the end to end latency with a “testing application at the MEP”.
g) New interfaces were introduced to support specific slicing use cases.
h) General key issues and gap analysis regarding how to achieve some of the proposed new solution especially, slice awareness at the MEAO and tenant awareness at MEPM-V.

9.1.5. 5G!Drones enablers: MEC and NS

Stemming from the facts:

(i) 3GPP has released a new architecture model to integrate NS in 5G, and a new framework to manage NS, and
(ii) the ETSI MEC group has proposed a solution to integrate MEC in NFV,

there is a need to update the current MEC architecture to comply with these evolutions, aiming at supporting NS at the MEC level (i.e. slicing the MEC). We distinguish two models for the support of Network Slicing in MEC. The first model assumes that the MEP is already deployed at the edge NFVI

and is shared among the slices; we term it the *multi-tenancy* model. In the second model, the MEP is deployed inside the slice. This is what we call *in-slice* deployment. For both models, we assume that the MEP is deployed as a VNF. Both the MEP and MEC applications are described using a VNF Descriptor (VNFD) and Application Descriptors (AppDs), respectively. The VNFD and AppD describe the necessary information required by the NFV Orchestrator (NFVO) and VIM to deploy instances of virtual applications, either at centralized clouds or the edge. AppD is specific to MEC applications. It contains specific fields related to MEC, such as traffic steering rules and MEC services required by the application. Note that we consider the MEPM as the Element Manager (EM) of the MEP. CSMF shows the global picture highlighting the envisioned network slicing orchestration/management architecture as proposed by 3GPP, and featuring MEC slicing. In terms of interfaces, we mainly highlight those needed to orchestrate and manage core and edge virtual applications. The RAN controller is the element that provides a northbound control interface to manage eNBs, while using a southbound protocol, such as FlexRAN [Foukas16], in order to remotely configure eNBs (e.g. to associate to a new AMF of a slice) or to obtain RAN-level information, such as UE statistics, which can be used by the operator or exposed to interested applications over the RNIS MEC API.

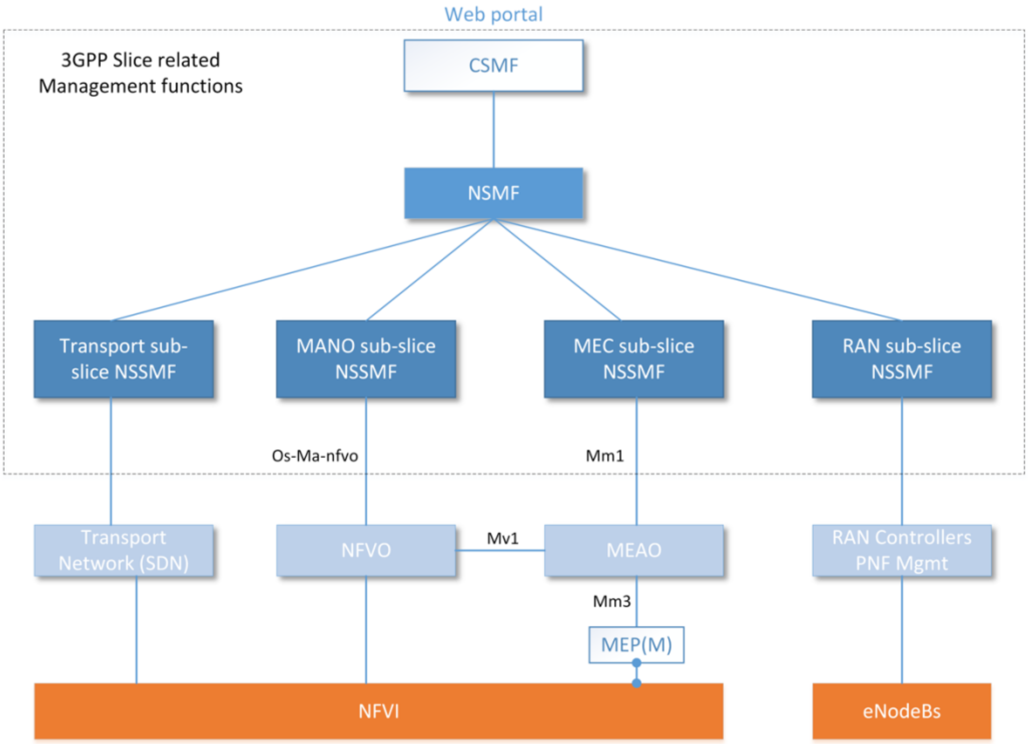

Figure 17: The proposed network slicing orchestration/management architecture, including MEC, in a 5G environment.

We assume that a vertical first accesses a front-end interface (such as a web portal) to request the creation of a network slice, using the NST made available by the CSMF. The NST could be extended according to the vertical needs, and by integrating network functions displayed by the CSMF through its network functions store or catalogue (i.e. add more MEC applications). The CSMF forwards the NST to request the creation of an end-to-end network slice composed by several sub-slices that span the RAN, CN, MEC and transport network. The NSMF organizes the NST into sections corresponding to each sub-slice. The Management and Orchestration (MANO) NSSMF component covers the CN functions and VNFs that need to be deployed over the cloud. All the network functions that need to be deployed over MEC should be managed by the MEC NSSMF. The NSSMF accepts as input a Network Service Descriptor (NSD) [NFV001] that contains VNFDs as well as AppDs. The NSMF requests the creation of each sub-slice to the corresponding NSSMF, as illustrated in Figure 16. The RAN NSSMF is in charge of updating the configuration of the RAN, via a RAN controller that interacts with the involved

eNBs (PNF) indicated in the NST. The NSSMF in charge of CN and VNF instantiation, requests the instantiation of the NSD to the NFVO using the Os-Ma-NFVO interface [IFA013]. The MEC NSSMF interacts with the MEAO by providing the AppDs of the applications that need to be deployed at the edge NFVI. The MEAO will use the same NFVO (as specified in [MEC017]) to request the creation of the AppD instance at the selected edge NFVI. Among the available edge NFVIs, the MEAO selects the appropriate one for the instantiation of a MEC application, according to its internal placement algorithm that may consider different criteria, such as latency and service availability [Yala18]. To recall the AppD includes important information related to the MEC application to be deployed, such as *appLatency*, *appTrafficRule*, *appRequiredService*.

Once the application is instantiated, the MEAO is informed of the MEC application's IP address, which it communicates to the MEC platform along with parameters such as specific traffic filters, to enforce traffic steering. The last subslice is about the transport part, where we assume that the NSSMF managing it interacts with Software Defined Networking (SDN) controllers to isolate and forward NS traffic to the Internet.

Once each subslice is created, the NSMF is in charge of stitching them together to build the end-to-end slice. The stitching process consists in interconnecting the different sub-slices using a sub-slice border API, as described in [Kuklinski18].

9.1.5.1. Multi-tenancy model

In the case of MEP multi-tenancy, the MEP and UPF are already deployed. The MEP is already aware about the IP addresses and interface endpoints of the NEF or PCF for traffic redirection, as well as those of the RAN controller, from which it can gather the necessary RAN-level data to provide MEC services, such as the RNIS and the Location Service. Once the MEC application is deployed by the NFVO, the latter informs the MEAO about the successful instantiation of the MEC application, along with its IP address. The MEAO then, via Mm3, requests the MEP to enforce traffic redirection rules as indicated in the AppD. Based on the description presented in section (II.C), the MEP, via the PCF's API, requests the redirection of specific traffic (via a traffic policy) toward the newly created MEC application. Here, the MEP uses the PCF, as it is considered a 5G AF: the MEP has been deployed by the network operator as a common 5G AF for all slices.

9.1.5.2. In-slice deployment model

In this case, the MEP has to be deployed along with the MEC application at the edge NFVI. Unlike the multi-tenancy model, here the MEAO requests the instantiation of both the MEP and MEC application at the same time. The NFVO deploys both, and it ensures that there is a virtual link between them. As in the previous case, the NFVO acknowledges the creation of the MEP and MEC application instances and indicates their IP addresses.

Here, we differentiate between two cases: (i) all the CN elements (including the UPF) are deployed inside the slice; (ii) the UPF is already deployed. In the first situation, the UPF is deployed also at the edge (for the sake of performance), and the MEP can implement traffic redirection using the internal PCF of the network slice. For the second scenario, the MEP has to discover the NEF of the operator, as the MEP is not considered as a trusted 5G AF. To solve this, we propose that the DNS running at the edge NFVI may help in this direction: Once instantiated, the MEP sends a DNS request to discover the NEF's IP address, and communicates with the latter to apply traffic redirection rules.

Regarding the needed access to the eNBs in order to provide MEC services (e.g. RNIS, Location Service), we propose to use the concept of zones, as introduced in [MEC013]. A zone indicates an area covered by a group of eNBs associated with a MEC host. These eNBs are assumed to be managed by a single RAN controller. For both scenarios, we propose that the MEP uses DNS to discover the RAN

controller that corresponds to the zone where it is instantiated, which in turn allows the MEP to retrieve RAN-level information from all eNBs of the zone.

9.1.6. 5G!Enablers: MEC and mobility management

EUR will provide a contribution on MEC mobility management in context of UAV.

9.2. 5G FACILITIES INTERFACES

9.2.1. Introduction

The first step for abstracting the heterogonous nature of trial facilities is the identification of the interfaces required by the trial controller and exposed by each facility. All the identified interfaces are subject to abstraction, wherein the aim is to provide unified interfaces to the trial controller for accessing, per facility, management, monitoring, and control, services. The interfaces required by the trial controller can be grouped in four categories:

- Network slices management interfaces,
- VNFs management interfaces,
- MEC applications management interfaces, and
- KPIs monitoring interfaces.

9.2.2. Network slices management interfaces

This set of interfaces is used by the trial controller for management of the lifecycle of NSIs and include the following interfaces:

- NSI feasibility check: Used by the trial controller to check whether the NSI requirements can be satisfied by the targeted facility.
- NSI creation interface: Used by the trial controller to deploy a NSI. This includes the reservation and configuration of all resources required by the NSI.
- NSI modification interface: Used by the trial controller to modify a running NSI.
- NSI termination interface: Used by the trial controller to terminate a running NSI. This includes releasing the resources allocated for the NSI.

9.2.3. VNFs management interfaces

This set of interfaces allows the management of the lifecycle of use case specific applications (e.g. video streamer, IoT data collector, flight controller) deployed in the facilities central cloud as network services. Based on ETSI NFV-IFA 013, VNFs can be manged using the following interfaces:

- VNFs packages management interfaces: Used by the trial controller on-board, enable, disable, delete, and fetch a VNF packages.
- NSDs management interfaces: Used by the trial controller to on-board, enable, disable, update, delete, and fetch an application descriptor (i.e. network service descriptor).
- NS management interfaces: Used by the trial controller to instantiate, scale, update, and terminate an application deployed as a network.

9.3. MEC management interfaces

This set of interfaces allows the management of the lifecycle of use case specific applications (e.g. video streamer, IoT data collector, flight controller) deployed in the facilities edge cloud as MEC applications. Based on ETSI GS MEC 010-2, MEC applications can be managed using the following interfaces:

- ***Applications packages management interfaces***: Allows the management of the applications packages that bundle the files required for the instantiation of the UAV applications:
  - Application package on-boarding interface: used by the trial controller to make the application package, stored in the VNFs repository, available to the MEC system.
  - Application package enabling interface: used to mark the application package as available for instantiation.
  - Application package disabling interface: used to mark the application package as not available for instantiation.
  - Application package deletion interface: used to delete the application package from the MEC system.
- ***Applications instances management interfaces:***
  - Application instance creation interface: used to create a new instance of an application whose package has been already on-boarded and enabled.
  - Application instance operation interface: used to start and stop an already created application instance.
  - Application instance termination interface: used to delete a running application instance.

9.3.1. Key Performance Indicators monitoring interfaces

This set of interfaces allows the real-time collection of performance data from different facilities:

- Measurement job creation interface: allows the creation of one measurement job that can collect the values of one or multiple KPIs from the targeted facility.
- Measurement job termination interface: used to terminate a running measurement job after the end of the UAV mission.
- List measurement jobs interface: used to list the running measurement jobs.

9.4. Abstraction Layer architecture

9.4.1. Architecture of the abstraction layer

Figure 18 depicts the proposed architecture of the abstraction layer, the description of each components is given in the following subsections.

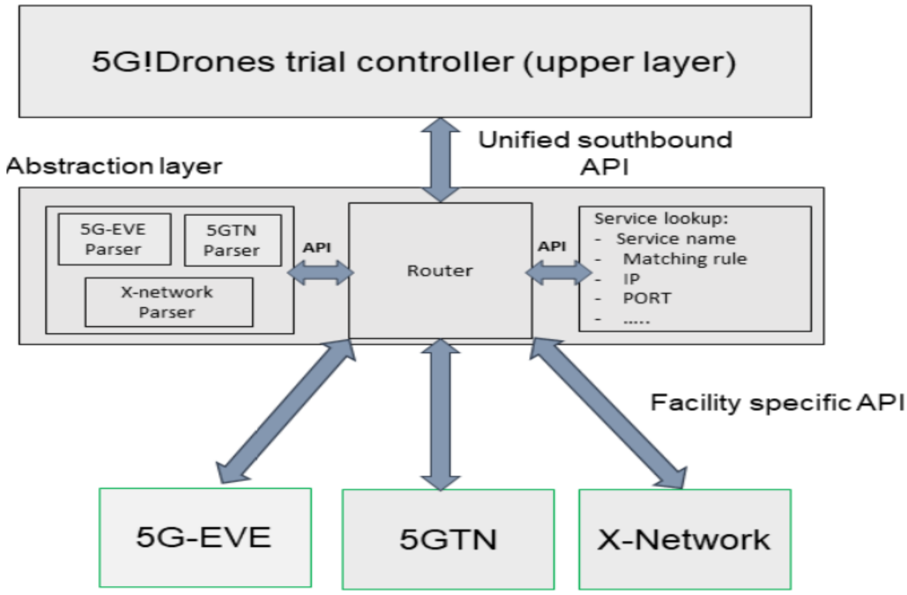

Figure 18: Architecture of the proposed abstraction layer.

9.4.2. Router

The Router is responsible for the routing of the generic requests received from the trial controller to the appropriates services. Indeed, whenever a request is sent from the trial controller to the router, this latter redirect the request to a parser service based on the matching rules configured in the service repository. The parser service transforms the generic request to a facility specific request and send it to the targeted facility using the router.

9.4.3. Service repository

The service lookup holds the details required by the router for the routing of requests between the parsers and the facilities. This include the matching rules that allows the identification of the destination of each request, and the communication details with each service (i.e. IP, port, protocol).

9.4.4. Parsers

Each parser is responsible for the translation of the generic requests sent by the trial controller to a facility-specific requests.

9.5. Implementation

9.5.1. Abstraction of the network slices management interfaces

Since network slicing is the main enabler of the different trial scenarios, task efforts are focused on the abstraction of NSIs management interfaces. In this context, an analysis of the implementation of network slicing in each facility is ongoing, where the aim is to define a unified NST that can be used for the management of NSIs across all the facilities.

9.5.2. Implementation of the abstraction layer

An open source solution was considered for the implementation of the router and the services lookup parts. Work on the parsers is planned.

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Appendix 2 – Preliminary Draft of D3.1 – Initial Report on infrastructure-level enablers for 5G!Drones

"5G for Drone-based Vertical Applications"

D3.1 Initial Report on infrastructure-level enablers for 5G!Drones – preliminary draft

Document ID:	**D3.1**
Deliverable Title:	**Report on infrastructure-level enablers for 5G!Drones**
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Executive Summary

The 5G!Drones is an innovative 36-month project focused on trials of several UAV use cases that cover eMBB, uRLLC and mMTC 5G services, validation of 5G KPIs for supporting such challenging use cases, and their enhancements with powerful features. This draft deliverable is a report on the design and implementation of enabling mechanisms for 5G!Drones at the (5G) infrastructure level including:

- end to end network slicing,
- incorporation of MEC to facilitate UAV services,
- network and compute resources abstraction,
- facility federation.

5G!Drones project aims to explore which of the 5G components need to be improved to support different UAV use cases. The large part of work is concentrated on how to build and secure network slices needed for the realization of the specific trial.

Network slicing enables creating parallel virtual telecommunication networks over a common distributed cloud infrastructure. The main advantage of this approach is the ability to create isolated networking solutions on-demand that are combined or tailored for specific applications and can be managed in a flexible manner.

Efficient slices management can be achieved by monitoring a specific combination of network features aggregated in the form of KPIs. An important task to be realized by 5G!Drones project is also the definition and validation of the set of representative KPIs that will enable UAV verticals to monitor and manage Network Slices running UAV applications.

MEC provides cloud-computing capabilities and an IT service environment at the edge of the network. The main advantages of the solution are the ability to achieve ultra-low latency, high bandwidths and real-time access to radio network information which can be further leveraged by applications deployed in the ecosystem. MEC solution also facilitates the operators in terms of opening RAN edge to authorized third-parties that can deploy innovative applications and services towards mobile subscribers, enterprises and vertical segments in a fast and flexible manner. MEC is also perceived as an important facilitation towards latency-critical applications.

Table of Contents

List of Abbreviations

3GPP	The Third Generation Partnership Project

4G	The Fourth Generation of Mobile Communications
5G	The Fifth Generation of Mobile Communications
5GC	5G Core network
5GPPP	Fifth Generation (5G) Public Private Partnership
ANM	Autonomic Network Management
AP	Application Plan
AppD	Application Descriptor
CNM	Cognitive Network Management
CP	Control Plane
DASMO	Distributed Autonomous Slice Management and Orchestration
DNS	Domain Name Service
DP	Data Plane
EEM	Embedded Element Managers
EM	Element Manager
eNB	Evolved Node B
EPC	Evolved Packet Core
ETSI	European Telecommunications Standards Institute
FCAPS	Fault, Configuration, Accounting, Performance, Security
ISM	In-Slice Management
ITU-R	International Telecommunication Union – Radiocommunication Sector
ITU-T	International Telecommunication Union – Telecommunication Standardization Sector
KPI	Key Performance Indicators
KQI	Key Quality Indicators
LCM	Life Cycle Management
MANO	Management and Orchestration
MAPE	Monitor-Analyze-Plan-Execute
MEAO	Mobile Edge Application Orchestrator
MEP	MEC platform
MEPM	MEP Manager
MF	Management Function
NF	Network Function
NFVO	NFV Orchestrator
NS	Network Slicing
OSS/BSS	Operation System Support/Base Station System Support

RAN	Radio Access Network
RNIS	Radio Network Information Service
SM	Slice Manager
SON	Self-Organizing Networks
TMN	Telecommunication Management Network
UAV	Unmanned Aerial Vehicle
UE	User Equipment
VFNM	VNF Manager
VIM	Virtualized Infrastructure Manager
VNF	Virtual Network Function

10. INTRODUCTION

10.1. Deliverable scope

The 5G!Drones context dictates an entire Work Package (WP3) to "Enabling mechanisms and tools to support UAV use cases". The main focus of WP3 is laid on the development of the 5G!Drones enablers that allow to run the UAV use cases and to meet their requirements identified within WP1 work. Specifically, the desired enablers include:

- **Scalable end-to-end slice orchestration, management and security mechanisms** (T3.1) with a special focus on security aspects and extensions in network slicing and advanced slicing mechanisms.
- **MEC capabilities for the support of 5G!Drones trials** (T3.2) especially the necessary support for the inclusion of MEC application instances and related network and compute resources into an end-to-end UAV slice, obligatory enhancements regarding isolation of slices, as well as extensions concerning slice awareness, resource isolation and security in multitenant MEC environment. Furthermore, challenges for MEC related to UAV mobility aspects is to be thoroughly researched.
- **Mechanisms of infrastructure abstraction and federation of 5G facilities** (T3.3). Specifically, a unified interface that will enable exposure of facility capabilities and to deploy functions, there are to be defined and developed. Its aim is to provide a single abstraction for the network (e.g. RAN) and compute resources (e.g. provided from a central or MEC datacentre).

This document reports work-in-progress related to the mentioned above topics.

10.2. Organization of the document

The document is organized as follows:

- **Section 1** (current section) is an overall introduction to the document and discusses the scope of WP3 as well as the role of interaction infrastructure enablers with aviation domain processes;
- **Section 2** focuses on scalable end-to-end slice orchestration management (T3.1);
- **Section 3** discusses MEC capabilities in terms of support for 5G!Drones trials (T3.2);
- **Section 4** focuses on infrastructure abstraction and federation of 5G facilities (T3.3);

- **Section 5** concludes the report.

11. SCALABLE END-TO-END SLICE ORCHESTRATION AND MANAGEMENT

11.1. RAN slicing issues and their impact on management

While network slicing in the Core Network has been defined, thanks to the well-known concepts of SDN and NFV, the development of network slicing in the Radio Access Network (RAN) is still in its early stages. The fact that part of the RAN relies on wireless communications brings new challenges to this concept, like resource management, spectrum sharing and isolation, for example. Indeed, on the radio segment, ensuring QoS mainly comes down to perform adapted scheduling to match the demands of each traffic. This allocation of radio/frequency resources (Resource Blocks) guarantees a bit rate for each service or slice. In order to extend the QoS guarantees on the radio segment, a module called RAN controller has been introduced in the literature to allow the extension of the QoS already established in the core and at the edge of the network. Of course, the policies applied by the RAN controller must reflect those of the core network slice orchestrator.

In order to address these challenges, we propose the architecture for implementing RAN slicing, which is described in the following sections.

11.1.1. RAN Controller and Agent

One of the key concepts of this architecture is the separation between the Control and Data Plane. This enables the independent management of both planes and thus facilitating the scalability of data plane nodes. In other words, a single RAN controller can be in charge of different base stations, through dedicated agents. And a base station can be added at any time.

In the proposed architecture, the RAN Controller is in charge of processing the information coming through its northbound interface from the management plane, and the network state information coming from the agents through its southbound interface. Based on the global network view built from this information, it provides configuration instructions to the Agents. One Agent is implemented in each base station. Its role is to implement the instructions issued by the controller.

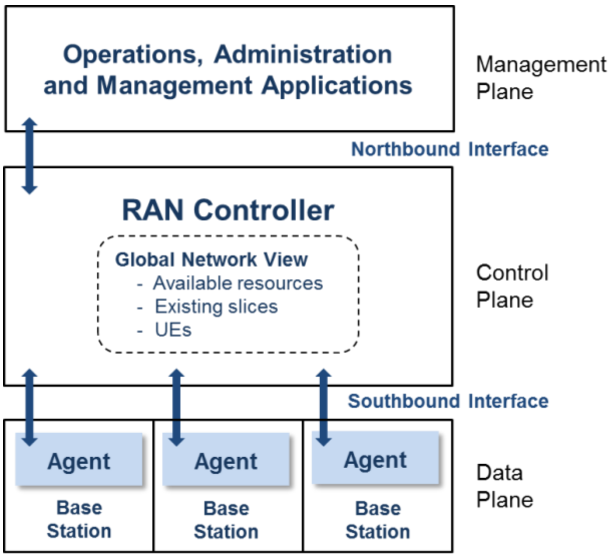

Fig. 1: High-level view of the proposed architecture

11.1.2. Resource management

The main goals of our solution regarding resource management are:

- To ensure performance isolation between slices, meaning that insufficient resource in a slice should not affect the performance of another slice.
- To allow each slice to allocate its resource in its own way between the different UEs attached.
- To efficiently use radio resources.

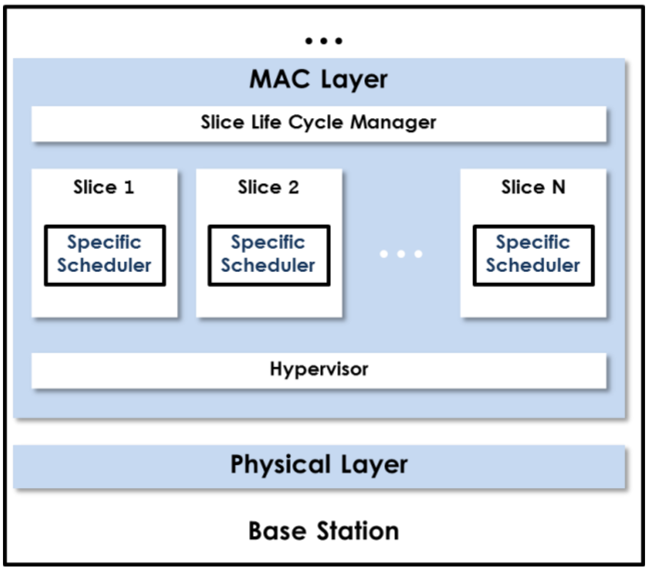

Fig. 2: Scheduling model

In order to achieve these goals, two levels of scheduling are performed. The first aims to allocate radio resources to each slice, and the second shares resources between UEs within a slice, depending on the slice's scheduling policy. Fig. 2 shows a high-level view of the scheduling model in this architecture.

The **Slice Life Cycle Manager** is responsible for the creation and destruction of slices. When the RAN controller receives a slice creation request, the Slice Life Cycle Manager checks that there is enough resource left and that the slice's configuration complies with the admission control mechanism.

The **Hypervisor** is in charge of allocating the radio resources to the different slices. It provides an abstraction of the physical resources in the form of Resource Blocks (RBs), without specifying their location on the grid. This way, the Hypervisor can reallocate the resource in real-time, and it will be invisible for the higher layers.

Within each slice, a **Specific Scheduler** is in charge of allocating the virtual resources provided by the Hypervisor to the UEs. The default scheduling policy is a Round Robin mechanism, but it can be modified in the slice configuration.

11.1.3. RAN controllers

The following section is a brief state of the art of available RAN controllers that could be used to implement slicing in the access network of the 5G!Drones environment.

FlexRAN

Slice management differs from classical network management. In the network slicing case, there is a need to manage not a single, but multiple networks – this makes the scalability of management extremely important. Moreover, as it has been already mentioned, the management functions of a slice should be split between slice tenants and the network slicing system operator. Due to the software dimension of slices, there is also a need to provide cooperation of the management and orchestration systems which functionalities partially overlap.

From the management point of view, a single network slice (network instance) can be treated similarly as a classical net-work. Therefore, the generic scheme of Telecommunication Management Network (TMN), as defined in the ITU-T recommendation M.3000 [1], can be applied. However, some modifications related to the software nature of such networks are needed.

As the network slices are mostly based on software entities, the management and orchestration of them can use the ETSI NFV MANO approach. In this framework, the management part of the system (OSS/BSS) drives the NFV Orchestrator (NFVO) to perform management and orchestration of MANO compliant solutions. The NFVO performs not only the NS lifecycle management but also dynamically allocates resources to provide the required performance and handle faults. Recently, ETSI started working on incorporating network slicing within the Release 3 of NFV MANO specifications [2]. They plan to address the scalability of orchestration, multi-tenancy of NFVO and support for the creation of the multi-domain slices.

FlexRAN (**Error! Reference source not found.**, [4]) is an SD-RAN platform enabling slicing and separation of control plane (CP) and data plane (DP) in the RAN. In this architecture, each base station has its own DP embodied by a FlexRAN agent. All of these agents communicate with a centralized controller through its southbound API. This flexible and programmable control plane makes it easier to manage all the base stations belonging to the network and facilitates the development of control applications. FlexRAN includes a mechanism allowing the master controller to delegate scheduling decisions to the agents, leading to reduced latency and distributed computation. FlexRAN is based on Open Air Interface, a stack implementing the radio access network as well as the core network in LTE or 5G NR.

Orion

Orion **Error! Reference source not found.** is a RAN slicing architecture based on FlexRAN that enables the dynamic on-the-fly virtualization of base stations. It introduces a hypervisor connecting each base station to the CP of each slice. This hypervisor must ensure that each slice has the resources necessary for its proper functioning and guarantee isolation from the other slices in a dynamic way. The resource can be reallocated to follow the requirements in real-time. In this system, the Physical Resource Blocks (PRB), radio resources to be allocated, are virtualized and allocated via pools of virtual resource blocks to the slices.

RAN Runtime

RAN Runtime [6] is a RAN slicing system also based on FlexRAN and developed by Eurecom. Its particularity compared to Orion, is the personalization it offers to the slices. A common set of RAN modules, accessible through the RAN Runtime API, is shared between slices. They include different RAN functions and resources that can be used to customize a slice. The isolation level of a slice can also be determined. It can be completely isolated, shared across all network layers, or customized for a subset of CP and DP. RAN Runtime also allows more flexible allocation of PRBs than Orion. Indeed, it allows reallocating resources not allocated to other slices. Four levels of granularity are introduced in RAN Runtime for the allocation of resource blocks:

- Contiguous – resource blocks allocated according to this granularity are contiguous in the grid;

- Non-contiguous – resource blocks allocated according to this granularity may not be contiguous in the grid;
- Fixed position – the resource blocks have a fixed position in the grid of resources and cannot be reallocated in another place;
- Minimum granularity – for this granularity, the slice does not require resource blocks but a certain capacity. RAN Runtime will then allocate as few resource blocks as possible while complying with the demand.

Each slice chooses the granularity according to its needs. The main objective of RAN Runtime is to maximize the satisfaction of the slices in terms of allocation of requested resources as well as to maximize the number of unallocated resources in the event that another slice comes to request these resources. This technology allows greater customization of slices and more flexible allocation of resource blocks.

5G-EmPOWER

5G-EmPOWER ([7], [8]) is an open-source platform supporting RAN slicing. It is composed of three main elements. On the data plane, an Agent is implemented in each base station to enforce the instructions issued by the controller. The latter is in charge of processing the information coming from the management plane through its northbound interface, and the network state information coming from its southbound interface. Based on the global network view built from this information, the controller provides configuration instructions to the Agents, using the OpenEmpower protocol. The last part is the management plane, relying on the REST API to manage slice parameters. Each slice can be configured independently with a number of allocated PRBs and a scheduling mechanism. The LTE stack used by default in 5G-EmPOWER is srs LTE. Implementation of Open Air Interface is also possible. One of 5G-EmPOWER's strength is that it is able to reallocate unused resources in order to increase performance.

REVA

REVA [9] is a metric used for RAN slicing to predict the number of PRBs to assign to links, depending on their load, as well as to make the necessary admission control decisions. The resource prediction algorithm is based on the last T predictions made.

This metric is based on an improved version of the LSTM architecture called X-LSTM. The latter obtains better results than LSTM with 91% accuracy. The cost of the operation per slice is also lower.

11.2. Scalable slice management architecture

In the context of 5G!Drones, each use-case has very special requirements, in terms of latency, throughput, reliability or number of supported devices, for example. Those needs are specified by the four categories defined in 5G NR standards:

- eMBB – enhanced Mobile Broadband;
- mMTC – massive Machine Type Communication;
- URLLC – Ultra-Reliable Low Latency Communication;
- V2X – Vehicle to Everything for vehicle communications.

Therefore, end-to-end network slicing is a crucial element of the 5G!Drones architecture, because it ensures that these heterogeneous service types coexist and provide each user with its required quality of service.

The concept of network slicing is a cornerstone of 5G NR to allow the coexistence of several verticals and different services on a single physical platform. Infrastructure virtualization is the main enabler of

network slicing by allowing the deployment and reconfiguration of new services on the fly in standard equipment. Thus, a vertical can independently deploy and orchestrate its own services on a network shared by several other verticals. More specifically, a slice can be deployed for each service with dedicated QoS guarantees.

This resource management technique ensures isolation between verticals and services and sharing the infrastructure, which reduces the cost for operators. Performance isolation between slices means that insufficient resource in a slice will not affect the performance of another slice. The possibility of slice reconfiguration on-the-fly is also the main advantage that allows fine management of infrastructure and services. In this context, 3GPP defines the "Network Slice Instances" distributed in the architecture in the form of "Network Slice Subnet Instances" (Fig. 4).

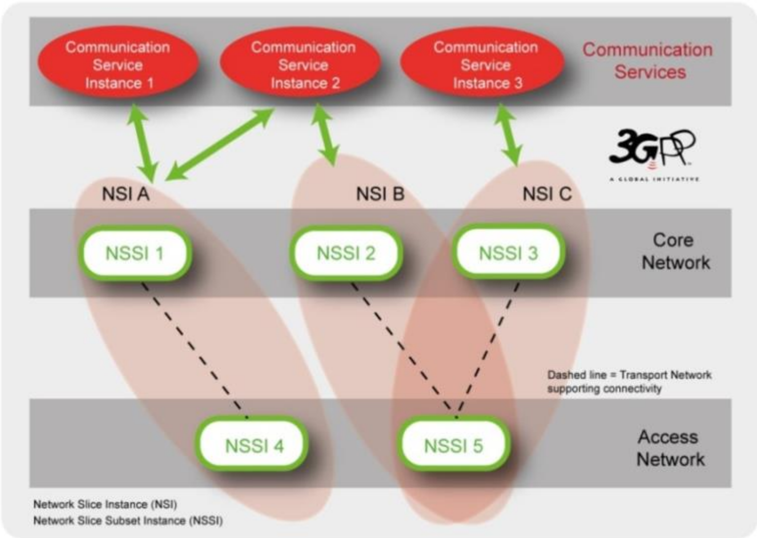

Fig. 4: 3GPP Slicing model

Slice management, it is also possible to use the latest management concepts. For example, the distribution of management functions according to the In-Network-Management concept (INM) [10], and the Autonomic Network Management (ANM) technique, can be used to solve the management scalability problem. The ANM concept was developed a long time ago in the context of autonomic computing [11]. The LTE SON (an ANM approach) is already used for automated RAN management (handover and coverage optimization, energy-efficient operations or plug-and-play eNodeB deployment). Recently, an ANM variant that has learning capabilities, called Cognitive Network Management (CNM) is popular in the context of 5G networks. It is worth noting that GANA (Generic Autonomic Networking Architecture) [12] is a subject of ongoing standardization by ETSI. Recently, ETSI started a new activity called Zero Touch Network, that is also based on ANM/CNM [13].

At present, there are several 5G PPP projects, focused on the orchestration and management of 5G networks. Some of them also address network slices management and orchestration. In that context, it is worth noting COGNET, which combines MANO with ANM. A synthesis of results of some 5G PPP projects related to 5G, network slicing and network management can be found in [14].

The 3GPP has also started working on several aspects of management of the lifecycle of network slices in the context of 5G network management and orchestration. The 3GPP has defined the following management functions (MFs) related to network slicing: Communication Service MF, Network Slice MF and Network Slice Subnet MF [15]. The report [16] lists the network slicing related issues that

include FCAPS of slices, SON evolution for network slice management and orchestration of network slices across single or multiple administrative domains.

So far, we have found none approach that is looking into the scalability of slice management – the existing approaches are typically centralized ones (at least per domain level). We have found an approach to the integration of CNM/ANM with ETSI MANO, but not in the context of network slicing [14].

11.2.1. Intra-domain management architecture

The management architectures for network slicing enabled softwarized communication networks by a principle follow the ETSI NFV concept. The 3GPP view on management architecture is complementary to ETSI NFV MANO framework, where the 3GPP management system is an expansion of the OSS/BSS and EM part of MANO (see Fig. 3 below).

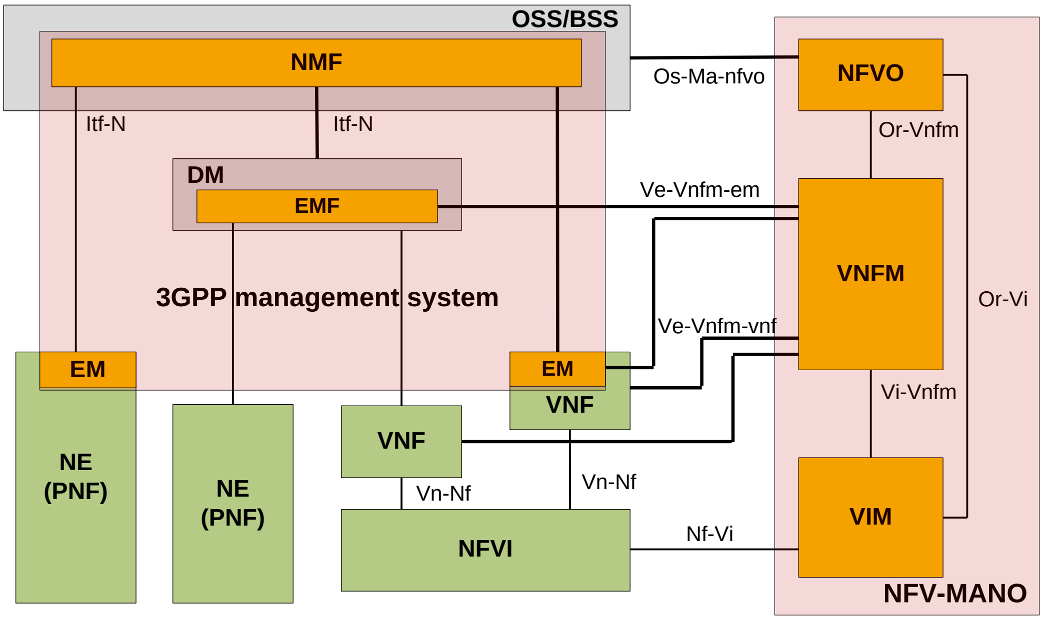

Fig. 3: The mobile network management architecture mapping relationship between 3GPP and NFV-MANO architectural framework [17]

The hierarchical 3GPP management vision distinguishes between NF management (i.e. EM according to ETSI), NSSI management and NSI management. The last two can be considered as two levels of OSS/BSS, according to ETSI. Additionally, 3GPP acknowledges utilization of reference points and interfaces defined by ETSI NFV MANO – the 3GPP management system shall be capable of consuming NFV MANO interface (e.g. Os-Ma-nfvo, Ve-Vnfm-em and Ve-Vnfm-vnf reference points) [18].

Both ETSI and 3GPP visions are operator-centric and do not include a broader perspective. The point is that the network slicing brings a serious revolution in the way the communication networks will be designed and operated. From the network operator's point of view this is just splitting of one, universal and multi-service communication into parallel component networks that are adapted to support certain specific classes of services with distinct properties, and hence having separate requirements, which may be conflicting with requirements of other classes. From the perspective of a global pool of interconnected infrastructural resources, able to host virtualized separate sliced networks of any operator. There is also no simple 1:1 mapping between the operation of the communication network and ownership of the infrastructure as well as operating an NFV MANO stack. This is the reason for concerns about proper

overall management architecture, especially with regard to its scalability, i.e. the ability of management environment to grow according to the managed entities expansion. Another issue is the optimization of the management in terms of information exchange, a delegation of tasks to shorten feedback loops, the ability of autonomous mechanisms implementation, exposure of management interfaces for slice users/tenants (not only for the host-operator) and finally resources consumption by the management itself.

As the future number of isolated slices will be huge, raising problems of management and orchestration scalability and complexity, such environment cannot be held by one huge central OSS/BSS and/or MANO stack. Additionally, the network slicing is perceived as a key tool for creation of slices that are tailored to the needs of 3rd parties (verticals), who – in most cases – want to manage their slices (need for quick reactions, customers profiling as well as confidentiality) do not need to be professional network operators (in some cases they may be even the end-users). Hence, the management system provided to the tenants should be relatively simple but powerful, i.e. with embedded intelligence.

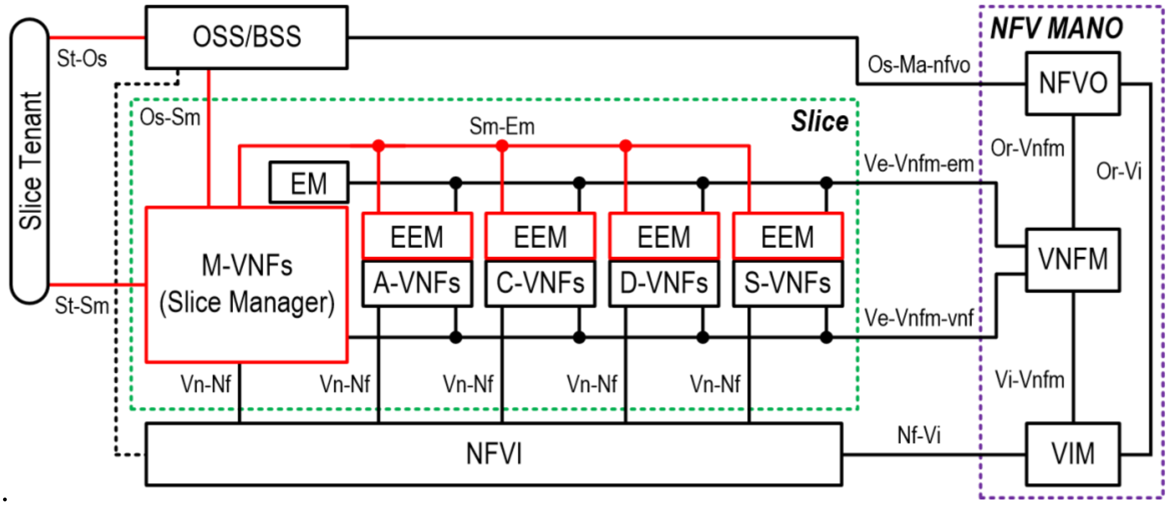

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Fig. 5: DASMO framework with internal structure of network slices – ETSI NFV MANO extensions (slice management plane shown in red)

Kukliński et al. have proposed a reference architectural framework for network slicing [19], which is based on the ETSI NFV MANO architecture [20], compliant with various communication network architectures and facilitates vertical and horizontal slice expansion due to incorporation of common/dedicated slice concepts, exposure of slice functions via slice API and slice stitching. The framework follows the paradigm of hierarchical multi-domain orchestration and supports tenant-oriented operations and interfaces based on embedded in-slice managers. In [21] the internal structure of slices has been further defined – the core part of the slice, consisting of functions composing the Application (AP), Control (CP) and Data (DP) Planes (A-VNFs, C-VNFs and S-VNFs, respectively), is accompanied by two special functional blocks: Slice Manager (SM) and Slice Operation Support (SOS), both implemented as sets of VNFs (M-VNFs and S-VNFs respectively), belonging to slice template and sharing the life cycle of their slice. The architecture is called "Distributed Autonomous Slice Management and Orchestration" (DASMO) and is presented in Fig. 5, SM is a central point of slice management plane and has links to Embedded Element Managers (EEMs) of all VNFs implemented within a slice. These EEMs follow the ETSI NFV concept of Element Manager (EM), but they are augmented with additional functionalities facilitating slice-level management support, VNF monitoring, actuating and autonomic control loop, etc. SM plays a role of slice OSS and incorporates the functions responsible for slice-level monitoring, analysis, actuating and autonomic control loop according to the

Monitor-Analyse-Plan-Execute (MAPE) [22] model (real-time feedback loop). Additionally, SM implements tenant-oriented functions: accounting, KPI monitoring and reporting, configuration support (following the "intent-based management" paradigm), which are exposed via the Tenant Portal functionality of SM. SM also exposes an interface to the global OSS/BSS, which is of importance, especially in multi-domain slicing. SOS functions support slice-level operations as slice selection, subscription, authentication and stitching of sub-slices to provide transparent communication between NFs belonging to different domains for creation of the end-to-end slice.

The described architecture implements the ISM concept, which – due to the hierarchical distribution of management tasks – is inherently scalable. The scalability of orchestration may be provided by recursive orchestration ("MANO in MANO"), and the DASMO concept is compliant with it.

The DASMO concept has some specific requirements related to its implementation. The first one concerns of adding to each VNF that composes the 'Core' part of the slice, i.e. the VNFs that are used for the implementation of the Data Plane, Control Plane and Application Plane, appropriate EEMs that implements the node level autonomic behavior and sends preprocessed monitoring data to SM.

The second one is related to adding to each 'Core' part of a slice its management counterpart, i.e. the SM, as a set of VNFs that implements most of the in-slice management functions, including the intent-based management by slice tenant. These VNFs can be distributed, providing further optimization of the management operations. The SM part should be included in a slice blueprint, similarly to the SOS part of the slice.

The DASMO-ready OSS/BSS should have appropriate interfaces for handling multiple SMs. DASMO, however, in contrast to OSS/BSS-only management, requires less a slice-specific functionality of the OSS/BSS. In fact, each created slice requires some supporting components of the OSS/BSS. These components should be initiated together with the slice. Therefore, they should be added to the Network Slice Description but placed within the OSS/BSS. That way, the OSS/BSS will have a certain level of programmability.

It is hard to define a priori an optimal split of management functions between EEMs, SM and OSS/BSS. The ultimate goal would be to obtain the OSS/BSS functionality slice agnostic as much as possible and to keep the slice specific management handled by the Slice Manager. It seems that such a goal will not be easy to achieve. Typically the split of the functionality will be dependent on the implementation.

11.2.2. Management-oriented KPIs

Assessment of network performance and resulting service quality is a fundamental issue for telco operators. Technology-related performance indicators, enable the provision of quantitative insight into the behaviour of equipment, sub-systems or entire telecommunication systems. A representative view of the end-to-end network can be achieved by higher-level abstraction performance indicators in the form of Key Performance Indicators (KPIs) that contribute to end-to-end communication service-level quality view, represented by Key Quality Indicators (KPIs). Currently used KPIs have been introduced by ETSI [23] and profiled by 3GPP [24], [25] based on the fundamental definitions of ITU-T [26] and offer a framework to assess performance and quality of 2G/3G/4G services' from the end-to-end perspective.

Currently, there is a lot of standardization efforts regarding the definition of criteria of 5G network performance and quality assessment. Typically, the quality assessment approach is focused on 5G services' requirements and characteristics, as defined by ITU-R (cf. [27], [28]) and 3GPP (cf. [29], [30]). So far, the following 5G KPIs related to network slicing has been defined [31]:

- Accessibility KPIs: registered subscribers, registration success rate per Network Slice Instance (NSI);

- Integrity KPIs: end-to-end latency of the 5G network, upstream/downstream throughput for NSI and at N3 interface, Radio Access Network (RAN) – User Equipment throughput;
- Utilization KPIs: mean number of Protocol Data Unit sessions for NSI, virtualized resource utilization for NSI.

The work on defining 5G network KPIs are also conducted within several research projects ([32], [33], [34], [35], [36], [37] and [38]). However, so far, the majority of approaches to 5G (defined by the above-mentioned SDOs or research projects) are unaware of the performance and quality of network slicing. To address this issue a small and representative set of KPIs that can be used to assess the impact of the implementation of certain networking solution (e.g. Evolved Packet Core – EPC) as a network slice has to be formulated. Bearing in mind a possibly large number of slices, the number of NS-related parameters has to be kept to the minimum to minimize the collection, calculation, and interpretation overhead. It is worth mentioning that NS-related KPIs should also be related to network slicing technology only, i.e. KPIs related to the certain solution implemented as a network slice should be the same as in non-sliced implementation.

Additionally, the set of KPIs should provide high-level, synthetic and comprehensible dashboard-level insight to network status. Typically, operators use the “top-down” approach, since the concept of KPIs should enable drilling-down for gradual isolation of degradation root-cause. The amount of defined KPIs should be limited so as to protect the network operation centre staff from the information overload.

Definition of the network slicing related KPIs has to be done in accordance with a certain functional model of network slicing as well as its implementation. The proposed solution follows the NGMN functional approach [39] with some extensions and ETSI NFV MANO approach for slice orchestration. The proposed concept partly uses and updates the KPIs defined by 3GPP [31] and performance measurements specified by ETSI [40] with the aim to simplify KPIs calculation and retain their informative character regarding the behaviour of the network slicing system. Additionally, an assumption is made that in case of detected issues, the management and orchestration system will trigger actions that will include more detailed monitoring and will solve the issue based on that information. The proposed KPIs refer to performance-related indicators that typically change dynamically. Therefore static slice parameters are not addressed. The proposed KPIs are split into two categories: slice run-time and slice life-cycle management-related.

Slice run-time KPIs regard performance of a network or a service that is implemented as a slice and typically do not differ in case of non-sliced implementation of the network or solution. The only new slice-agnostic (in the virtualized implementation) mechanisms are related to the consumption of virtual resources by a slice and orchestration operations. One of the key operations regarding resources management is resource scaling in accordance with their usage. The focus is laid on three types of virtual resources, namely connectivity, computing, and memory. Additionally, a single, synthetic parameter related to the usage of all kinds of memory is introduced in comparison to ETSI NFV framework, where memory, i.e. RAM and swap space and disc measurements are performed separately [40].

An additional assumption of using MANO orchestrator is made due to its capability of the virtual resources dynamic allocation according to slice needs (resource scaling). Following the KPIs definition, two cases are evaluated: (i) underutilization of allocated resources and (ii) overutilization of resources. Overutilization of resources may lead to the degraded performance of the sliced solution, whereas underutilization of resources leads to ineffective network slice implementation. Two sets of thresholds are proposed: threshold for too high (Th_{hi}) and too low (Th_{lo}) resources usage. KPIs reporting is done according to the observation period To. During the time the measured parameter is averaged. We propose using Th_{hi} = 80% and Th_{lo} = 20% and observation interval To = 30 s. The chosen values and thresholds are not mandatory. However, it is worth mentioning, that alteration of observation time can impact KPIs calculations effectivity (e.g. significantly increase overhead if the time is reduced).

For all KPIs, calculation of absolute as well as normalized values is advised, e.g. a number of links in which the threshold has been crossed related to all links of the slice. In the case of memory KPIs, we propose a synthetic approach, i.e. the KPI is affected if at least one type of VNF's monitored memory resources crosses the threshold.

11.2.2.1. Slice life-cycle KPIs

The defined below life-cycle KPIs refer to the end-to-end operational agility of the network slicing platform and communications networks implemented on it. Due to the vast diversity of complexity of network slices (i.e. the geographical distribution of interconnected functions, etc.), defining life-cycle KPIs in advance, regardless of the details of network slice blueprint is problematic. However, once defined, they may be used for comparative benchmarking of network slicing platforms including orchestration or functionally equivalent blueprints based on VNFs of different providers. Furthermore, after validation, they may be used as a reference for instantiation of the blueprint on the production platforms. On the other hand, the limits of KPI values defined by an operator as a general policy may serve for blueprint feasibility validation. Therefore, poor operational agility blueprints may be split into sub-parts to be orchestrated faster in parallel.

The list of the proposed KPIs is presented in subsequent subsections.

- KPI-L1: Slice Deployment Time (SDT);
- KPI-L2: Slice Deployment Time Scalability (SDTS);
- KPI-L3: Reconfiguration Execution Time (RET);
- KPI-L4: Slice Termination Time (STT).

11.2.2.2. Network slicing KPIs computation in the NFV MANO case

To calculate the described KPIs, in the MANO environment, the information about the resource allocation, usage and the occurrence of certain operations with their completion time is required that can be categorized into:

- Information related to computing, memory, storage and connectivity resources allocated to VNFs and consumed by them;
- Information about initiation and completion time of selected NFVO procedures that are driven by OSS/BSS;
- Information about VNFM operations (initiation, completion).

In the proposed approach, the OSS/BSS of the MANO architecture is used to calculate and collect the network slicing KPIs. For the collection of information required for KPI calculation, the OSS/BSS has to interact with other components of the MANO architecture. VIM can expose the information about the underlying NFVI at the reference points Vi-Vnfm [41] and Or-Vi [42] to higher-level MANO entities, VFNM and NFVO. These entities are able to understand, correlate and further enrich this received information in the context of the installed network service description. The OSS/BSS can directly use the Os-Ma-Nfvo reference point of NFVO [43], for the purpose of Network Service Life-cycle Management (instantiating, scaling, updating, healing, terminating, deleting, etc.), Performance Management (management of performance management jobs and thresholds), Fault Management (management of subscriptions to notifications, querying alarms lists, acknowledging alarms) and NFVI Capacity Information (querying and notifications about underlying infrastructure capacity and its shortage). Hence, the OSS/BSS is able either to determine the life-cycle operations performance based on a request-response time interval or get directly the subscribed or requested run-time performance/fault/capacity information. While the information exchange between NFVO and OSS/BSS

is at the level of Network Service Instance, the individual VNF's Element Manager (EM) is partially able to exchange similar information with the VNFM at the level of its VNF/VNFCs via the reference point Ve-Vnfm-em [44] and to share further the information with its own OSS.

Mechanisms of premium importance for KPIs calculation has also been described in [40]:

- VIM uses reference points Vi-Vnfm and Or-Vi to report NFVI-related performance indicators to VNFM and VNFO, respectively. The performance metrics include mean/peak usage of virtual CPU, memory, disk, and virtual storage, number of incoming/outgoing bytes/packets on the virtual computer (split per virtual interface) or virtual network (split per virtual port);
- VNFM maps the above-mentioned information from VIM to specific VNFs/VNFCs and exposes the performance measurements at reference points Ve-Vnfm-em (for VNFs/VNFCs) and Or-Vnfm (for VNFs only). These are VNF/VNFC-specific mean/peak usages of virtual CPU, memory, disk and virtual storage, numbers of incoming/outgoing bytes/packets at VNF internal/external connection points;
- The performance measurements produced by NFVO can be transferred to OSS/BSS via the reference point Os-Ma-Nfvo. They include numbers of incoming/outgoing bytes/packets at Network Service border interfaces.

Other important features have been presented in [45], where charging-related capabilities have been described. In general, MANO enables charging of two categories: Usage Events and Management and Orchestration Events. Both types of events can be used to calculate KPIs

The presented capabilities of MANO enable data collection by OSS/BSS, necessary for network slicing KPIs calculation and correlation. These data, processed mainly by VNFM, can be obtained via several paths by the direct interaction of OSS/BSS with NFVO or through EM. The EM of VNF can also be implemented in that way that it will calculate VNF-level KPIs directly. In some implementations, the OSS/BSS can interact with NFVI directly in order to obtain knowledge about resource allocation and consumption. The ways in which the required information is collected by OSS/BSS is partly implementation-dependent and therefore cannot be defined a priori. However, MANO provides enough information to calculate all of the defined network slicing KPIs.

The performance management abilities of the ETSI NFV MANO framework allow for the direct collection of all resource-related defined metrics. The mechanism called Performance Management Job (cf. [43], [44]) enables the creation of measurements of specified parameters upon the OSS/BSS or EM request. After the creation of relevant jobs, the OSS/BSS requests MANO (directly or via EMs) to set thresholds on these measurements and then only the threshold-crossing notifications are sent by MANO entities to the requester. The measurements of computational and memory (all types) resources are produced and exposed as a percentage of maximum value. Hence, their thresholds settings are directly $Th_{hi/lo}$. The connectivity measurements are based on counts of packets/bytes at the measurement points. Therefore, the connectivity overutilization/underutilization thresholds settings should take into consideration also the observation time To and the maximum link speed.

The proposed life-cycle KPIs can be obtained using the interaction between the OSS/BSS and NFVO. The relevant procedures are based on a request-response handshake, and OSS/BSS has to have the definition of message sequences implemented in Application Programming Interface (API) [46]. Hence, it is able to determine clearly both the beginning and the end of the procedure, also in case of disturbances of intra-MANO communication (e.g. OSS/BSS is notified about the delay of procedure execution due to the need of retrying). There are two possible ways of calculation of these KPIs: (i) based on events logging in the on-board OSS/BSS log – each event is logged with a timestamp, and correlated search of beginning/finishing event for a specific procedure is sufficient; (ii) the API for OSS/BSS-MANO communication will typically use the time-out mechanism and the time-out timer will be implemented

– its value at the end of the procedure may be instantly passed to the Performance Management engine of the OSS/BSS. The OSS/BSS operations can be supported by EMs of VNFs in order to increase KPIs calculations scalability.

The proposed set of KPIs describes the network slicing impact on the behaviour of the sliced solutions. However, more work is needed for network slicing KPIs evaluation and estimation, e.g. the network slice metrics that include the number and size of footprints of all VNFs that compose the slice, number of slice links, number of operations concerning slice configuration can be used for the estimation of slice deployment time.

11.2.3. UAS operator management interface

From the UAS operator point of view, the standardized, reliable channel of communication with UTM should be available. Reliability is provided by the mechanism of request-confirmation type of communication: each request must be clearly acknowledged by the UAV operator. This channel is used to pass emergency information and notifications between the operator and air traffic controller (ATC). Following types of information/messages are typically exchanged through this channel:

- Check-in request/approval;
- Notification about lost control of the drone;
- Request for immediate landing or leaving the zone.

Example of the existing bidirectional, non-verbal communication protocol used for this purpose is CDDLC (Controller-Drone Data Link Communication).

As discussed in Section 1.2.2, UAS operator service components are modelled as virtual network functions (VNFs) on the network edge and user equipment (UE) on the access side. Drone UEs on the access side is managed on an application-level by UAS operators and hence require no infrastructure-level management outside providing them with network connectivity such that they can communicate with VNFs on the network edge.

UAS operator VNFs on the network edge such as software pilots or supporting services (e.g. video analysis) are managed by infrastructure-level enablers only in the sense that infrastructure-level enablers are expected to provide services for the instantiation of those VNFs. Once the VNFs have been initialized, application-level management (e.g. mission configuration, drone deployment, application lifecycle transitions) is the responsibility of WP2 enablers or UAS operators and hence is not in the scope of WP3.

11.3. End-to-end orchestration

11.3.1. Components of E2E network slices

A Fully-Fledged end-to-end Network Slice Instance (NSI) consists of the interconnection of multiple Network Slice Subnet Instances (NSSIs), each NSSI belonging to a different technology domain. In general, an E2E NSI should be composed of three NSSIs: RAN NSSI, Transport Network (TN) NSSI, and Core Network (CN) NSSI.

RAN NSSI

Access points that constitute the RAN of 5G networks should support the slicing of radio access services and radio resources. While the slicing of radio access services consists on creating a set of isolated VNFs that run the access functions, the slicing of the radio resource is provided as a set of Radio Resource

Management (RRM) policies that enforce the allocation of Radio Resource Blocks (RRBs) needed to run an NSI with a specific SLA.

CN NSSI

A CN NSSI includes the elements that constitute a full or partial instance of the core network. Each element in the CN NSSI runs as an isolated VNF on top of the virtualization infrastructure. Moreover, the components of a CN NSSI are interconnected internally and externally (i.e. with TN and Data network) using a set of virtual links. The service differentiation is ensured at the level of CN NSSI by the customization of the number of computing resources allocated to each VNF, and the number of network resources allocated to the virtual links interconnecting the VNFs. Another important factor that can be used for achieving service differentiation at the level of CN NSSI is the customization of the placement of the composing VNFs, for instance, the placement of User Plan Functions (UPFs) near to the end-users (i.e. at the edge of the network) can reduce the communication latency considerably.

TN NSSI

The TN NSSI allows the interconnection of the distributed VNFs that constitute the CN NSSI with each other, as well as with the RAN NSSI. TN NSSI is enforced by the instantiation of a set of VNFs (e.g. switches, routers, firewalls, etc.) that realize the network data plane, and by the configuration of traffic rules that realize the network control plane (usually using SDN). Same as the CN NSSI, the service differentiation is ensured at the level of TN NSSI by the customization of the amount of computing resources allocated to each VNF, and the number of network resources allocated to the virtual links interconnecting them. Moreover, SDN-based control of traffic can enable comprehensive QoS management for the different TN NSSI.

11.3.2. The lifecycle of E2E network slices

11.3.2.1. Preparation phase

The preparation phase includes the design of the network slice, evaluation of network slice requirements, feasibility check (e.g. availability of resources), on-boarding of VNFs packages, configuration and insanitation of the dependencies required for instantiating the new network slice.

11.3.2.2. Commissioning phase

The commissioning phase includes the reservation of computing and network resources required by the new network slice instance. Moreover, the commissioning phase may trigger NSSI(s) creation or using existing NSSI(s) and setting up the corresponding associations with the new NSI.

11.3.2.3. Operation phase

The operation phase includes the activation/deactivation of the NSI to indicate its availability/unavailability providing communication services. Moreover, in this phase, it would be possible to modify the NSI, e.g. changes of NSI capacity, changes of NSI topology, NSI reconfiguration

11.3.2.4. Decommissioning phase

The decommissioning phase includes the termination of the NSI by releasing all the resources used by the NSI.

11.3.2.5. Orchestration architecture

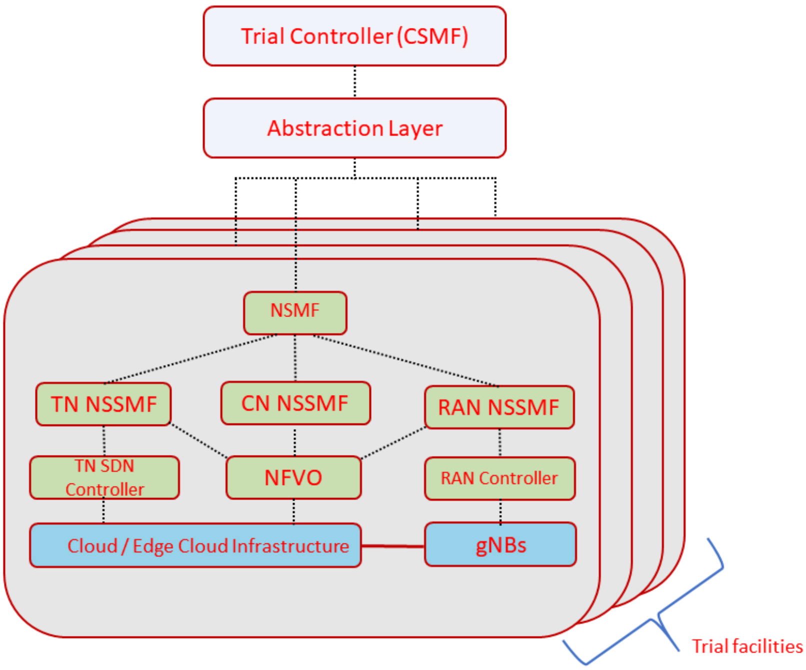

Fig. 6: Overall orchestration architecture

As shown in Fig. 6, the orchestration architecture responsible for the management of the lifecycle of end-to-end network slices on top of the trial facilities can be divided into three parts:

- **The trial controller:** Plays the role of the Communication Service Management Function (CSMF), which is, according to 3GPP [47] responsible for triggering different operation related to the management of the lifecycle of NSIs (i.e. creation, termination, modification, etc.). Moreover, this function is responsible for translating the communication service-related requirements to network slice related requirements during preparation phase [16]. The CSMF consumes the services provided by the NSMF.
- **Abstraction Layer:** Intercepts the generic requests sent by the trial controller to the trial facilities and translates them to facility-specific requests. Indeed, since each trial facility has its own implementation of network slicing, it is mandatory to abstract this heterogeneity by adding an abstraction layer between the trial controller and the trial facilities. This will provide a unified interface to the trial controller for accessing, per facility, network slices management services.
- **Trial facilities:** The trial facilities expose the network slicing management interfaces via the Network Slice Management Function (NSMF) which is responsible for the management of the lifecycle of NSIs within a specific trial facility. For managing the lifecycle of an E2E NSI, the NSMF delegates the management of each part of the slice (i.e. RAN NSSI, TN NSSI, and CN NSSI) to a specific Network Slice Subnet Management Function (NSSMF) that correspond that part. The CN NSSMF makes use of the facility's NFVO to manage the lifecycle of the VNFs that constitute the CN. It has to be noted that the NFVO implementation is facility-dependent, and it may be compliant to ETSI NFV or not. The RAN NSSMF makes use of the RAN controller to translate slice requirements into radio resource allocations and carry out high-level RAN resource management. Moreover, it makes use of the NFVO to manage the lifecycle to virtual RAN access functions. Finally, the TN NSSMF interacts with the network control plane (i.e. SDN controllers) and the NFVO to manage the provisioning and isolation of the virtual network connecting the VNFs of the access and core networks.

11.3.3. Domain-level orchestrators

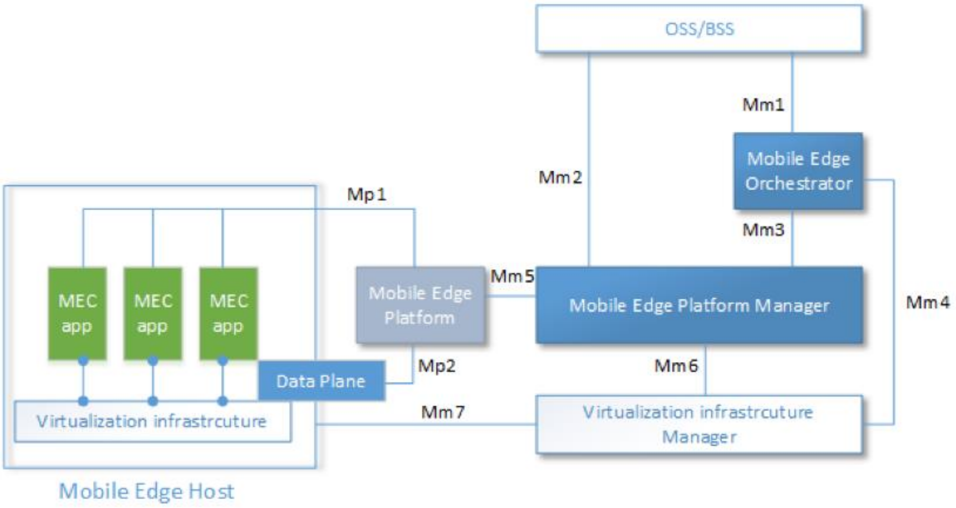

Fig. 7: A high-level view of the MEC architecture.

Since its creation in 2013, the ETSI ISG MEC group has been working on the development of standardization activities around MEC. The first released document of the group covers the reference architecture [48], which aims to specify the different necessary components; a high-level representation of the architecture is shown in Fig. 7. It introduces three main entities:

- The MEC host, which provides the virtualization environment to run MEC applications, while interacting with mobile network entities via the MEC platform (MEP) to provide MEC services and data offload to MEC applications. Two MEC hosts can communicate via the Mp3 interface aiming at managing user mobility via the migration of MEC applications among MEC hosts.
- The MEC platform (MEP), which acts as an interface between the mobile network and the MEC applications. It has an interface (Mp1) with MEC applications so that the latter can expose and consume MEC services, and another interface (Mp2) to interact with the mobile network. The latter is used to obtain statistics from the RAN on UEs and eNBs, e.g. in order to provide the Radio Network Information Service (RNIS) and the Location Service and to appropriately steer user-plane traffic to MEC applications.
- MEC applications that run on top of a virtualized platform.

Another concept introduced by ETSI MEC is the MEC service, which is either a service provided natively by the MEC platform, such as the RNIS and traffic control, or a service provided by a MEC application, e.g. video transcoding. MEC services provided by third-party MEC applications should be registered with the MEP and made available over the Mp1 reference point. Once registered, a service may be discovered and consumed by other MEC applications. Regarding the management and orchestration plane, ETSI MEC introduced the Mobile Edge Orchestrator (MEO), which is in charge of the life-cycle of MEC applications (instantiation, orchestration and management), and acts as the interface between the MEC host and the Operation/Business Support System (OSS/BSS).

Several interfaces have been specified for the MEC management plane. The Mm1 interface is used to communicate with the OSS/BSS, allowing the latter to onboard MEC application packages and request application instantiation and termination. The MEO uses the Mm3 reference point to interface with the MEP Manager (MEPM) for application lifecycle management and configuration, and Mm4 to manage application images at the edge Virtual Infrastructure Manager (VIM), which is in charge of launching application instances on the MEC host. The MEPM element is in charge of the life-cycle management

of the deployed MEC applications, and the configuration of the MEC platform, via the Mm5 interface. This includes MEC application authorization, specification of the type of traffic that needs to be offloaded to a MEC application, Domain Name Service (DNS) management, etc.

The Mm6 interface is used by the MEPM to obtain information on the virtual resources used by a MEC application from the VIM and implement their life-cycle management. Such information can be passed on via Mm3 to the MEO to check the MEC application resource status, and, if deemed appropriate, add more resources to it. This information is also exposed to the OSS/BSS over the Mm2 reference point.

As defined in ETSI MEC, a MEC application's LCM is handled by the MEO. If vertical wishes to deploy a network slice at the MEC, the first step is to onboard the MEC application image (i.e. VM or container image) at the MEO catalogue. The onboarding process consists of providing metadata on the MEC application and the location of the application image. These metadata are described in a specific format, which is known as the Application Descriptor (AppD) [49]. It includes information on the location of the virtual image, security information, and other fields related to the requirements of the MEC application, such as its maximum tolerated latency, traffic steering rules, and required MEC services. Since the MEC application image is on-boarded, the MEO creates an identifier for the MEC application, which is communicated to the vertical, and used by the latter to instantiate the MEC application. Following the request of the vertical to instantiate the MEC application, the MEO uses the AppD, and more specifically the three fields described earlier, to select the appropriate MEP that satisfies the combined requirements, and requests the deployment of the MEC application to the VIM (at the selected MEC host). Once the MEC application is up, the next step consists in allowing the latter to discover the MEP resources over the Mp1 reference point.

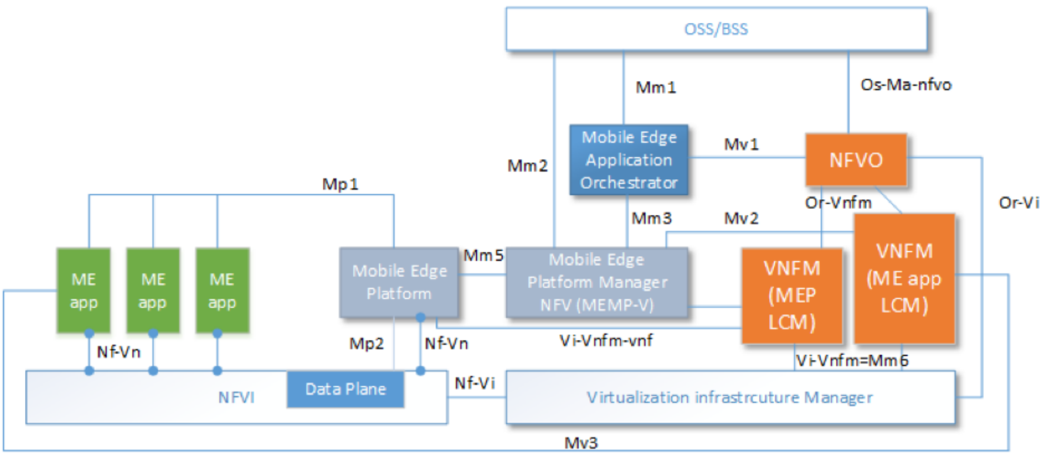

Fig. 8: An updated version of the MEC architecture featuring MEC in NFV

As described in the preceding part, the MEC architecture is defined to run independently from the NFV environment. However, the advantage brought by NFV, and aiming to integrate and run all MEC entities in a common NFV environment, has led the MEC ETSI group to update the reference architecture. The proposed document [50] updates the reference architecture, as shown in Fig. 8. As it could be noticed, the MEC platform and the MEPM are run as a VNF. The MEO became the MEAO (Mobile Edge Application Orchestrator); it keeps the main functions described before, excepting that it should use the NFVO to instantiate the virtual resources for the MEC applications as well as for the MEP. Consequently, all the process of instantiation and management of resources will follow the NFV well-defined interfaces. By doing so, the edge resources can be seen as classical computation and storage resources, and managed by the same VIM software. Note that Table 1 summarizes the difference between the MEO and MEAO, in term of functionality.

Table 1. Differences between MEO and MEAO

Function	MEO	MEAO
Maintaining an overview of the MEC, available resources, available MEC hosts, topology	Yes	Yes
Selecting appropriate MEC host based on constraints (latency, available resources and available services)	Yes	Yes
Triggering application instantiation and termination	Yes	Via the NFVO
Triggering application relocation as needed when supported (migration due to mobility)	Yes	Yes

12. MEC CAPABILITIES FOR THE SUPPORT OF 5G!DRONES TRIALS

12.1. UAV use case service components interact with infrastructure enablers

From the U-space perspective, when the UTM as a use case service component is considered, there are few types of interactions with infrastructure enablers. They might have different characteristics: some of them are related to strategical (pre-flight) information exchange, and others are related to dynamic, tactical (in-flight) information flows.

On strategical level, when flight security evaluation and approval is considered, it should be ensured that network-related information like radio coverage and related quality KPIs are provided to the UTM system for SORA analysis purposes. This kind of information most probably would be updated occasionally, whenever updates to network coverage or related network configuration are changed in the way, that flight-related KPIs will be impacted. This information will be used for SORA analysis.

On the other side, there is a “dynamic” (online, real-time) exchange of the information between U-space and infrastructure that impacts on-going missions. This information covers:

- Telemetry data – this information must be provided from all UAVs, constantly during the mission with short time intervals (every 1-3 sec) and passed to U-space for the purpose of traffic monitoring in the airspace;
- Immediate alarms from infrastructure to U-space related to the infrastructure failures, which might impact vital KPIs of the service and thus all ongoing missions in the impacted area;
- Notifications passed between U-space and UAVs operators (e.g. emergency requests to change/abort the mission).

Use-case service components provided by UAV operators interact with infrastructure enablers in two locations: the network edge and the access side. The access side provides UAVs with the network connection required to connect to services hosted at the edge. To infrastructure enablers, UAVs on the access side are generic user equipment (UE). The network edge hosts supporting services for UAV

flights. These services include both primary flight services, which enable the control and command of UAVs and auxiliary services, which support the requirements of the use case or vertical. Primary flight services include software pilots or ground-control stations (GCS) and are responsible for coordinating and controlling associated UAVs. In this capacity, these services typically require low latency communication to the UAVs. Auxiliary services cover a broader range of use-case specific functionality. Examples include video analysis services which provide, e.g. real-time object recognition for in-flight use or mapping services which use measurements obtained during a flight to provide real-time information to the operator or experimenter. Given that these services cover a broad range of functionality, their slicing requirements vary and hence should be specified on a case-by-case basis. In both cases, these services are provided as generic virtual network functions (VNFs) and are managed or deployed by infrastructure enablers like any other VNF. Requirements such as latency or bandwidth should be specified as generic slicing requirements as opposed to providing special consideration to these services. This promotes a healthy separation of concerns between infrastructure components and UAV use-case components.

From the UAS operator point of view, the standardized, reliable channel for communication with UTM should be available. Reliability is provided by the mechanism of request-confirmation type of communication: each request must be clearly acknowledged by the UAV operator. This channel is used to pass emergency information and notifications between the operator and air traffic controller (ATC) that typically include:

- Check-in request/approval;
- Notification about lost control of the drone;
- Request for immediate landing or leaving the zone.

Example of the existing bidirectional, non-verbal communication protocol used for this purpose is CDDLC (Controller-Drone Data Link Communication).

UAS operator service components are modelled as virtual network functions (VNFs) on the network edge and user equipment (UE) on the access side. Drone UEs on the access side is managed on the application level by UAS operators and hence require no infrastructure-level management outside, providing them with network connectivity such that they can communicate with VNFs on the network edge. UAS operator VNFs on the network edge such as software pilots or supporting services (e.g. video analysis) are managed by infrastructure-level enablers only in the sense that infrastructure-level enablers are expected to provide services for the instantiation of those VNFs. Once the VNFs have been initialized, application-level management (e.g. mission configuration, drone deployment, application lifecycle transitions) is the responsibility of WP2 enablers or UAS operators and hence is not in the scope of WP3. There is a number of software components that a UAS operator wants to use with MEC, based on the facilitation it provides. These include:

- C2 software for conducting drone flights etc.;
- 5G QoS mapping software;
- Video analyzing software;
- IoT devices management and data processing etc.

Therefore, the UAS operator needs an interface through which it can order MEC services and install MEC-based applications, monitor application performance and integrate them into its company's ICT systems. Such access must be flexible, but at the same time, sufficient security must be ensured for the MEC infrastructure. A possible solution is described in Table 2.

Table 2. Core functions of UAS operator management interface

Function of MEC interface	Description	5G MEC requirements

Installation of MEC applications and ordering services	Install, configure, modify, and test applications. Ordering MEC services and resources with specific parameters	When granting access to the MEC, the security of the rest of the MEC infrastructure must be ensured
Monitoring of MEC applications performance and data analytics	Analyzing the applications Possibility to analyze 5G network KPIs	Technical possibilities for identifying KPIs
Integration of MEC services into the UAS operator's own ICT systems.	Integrations that ensure both the management of MEC applications by the UAS operator's own ICT systems and automated information exchange.	Security and load limitations must be ensured, taking into account the MEC infrastructure capabilities.

12.1.1. Use Case 1: Command and Control (C2) with telemetry and video

To progress further, the UAV industry needs to pass from VLOS to BVLOS mode of operation. It means that operations, which are now performed or supervised by human pilots, must be automated in the future, which high degree of confidence. Apart from the algorithms designed to react and answer to all kind of situations, the latency factor will play the highest importance. And the answer is Edge Computing solution, plus additional functionality, like slicing and mobility.

This Use Case is allowing remote supervision and control of the autonomous drone flight from any place in the world, using the 5G mobile network (the link between drone – GCS) and internet connection (the link between GCS and UAV Traffic Management - UTM). The main responsibility for collision avoidance, de-conflicting and reacting to unforeseen situations is placed in GCS, which makes decisions related to the flight. In the experiment setup, pilot on the place is required for safety backup, where an unforeseen situation can happen, which cannot be managed by GCS software. Hence for this scenario, the main importance is the low latency of the communication between drone and GCS, assured by the short distance between UAV in the air – GCS running in the MEC. Other monitoring functions and UTM are placed on internet, and the max requirement in terms of latency is 2.2 seconds.

12.1.2. Use Case 2: Mapping and video processing

In smart city applications relevant to this use case, the MEC services will facilitate cloud applications for computer vision and autonomous UAV management. In traffic monitoring and object localization, MEC services can be used to offload computational tasks from UAVs and control the UAVs based on the models being processed in the cloud/edge server applications. Mapping can be used to update a real-time model of the environment used by the UAVs and the control applications.

The ETSI MEC will bring many benefits to these use cases since they are latency-sensitive and require RNIS, Location API, video processing at the edge etc. ETSI MEC will further improve the scalability and allows the sensor and components involved in these use cases to maintain a consistent and reliable connection.

12.1.3. Use Case 3: Connectivity extension & offloading during crowded events

The purpose of this scenario is to demonstrate how UAVs through 5G network capabilities can improve connectivity services in a highly crowded environment, e.g. during large events. The concept relies on providing end-to-end dedicated and reliable communication targeting specific user groups such as the event organisers to supervise and manage large events in an unhindered manner. At the same time, and with the proper dimensioning of the deployed solution in terms of capacity, the connectivity services can also be offered to the spectators.

Controlling a drone via software components demands a guaranteed low-latency communication link, and deploying the UAS at the edge seems the perfect fit.

12.2. Extending the MEC architecture towards slicing

The proposed MEC-enabled 5G network slicing architecture is based on the following principles:

- MEC services, similarly as NSIs, have limited geographic scope and are focused on a specific service – this is in line with the network slicing philosophy, which emphasizes customization of NSI to its service or a group of services with similar characteristics. In more complicated use cases, like UAV or V2X, the overall service uses several NSIs of a different type. Utilization of MEC as a platform offers useful mechanisms to provide a specific service. Consequently, in the case of network slicing, the number of MEC Apps will be limited, and they will be defined during the slice creation. Therefore, the orchestration of MEC Apps during the NSI run-time will be rather rare.
- Flexible architectural approach, adapted to NSI characteristics (complexity, longevity, critical deployment time, etc.), is required. As a result, the coexistence of various architectural variants can be expected.
- Implementation of MEC Apps as a part of slice AP – the same NFVI is used by CP/DP, and no separated MEC orchestration domain is needed. Therefore, the orchestration of MEC Apps belongs to slice-level orchestration activities.
- Tight integration on an equal basis of MEC APIs (RNIS, Localization, etc.) with information obtainable from 5GC via NEF, to extend the amount of information available for slice creation and for the avoidance of duplication of 5G and MEC functions like Network Repository Function (NRF), etc.

Fig. 9 shows the proposed generalized architecture of MEC and 5G integration. All VNFs are implemented in the VNF space, using common NFVI managed by VIM (omitted in the picture for simplification). NFVI can be single- or multi-domain (cf. [51]). All VNFs have their EMs (symbolized by red dots) connected to OSS/BSS (red arrows). In the case of MEC Apps, their management functions may be embedded in applications, externalized or nonexistent. VNFs and their EMs are also connected to VNFM(s) (single- or multi-VNFM options are possible, cf. [51]), which are responsible for LCM of both MEC Apps and other VNFs (VNFM* in Fig. 9). Even if the ETSI MEC framework assumes Ve-Vnfm-vnf variant (light) of MEC App–NFVO reference point, it may be potentially useful in specific cases to implement fully functional Ve-Vnfm-em variant, instead.

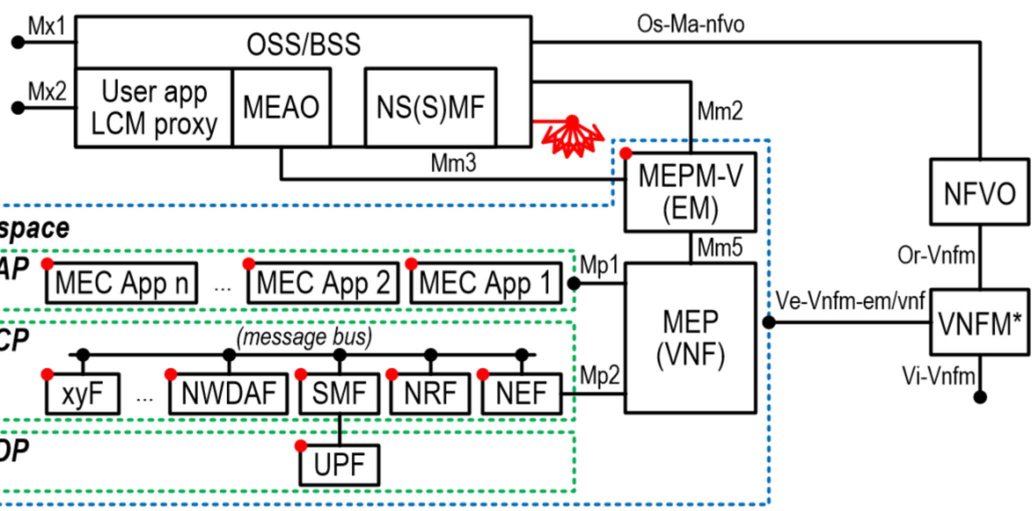

Fig. 9: General slicing architecture of MEC-enabled 5G network

Orchestration of MEC is located at OSS/BSS together with the management of a 5G network and Network Slice (Subnet) Management Function – NS(S)MF. Therefore, all interactions with the ETSI NFV MANO stack are performed via one common OSS–NFVO interface. As MEAO and User app LCM proxy are functional modules of OSS/BSS, some ETSI MEC reference points are internalized. OSS/BSS opens both interfaces Mx1/Mx2 to the customer domain. MEP exposes platform's services to MEC Apps (Mp1) and in case of 5GS-interacting ones, acts as a mediator to 5GC-CP via NEF (Mp2, considered as Naf at the 5GC-CP bus).

The described generalized architecture is valid both in case of 5G network with its own MEP/MEPM-V (Variant 1) and for MEP/MEPM-V sharing by multiple networks (Variant 2). In the case of Variant 1, the "VNF space" in Fig. 9 can be simply renamed to "5G network". As MEP/MEPM-V are dedicated, they can be a part of the template of the virtualized 5G network and share its life cycle. In case of Variant 2 (suitable rather for short-lived and simple slices), they will be external to 5G networks (now consisted of AP, CP and DP only). As the shared MEP is interfaced with CPs and APs of separate networks, it has to provide mechanisms for mutual isolation between these networks, i.e. their reciprocal unawareness and prevention of cross-exchange of information or unauthorized access to foreign 5GC-CP. The issue of protection of individual networks privacy is an additional factor for externalization of MEP towards all connected networks in Variant 2. Additionally, inter-App privacy should be ensured in both variants (e.g. awareness of users, their sessions metadata, etc.), but it can be provided by their own 5GC-CP. If network slicing is enabled (the case of multiple-NSI networks, providing services with different characteristics), both MEP/MEPM-V and MEAO have to be NSI-aware, i.e. recognize and distinguish NSIs, as it is required from all 5GC-CP entities (cf. [52]).

12.2.1. Scalable MEC-enabled slicing architecture

In geographically distributed architecturally complex communication networks, moving network functions of high granularity towards the edge have positive consequences for user traffic transport and performance but at the expense of the control and management planes. Centralized management of highly distributed networks is vastly inefficient, especially due to the necessity of transporting huge volumes of data needed for analysis, decision-making and execution of automated management processes. DASMO architecture faces this problem.

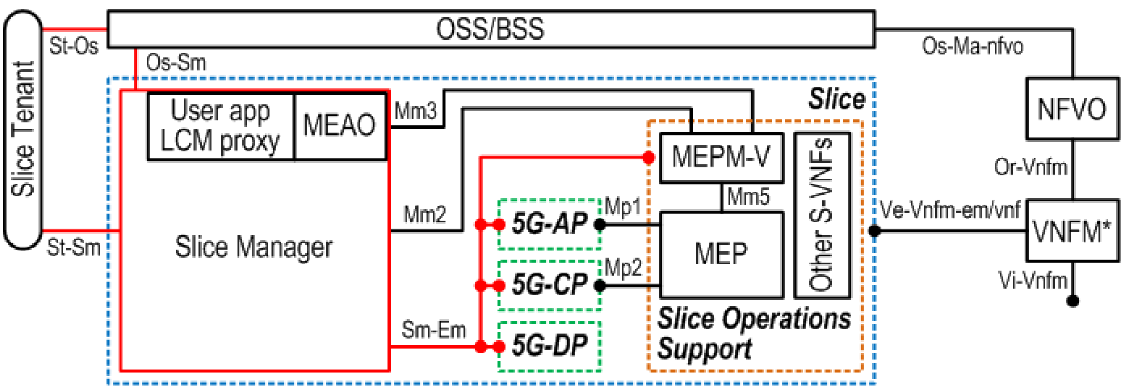

Fig. 10. MEC-enabled DASMO architecture

The single-domain scalable MEC-enabled slicing architecture (DASMO extended with MEC) is presented in Fig. 10. All VNFs of the slice have their own EEMs, as it is required by the DASMO

concept. EEMs are connected to SM, to provide the slice management plane communication. MEP/MEPM-V belong to the SOS area because their role is in line with the SOS definition, especially the exposure of transparent mechanisms for slice VNFs interconnection. MEAO and User app LCM proxy are located in SM because it plays the role of slice OSS.

The important task of SM is the proper routing of the MEC framework-related exchange. The Mm1 communication will be forwarded to the global OSS/BSS, which concentrates the exchange with NFV MANO. The Mx1/Mx2 reference point communication will be exposed through the St-Sm interface. Alternatively, it may be forwarded to the global OSS/BSS if the Slice Tenant prefers interactions that way (e.g. utilization of multiple separate NSIs; the consolidated global view is then desired).

It has to be noted that the DASMO architecture also supports the multi-domain sliced networks. The global OSS/BSS contains the Multi-Domain Management and Orchestration Support functions composed of Multi-Domain Slice Configurator (MDSC) and Multi-Domain Orchestrator ("Umbrella NFVO", cf. [51]). MDSC, during the slice run-time, keeps monitoring of the end-to-end slice and coordinates its reconfiguration, also taking care of MEC-related activities. It is responsible for the proper configuration of local SOS entities for inter-domain operations.

To enable operations in a multi-domain environment, it is essential to provide means of horizontal end-to-end slice stitching, i.e. concatenation of sub-slices from different domains. Inter-Domain Operations Support (IDOS), a functional part of SOS, is defined for this purpose. IDOS acts as an inter-slice gateway, implementing information exchange between neighboring domains, i.e. exposure of domain abstracted view and support for inter-domain communication (relevant protocols, transcoding, mediation, etc.). In the MEC-enabled DASMO architecture, the Mp3 reference point control information transfer between MEPs shall be carried out via IDOS.

12.2.2. 5G!Drones: End to end Network Slicing including MEC

Stemming from the facts that (i) 3GPP has released a new architecture model to integrate NS in 5G, and a new framework to manage NS, and (ii) the ETSI MEC group has proposed a solution to integrate MEC in NFV, there is a need to update the current MEC architecture to comply with these evolutions, aiming at supporting NS at the MEC level (i.e. slicing the MEC). We distinguish two models for the support of Network Slicing in MEC. The first model assumes that the MEP is already deployed at the edge NFVI and is shared among the slices; we term it the multi-tenancy model. In the second model, the MEP is deployed inside the slice. This is what we call in-slice deployment. For both models, we assume that the MEP is deployed as a VNF. Both the MEP and MEC applications are described using a VNF Descriptor (VNFD) and Application Descriptors (AppDs), respectively. The VNFD and AppD describe the necessary information required by the NFV Orchestrator (NFVO) and VIM to deploy instances of virtual applications, either at centralized clouds or the edge. AppD is specific to MEC applications. It contains specific fields related to MEC, such as traffic steering rules and MEC services required by the application. Note that we consider the MEPM as the Element Manager (EM) of the MEP.

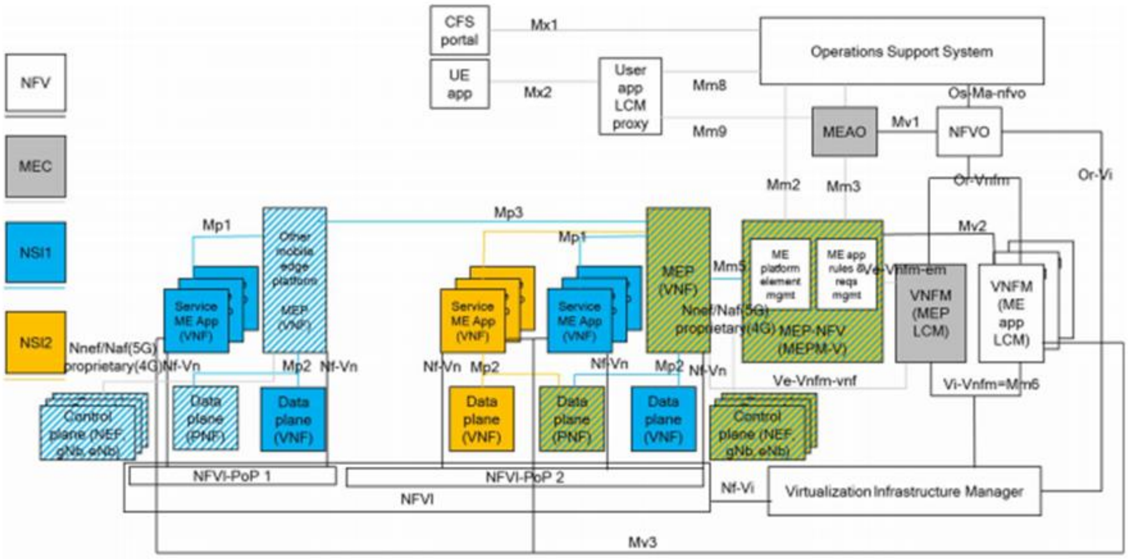

Figure 5.2.1-1: Example of MEC in NFV supporting network slicing

Fig. 11. Example of MEC in NFV supporting slicing [52]

CSMF shows the global picture highlighting the envisioned network slicing orchestration/management architecture as proposed by 3GPP, and featuring MEC slicing. In terms of interfaces, we mainly highlight those needed to orchestrate and manage core and virtual edge applications.

Mobility management in sliced MEC, in order to remotely configure eNBs (e.g. to associate to a new AMF of a slice) or to obtain RAN-level information, such as UE statistics, which can be used by the operator or exposed to interested applications over the RNIS MEC API.

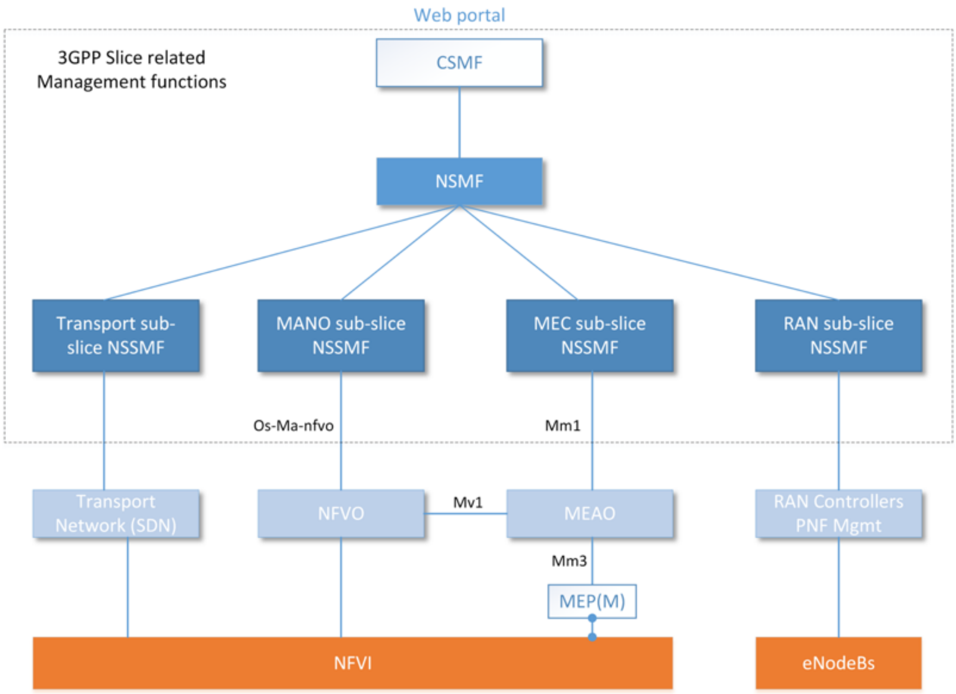

Fig. 12. The proposed network slicing orchestration/management architecture, including MEC, in a 5G environment

We assume that a vertical first accesses a front-end interface (such as a web portal) to request the creation of a network slice, using the NST made available by the CSMF. The NST could be extended according to the vertical needs, and by integrating network functions displayed by the CSMF through its network functions to store or catalogue (i.e. add more MEC applications). The CSMF forwards the NST to request the creation of an end-to-end network slice composed by several sub-slices that span the RAN, CN, MEC and transport network. The NSMF organizes the NST into sections corresponding to each sub-slice. The Management and Orchestration (MANO) NSSMF component cover the CN functions and VNFs that need to be deployed over the cloud. All the network functions that need to be deployed over MEC should be managed by the MEC NSSMF. The NSSMF accepts as input a Network Service Descriptor (NSD) [53] that contains VNFDs as well as AppDs. The NSMF requests the creation of each sub-slice to the corresponding NSSMF, as illustrated in Fig. 12. The RAN NSSMF is in charge of updating the configuration of the RAN, via a RAN controller that interacts with the involved eNBs (PNF) indicated in the NST. The NSSMF in charge of CN and VNF instantiation requests the instantiation of the NSD to the NFVO using the Os-Ma-NFVO interface [54]. The MEC NSSMF interacts with the MEAO by providing the AppDs of the applications that need to be deployed at the edge NFVI. The MEAO will use the same NFVO (as specified in [50] to request the creation of the AppD instance at the selected edge NFVI. Among the available edge NFVIs, the MEAO selects the appropriate one for the instantiation of a MEC application, according to its internal placement algorithm that may consider different criteria, such as latency and service availability [55]. To recall the AppD includes important information related to the MEC application to be deployed, such as *appLatency*, *appTrafficRule*, *appRequiredService*.

Once the application is instantiated, the MEAO is informed of the MEC application's IP address, which it communicates to the MEC platform along with parameters such as specific traffic filters, to enforce traffic steering. The last subslice is about the transport part, where we assume that the NSSMF managing it interacts with Software Defined Networking (SDN) controllers to isolate and forward NS traffic to the Internet.

Once each subslice is created, the NSMF is in charge of stitching them together to build the end-to-end slice. The stitching process consists of interconnecting the different sub-slices using a sub-slice border API, as described in [19].

12.2.2.1. Multi-tenancy model

In the case of MEP multi-tenancy, the MEP and UPF are already deployed. The MEP is already aware of the IP addresses and interface endpoints of the NEF or PCF for traffic redirection, as well as those of the RAN controller, from which it can gather the necessary RAN-level data to provide MEC services, such as the RNIS and the Location Service. Once the MEC application is deployed by the NFVO, the latter informs the MEAO about the successful instantiation of the MEC application, along with its IP address. The MEAO then, via Mm3, requests the MEP to enforce traffic redirection rules as indicated in the AppD. Based on the description presented in section (II.C), the MEP, via the PCF's API, requests the redirection of specific traffic (via a traffic policy) toward the newly created MEC application. Here, the MEP uses the PCF, as it is considered a 5G AF: the MEP has been deployed by the network operator as a common 5G AF for all slices.

12.2.2.2. In-Slice deployment model

In this case, the MEP has to be deployed along with the MEC application at the edge NFVI. Unlike the multi-tenancy model, here the MEAO requests the instantiation of both the MEP and MEC application

at the same time. The NFVO deploys both and ensures that there is a virtual link between them. As in the previous case, the NFVO acknowledges the creation of the MEP and MEC application instances and indicates their IP addresses.

Here, we differentiate between two cases: (i) all the CN elements (including the UPF) are deployed inside the slice; (ii) the UPF is already deployed. In the first situation, the UPF is also deployed at the edge (for the sake of performance), and the MEP can implement traffic redirection using the internal PCF of the network slice. For the second scenario, the MEP has to discover the NEF of the operator, as the MEP is not considered as a trusted 5G AF. To solve this, we propose that the DNS running at the edge NFVI may help in this direction: Once instantiated, the MEP sends a DNS request to discover the NEF's IP address and communicates with the latter to apply traffic redirection rules.

Regarding the needed access to the eNBs in order to provide MEC services (e.g. RNIS, Location Service), we propose to use the concept of zones, as introduced in [56]. A zone indicates an area covered by a group of eNBs associated with a MEC host. These eNBs are assumed to be managed by a single RAN controller. For both scenarios, we propose that the MEP uses DNS to discover the RAN controller that corresponds to the zone where it is instantiated, which in turn allows the MEP to retrieve RAN-level information from all ends of the zone.

12.3. 5G-MEC implementation remarks

12.3.1. MEC service APIs

The MEC framework defines special service APIs exposed by MEP to MEC Apps: Radio Network Information – RNIS [57] (PLMN information, E-RAB information, S1 Bearer information and L2 measurements), Location [56] (zonal presence and terminal location, including information about distance from a specific location or between terminals), UE Identity [58] and Bandwidth Management [59] (management of bandwidth on per application session basis). These services shall be provided via the Mp2 reference point, which will need special enablers within 5GC-CP. It has to be noted that the ETSI MEC framework is currently defined for integration with the 4G network (it is especially reflected in RNIS data model, which is not radio technology-agnostic). Therefore, specifications of these APIs have to be updated, and corresponding 5GS-side enablers have to be available. This mainly applies to mechanisms provided by NEF, NWDAF [60] and LCS [61]. It is particularly important to ensure the availability of RAN related information. Although the 5G RAN physical layer measurements at UE have been specified [62], the mechanisms similar to 3G/4G radio measurements collection (MDT, cf. [63]) for further processing and use are still undefined, but they are in the scope of Release 17.

Additionally, it is hereby proposed to define the special MEP-facing gateway function located in 5GC-CP to provide a single and standardized interface for MEP and ensure smooth and optimized interaction (especially for avoiding excessive signaling exchange within 5GC-CP). Such initiative needs bilateral cooperation of the 3GPP and ETSI MEC group.

12.3.2. Application mobility in demanding use cases

In [64] it has been demonstrated that the total time needed for MEC application deployment can vary from ~60 s (application instantiation only) to ~180 s (onboarding and instantiation) or even ~440 s (full onboarding and instantiation of both MEP and application). In high-mobility use cases (speeds of several kilometers per minute, which is typical for drone, railway or automotive ones) MEC Apps cannot just follow the UE, but they must overtake it. Utilization of standard location tracking mechanisms, even with additional prediction, will not be sufficient. Therefore, integration with drone traffic management system, which is aware of flight plan, with UE context-awareness mechanisms driven by mechanisms

of Artificial Intelligence and Geographic Information Systems to deduce, e.g. following a motorway or railway line, or with onboard navigation, aware of the desired route, can be utilized.

12.3.3. Service continuity in roaming

Special concern should be dedicated to roaming cases. Maintaining service continuity requires replication of its architecture at VPLMN and an acceleration of the re-registration process during the operator change. This issue is partially discussed in [65]. In case of MEC-enabled service architecture, the entire NSI, along with the MEC App residing in the AP, must be instantiated on VPLMN resources in local breakout mode. To some extent, service architectures (i.e. NSI templates) standardization together with MEC applications porting mechanism can be a solution, but a general mechanism for any NSI portability will be needed.

12.3.4. Availability of 5G enablers for MEC

Majority of R&D projects are based on popular 5GS implementations, such as OpenAirInterface, Open5GCore or free5GC. However, these solutions implement fundamental functionalities of the 3GPP 5G architecture, but unfortunately NEF, NWDAF or LCS are missing there. Even handover support can be somewhat problematic. Additionally, whenever not-UE-based positioning is required, the Network-Assisted Positioning Procedure shall be used, which has to be supported by gNB (positioning based on RAN measurements, cf. [66]). Individual efforts on implementation of these mechanisms or an initiative on public-domain tools are needed. The list, review and status of open source tools for 5G (3GPP Release 15) can be found in [67].

12.4. Identification of MEC enablers for UAV services (gap identification)

As a trial (ICT-19) project, 5G!Drones conduct trials implicating UAVs on two ICT-17, namely 5G-EVE and 5Genesis facilities. The project also extends its trials to 5GTN and X-Network testbeds in Finland. All four platforms embed advanced ETSI MEC and advanced Edge cloud capabilities. We survey herein the pre-existing MEC and edge cloud features in the four considered facilities then discuss the required MEC enablers required to trial UAV based services.

5G-EVE ETSI MEC edge computing solution is used in 5G-EVE as it is compliant with the 3GPP architecture and includes several recommendations on how to offload the traffic to the Edge application. In addition, the ETSI MEC includes specifications on how to describe a MEC application via the AppD and the process of its LCM via the MEC Edge Orchestrator.

5GENESIS The Athens Platform integrates edge computing infrastructure in various locations within its topology, for the deployment of edge applications and Network Service components. Adopting virtualization and Service Function Chaining capabilities offered by NFV enables the creation of a local breakout point. As a result, traffic that would normally reach the services sitting behind the 4G/5G core utilizing the backhaul connection can now be steered locally and either reach services instantiated at the edge or reach through the internet using local connections. In order to achieve that there is a need to deploy a 5GC function locally at the edge computing infrastructure. The current solution only supports edge computing but not following concretely specific ETSI standardisation. The next iteration of updates on Athens platform will enhance this capability and allow proper local break out, following MEC specifications, where the solution will be based on a commercial product (i.e. Athonet).

5G-TN The Nokia vMEC, based on ETSI MEC architecture, is used in the UO 5GTN because of its current availability in the facility. The Nokia vMEC also brings many benefits to the implementation of several use cases in the 5G!Drones project. It includes a rich software suite that provides MEC services such as RNIS, Location API etc. The MEC is required for the processing of specific applications at the edge. These applications include video processing apps, 3D map processing apps, etc.

X-Network, The edge resources at Aalto university's X-Network, are composed of ETSI compliant MEC platform developed by NOKIA and a set of Fog servers. Nokia MEC was adopted due to its rich functionalities and its compatibility with other Nokia products available in the same facility. Meanwhile, Fog servers allow the deployment and the trial of new functionalities not available in the closed source Nokia MEC (e.g. edge services migration, container-based service orchestration).

13. INFRASTRUCTURE ABSTRACTION AND FEDERATION OF 5G FACILITIES

13.1. Abstracted Interface definition

When defining abstracted interfaces of the 5G!Drones overall solution, two contexts should be taken into consideration:

- Aviation Multi-domain context and
- 3GPP mobile network context

There are plenty of publications, ongoing research projects related to this topic. One of the most recent summaries and the synthesized view is provided in this article [68].

From the 3GPP perspective, the key reference documents are:

- "Unmanned Aerial System support in 3GPP; Stage 1", TS 22.125, ver. 17.1.0, Dec. 2019 [69] and
- "Study on supporting Unmanned Aerial Systems (UAS) connectivity, identification and tracking", 3GPP TR 23.754, ver. 0.1.0, Jan. 2020 [70].

Described in the latter document reference architecture is presented in Fig. 13.

The first step for abstracting the heterogonous nature of trial facilities is the identification of the interfaces required by the trial controller and exposed by each facility. All the identified interfaces are subject to abstraction, wherein the aim is to provide unified interfaces to the trial controller for accessing, per facility, management, monitoring, and control, services. The interfaces required by the trial controller can be grouped into four categories:

- Network slices management interfaces;
- VNFs management interfaces;
- MEC applications management interfaces;
- KPIs monitoring interfaces.

13.2. Network slices management interfaces

This set of interfaces is used by the trial controller for management of the lifecycle of NSIs and include the following interfaces:

- NSI feasibility check: Used by the trial controller to check whether the NSI requirements can be satisfied by the targeted facility;
- NSI creation interface: Used by the trial controller to deploy an NSI. This includes the reservation and configuration of all resources required by the NSI;
- NSI modification interface: Used by the trial controller to modify a running NSI;
- NSI termination interface: Used by the trial controller to terminate a running NSI. This includes releasing the resources allocated for the NSI.

13.3. VNFs management interfaces

This set of interfaces allows the management of the lifecycle of use case-specific applications (e.g. video streamer, IoT data collector, flight controller) deployed in the facilities central cloud as network services. Based on ETSI NFV-IFA 013, VNFs can be managed using the following interfaces:

- VNFs packages management interfaces: Used by the trial controller on-board, enable, disable, delete, and fetch a VNF package.
- NSDs management interfaces: Used by the trial controller to on-board, enable, disable, update, delete, and fetch an application descriptor (i.e. network service descriptor).
- NS management interfaces: Used by the trial controller to instantiate, scale, update, and terminate an application deployed as a network.

13.4. MEC management interfaces

This set of interfaces allows the management of the lifecycle of use case-specific applications (e.g. video streamer, IoT data collector, flight controller) deployed in the facilities edge cloud as MEC applications. Based on ETSI GS MEC 010-2, MEC applications can be managed using the following interfaces:

- **Applications packages management interfaces** allows the management of the applications packages that bundle the files required for the instantiation of the UAV applications:
  - Application package on-boarding interface: used by the trial controller to make the application package, stored in the VNFs repository, available to the MEC system.
  - Application package enabling interface: used to mark the application package is available for instantiation.
  - Application package disabling interface: used to mark the application package as not available for instantiation.
  - Application package deletion interface: used to delete the application package from the MEC system.
- **Applications instances management interfaces:**
  - Application instance creation interface: used to create a new instance of an application whose package has been already on-boarded and enabled.
  - Application instance operation interface: used to start and stop an already created application instance.
  - Application instance termination interface: used to delete a running application instance.

13.4.1. Key Performance Indicators KPI(s) monitoring interfaces

This set of interfaces allows the real-time collection of performance data from different facilities:

- Measurement job creation interface: allows the creation of one measurement job that can collect the values of one or multiple KPIs from the targeted facility.
- Measurement job termination interface: used to terminate a running measurement job after the end of the UAV mission.
- List measurement jobs interface: used to list the running measurement jobs.

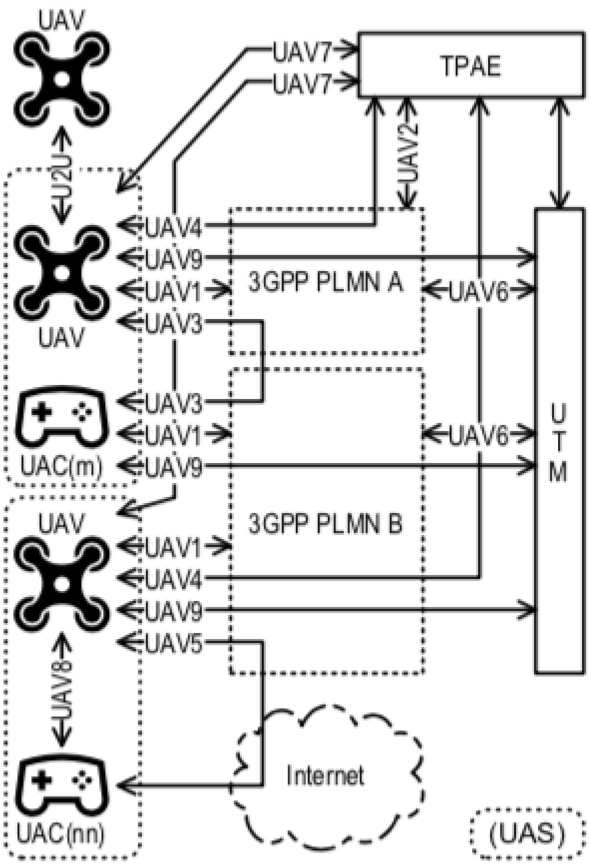

Fig. 13. 3GPP reference architecture of U-Space ecosystem

In this referenced architecture, the following interfaces were defined (interfaces marked in bold are interfaces, which will be implemented within 5G!Drones architecture):

- **UAV1**: interfaces the UAV with the 3GPP system to support UAV authorization, authentication, identification, and tracking;
- **UAV2**: interfaces a TPAE (Third Party Authorized Entity, which is a privileged Networked UAV Controller or a privileged Non-Networked UAV Controller) with the 3GPP system for remote identification and tracking;
- **UAV3**: 3GPP user plane connectivity for transporting C2;
- **UAV4**: interfaces a TPAE with a UAV over 3GPP network for:
  - Command and control (C2);
  - Remote identification (RID) and tracking of the UAV;
  - NOTE 3: at any given time, a UAV may be controlled mutually exclusively by a UAVC, a TPAE, or the UTM. Therefore, C2 to a UAV may be either over UAV3 or UAV4.
- **UAV5:** like UAV3 but on a transport outside the scope of 3GPP;
- **UAV6:** interfaces the 3GPP system with external USS/UTM for functionality exposure, support of identification and tracking, and UAV authorization;
- **UAV7:** for RID information sent in broadcast, on a transport outside the scope of 3GPP;
- **UAV8:** UAV8 is used for C2 over a transport outside the scope of 3GPP;
- **UAV9:** UAV9 supports connectivity between the UAV or a networked UAV Controller and the USS/UTM;
- **U2U:** supports UAV to UAV communications for broadcast RID.

Based on the above reference architecture model, 5G!Drones implementation of U-space related interfaces (described in Chapter 1.2.2 and 2.1.4) should be as follow:

- **UAV6** interface is used for the purpose of sending notifications/alarms from the PLMN network to USS/UTM (U-space);
- **UAV6** interface is also used to provide network-related information like radio coverage and related quality KPIs used for SORA analysis;
- **UAV9** is used for telemetry data gathering and non-verbal bi-directional communication between ATC and UAV operator (e.g. CDDLC).

14. CONCLUSIONS

This document is reporting work-in-progress of WP3 in the context of network slicing and MEC.

It describes initial approaches to RAN slicing scalable end-to-end slice orchestration, management, MEC capabilities for the support of 5G!Drones trials and some elements of the infrastructure abstractions. It has to be noted that many network slicing issues are yet open; one of them is the integration on MEC with network slices of the 5G network. The work on the mentioned topics will be continued (according to DoW), and the final, significantly updated version of the document will be provided at the end of 2020.

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