



## 5G experimentation environment for 3<sup>rd</sup> party media services

### D6.8 – Report on joint planning activities with the 5GPPP

#### Document Summary Information

<b>Grant Agreement No</b>	101016714	<b>Acronym</b>	5GMediaHUB
<b>Full Title</b>	5G experimentation environment for 3 <sup>rd</sup> party media services		
<b>Start Date</b>	01/01/2021	<b>Duration</b>	39 months
<b>Project URL</b>	<a href="http://www.5gmediahub.eu">www.5gmediahub.eu</a>		
<b>Deliverable No/Title</b>	D6.8 – Report on joint planning activities with the 5GPPP - Intermediate		
<b>Related Work Package</b>	WP6	<b>Related Task</b>	Task 6.3
<b>Contractual due date</b>	30/04/2022	<b>Actual submission date</b>	
<b>Type</b>	Report	<b>Dissemination Level</b>	Public
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**Revision history (including peer reviewing & quality control)**

Version	Issue Date	% Complete	Changes	Contributor(s)
V1.0	10/03/2022	10%	Initial Deliverable Structure	Barbara Ferraioli (PIIU)
V2.0	10/03/2022	70%	First contribution by partners	Frizzel, Stamou, Ribback, Castelli, Agustin, Kartakoullis, Berdik Erdal, Famelis
V3.0	6/4/2022	90%	Intermediate Versions with Updated Content	Barbara Ferraioli (PIIU)
V4.0	8/4/2022	95%	Version ready for Peer Review	Maurizio Cecchi (PIIU)
V5.0	11/4/2022	99%	First quality check, ready for Peer Reviewers	Barbara Ferraioli (PIIU)
			Peer review and Quality Check	George Margetis (FORTH) Stefania Stamou (FORTH) Jane Frances Pajo (TNR)
Final	26/4/2022		Final release delivered	Maurizio Cecchi

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## Glossary of terms and abbreviations used

Abbreviation / Term	Description
5G-PPP	5G Infrastructure Public Private Partnership
ALLEA	All European Academies
API	Application Programming Interface

AR	Augmented Reality
BMC	Business Model Canvas
CA	Consortium Agreement
CDN	Content delivery Network
CNF	Cloud-Native Functions
DevOps	Development and Operations
DoA	Description of Actions
DMP	Data Management Plan
DPIA	Data Protection Impact Assessment
DPO	Data Protection Officer
eMBB	enhanced Mobile BroadBand
EAB	External Advisory Board
EC	European Commission
ENISA	European Union Agency for Cybersecurity
EPCIS	Electronic Product Code Information Services
ESF	European Science Foundation
EU	European Union
FRA	Agency for Fundamental Rights
GA	Grant Agreement
GDPR	General Data Protection Regulation
GS	Global Standard
GUI	Graphical User Interface
IDE	Integrated Development Environment
IDEF	Integrated Definition Methods

IoT	Internet of Things
IPSE	IoT Privacy, Security and Safety Supervision Engine
KPI	Key Performance Indicator
KOM	Kick Off Meeting
LL	Living Lab
mMTC	massive Machine Type Communication
IDN	Interactive Digital Narrative
M&E	Media & Entertainment
MS	Milestone
MCDN	Multi Content delivery Network
MNOs	Mobile Network Operators
NDA	Non-Disclosure Agreement
NFV	Network Function Virtualization
NIS	Network and Information Security Directive
OB	Outside Broadcasting
PM	Project Meeting
PoC	Proof of Concept
PPP	Public Private Partnership
PR	Peer Review
QoE	Quality of Experience
QA	Quality Assurance
QM	Quality Manager
R&D	Research and Development
RE	Risk Exposure

RI	Risk Impact
RM	Review Meeting
RTD	Research and Technical Development
SCM	Source Code Management
SLAs	Service Level Agreements
SME	Small and Medium Enterprises
T&M	Test and Measurement
TM	Technical Meeting
TMV	Test, Measurement, and KPIs Validation
UC	Use Case
UGC	User Generated Content
UHD	Ultra High Definition
UML	Unified Modelling Language
URLLC	Ultra-Reliable Low-Latency Communication
VCDN	Virtual Content Delivery Networks
VR	Virtual reality

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## Executive Summary

The 5GMediaHUB consortium members are aware of the contractual commitment of the 5G-PPP as well as the organization structure as described in the 5G-PPP contract and its technical annex. They acknowledge the roles and commitments of the European Commission, the PPP board, the Networld2020 ETP, and the 5G Infrastructure Association.

The 5GMediaHUB consortium members participate in the 5G-PPP Steering and Technical Boards and participate in several WGs that are relevant to the project and contribute to their outputs, such as whitepapers, showcases and workshops.

Personnel time and funding have been allocated in the project budget to take this participation into account through its dissemination channels.

The various documents and deliverables from the project will be shared with other 5G-PPP projects via the cross-project collaboration agreement, and uploaded to a shared document repository. Alongside the 5G-PPP, the project will assess impact in other sectorial initiatives such as NEM.

In this document we are defining a clustering plan with associated activities aiming to advance the 5G vision, to promote the exchange of results, to share knowledge and experience as well as best practices for the emerging 5G services to different relevant verticals.

Specific activities and initiatives contributing to the 5G Public Private Partnership are described.



# 1 5GMediaHUB approach to joint activities with the 5GPPP

5GMediaHUB welcomes the Innovation Union<sup>1</sup> where world-class science leverages the removal of “obstacles to innovation” (improving skills, setting standards, improving time to market), and where the public and private sectors work together. In particular, it stands in full support of the 5G-PPP where public and private actors cooperate in implementing technological priorities in 5G. 5GMediaHUB participates in this effort by bringing researchers and industrial organisations together in a determined and focused consortium. The project plans to link research to the needs of the marketplace and service providers as closely as possible, aiming to be an exemplar of this in action and anticipates that opportunities arising from 5GMediaHUB will have an impact on the EU employment and research and development (R&D) targets, as well as accelerating commercial interest in 5G use cases (UCs) across multiple industry domains/verticals.

The 5GMediaHUB project in the Phase 3 of the 5GPPP is building an elastic, secure and trusted multi-tenant service execution environment based on an open cloud-based architecture and application programming interfaces (APIs), by developing and integrating a testing and validation system with existing 5G-PPP experimental testbeds, for enabling the fast prototyping, testing and validation of novel 5G services and applications for the media vertical, thus reducing the entry barrier to 3rd party application developers.

It aims at offering any 5GPPP participant a development and operations (DevOps) environment for 3rd party media applications developers and experimenters, which will hide the complexity of service deployment, and deliver a 5G testing playground for media applications.

## 1.1 Mapping 5GMediaHUB outputs

Purpose of this section is to map 5GMediaHUB’s Grant Agreement commitments, both within the formal Deliverable and Task description, against the project’s respective outputs and work performed.

Table 1: Adherence to 5GMediaHUB’s GA Deliverable & Tasks Descriptions

GA Component	GA Component Outline	GA Title	Justification
<b>TASKS</b>			
Task T6.3	The task “defines and prepare a clustering plan with associated activities aiming to advance the 5G vision, to promote the exchange of results, to share knowledge and experience”	5G PPP collaboration activities, recommendations and scale up; 5GMediaHub initiatives in the frame of 5GPPP.	Given that within the 5G PPP there are a number of cross-project Working Groups (WGs), in which shared issues and outputs of several projects are identified, 5GMediaHUB will have representatives from partners, participating in the 5G PPP. This participation would include contacts and coordination to a number of 5G PPP WG.
<b>DELIVERABLE</b>			
D6.8 - Report on joint planning activities with the 5G PPP - Intermediate			

<sup>1</sup> <http://ec.europa.eu/research/innovation-union/index.cfm>

## 1.2 Deliverable Overview and Report Structure

5GMediaHUB objectives and results are expected to be a key stimulus to the activities of the 5G IA (with many of its consortium partners having a primary role in it), of the 5G-PPP at large and as part of the program development activities for all the 5G-PPP projects.

The structure of this document respects the logical flow of the activities carried out in Task 6.3, i.e.:

- After a brief introduction outlining the objectives of this deliverable D6.8, we present in chapter 1 the 5GMediaHUB approach to joint activities with the 5GPPP and how we support the 5GPPP activities.
- In chapter 2 we describe the specific initiative performed by 5GMediaHUB.
- In chapter 3 we report the contribution of the project to the major Working Groups (WGs) in the 5G-PPP ecosystem (5G PPP, 5G IA and Network2020) and specifically to the following:
  - a. BVME 5G Business Validation Sub-Group
  - b. 5G IA Trials WG, providing contribution from the results from 5GMediaHUB experiments.
  - c. 5G PPP Pre-Standardisation WG, stimulating and supporting the bidirectional interactions with 5G
  - d. 5GPPP Pre-Standardisation (SDOs).
  - e. 5G PPP 5G Architecture WG, contributing to next releases of the 5G PPP architecture
  - f. 5G PPP SDN / NDF and Network Management & QoS WGs, contributing to the evolution of the software network architecture and tools selection based on inputs from the experience in 5G facilities of the project.
  - g. Network2020 SME WG, contributing to define engagement strategies towards 5G Trials for SMEs developing solutions for the control of the 5G network and the for the vertical applications.

## 1.3 Gender aspects in the 5GPPP

According to the Description of Activities (DOA), 5GMediaHUB is a 5G-PPP project supporting the EC's 5G policy by implementing the last phase of the 5G-PPP roadmap. It aims to prove and validate that 5G provides prominent industry verticals with ubiquitous access to a wide range of forward-looking services with orders of magnitude of improvement over 4G, thus bringing the 5G vision closer to realisation.

The 5GMediaHUB consortium is convinced that, in agreement with the Vade Mecum on Gender Equality in Horizon 2020, an *'in-depth understanding of men and women's needs, behaviours and attitudes can improve the scientific quality and societal relevance of the produced knowledge, technology and innovation'*. We recognise that the end-users of the media applications have different characteristics (gender identities, sex, age, ethnicity, profession, occupation, education, income, age, interests, household and living arrangements, familiarity with and attitudes towards technology, etc.). In addition, we are aware of the role that gender can play with regard to the technologies to be developed. We will systematically analyse the relevance of sex/gender when it comes to the different expectations males and females may have towards 5GMediaHUB innovation. This approach is formally included in the Grant Agreement (GA) and in the DoA.

Our innovation and the project will consider the gender dimension and cater for the needs, motivations and differences between the requirements analysis in WP1: A balanced participation of male and female professionals will allow gender analyses to be incorporated into the early user requirement definition. We will sex-disaggregate the data to find out whether different expectations regarding the Graphical User Interface (GUI) , features, functionality, etc., exist based on sex/gender. How this will be achieved is mentioned below:

- Throughout the development of the Experimentation Tools components in WP2: The GUI interface design of the Experimenters Portal will be consulted with both males and females at different ages, and posterior alpha and beta versions will be trialed by both males and females. We will pay attention to gender differences of perception, understanding, cognition and reaction when it comes to the development of the system.
- During the validations and the evaluation of results in WP4: In terms of usage, the innovation will benefit both males and females equally, either as direct or indirect end-users. During the validation of the Experimentation Facility and the NetApps through the use cases, we will also consider particularities in behavior, and ensure diversity and gender balance within test groups.
- In our exploitation, dissemination and communication activities in WP5 and WP6: We will consider gender in the training and education materials, in the target groups of the community building and outreach activities as well as in the business models. This is important in ensuring the education of the current professional and next generation of scientists and others needed in the EU to maximize its creativity and innovation potential in the European Union.

## 2 5GMediaHUB initiatives in the frame of the 5GPPP

Acknowledging the importance of participating in activities organised by 5GPPP and in accordance with 5GPPP’s encouragement and strong recommendation to collaborate with other 5GPPP projects, 5GMediaHUB participated or organised five 5GPPP-related activities and collaborated with other 5GPPP projects.

Partner	Type of activity	Name of activity	Involved projects	Date & place	Description	Link to event
IQUADRAT	Webinar	5G PPP Webinar: 5G Innovations for Verticals		5 March 2021, virtually	Presentation of 5GMediaHUB	<a href="https://5g-ppp.eu/event/5g-ppp-webinar-5g-innovations-for-verticals/">https://5g-ppp.eu/event/5g-ppp-webinar-5g-innovations-for-verticals/</a>
	Contribution to the European 5G Annual Journal 2021	The European 5G Annual Journal / 2021 (6th issue)		mag-21	Presentation of 5GMediaHUB (introduction, major achievements and innovations, use cases) (pp 102 - 103)	<a href="https://bscw.5g-ppp.eu/pub/bscw.cgi/d424095/5G%20European%20Annual%20Journal%202021.pdf">https://bscw.5g-ppp.eu/pub/bscw.cgi/d424095/5G%20European%20Annual%20Journal%202021.pdf</a>
	Contribution to 5G PPP Projects - Phase 3 brochure	5G PPP Projects - Phase 3		giu-21	Presentation of 5GMediaHUB (main objectives and challenges, applications & expected impact) (p. 50)	<a href="https://5g-ppp.eu/wp-content/uploads/2021/06/5GPPP_Phase3_Brochure_WEB-2.pdf">https://5g-ppp.eu/wp-content/uploads/2021/06/5GPPP_Phase3_Brochure_WEB-2.pdf</a>
BRA,IQU,FORTH	Workshop	5G Experimentation Facilities, Vertical Trials and Cross-testbed Service Orchestration	5GMediaHUB and 5G-EPICENTRE	7 September 2021, 10:30-12:15, virtually, in conjunction with IEEE MeditCom	Novel approaches and results were presented by the partners of both project consortia, focusing on 5G experimentation facilities, vertical trials and cross-testbed service orchestration.	<a href="https://meditcom2021.ieee-meditcom.org/program/">https://meditcom2021.ieee-meditcom.org/program/</a>
ICP, PIJU, EKTA, NOR	Workshop	5G impact in media and entertainment	Organised by 5G-Solutions	10 November 2021, Virtual	Objective of the workshop: Engage M&E stakeholders and gather feedback on benefits and barriers for their businesses related to adoption of new 5G-based M&E services; Participation in the workshop, where 5GMediaHUB and the goals of the project were discussed	
ICP, PIJU, EKTA, NOVA, BRA, STXT, FORTH	Workshop	5G-SOLUTIONS broadcaster workshop	Organised by 5G-Solutions	02-feb-22	validate requirements of the projects match with what defined in 3GPP (rel.18)	

Figure 1 - 5GMediaHUB activities related to the 5GPPP

On 5 March 2021 the project was presented in the 5GPPP webinar “5G Innovations for Verticals”. The purpose of this webinar was to introduce ICT-41 projects. Also, several partners participated in two virtual workshops organised by 5G-SOLUTIONS. The aim of the first workshop, titled “5G impact on media and entertainment” and held on 10 November 2021, was to engage media and entertainment stakeholders and gather feedback on benefits and barriers for their businesses related to the adoption of new 5G-based M&E services.

The purpose of the second workshop, titled “5G-SOLUTIONS broadcaster workshop” and held on 2 February 2022, was to validate that the requirements of the projects match with what defined in 3GPP (rel.18). The partners grabbed the opportunity of attending this workshop to discuss the goals and ambition of 5GMediaHUB. In addition, in the latter workshop the project’s three use cases were presented.

5GMediaHUB contributed to the European 5G Annual Journal and 5GPPP 3 Projects – Phase 3 Brochure. The project’s contribution can be viewed on pages 102-103 and page 50 respectively.

A virtual workshop was organised by 5GMediaHUB in collaboration with 5G-EPICENTRE, another ICT-41 5G project. The workshop revolved around 5G experimentation facilities, vertical trials and cross-testbed service orchestration and took place in conjunction with IEEE MeditCom, a hybrid conference which was held 7-10 September 2021 in Athens, Greece. Approximately 15 people participated in this event.



Figure 2 - IEEE MeditCom workshop banner

## 3 Contributions by 5GMediaHUB to 5GPPP Working Groups

### 3.1 Business Validation Subgroup (BVME-5G)

5GMediaHUB has contributed to the recent activities of the BVME-SG in two key areas:

- Preparation of an EUCNC 2022 workshop proposal, especially in terms of supporting the development of the workshop's motivation. Also, 5GMediaHUB is represented on the technical committee for the workshop.
- The BVME-SG is currently active in developing its next white paper and, although still at an early point in the development, 5GMediaHUB is contributing to the related work.

One of the central objectives of 5GMediaHUB is to identify the project outcomes with commercial potential and develop plans describing how they could impact the market. As discussed above, one of the core requirements to achieving this is to ensure relevant information from the market is taken into account when developing the project's commercially relevant assets. It is particularly important that the views of potential customers of these assets are accounted for when developing solutions to ensure assets are market-aligned, meaning they are relevant to customers and those customers will be willing to pay for the products/services being offered. Without such considerations, any business built around the commercially relevant assets coming from the project will likely not have the opportunity to be sustainable.

These points are intended to highlight the value of the BVME-SG for 5GMediaHUB, which is related to the subgroup's activities around monitoring the 5G market and providing updates on relevant business-related developments. The outcomes and discussions of this subgroup are therefore directly relevant to supporting the commercially focused goals of the project. Essentially, the involvement of 5GMediaHUB in the BVME-SG is expected to help ensure the project outcomes are well aligned with the latest market trends and activities in the 5G ecosystem, which will help maximise the potential commercial impact of the project.

The information coming from the BVME-SG is particularly important to WP5, which is focused on exploitation, and also covers the project's standardisation activities. The outcomes of this WP can significantly benefit from the latest market knowledge and a deeper understanding of the activities of other funded projects in the areas of exploitation and standardisation. These are topics of interest for the BVME-SG and thus very relevant to the project activities. For example, 5GMediaHUB is particularly interested in developing an understanding of commercial opportunities for the experimentation facility being developed in the project. This facility aims to offer experimentation services to application developers and those interested in developing NetApps. Such services are intended to allow clients of the facility to test, optimise and validate the operation of their applications on 5G infrastructure using a set of software tools that allows users to experiment without having to engage with the complexities of the underlying 5G communication network. Commercial success after the end of the project will depend on how this facility can engage with the wider 5G ecosystem, particularly in terms of the verticals looking to capitalise on 5G's advanced features. The information from the BVME-SG can help to align the developments in the project such that they more effectively address market needs and integrate with the wider ecosystem.

Beyond having access to the market information mentioned above, engaging with this subgroup creates opportunities to disseminate information from the project through the initiatives organised by the subgroup, such as white papers and conference workshops.

The BVME-SG was created to analyse and report on the new business opportunity potential arising from the rollout of 5G networks. This is to complement the more technological-focused research and monitoring being examined in other 5G PPP working groups.

The goal of the BVME-SG is to provide an understanding of the future potential of the 5G market. In addition, the subgroup supports the wider 5G community by assessing the wide variety of approaches to describing the business-related activities being conducted across the 5G PPP projects, such that the challenges and insights of the approaches taken can be described. The focus is to identify the key stakeholders in the 5G and beyond-5G ecosystems, describe their current and/or future roles, and ultimately define the business models that could apply to delivering products/services to this market. A targeted outcome of the BVME-SG is therefore to create guidelines on business validation for 5G-PPP projects, which provide best practice for the stakeholders involved and facilitate sustainable development of the 5G market.

To provide further context, the role of the wider 5G Infrastructure Association Vision and Societal Challenges WG, which the BVME subgroup is a member of, is stated on the 5G-PPP website (<https://5g-ppp.eu/5g-ppp-work-groups/>) as being able to:

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

The BVME-SG is a relatively new subgroup within the Vision and Societal Challenges Working Group, however, there have already been strong outputs from the group, particularly in terms of two white papers focusing on 5G business-related topics. The remainder of this section is structured to provide an overview of those contributions in order to provide insight into the activities of this subgroup, which facilitates understanding the connection of 5GMediaHUB to the BVME-SG.

#### *Business Validation in 5G PPP Vertical Use Cases: White Paper*

There is a particular focus within the BVME-SubGroup on verticals, such that the work of the SG contributes to the European vision of “5G empowering vertical industries”. In fact, the initial positioning paper released by the BVME-SG **Errore. L'origine riferimento non è stata trovata.** emphasises that their initial focus would not be on the products and services of major actors, such as mobile network operators. Rather the group worked to conduct an initial survey of different 5G-PPP projects, such that commonalities across the projects in terms of approaches to business validation could be identified.

The subgroup’s work presented the overall goal of the business validation activities in 5G-PPP projects, which centres on trying to avoid poor product/market fit. This is the situation where products/services do not sufficiently address customer needs, such that sales are not at the scale needed for sufficient return on investment. The role of the Lean Start-up Methodology **Errore. L'origine riferimento non è stata trovata.** is highlighted as a way to guide development of new products/services such that they address validated customer needs, thus enhancing the probability that new solutions will be accepted, i.e. paid for in the market. It is highlighted that adopting such an approach in research projects can enhance the resulting products/services such that commercialisation of project outcomes is more likely and/or resulting outcomes could reach the market faster.

A generalised approach for business validation was presented by the group, covering elements often present in most such approaches observed in the literature. The key phases include:

1. Customer validation, where the key customer needs are highlighted;

2. Solution alignment;
3. Business model development; and
4. Growth trajectory, which outlines the viability of the overall business plan.

Customer validation is highlighted as the most important phase of business validation, since if the customer perspective is not strongly considered throughout the validation process, then future interest from the market is likely to be significantly impacted. Key to the business validation process is also the need to continually test and adjust assumptions in an iterative manner, including consideration of the technical developments in a project, such that proposed business plans deliver value to the market.

The BVME-SG reported on the status and challenges of business validation across the 5G-PPP projects based on an initial examination of the Phase II and Phase III projects and more recent projects validating 5G technology within numerous vertical industries. The work gathers together summaries of the approaches taken in the various projects examined, the benefits of which, in terms of knowledge sharing and innovation in 5G, are highlighted by the subgroup.

The well-known business model canvas (BMC) tool is shown to be widely used across the projects as a means of summarising the key aspects of the business validation being explored. Other business development tools, such as customer journey maps, customer storyboards and design thinking, are also highlighted.

The key challenges reported by the BVME-SG in relation to conducting business validation are listed below  
**Errore. L'origine riferimento non è stata trovata.:**

- “Vertical industry value proposition enhancement vs dependability”
  - This relates to the need for including 5G enhancements in industry processes, while considering how much reliance on MNO this would create.
- “Gap in demand and supply”
  - This relates to misunderstanding/miscommunication between telecommunication providers and vertical industries that dampens the impact of 5G in the vertical industries.
- “Emergent roles in the value chain and candidate stakeholders”
  - This challenge arises from the uncertainty associated with new and traditional roles in the 5G ecosystem, the ability of different actors to take on these roles, and what the impact of different actors in the various roles will have on the applicable business models.
- “Complexity of existing and new supply chains”
  - This relates to the high numbers of business relationships envisaged for the 5G ecosystem, which represents a barrier to the development of the market.
- “Representative analytic models and visualisations”
  - It was highlighted that there is a need for new tools helping to map the complex socio-technical 5G ecosystem, in order to more clearly articulate where stakeholders can contribute for their maximum benefit.
- “Availability of information for accurate Techno-economic analysis”
  - This refers to the challenges identified in evaluating the economic value of solutions, which add to uncertainty associated with financial modelling for verticals.

### Summary:

The BVME-SG recognise that there are difficulties in applying business validation process across the wider 5G ecosystem and created the white paper to describe what the groups sees as a general approach to support business validation, with a particular focus on the need to identify and adjust to the real demands of customers. To support understanding, the subgroup included a more detailed review of the business validation processes employed in various 5G-PPP projects.

### *5G Ecosystems: White Paper*



A key consideration concerning European investment in 5G networks is how to overcome challenges associated with value creation from those networks. To support this, the BVME-SG examined 5G ecosystems, in an effort to explore how stakeholders can engage and how value can be created within the ecosystem for those stakeholders. The findings of this exercise were summarised in the comprehensive BVME-SG white paper on “5G Ecosystems”, which is summarised in this section **Errore. L'origine riferimento non è stata trovata.**

In order for the reader to understand the scope of the 5G ecosystem, the following summarises a non-exhaustive list of stakeholders involved, which includes small and medium enterprises (SMEs) and larger companies/organisations, and academic institutions:

1. 5G industry actors
2. Research organisations
3. Vertical sector firms
4. Complementor firms (i.e. those supporting 5G service delivery, e.g. software firms)
5. Standards organisations
6. Open-source organisation
7. All levels of governmental agencies

Considering the interactions and relationships that could potentially occur between these actors, the ecosystem can be seen as a complex network of actors interacting to create value for their customers. To simplify the discussion of such a complex ecosystem, the BVME-SG grouped the stakeholders into 2 main groups, namely, the 5G network service provisioning actors and those actors involved in the delivery of vertical sector services using 5G networks. A more detailed description of these groups is as follows:

1. 5G Provisioning Ecosystem: those actors needed to deliver 5G communication services to the market, covering providers, operators and other 5G network service suppliers.
2. 5G Vertical Ecosystem: this subset of the 5G ecosystem focuses on those actors who are not part of the telecommunications provisioning group but rather who work together as part of vertical businesses. These firms are often domain specific (automotive, manufacturing, transport and logistics service providers, etc.) and employ 5G services to create value.

Because of the dynamic nature of the 5G ecosystem, these actors are expected to refine their strategies iteratively as the 5G ecosystem evolves, such that actors maximise the value created. The key benefit of creating value and growth in an ecosystem-based market is that such growth is likely to have mutual benefits for all those involved, and so creating a system that enables innovation within an ecosystem is in the best interests of each individual firm involved in the ecosystem.

The BVME-SG highlight how a number of questions exist in terms of the interaction between the two main subsets of the 5G ecosystem discussed above. Of particular interest is the fact that within ecosystems, roles can evolve over time, leading to the situation where a firm's position in the ecosystem could diminish, causing that firm to lose market share or even become obsolete over time. Such dynamics can create uncertainty, which serves to dampen the evolution of the overall ecosystem. To balance this, the subgroup also report on what are termed “success factors” that facilitate firms joining the ecosystem and innovating in it. These factors include technology openness (e.g. open APIs), standards and decreased knowledge barriers, particularly between those involved in applying 5G technologies. A number of approaches were proposed to encourage a wider variety and increased number of firms engaging in the 5G ecosystem: 1) implementing use cases; 2) ensuring adequate regulation to avoid barriers to innovation; and 3) stakeholders being clear on their intentions to share roles and revenues with others in order to develop the 5G market.

#### *Focus on the 5G Provisioning Ecosystem*

The main challenges identified by the BVME-SG for the 5G Provisioning Ecosystem is the need to jointly consider technical and business issues in order to ensure efficient interactions between all stakeholders needed to deploy and operate future 5G systems. This is driven by the fact that 5G networks are technologically different and can

be operated such that commercial value can be derived in a different manner than earlier generation communication networks. The overall result is that 5G networks are likely to require a larger set of stakeholders taking on new roles in order to enhance value creation compared to earlier generation networks. In terms of technology, 5G networks are becoming more software-based compared to older network types, which were more hardware-/equipment-based. These differences in network technologies have the potential to create more open networks, allowing a larger number of customers and partners to innovate with the network capabilities made accessible by the software-based design of 5G networks. Such differences are expected to underpin the change from traditional value chains that exist in telecom provisioning markets today, to the ecosystems discussed by the BVME-SG.

The group's work also overviews the roles within the provisioning ecosystem and consider how these roles could interact to derive value. Of particular interest is the expected relaxation in boundaries within which businesses conduct their activities. For example, telecom operators may be willing to collaborate/outsourcing certain activities, such as IT management services, and/or lease infrastructure from third parties, and could become more involved in software development activities, the output of which could be adopted by the telecom operator.

The BVEM-SG reported on the challenges associated with the development of the 5G provisioning ecosystem. These fall into certain categories, namely: 1) technical; 2) economic and business; 3) societal and end-user related; 4) market and policies related. Overcoming these challenges are seen by the BVME-SG as necessary to address two core principles to encourage investment, participation and growth in the 5G ecosystem, which are "making it easy" and "making it attractive" for firms to engage in the 5G ecosystem. Of these, the challenges discussed under 1) Technical and 2) economic and business are the most important to elaborate on here:

- **Technical:** The BVME-SG discussion on technical issues focused on the need for open, easily accessible and known interfaces, which are seen as essential for enabling engagement of various actors across the ecosystem, since they allow the integration of technologies from different domains. This is seen as key to encouraging growth in the wider ecosystem, to the benefit of those involved. Despite the clear need for these types of APIs, it is reported that the ability for actors to use APIs with 5G systems is not well matured.
- **Economic and Business:** These challenges focus on the need to rely on others in the ecosystem to fill roles and the decisions that need to be made by telecom operators on when, how and under what conditions it would be advantageous to open their networks to other actors, such that they do not compromise their market position but allow further value creation in the market.

### Focus on the 5G Vertical Ecosystem

The BVME-SG sees the success of the 5G Provisioning market as being based on sustained and growing demand from the various vertical sectors in which 5G can enhance value creation. Key to this value creation is to determine not only the value created for the vertical but the value for all the actors required in the 5G ecosystem to deliver the full vertical solution. This relates to the fundamental nature of the ecosystem where roles are dependent on each other, and so considering value creation across the wider ecosystem is important for maximising chances for it to succeed.

The white paper provides a detailed overview of the roles in the 5G vertical ecosystem, covering the vertical enterprise customer, the generic solution providers (e.g. computer consultancy, web portals, data processing/hosting, etc.) and the vertical specific solution providers (e.g. operational technologies, industrial automation, machine builders, etc.).

The BVME-SG acknowledges that despite the vast set of market opportunities that 5G could enable, there remains challenges and concerns for verticals to engage and innovate with 5G networks. The main challenges from the verticals' point of view are not related to the 5G technology itself but rather in relation to the business relationships that would need to exist for the verticals to derive value from engaging in the 5G ecosystem. For example, there are concerns over how actors will share liability in service provisioning, especially with services

that are business critical (i.e., where does responsibility lie should there be production errors due to delays in URLLC communications). It is also noted that verticals are not always clear on the cost of deploying 5G-based services and the associated return on investment. This is especially so when numerous partners are involved and revenues will be shared in deploying a vertical service. The impact 5G service deployments will have on existing business models is also unclear, as is the control of data.

The commercially focused examples covered by the BVME-SG from EC funded research and innovation projects show emerging 5G vertical ecosystems focused on different areas (e.g. Smart City, tourism, health, Industry 4.0, and transport). One common observation is that across each of these use cases all roles within the ecosystem have not been fully defined. In order to encourage the growth of this ecosystem for the mutual benefit of all partners involved, the BVME-SG highlight the need to ensure that active parties encourage participation by other firms in such a way as to make it simple to innovate. In addition, where competition between collaborators can occur, the BVME-SG highlight the need to clearly define the division of roles and consistent communication between partners.

### *New challenges for the 5G ecosystem*

The BVME-SG highlights certain challenges that will likely affect the future development of the 5G ecosystem. The key challenges reported have been grouped into two areas related to energy efficiency and data management/privacy. These challenges are driven by the continued emphasis on climate change and increased focus on data security throughout our society, which is becoming increasingly dependent on digital technologies. The reasoning for addressing these topics by the subgroup is related to the fact that these challenges can impact market growth, particularly in relation to how such issues are managed by regulators. The subgroup does however highlight that such challenges could become opportunities within the future 5G ecosystem. This is because addressing these challenges in the products and services being offered in the 5G market are likely to better align with the requirements of users and so is a mechanism to enhance demand.

The challenge related to energy efficiency is driven by the rollout of 5G networks coupled with global data traffic increases, which is likely to lead to energy consumption and CO2 emission increases in communication networks. The subgroup highlights the reactions to this issue from the EC regulators, pointing to the European Green Deal as an issue that could impact the ICT industry. The subgroup flag issues such as “digital sobriety” as a means mooted for dealing with such increases in energy consumption. It is flagged, however, that 5G technology has already been developed in such a way as to address some of these energy consumption concerns, particularly around such features as beamforming, new communication protocols, and the use of new bands, which all can have positive effects on the energy consumption of 5G networks. On the other hand, the capabilities of 5G allow for increased demand for high-bandwidth services, such as high-resolution video or cloud-based gaming, which will act against some of the energy savings brought on by advances in 5G technology and will contribute negatively to the energy issues associated with future communication networks. The business impacts of this issue relate to the electricity prices and the cost of deploying / running services and also the impact energy consumption will have on people’s willingness to consume ever larger volumes of data, due to its impact on climate change.

The data challenges, as mentioned above, arise from the fact that there is high value associated with the data available within communication networks. The volume and speed at which data moves over future communication networks is increasing and 5G allows such increases in data rates and volume to extend to the network edge. This increases the opportunity for issues such as data theft and therefore data must be managed effectively if trust is to be built in the use of future network technologies. Data privacy has already been regulated within Europe and how such regulations evolve will have an impact on the 5G market and the types of services that can be offered.

### *Current Status and Outlook*

To conclude the work from this subgroup the BVME-SG highlights how there is uncertainty associated with the growth prospects of the 5G ecosystem and uncertainty on how it will develop over time. In order to drive and

shape the ecosystem, which is likely to have mutual benefits for all those involved, the subgroup recommend identifying and addressing all barriers and develop the enabling mechanisms that support growth of the ecosystem, as discussed in the white paper. The subgroup recognises that the growth of ecosystems will depend on local as well as global factors, resulting in differences in the 5G ecosystem active in various local markets and between different vertical industries. They also stress that the natural development of an ecosystem will lead to the situation where firms will compete for market share, leading to tensions among the actors that will rely on each other for value creation. In their conclusions to the white paper, the group reiterates the factors that will encourage growth of the 5G ecosystem; namely, making the ecosystem more attractive to join and easier to innovate within. It is pointed out that these factors are largely in control of the industry and include: 1) the Open-X paradigm (e.g. open-software, open-APIs, open-platforms, etc.); 2) standards; 3) cross-border/cross-domain interoperability; 4) regulation; and 5) firms signalling their intent to take on roles in an ecosystem.

### 3.2 Trials WG

The Trials Working Group – which is managed by the 5GMediaHUB partner CTTC - was launched in the context of the 5G Action Plan of the EU Commission with the objective of providing answers to the following questions:

1. Why is 5G good for me?
2. How do I prove that 5G is good for me?
3. Why hasn't this already been achieved?
4. What is 5G bringing that makes this possible?
5. How do I transition from 4G to 5G?

5GMediaHUB contributed with specific activities as follows:

- Contribution to the main white paper
- Presentations of the obtained results in the WG meetings
- Participation in a joint workshop/webinars
- Contribution to the brochures

5GMediaHUB participated in four streams with the following objectives:

- 5G Private Trials / Observatory stream
  - Experimentations and trials done on bilateral (Networks Operator-Manufacturer/Vendor), trilateral (Network Operator-Manufacturer/Vendor-Vertical stakeholder) and multilateral (Network Operator-Manufacturer/Vendor-different stakeholders) basis.
  - Interface between the 5G Private Trials Stream and EU 5G Observatory, defining actions to complement the work in the 5G Observatory
  - Provision of feedback and potential up-dates/grades and/or recommendations towards other groups such as 5G Verticals Trials & Pilots, 5G Observatory Quarterly Reports
  - Participation in activities or events organized by the 5G Observatory
- 5G and towards 6G Verticals stream
  - Extend the scope of this stream to “Verticals towards 6G”
  - Strengthen synergies with the other streams and Working Groups of 5G-IA/SNS
  - Establish regular calls with all 5G-IA/SNS partners interested to play an active role in the Stream activities

- Contribute to all activities of dissemination to international conference to increase the visibility of the work of the stream
- 5G Trials Cities stream
  - Strengthen the liaison with smart city initiatives in Europe
  - Align and synchronize the 5G Trial Cities and 5G Verticals stream especially on smart city verticals
  - Increase the visibility of smart city trials in Europe
- 5GPPP sharing of results
  - Engage European players to contribute to EU SMEs (see specific WG in Chapter 3) and end user devices and Apps understanding of where 5G international deployments may go by publishing the information gathered about the international tests and pilots

The activities carried out by the trial WG are the following:

- Elaboration of the trials and Pilots Brochure: this is a report that collects information from the different projects involved in the WG. An evaluation panel of experts selects 10 out of all the received proposals. See for example the brochure no.3 released in August 2021 in <https://5g-ppp.eu/the-5g-ppp-infrastructure-trials-and-pilots-brochure-3-is-out/> . Each contribution consists of a two-page flyer including: 1) an overview; 2) network architecture; 3) deployment aspects; 4) obtained key results and key features brought by 5G

**DEPLOYMENT**

The use-case aimed at measuring uplink bandwidth and latency under different conditions and sub-scenarios. Multi-camera feeds at low (<0.6 sec to allow remote interviews), consistent latency and uplink bandwidth validate and evaluate 5G-bonding using multi-link bonding, multi-link with WiFi, multi-link of 5G with 4G, etc. combinations the uplink contribution at various network conditions such as cell-edge, and impact of uplink congestion on said performance.

Several products were used - LU600 and LU800 which have multi camera built-in capabilities.

**RESULTS**

In the table below the key service KPIs are illustrated. All target values were met during the trials.

	Trial Target	Measurement Method
5G latency	< 20 ms	Measure 5G RAN + network latency
E2E Uplink stream latency	< 0.6 s	Including video capture, compression, and transmission to cloud/studio and decoding.
5G latency sustainability	< -1% fluctuations over > 3 hours continuous transmission durations	Application and network parameters at various scenarios
Uplink Bandwidth per camera	> 40 Mbps, consistent over > 3 hours transmission	Transmission with LiveU LU800, single and bonded 5G (same operator, as this is what's available at VINNI)

**5G EMPOWERMENT**

5G is required in order to solve issues of the current on-site production allowing the production to be done remotely, while sending to the field only the camera and the cameraman. 5G is expected to provide higher uplink bandwidth, consistency, latency sustainability and overall uplink guaranteed SLA/QoS for multiple uplink cameras/feeds. This is expected to be done with SA with slices/services, PN and NPN networks. In this UC 5G can turn the impossible to possible. High upload bandwidth is required for live multi-camera production at high quality video (Full HD, 4K and 8K). Latency stability is required to support this synchronization as well as to allow the remote production studio to output the live streams in confidence.

5gsolutionsproject.eu

technology (5G empowerment).

Figure 3 - Description of 5G Solutions in 5GPPP Trials and Pilots Brochure no.3

- White Papers: Editorship of the Trials WG chair for the section entitled “5GPPP Projects approach to Edge Computing” in the white paper “Edge Computing for 5G Networks”

- Keynote speeches
- Joint webinars / Workshops

Although the WG is currently defining for workplan for 2022, there are two activities already scheduled for mid 2022, presented below:

- 5GPPP Trials & Pilots Brochure no.4 [May 2022]
- White paper “Verticals towards 6G: challenges and opportunities” [May 2022]

The main **reference** is 5G PPP Progress Monitoring Report 2020

[https://5g-ppp.eu/wp-content/uploads/2021/09/5G-PPP-PMR2020\\_Final.pdf](https://5g-ppp.eu/wp-content/uploads/2021/09/5G-PPP-PMR2020_Final.pdf);

### 3.3 Small and medium enterprises

SMEs are the backbone of Europe’s economy, representing 99% of all businesses in the EU, creating in the past five years around 85% of new jobs and providing two-thirds of the total private sector employment in the EU<sup>2</sup>. SMEs have a great added value in providing innovative concepts and solutions that could be used in various places of the 5G value chain. SMEs are important stakeholders in the overall development chain towards future communication networks<sup>3</sup>. In particular, the development of innovative applications and NetApps – which is an essential part of use case validation approach – requires heavy SME involvement. High-tech SMEs will be early adopters of 5G technology and will build the future market for innovative, advanced next-generation media services and NetApps.

These concepts are the main drivers of 5GMediaHUB contribution to the SME WG of Networld Europe.

These arguments resulted in including the activities planned in WP6 task T6.2 that will enable us to identify the right stakeholders. In particular, awareness campaigns covering at least 4 networking events: the first has already been organized on the 13<sup>th</sup> of April 2022 by PIIU during the 5G/IoThings Conference in Milan (results will be reported in D6.5); other 3 events will be organised in other three different EU countries.. The consortium will attempt to align such events with relevant pre-scheduled conferences/exhibitions/trade fairs/workshops/webinars to raise awareness to interested 3<sup>rd</sup> party experimenters and NetApps developers with an overall aim to organise an EU-wide open competition, requesting from such external stakeholders (i.e. developers and media application experimenters from SMEs and spin-offs of research institutes), who are willing to contribute to the project’s experiments, to 1) create and submit their own developed NetApps in 5GMediaHUB’s NetApps Repository; 2) submit their ideas on how to best exploit 5GMediaHUB’ results through innovative and business-relevant models; 3) have the opportunity to onboard their own media applications and experiment with the 5GMediaHUB Experimentation Facility.

The competition will be published at the project’s website and highly advertised through the project’s and partner’s social media channels. The external 3<sup>rd</sup> parties/SMEs with the best NetApps and ideas will be selected and 3 prizes (e.g. opportunity to participate in a joint booth at a major 5G event alongside with the project’s coordinator) will be offered to the winners (relevant budget has been assigned to CTTC for this purpose).

The 5G MediaHub engagement in the SMEs WG will be assessed through direct evaluation of targets. Focus will be placed on attracting, onboarding and engaging external SMEs, including start-ups and (public/private) research spin-offs during the networking events, and on selecting the best innovative ideas and NetApps based on a set of pre-defined criteria. A multi-stage involvement process to reach adequate participation will be followed.

The above activities brought by 5GMediaHUB contributed to increasing SME participation in 5G-PPP; this participation in the Program increased in 2020 to reach and even exceed the original objective of 20%

<sup>2</sup> [https://ec.europa.eu/growth/smes\\_en](https://ec.europa.eu/growth/smes_en)

<sup>3</sup> <https://bscw.5g-ppp.eu/pub/bscw.cgi/d119698/SME-A5-brochure-final-web.pdf>

participation defined as a key performance indicator (KPI) of the programme. According to the H2020 dashboard, the participation of SMEs in the 5G PPP has reached 21.95% of EU funding, representing a total of 156.3 M€. SMEs have contributed to 24.43% of the total participation in 5G PPP projects, i.e., 426 SME participations out of 1,744. There were 738 unique SME participations. It is worth noting that 65% of the SMEs participated in 1 project, and 35% in 2 or more projects. Besides, the level of participation of SMEs in RIAs and IAs is similar. The interest of the SMEs in the 5GPPP and more generally in H2020 and in Smart Networks & Services (SNS) Joint Undertaking, established in November 2021<sup>4</sup>, has increased throughout the year. Membership in the Networld SME Working Group increased by 17% during the year 2020, reaching 200 members, out of which 170 are SMEs. The SME Working Group was keen to contribute to the upcoming SNS Joint Undertaking, releasing in December 2020 a position paper highlighting recommendations, comments, and questions from SMEs in relation with SNS. The SME contribution was conveyed and considered by the 5G IA Board and the 5G IA Vision WG sub-group working on the draft of the 1st SNS work programme.

The SME-related web pages on the Networld2020 web site were revisited and updated, supporting the achievement in terms of participation in the 5GPPP, as highlighted above. A new “SME WG” web page was created. The “Find the SME you need” web page was updated a couple of times during the year. Not only does it include information on more SMEs than before, but it is also possible to sort SMEs by technological expertise or by knowledge of vertical sectors. New success stories have been released.

In addition, there were also a couple of updates of the “European SME Expertise in 5G and Beyond” brochure. Information on 61 European SMEs is now included in the brochure<sup>5</sup>, along 55 with significant success stories, most of which are related to the participation of SMEs in 5G-PPP projects. It is worth noting that the SME brochure has been downloaded more than 1,000 times, showing its interest among all stakeholders.

### 3.4 Task Force on mapping the vertical KPIs to network KPIs

This task force, led by the 5GMediaHUB partner NOVA, issued a white paper that analyses vertical use cases of various domains for their performance KPIs and their mapping to 5G network KPIs. The scope is to identify (based on architectural elements analysis, information flow, etc.) the potential impact on the service performance and user-perceived quality. The challenge is to understand the relative influence of 5G network performance indicators to the vertical services.

To achieve this, a detailed analysis of the mapping of performance KPIs to 5G network KPIs is provided. The target KPIs values for specific use cases and services are analyzed setting the benchmarking basis for the collection and evaluation of performance measurements in similar cases.

The KPIs mapping methodology includes three steps:

- Research on definitions and information derived from the respective 5G-PPP projects, standardisation bodies and respective alliances, e.g. ITU, NGMN, etc., as well as definition of use cases from 5G-PPP projects' respective.
- Identification of relevant service KPIs and their definitions that are of importance to the respective industry.
- Mapping of selected service KPIs on the respective network KPIs that impact the operation of the architectural elements that participate in the service provision process.

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<sup>4</sup> <https://digital-strategy.ec.europa.eu/en/policies/smart-networks-and-services-joint-undertaking>

<sup>5</sup> [https://bscw.5g-ppp.eu/pub/bscw.cgi/d391067/2021-01\\_5G\\_SME\\_Brochure.pdf](https://bscw.5g-ppp.eu/pub/bscw.cgi/d391067/2021-01_5G_SME_Brochure.pdf)

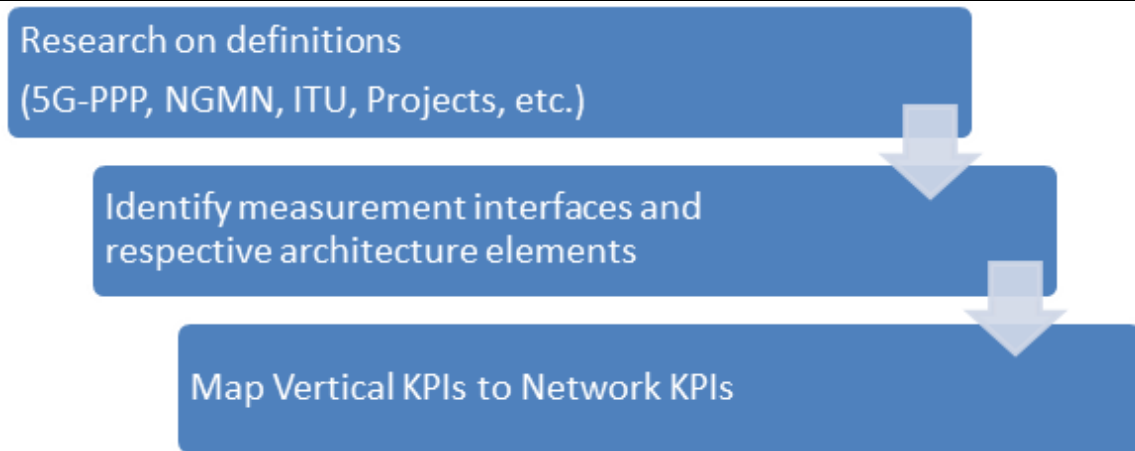


Figure 4 – KPI mapping process

This white paper defines in a clear and solid way the KPIs mapping and their target values in order to prove and validate that the 5G technology can provide prominent industry verticals with ubiquitous access to a wide range of forward-looking services with orders of magnitude of improvement over 4G.

The white paper analyses use cases in the following industry domains:

- Industry 4.0
- Smart Cities & Utilities
- Transportation
- Automotive
- Media & Entertainment
- Agriculture & Agri-food
- Smart (Air)ports
- Energy
- E-health & Wellness

Vertical industries address their connectivity and communication requirements with dedicated specific solutions. 5G technologies, slicing and virtualization will provide a common base that delivers an open, cost-efficient and interoperable eco-system enabling a solution platform for the different verticals. 5G must also cater in an economical way the diverse requirements and business needs of a multitude of verticals. In addition, the 5G infrastructure and architecture will integrate heterogeneous technologies and enable network slicing, so that the multiple concurrent execution of vertical operational services is performed regardless of their diverse requirements.

The 5G System is expected to quickly address a multiplicity and diversity of services coming from various vertical sectors. 3GPP and ITU have mapped in a similar way the vertical industries to large service categories called service classes by ITU-T [1], allowing for the design of a more 5G user-centric platform dictated by service types for specific uses cases with optimised networks with different characteristics and behaviours determined by key performance requirements.

The concept of a “**Service**” as well as some additional terminologies around it used throughout the paper relate to the verticals.

First the “**vertical domain**” or sector, is an industry or group of enterprises in which similar products or services are developed, produced, and provided [2].

As for the “**vertical**”: it is the stakeholder belonging to an industrial sector and consuming services.



A “**vertical service**” then, from a business perspective, is a service focused on a specific industry or group of customers with specialised needs (e.g., automotive services, entertainment services, e-health services, industry 4.0).

In this context, **service performance** shall refer to the evaluation of the overall behavior of the high layer service with the targeted values of the relevant KPIs dictated by the actual service provided to the end-user (could also be referred to as application level KPIs) and not only by the network performance results. It is also important to note that when it comes to the measurements of such service KPIs, it may not be directly measurable, hence the need for an analysis on possible aggregation/correlation between different KPI levels.

Service/vertical and network/core KPIs might have a relationship that can be different from a one-to-one mapping. Indeed, a service might imply the elaboration of information that is not only handled by network functions but also by instruments (e.g., hypervisors) that are virtualising resources. In particular, if network functions are virtualized, the end-to-end delay is impacted not only by the data packet propagation time but also by the load of the computing resource where the functions elaborating the packet are virtualised. In addition, service KPIs might not be directly measurable, and this is the reason why a mapping between network/core 5G KPIs and service/vertical KPIs is needed. In this way, combining different core 5G KPIs (completely transparent for the verticals), specific service KPIs can be obtained, which allow verticals to determine whether the use cases deployed using the 5G technology and the utilised resource fulfil the expected performance and functional requirements.

The methodology followed by the white paper begins with the analysis of use cases in the aforementioned domains. For each domain, both core and service KPIs are identified, while at the same time an initial mapping between those categories is provided. Additionally, the authors define in a concrete way the various indicators that have emerged, based on ETSI standards when possible. Building in the above definitions, the initial mapping is refined to match the existing standards and gather service KPIs in more complete business and service requirements.

#### *Media & Entertainment domain*

More specifically in the Media & Entertainment (M&E) domain, which is the focus of 5GMediaHUB activities, the white paper begins by explaining the new environment the M&E services have to evolve into. M&E services need to cope with the increasing demand in terms of data rates, number of simultaneous users connected and/or more stringent QoS requirements. High-quality and high-resolution audio-visual services are important drivers for increased downlink data rates, where 5G promises to provide cost-effective alternatives to today’s Content Delivery Network (CDN) approaches. At the same time, user generated content as well as the use of cellular technology for professional and semi-professional media production are key drivers for increased uplink data rates. Cellular, especially when used in bonding multiple links, has been replacing the traditional uplink method of satellite trucks transmission and enabled live high-quality transmission to all sorts of media content providers. 5G will enable this viable and immensely growing area of cellular and IP-based live media production as a business to grow further, supporting new business models, such as production in the cloud, at lower costs. 5G will seamlessly integrate services over different network technologies (fixed, wireless), topologies (including e.g. unicast, multicast and broadcast) and capabilities (e.g. caching and multi-link), which may be needed to cover all M&E use cases.

As such, the Use Case under study concerns ultra-high-fidelity media. In order to guarantee a high quality of experience the 5G network should be able to support efficient network management, fair resource allocation, high speed transport capabilities and strategies, e.g. by means of local and network caching of content. This use case involves media streaming to devices using a variety of applications supported by the partners under different network configurations.

The challenge broadcasters currently face is the understanding of pros, e.g. additional capabilities such as slicing, or limitations that emerging networks (with focus on 5G) offer in order to take advantage and adapt technological infrastructures and business models. Respective efforts over 4G networks demonstrated great capacity, latency

and density limitations. To this end, no matter if content mobile distribution services exist over current mobile networks, they cannot guarantee higher quality and eventually support lower content formats most of the times.

Along with the identification of Service KPIs for the UHF Media, 5G-PPP and 3GPP architecture definitions targeting media distribution in various domains and not only in the M&E are studied. In this way both SKPIs and **core KPIs (CKPI)** are provided and a common mapping could be produced, as described below:

- **SKPI-1:** the server accessibility (application accessibility). **Mapping to CKPI:** End-to-end, Latency Coverage, Availability, Slice Creation Time, Connection Density, Area Network Capacity, Mobility / Speed, Handover time.
- **SKPI-2:** the waiting time (time to first picture). **Mapping to CKPI:** End-to-end Latency, Coverage, Availability, Slice Creation Time, Connection Density, Area Network Capacity, Mobility / Speed, Handover time.
- **SKPI-3:** user defined timeout (emulates the user's patience) leads to a "failure". **Mapping to CKPI:** End-to-end Latency, Packet Loss, Coverage, Availability, Slice Creation Time, Connection Density, Area Network Capacity, Handover time, Reliability
- **SKPI-4:** very importantly the picture quality (MOS for each 10s interval of a video, and certainly as the average MOS for the whole video). **Mapping to CKPI:** End-to-end Latency, Packet Loss, Guaranteed Data Rate, Data Volume, Jitter, Area Network Capacity, Mobility / Speed, Handover time, Reliability
- **SKPI-5:** freezing / stalling of the video in % and **SKPI-6:** lost streams (constant freezing). **Mapping to CKPI:** Packet Loss, Coverage, Availability, Connection Density, Jitter, Mobility / Speed, Handover time, Reliability.
- **SKPI-7:** jerkiness in % (if frame rate is not high enough, e.g., < 20 fps, the video is not perceived as fluent). **Mapping to CKPI:** Packet Loss, Coverage, Availability, Connection Density, Jitter, Mobility / Speed, Handover time, Reliability.

The aforementioned KPIs should be a guide in the evaluation of the use cases that will be implemented and executed in the context of 5GMediaHuUB.

5GMediaHUB UCs could further refine and discover new KPIs in more specific scenarios or in broader domains, not taken into account in the original mapping.

### 3.5 Vision and Societal Challenges, Software Networks WGs

Many 5GMediaHUB partners are participating in "The 6G Smart Networks and Services Industry Association" (6G-IA)<sup>6</sup>, which has an ambition to be the voice of the European Industry and Research for next generation networks and services. The 6G-IA represents the private sector in both the 5G-PPP and the SNS Joint Undertaking. The 6G-IA brings together a global industry community of telecoms & digital actors, such as operators, manufacturers, research institutes, universities, verticals, SMEs and ICT associations. The 6G-IA carries out a wide range of activities in strategic areas including standardization, frequency spectrum, R&D projects, technology skills, collaboration with key vertical industry sectors, notably for the development of trials, and international cooperation.

This WG is organized under 6GIA. The mission of the WG is to develop a consensus in Europe on 5G systems with respect to infrastructures and services based on identification of vertical application domains which would benefit from 5G and their associated challenges and requirements. One sub-group in the WG is addressing Business Validation, Models and Ecosystems. It is currently working on a white paper on 5G /6G Business models. It has also submitted a workshop proposal on these topics to [EuCNC 2022](#).

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<sup>6</sup> <https://6g-ia.eu/>

The WG was a main contributor to a white paper published in June 2021 describing a [European Vision for the 6G Network Ecosystem](#)<sup>7</sup>. The White Paper explains how 6G is expected to play a key role in the evolution of the society towards the 2030's, as the convergence between the digital, physical and personal worlds will increasingly become a reality. 6G is assumed to bring a new era in which billions of things, humans, and connected vehicles, robots and drones will generate Zettabytes of digital information. 6G will be dealing with more challenging applications, e.g., holographic telepresence and immersive communication, and as such meet far more stringent requirements than 5G. Furthermore, 6G will support the European Green Deal's objective of reaching climate neutrality for Europe by 2050. Key features of 6G are assumed to include intelligent connected management and control functions, programmability, integrated sensing and communication, reduction of energy footprint, trustworthy infrastructure, scalability, and affordability. The 6G architecture should be sufficiently flexible and efficient so as to enable easy integration of everything, i.e., a network of networks, joint communication and sensing, non-terrestrial networks and terrestrial communication, encompassing novel AI-powered enablers as well as local and distributed compute capabilities. From 5G IA's point of view it is considered a major milestone as input to the new 'Smart Networks and Services' (SNS) European Partnership framework of the Horizon Europe program.

By September 2021 the sub-group published a whitepaper called [5G Ecosystem](#)<sup>8</sup>. This white paper discusses the ecosystem as a prerequisite for value creation, as well as identifies stakeholders and how they can get return of investment as potential awards for their engagement. The white paper describes an ecosystem as a complex network of interacting cross-industry actors who work together and are dependent on each other to define, build and deliver value creating customer solutions. The 5G ecosystem is considered in two main aspects: 1) the network service provisioning aspect and 2) the vertical sector service consumption aspect. In the 5G provisioning ecosystem, the needed services are mapped to roles that are expected to deliver these services. In the context of 5G vertical enterprise customers, a large number of actors can assume complementor roles and are often competency specific to the vertical sector they act in.

The identified stakeholder groups include 5G industry and research organizations, vertical sectors' firms, complementor firms, as well as organizations and associations of providers and consumers active in the value network representing the interests of a larger collection of firms and organizations. Those stakeholder groups include both SMEs and larger companies, and whenever relevant academic institutions. In addition, standardization organizations, open-source organizations and policy makers are an inherent part of the 5G ecosystems, as are governmental agencies at regional, national and European level that support the creation of value in the 5G ecosystems through funding or procurement of innovations.

Neither the 6G vision paper nor the 5G ecosystem paper is discussing media applications explicitly. However, the 6G Vision paper are mentioning AR/VR/XR and immersive communications that are within the scope of 5GMediaHUB's UC scenarios 1.1 and 1.2. The 6G vision paper is also mentioning (geographic) positioning and sensing as 6G applications. These applications are highly relevant for advanced media applications that are combining physical and virtual objects in extended video and gaming services.

None of the papers are discussing specific 5G or 6G applications or services with respect to KPIs.

### 3.6 Software Network WG

The purpose of this WG is to analyze and address unification and applicability of key research topics related to software networking including software defined concepts, infrastructures, systems and components for wired and wireless networks, including networked clouds, IoT and services, i.e. SDN and Network Function Virtualization (NFV) as developed and promoted by the 5GPPP projects. The latest White Paper from this WG,

<sup>7</sup> <https://5g-ppp.eu/wp-content/uploads/2021/06/WhitePaper-6G-Europe.pdf>

<sup>8</sup> [https://5g-ppp.eu/wp-content/uploads/2021/09/White\\_paper\\_5G-Ecosystems\\_1-0-final.pdf](https://5g-ppp.eu/wp-content/uploads/2021/09/White_paper_5G-Ecosystems_1-0-final.pdf)

released February 2020, is called [Cloud Native and 5G Verticals' services](#)<sup>9</sup> depicting the three phases to evolve from Virtual Network Functions (VNFs) to Cloud-Native Functions (CNFs).

Another paper focusing on software networks is [Edge Computing for 5G networks](#)<sup>10</sup> prepared and published February 2021 by 5GPPP Technology Board Working Group / 5G-IA's Trials Working Group. This white paper provides 1) a brief introduction to the Edge computing concept; 2) an exhaustive technology review focusing on virtualisation, orchestration, network control, and operational frameworks; 3) a discussion about the role of security; and 4) an analysis of several business aspects around the Edge ecosystem. Moreover, the white paper provides an in-depth analysis of Edge solutions that have been selected, deployed and validated by 17 different EU-funded 5GPPP projects.

The latter White Paper may be relevant to 5GMediaHUB especially with respect to Chapter 4 discussions of actor, business and competitive aspect related to Edge computing.

A White Paper called [Service performance measurement methods over 5G experimental networks](#)<sup>11</sup> was published in June 2021. This white paper analyses the 5G-PPP projects' UCs of various verticals with respect to their respective performance KPIs and their mapping to the 5G network KPIs. The scope is to identify the potential impact on the service performance and the perceived user quality. The white paper is addressing UCs from the M&E domain as well as Smart Cities & Utilities, Transportation, Automotive, Agriculture & Agri-food, Smart (Air)ports, Energy and E-health & Wellness.

The described methodology and metrics are similar to what is being applied in 5GMediaHUB. Additional considerations are included regarding the following:

- areal density of media devices and their demand of capacity with respect to edge and core network functionalities
- HD media applications in vehicles

Another White Paper called [Delivery of 5G Services Indoors](#)<sup>12</sup> was published in 2021. It discusses special issues related to indoor environments such as manufacturing halls offices, shopping malls and commercial buildings but also environments in the M&E sector and residential spaces with wireless connectivity of appliances and devices in the home. Some of these spaces are exhibiting very high requirements in terms of device density, high accuracy localisation, reliability, latency, time sensitivity, coverage and service continuity. The white paper also introduces the first KPI achievements in this context.

In the frame of this 5GPPP WG Telenor Research is contributing to the One6G initiative, which brings together partners from various research/technological areas and vertical domains, facilitating partnerships for 6G solutions targeting economic and societal needs.

In 2021 One6G released a [6G vision paper](#) and organized a [One6G Summit](#) for all stakeholders where Telenor Research, among others, presented overall visions for 6G. Telenor is engaged in One6G's WG1 and contributing to a whitepaper on 6G use cases and requirements.

Some UCs in One6G are focusing on 6G as a shared infrastructure for telecom, positioning, and sensing type of systems and services – not only for connected objects but also for objects, processes and conditions that are NOT connected to networks. Accurate positioning and network-enabled sensing may eventually become relevant for media applications, e.g. for positioning and deployment of augmented reality (AR) type of applications into live video streams.

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<sup>9</sup> <https://5g-ppp.eu/wp-content/uploads/2020/02/5G-PPP-SN-WG-5G-and-Cloud-Native.pdf>

<sup>10</sup> <https://bscw.5g-ppp.eu/pub/bscw.cgi/d397473/EdgeComputingFor5GNetworks.pdf>

<sup>11</sup> [https://5g-ppp.eu/wp-content/uploads/2021/06/Service-performance-measurement-methods-over-5G-experimental-networks\\_08052021-Final.pdf](https://5g-ppp.eu/wp-content/uploads/2021/06/Service-performance-measurement-methods-over-5G-experimental-networks_08052021-Final.pdf)

<sup>12</sup> <https://5g-ppp.eu/wp-content/uploads/2021/09/Delivery-of-5G-services-indoors-v1.0-final-2.pdf>

5GMediaHUB partners have been invited to participate in a questionnaire from the One6G consortium, and one of Telenor's employees have answered with media services in mind. It is currently a short window of opportunity for 5GMediaHUB project or partners to formulate UCs that might be included in One6Gs upcoming whitepaper.

### 3.7 Test, Measurement and KPIs Validation WG

5GMediaHUB plans to allow for the automated execution and evaluation of network-oriented and/or service-oriented testcases, based on high-level test plan descriptions of the intended experiments, and based on the experimentation service concepts and available 5GMediaHUB Experimentation Facility Engines as described in D1.5 "DevOps implementation and testing methodology and benchmarking of results – Initial"<sup>13</sup>, and D1.7 "Architecture Design & Technical Specifications – Initial"<sup>14</sup>. This will enable advanced testing capabilities by utilizing the testbed-specific monitoring and testing tools as well as the globally available platform testing and validation tools, to enable the validation of network and vertical services across all the UC scenarios. Access to these capabilities will be provided to the experimenters in a central manner via the 5GMediaHUB Experimenters Portal, through which they will be able to define their experiment, configure the specific testcases of interest, define the validation parameters and receive the validation report. More specifically, during the experiment execution stage, the various local (testbed) and global (platform) monitoring and metric/data collection tools are engaged and are continuously collecting information according to the measurement points, requirements and KPIs defined in the testcase by the experimenter. Real-time visualization of the experimentation status is supported during this stage, via the 5GMediaHUB portal and its monitoring/visualization tools, as described in D2.3 "Experimenters portal & user management development – Initial".

These activities were presented in the Test, Measurement, and KPIs Validation (TMV) Working Group whose interests are in the following research areas and technology domains:

- Testing KPI definition, KPI sources, collection procedures and analysis;
- Testing frameworks (requirements, environment, scenarios, expectations, limitation) and tools;
- Testing methodologies and procedures;
- KPI validation methodologies;
- Testing lifecycle (i.e. testing execution, monitoring, evaluation and reporting);
- Common information models for 5G Test and Measurement (T&M).

Developing testing tools is an essential part for 5G networks because of the softwarization that has created a large number of new parameters that can affect the overall network performance. Constant software updates, and optimization of NFVI parameters are only two examples of the huge number of possible use cases.

Therefore, testing is an important tool for guaranteeing the Service Level Agreements (SLAs) for the various vertical services and TaaS is expected to play a major role in the 5G softwarized network<sup>15</sup>. By simplifying the testing operations and providing an interface to connect to the Continuous Integration / Continuous Deployment pipelines of the Mobile Network Operators (MNOs) is promising a stable performance delivery while maintaining (or even reducing) the operational expenditures under control.

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<sup>13</sup> 5GMediaHUB Deliverable D1.5 - DevOps implementation and testing methodology and benchmarking of results – Initial," [Online]. Available: [https://www.5gmediahub.eu/wp-content/uploads/2021/09/D1.5-DevOps-implementation-and-testing-methodology-and-benchmarking-of-results-v1-20210830\\_Final.pdf](https://www.5gmediahub.eu/wp-content/uploads/2021/09/D1.5-DevOps-implementation-and-testing-methodology-and-benchmarking-of-results-v1-20210830_Final.pdf).

<sup>14</sup> 5GMediaHUB D1.7 Architecture Design & Technical Specifications – Initial," [Online]. Available: [https://www.5gmediahub.eu/wp-content/uploads/2021/09/5GMediaHUB-D-1.7-Architecture-design-and-technical-specifications\\_20210830\\_Final.pdf](https://www.5gmediahub.eu/wp-content/uploads/2021/09/5GMediaHUB-D-1.7-Architecture-design-and-technical-specifications_20210830_Final.pdf)

<sup>15</sup> 5G PPP TMV White Paper 2019, "Validating 5G Technology Performance Assessing 5G architecture and Application Scenarios", <https://5g-ppp.eu/wp-content/uploads/2019/06/TMV-White-Paper-V1.0-03062019.pdf>

The most common method for testing methodology is the employment of Test Case Templates for System Under Test experiments that can be used for measuring and validating the 5G network performance testing. A Test Case template is a document that defines all the needed information (e.g., inputs, hardware and software resources) and specifications (e.g., execution steps, testing procedure) to complete SUT experiments. It is also used to register the results of the experiments and monitor the KPIs of the whole experimental process.

The first essential step for creating the needed Testcases is to identify which KPIs shall be stressed by the test. The priority was, for the TMV working group, to identify those technical KPIs that were supporting the 5GPPP contractual KPIs validation<sup>16</sup>. The initial identified KPIs support mostly the following two contractual KPIs:

- P1: Providing 1000 times higher wireless area capacity and more varied service capabilities compared to 2010.
- P4: Creating a secure, reliable and dependable Internet with a “zero perceived” downtime for services provision.

In practice, those two contractual KPIs can be translated in a series of Technical KPIs<sup>17</sup>, as displayed in Table 2.

Table 2: Technical KPIs [17]

Type	KPI Name	KPI Measurement Points	5G PPP KPI Validated
SLA	Minimum Expected Upstream Throughput	UE transmitting IP packets to the N6 interface	P1
SLA	Minimum Expected Upstream Throughput	UE transmitting IP packets to the N6 interface	P1
SLA	Maximum Expected Latency	RTT of UE IP packets transmitted to the N6 interface.	P1, P4
SLA	Network Reliability	Transport layer packets are lost between the UE and the N6 interface	P4
SLA, Technology Validation	Quality of Experience	Measured at the UE side at application or application API level	P1, P4
Technology Validation	UL Peak Throughput	Single UE transmitting IP packets to the N6 interface.	P1

<sup>16</sup> ETSI Zero touch network and Service Management (ZSM) Industry Specification Group (ISG), <https://www.etsi.org/technologies/zero-touch-network-service-management>

<sup>17</sup> 5G PPP TMV White Paper 2021, “Basic Testing Guide A Starter Kit for Basic 5G KPIs Verification”, <https://doi.org/10.5281/zenodo.5704519>

Technology Validation	DL Peak Throughput	Single UE transmitting IP packets to the N6 interface.	P1
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### 3.8 Pre-Standardization WG

The use cases defined in 5GMediaHUB project are related with media content generation and transmission over 5G network. The UC categories defined are:

- Immersive AR, VR and XR Applications
- Smart media production
- Smart media content distribution

These categories are also defined and tested in other 5G technology validation projects and the aim of the standardization should find common needs and define related requirements for the experimental validation methodology.

The work to align the experimental methodologies has been started in collaboration with the 5G-SOLUTIONS Project, organizing regular workshops to present the UCs and detect similarities of the validation activities.

During the first broadcaster workshop in February 2022, the 5GMediaHUB group presented the UCs and their different scenarios, trying to delve deep into details allowing participants to understand the setup modalities and the characteristics of the developed project infrastructure, aimed to carry out automated dry testing to ensure the reliability of the media NetApps involved in the different media production and distribution pipelines. The concept, already applied in industrial and mobility projects applications, is a novel approach for the media environment and represent an important step towards providing reliable software assets for production and a platform where developer and MNOs can test, respectively, their developments and infrastructure configurations and adjust them optimally for every specific media application: content generation, cocreation, transmission and distribution.

During the mentioned workshop, the first similarity within different project UCs was detected. One of the scenarios developed in 5GMediaHUB project and specifically related with Smart city co creation is similar to a scenario presented in 5G SOLUTIONS. Both scenarios involve different musicians playing their instrument in different locations.

One of the most challenging aspects in these scenarios is the correct synchronization of the contents to provide a fine quality of experience for the audience.

The participating technical partners interchanged their strategies and possible solutions for this issue and found that the infrastructure configuration was so different that the solution for one side was not useful for the other. This point stresses how relevant the standardization activity will be to the media sector in order to align and define common strategies to set up the UCs and generate useful knowledge for more media projects developed in the future.

The 5G-PPP is a joint initiative between the European Commission and European ICT industry (ICT manufacturers, telecommunications operators, service providers, SMEs, and researcher Institutions). The 5G-PPP has as goal to deliver solutions, architectures, technologies, and standards for the ubiquitous next generation communication infrastructures of the coming decade. CTTC and TNOR are both participating in some pre-standardisation working groups within 5G-PPP.

Within the 5G-PPP there are several working groups, where the work of projects and other stakeholders converges upon the identification of shared issues and development of supported program level positions on technical and strategic items.

The working group of pre-standardization on next media services based on 5G technology is starting its activities, thanks to the release 17 and the following release 18, which carry specific features for the media sector. The release 16 already presents a structure for media services (further introduced in this section), but the specific features will be deployed in release 17.

The main work carried out on standardization for other sectors, during the first phases of the 5G infrastructure deployment, have been centred on the experimentation and validation of the 5G technology infrastructure related with industrial and mobility sectors in addition to the general communication sector. As can be observed in Figure 5, the different releases of the 5G technology, deployed before the 17<sup>th</sup>, had no specific features for the media sector.

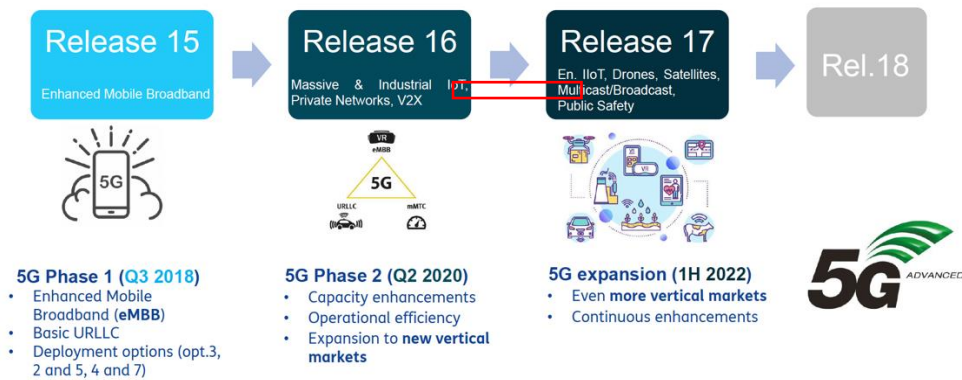


Figure 5 – 3GPP releases addressed by 5GMediaHUB

The Release 17, which will be deployed in 2022, includes some specific features defined for the media sector, mainly related with multicast/broadcast contents.

The objectives of the technical group are related with the development of UHFM. The rapid progress in display and capture technologies is enabling a new, highly immersive production and viewing experience with ultra-crisp, wide-view pictures with deep contrast and multi-channel sound. Both linear and nonlinear content will be used for testing the UHFM experience. In order to guarantee a high-quality experience for UHFM, 5G network should be able to support efficient network management, fair resource allocation, high speed transport capabilities and strategies, e.g. by means of local and network caching of content.

The mentioned capabilities and strategies are reported in the 3GPP 5G Media Streaming technical specifications overview<sup>18</sup>.

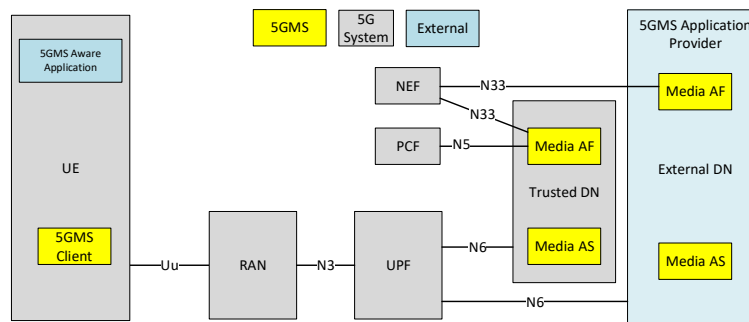


Figure 6 - Requirements and features of media applications

<sup>18</sup> 3GPP TS 26.501 V16.2.0 (2019-12), 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; 5G Media Streaming (5GMS); General description and architecture (Release 16) - Section 4: Media Streaming General Service Architecture [https://www.3gpp.org/ftp/Specs/archive/26\\_series/26.501/26501-g20.zip](https://www.3gpp.org/ftp/Specs/archive/26_series/26.501/26501-g20.zip)



The requirements and related features for the development of specific services for 5G media-related applications are already defined and the work aimed to standardize the media-related developments, after the next release deployment, should be centred on testing different UCs to provide feedback to technical working groups to adjust and improve the provided features.

To proceed on elaborating common strategies to test and validate such technologies, the work of 5GPPP Pre-standardization working group should be focused on establishing synergies within projects oriented to the media sector, identifying similar use cases along these projects and start elaborating common validation strategies to enhance the comparability of the results obtained in similar UCs, validated in different projects.

This work should also take into consideration already completed work in past 5G media projects such 5G-MEDIA, 5G-TANGO, 5G-PICTURE, 5G-XCAST, to exploit all the already generated knowledge applied to the media sector.

This activity will lead to placing a solid base for the pre-standardization activities taken into consideration all the validating experiences on 5G network technology carried out during all the 5G media-related projects.

This work already started with the organization of the first broadcaster standardization workshop, held remotely in February 2022, with the participation 5GMediaHUB as well as promoters of the 5G Media Action Group

This event represented the start of collaboration activities to define common use cases designs, and technological methodologies for the setup and validation of the 5G technology features applied to media-related applications.