5G RECORDS

5G key technology enableRs for Emerging media COntent pRoDuction Services

Deliverable D6.4
Final exploitation and dissemination results

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Abstract

This deliverable explains the final exploitation and dissemination results of the 5G-RECORDS project.

[1] CO = Confidential, only members of the consortium (including the Commission Services)

PU = Public

Keywords

Exploitation, dissemination, communication, standardization

Disclaimer

This 5G-RECORDS D6.4 deliverable is not yet approved nor rejected, neither financially nor content-wise by the European Commission. The approval/rejection decision of work and resources will take place at the Final Review Meeting, after the monitoring process involving experts has come to an end.

Executive Summary

Deliverable D6.4 presents the summary of the exploitation and dissemination activities carried out after the publication of the deliverable D6.3 about the mid-term exploitation and dissemination results in September 2021.

Section 1 lists the exploitation activities.

Section 2 shows the dissemination and communication activities.

Annex A describes the organizations 5G-RECORDS partners have been involved.

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List of Acronyms and Abbreviations

3GPP	3rd Generation Partnership Project
5G	5th Generation of mobile communications systems
5G-PPP	5G Public-Private Partnership
5GC	5G Core
6G	6th Generation of mobile communications systems
AMWA	Advanced Media Workflow Association
AVPROD	Advanced Audio Video Production
BBC	British Broadcasting Corporation
BMSB	Broadband Multimedia Systems and Broadcasting
BTS	Broadcast Technology Society
EBU	European Broadcasting Union
EC	European Commission
EOT	Electronics of Tomorrow
ESO	European Standards Organization
ETSI	European Telecommunications Standards Institute
EuCNC	European Conference on Networks and Communications
FAQs	Frequently Asked Questions
ICT	Information and Communication Technology
IEEE	Institute of Electrical and Electronics Engineers
IEM	In-Ear-Monitoring
IoT	Internet of Things
ITU	International Telecommunications Union
KPI	Key Performance Indicator
LTE	Long-term evolution
MAG	Media Action Group
MNO	Mobile Network Operator
NPNs	Non Public Networks
OAK	OpenCV Artificial Intelligence Kit
PMSE	Programme Making and Special Events
PTP	Precision Time Protocol
QoE	Quality of Experience
QoS	Quality of Service
RAI	Radiotelevisione Italiana
R&D	Research and development
RIST	Reliable Internet Stream Transport
RRS	Reconfigurable Radio Systems
SME	Small and medium-sized enterprise
SMPTE	Society of Motion Picture and Television Engineers
RSPG	Radio Spectrum Policy Group
SVG	Sports Video Group
TV2	Television 2
UK	United Kingdom
UPM	Universidad Politécnica de Madrid
UPV	Universitat Politècnica de València
V5G	Valencia 5G
VIAPA	Video, Imaging and Audio for Professional Applications
VQEG	Video Quality Experts Group
VSF	Video Services Forum
VSF	Video Service Forum
WG1	Working Group 1
WP	Work Package
WS	Workshop

1 Introduction

This deliverable presents the summary of the exploitation, dissemination and communication activities carried out during the lifetime of the project.

The following table contains the target numbers for the dissemination, communication and exploitation activities and what was achieved.

Table 1. Project targets and current numbers on dissemination, communications and exploitation activities.

Category	Type of activity	Target	Expected M12	Achieved (M12)	Achieved (M26[2])
Dissemination	Public deliverables	15	8	8	14
	Journal papers, whitepapers and international conference papers	20	10	3	14
	Keynotes, presentations and panels in major conferences	15	7.5	22	65
	Participation in events and forums in Europe and worldwide	10	5		
	Workshops in major IEEE conferences	4	2	3	5
	Summer schools, tutorials, training	2	1	2	2
Communication	Website	1	0.5	1	1
	Press releases	15	7.5	5	40
	Social networks	3	1.5	3	3
	Audiovisual resources	6	3	3	20
Exploitation	Standardization contributions	40	20	16	21
Others	Filed patents	5	2.5	3	6
	Open source repositories	2	1	2	2
	Collaborations with other research projects	4	2	0	4

As shown in Table 1, all targets related to the number of dissemination activities have been exceeded compared to the targets achieved in the first year of the project.

All the public deliverables have been completed, published and made available on the project website.

[2] The duration of the 5G-RECORDS was initially 24 months, but the project was granted an extension of two months.

The scientific publications have slightly improved compared to the previous year, the project has **12 conference and journal papers**, and **1 Whitepaper**. We are aware that the number of dissemination activities related to international scientific articles is below, but close to the planned target. Many of the results obtained by the project are planned to become scientific articles after the end of the project.

On the other hand, the number of keynotes, presentations and panels, as well as participation in 5G events and forums, has far exceeded the number of activities for the total duration of 5G-RECORDS.

The planned number of workshops at renowned conferences has also been reached. The 5G-RECORDS project has participated in **4 workshops** and organized **one workshop bringing together eleven other 5G-PPP projects**.

As for the summer schools, tutorials and training events, the number of activities has reached the expected values at the end of the project life.

At the beginning of the project, 5G-RECORDS created a **public website** and **three social media accounts**: A LinkedIn group and a Twitter profile where project progress has been regularly posted and a YouTube channel where test videos and promotional material have been published.

40 press releases in multiple languages have been published on the corporate websites of the project partners, providing relevant and interesting information on the progress of the project to the scientific and industrial community and the general public.

All these dissemination and communication activities have made it possible to reach a large number of people from academia, industry, civil society, the media, etc. Specifically, 505 people from the scientific community, 657 from industry, 268 from civil society, 4 from general public, 42 policy makers, 62 from the media, 7 from investors and more than 2.880 from other sectors. Thus, **5G-RECORDS dissemination activities have reached 4.425 people.**

Finally, the project set an initial target of five patents and **6 patents** have been filed. Inputs and contribution have been proposed especially to **3GPP, ITU-T, AMWA**.

2 Deliverables

The **eighteen** scheduled **deliverables** of the 5G-RECORDS project are listed in the following table:

Table 2. 5G-RECORDS project deliverables.

ID	Deliverable Name	WP	Month
D1.1	Project management and administration guidelines	WP1	1
D1.2	Mid-term management and administration activities		12
D1.3	Final management report		26
D2.1	Use cases, requirements and KPIs	WP2	9
D2.2	5G regulatory framework for content production		14
D2.3	Business analysis		25
D3.1	First description of 5G components	WP3	11
D3.2	Complete description of 5G components		19
D3.3	Media production orchestration layer		25
D4.1	Integration of 5G components (phase-1)	WP4	11
D4.2	Integration of 5G components (phase-2)		21
D5.1	Test-beds and trials roadmap	WP5	12
D5.2	Trials initial deployment		16
D5.3	Final trials and technology validation		26
D6.1	Project exploitation and dissemination plan	WP6	2
D6.2	Data management plan		6
D6.3	Mid-term exploitation and dissemination results		12
D6.4	Final exploitation and dissemination results		26

All the expected deliverables have been published according to the deadlines in the project proposal.

3 Dissemination Results

The dissemination plan was designed to ensure that the outcomes of the project reach all the communities active in the technologies, systems, and services to which the project is directed.

Table 3. Project targets the dissemination activities.

Category	Type	Target
Dissemination	Whitepapers, journal and conference papers	20
	Keynotes and panels	15
	Participations in events and forums	10
	Workshops	4
	Tutorials	2

3.1 Dissemination events

It considered a set of minimum events to be achieved throughout the life of the project:

Table 4. Dissemination events.

Category	Type	Target	Achieved (M12)	Achieved (M26)
Dissemination events	Advisory Board meetings	---	0	1
	Booth/demos	---	0	3
	Meetings with other 5G-PPP projects	---	0	4
	keynotes/presentations/panels	15	22	65
	Workshops in major IEEE conferences	4	3	5
	Summer schools, tutorials[3] and training	2	2	2

The following subsections present the results of the dissemination activities during the first year of the project.

3.1.1 Keynotes, presentations and panels

The following **sixty-five keynotes, presentations and panels** have been presented by partners of the 5G-RECORDS project:

Table 5. Keynotes, presentations and panels.

Type	Target	Achieved (M12)	Achieved (M24)
Panels	15	4	6
Keynotes		16	25
Presentations		2	34

[1] P. Sunna, “5G-RECORDS project summary”, Keynote on SMPTE, September 2020. [Link]

[2] D. Gómez-Barquero, “5G-RECORDS, 5G Key Technology Enablers for Emerging Media Content Production Services”, Panel on Convergence of Broadcast and Broadband, IEEE Symposium on Broadband Multimedia Systems and Broadcasting, October 2020. [Link]

[3] I. Wagdin, “Overview of 5G-RECORDS project”, Keynote on 5G CP EBU Group, November 2020. [Link]

[4] I. Wagdin, “5G in Content Production, work in standards and deployments - 2 December 2020”, Panel on 5G Content Production Cambridge Wireless, December 2020. [Link]

[5] P. Sunna, “5G for Content Production” Panel on 5G Content Production Cambridge Wireless, December 2020. [Link]

[6] P. Pérez, P. Sunna, M. Brandstrup, I. Wagdin, T. Lohmar, N. Werner, “5G for Content Production” Keynote on VQEG, December 2020. [Link]

[7] I. Wagdin, “Overview of 5G-RECORDS project”, Keynote on UK5G Creative Industries Working Group, December 2020. [Link]

[3] See tutorials in section 3.2.5

[8] M. Pérez, “3GPP, EBU and 5G-MAG for the development of 5G technology for content production”, Keynote on IEEE BTS Webinar, December 2020. [Link]
[9] D. Gómez-Barquero,” Introduce of 5G-RECORDS project”, Keynote on IEEE BTS Webinar, December 2020. [Link]
[10] I. Alepuz, “Overview of 5G-RECORDS project”, New 5G Core Technologies Innovation Projects, Keynote on 5G-PPP Webinar, February 2021. [Link]
[11] P. Sunna, “The 5G-RECORDS and use-cases”, Keynote on 5G-MAG Meetings, February 2021. [Link]
[12] M. Fuentes, A. García, J. Costa-Requena, “Overview of 5G-RECORDS project and its three use cases”, Keynote on SME WG meeting, 5G-PPP. [Link]
[13] M. Brandstrup, “Overview of the 5G-RECORDS project”, Keynote on DK IoT Tech Seminar for Industry EOT-CONNECT, June 2021. [Link]
[14] I. Wagdin, “5G Media Action Group”, Keynote on Audio Group, SVG, May 2021. [Link]
[15] M. Pérez, “5G Audio Production”, Presentation on Audio Group SVG, May 2021. [Link]
[16] I. Wagdin, P. Brightwell, P. Sunna, “Use case 2 – Multiple wireless cameras”, Keynote on Video Service Forum, April 2021. [Link]
[17] I. Wagdin, “5G in content production The European perspective”, Keynote on Video Service Forum, April 2021. [Link]
[18] P. Brightwell, “Operational Control Layer”, Keynote on Video Service Forum, April 2021. [Link]
[19] I. Wagdin, P. Brightwell, P. Sunna, “5G key technology enablers for emerging media content production services”, Keynote on Video Service Forum, April 2021. [Link]
[20] T. Lohmar, “5G System interactions wrt QoS / Network Slicing”, Keynote on Advanced Media Workflow Association, April 2021. [Link]
[21] P. Brightwell, “Operational Control Layer”, Keynote on Advanced Media Workflow Association, April 2021. [Link]
[22] M. Pérez, “5G-RECORDS project”, Panel on V5G Valencia, June 2021. [Link]
[23] P. Brightwell, “Media orchestration and control”, Presentation on the EBU Project group 5G in content production, July 2021. [Link]
[24] M. Brandstrup, “5G-RECORDS project”, Keynote on EOT - Electronics of Tomorrow, September 2021. [Link]
[25] M. Brandstrup, M. Pérez, J. Dürre, N. Werner, “5G Technology in Pro Audio” Panel on Danish Sound Cluster Webinar, September 2021. [Link]
[26] B. Altman, “5G Tests & Pilots”, Keynote on 5G-IA, TSDSI, September 2021. [Link]
[27] M. Skarp, “5G Time Sensitive Network (TSN)”, Keynote on ONF Spotlight, September 2021. [Link]
[28] M. Brandstrup, “5G-RECORDS project”, Keynote on PROAVEXPO, October 2021. [Link]
[29] P. Pérez, “5G Immersive Media Production”, Keynote on 4KHDR Summit, November 2021. [Link]
[30] D. Gómez-Barquero, “5G-RECORDS: enabling media content production” Keynote on EBU Forescast, November 20211. [Link]
[31] D. Ratkaj, “5G-RECORDS - Preliminary findings on business and regulatory aspects of 5G in content production”, Presentation on 5G-MAG Working group Production – Commercial, November 2021. [Link]
[32] M. Brandstrup, “First feedback from the private 5G pioneers” Panel on /reveal/ b<>com, November 2021. [Link]
[33] M. Brandstrup, “Innovation funding, EU Horizon 2020 and 5G-RECORDS”, Presentation on DI Digital Webinar, January 2022. [Link]
[34] D. Ratkaj, “The regulatory framework for 5G in Europe”, Presentation on EBU Production Technology Seminar), February 2022. [Link]

[35] C. Avellán, “Use Case 1: Live audio production”, Presentation on EBU Production Technology Seminar), February 2022. [Link]
[36] I. Alepuz, “Use Case 2: Multiple camera wireless studio”, Presentation on EBU Production Technology Seminar), February 2022. [Link]
[37] N. Cilleruelo, “Use Case 3: Live immersive content production”, Presentation on EBU Production Technology Seminar), February 2022. [Link]
[38] I. Kostiukevych, “Practicalities and analysis of using PTP over 5G systems with dedicated time synchronization support for media production”, Presentation on NAB Broadcast Engineering and IT Conference (BEIT), April 2022. [Link]
[39] I. Kostiukevych, “Practicalities and analysis of using PTP over 5G systems with dedicated time synchronization support for media production”, Presentation on IP Showcase sessions, April 2022. [Link]
[40] N. Werner, “5G for Wireless Microphones - A Standardized Technology for Professional Audio Productions?”, Presentation on EBU Network Technology Seminar, June 2022. [Link]
[41] P. Ferreira, S. S. Thilakawardana, “Media gateway and MOCG”, Presentation on EBU Network Technology Seminar, June 2022. [Link]
[42] M. Brandstrup, “How 5G will impact media and entertainment – and how can Content production utilize from 5G professional services?”, Presentation on MediaCityBergen – Future Media Week - “5G impact on media”, June 2022. [Link]
[43] M. Brandstrup, “5G – the Reality is Here and Now”, Presentation on WBU-IMCG Forum, World Broadcasting Unions International Media Connectivity Group Forum, June 2022. [Link]
[44] M. Brandstrup, Presentation on Copenhagen – 5G EVENT, June 2022. [Link]
[45] M. Brandstrup, Presentation on IBC brief – webinar, July 2022. [Link]
[46] M. Brandstrup, Presentation on SMPTE LIVE: PULSE IEEE BTS, July 2022. [Link]
[47] J. Dürre, “5G and Professional Live Audio Production?”, Keynote on IEEE BTS Pulse 2022, July 2022. [Link]
[48] M. Brandstrup, “5G Professional Live Multi-Camera Production”, Keynote on IEEE BTS Pulse 2022, July 2022. [Link]
[49] M. Brandstrup, Presentation on FurtureMediaHub, VRT, Bruxelles – MeetTheMakers, September 2022. [Link]
[50] M. Brandstrup,” Brief on 5G-RECORDS status”, Presentation on Nordic Technical Chef Meeting NTCM Autumn meeting in Copenhagen hosted by DR & TV 2, September 2022.
[51] P. Brightwell, P. Ferreira, I. Wagdin, “Use-case 2 (MG/MOCG)”, Presentation on SMPTE TC-Meetings (EBU), September 2022. [Link]
[52] M. Brandstrup, P. Brightwell, D. Desirello, P. Ferreira, M. Fuentes, T. Lohmar, A. Rodrigo Castillo, P. Sunna, I. Wagdin, “5G S-NPN (Standalone Non-Public Network) for Professional Media Production”, Presentation on International Broadcasting Convention (IBC), 2022. [Link]
[53] P. Sunna, M. Brandstrup, P. Brightwell, P. Ferreira, I. Wagdin, Presentation on IBC 2022, September 2022. [Link]
[54] I. Kostiukevych, M. N. Ibrahim, P. Kondratenko, T. Lohmar, T. Kernen “Practicalities and Analysis of Using PTP over 5G systems with Dedicated Time Synchronization Support for Media Production”, Presentation on SMPTE Media Technology Summit, October 2022. [Link]
[55] L. Gaye, D. Gómez-Barquero “5G RECORDS: Challenges, achievements, and learnings: Introduction”. Presentation on EBU Tech Webinar on 5G-RECORDS, October 2022. [Link]
[56] T. Lohmar, “What 5G are we talking about?”. Presentation on EBU Tech Webinar on 5G-RECORDS, October 2022. [Link]
[57] I. Wagdin, “5G regulations”. Presentation on EBU Tech Webinar on 5G-RECORDS, October 2022. [Link]

[58] I. Wagdin, “Live production vs. contribution: Differences and why replace traditional COFDM cameras”. Presentation on EBU Tech Webinar on 5G-RECORDS, October 2022. [Link]
[59] M. Brandstrup, “Use Case 2: Multiple camera wireless studio: The Tivoli trial workflow, components, and results”. Presentation on EBU Tech Webinar on 5G-RECORDS, October 2022. [Link]
[60] T. Lohmar, “Use Case 2: Achieving synchronization among devices”. Presentation on EBU Tech Webinar on 5G-RECORDS, October 2022. [Link]
[61] P. Brightwell, “Making 5G talk with IP production facilities”. Presentation on EBU Tech Webinar on 5G-RECORDS, October 2022. [Link]
[62] J. Dürre, “Use Case 1: Live audio production”, Presentation on EBU Tech Webinar on 5G-RECORDS, October 2022. [Link]
[63] D. Ratkaj, “5G is not only about technology but also regulation plays a big role”, Presentation on EBU Tech Webinar on 5G-RECORDS, October 2022. [Link]

3.1.2 Workshops

During these two years in the context of the 5G-RECORDS project there have **been five workshops** (Table 6).

Table 6. Workshops.

Type	Target	Achieved (M12)	Achieved (M26)
Workshops	4	3	5

3.1.2.1 5G Content Production in IEEE BTS Pulse 2021

The PULSE event provides BTS with the opportunity to fulfill our integral role of industry information sharing [2].

IEEE BTS Pulse 5GCP 2021 was a three-day virtual event bringing together top experts covering technologies that are currently challenging the broadcast industry. In particular, the third day, February 11th, 2021, proposed an insight on 5G Content Production.

This session explored the opportunities and challenges of 5G for the professional audiovisual content production industry. 5G offers improved performance in terms of bandwidth, reduced latency, timing and quality of service. It was expected that standardized 5G-based solutions would bring down production costs and increase the operational efficiency and flexibility of production workflows, in particular, in news gathering, remote production and coverage of live events.

It was organized by the European H2020 project 5G-RECORDS. The project aimed to explore the opportunities which new 5G technology components bring to the professional audiovisual content production, including PMSE. Three use cases were demonstrated in the project: live audio production, a multi-camera wireless studio and live immersive media production.

The session started with a presentation of the activities led by the European Broadcasting Union on 5G content production, which has successfully engaged in 3GPP Release-17 5G standardization. The session continued with presentations from Ericsson and Nokia about key 5G technology enablers for professional content production, such as network slicing for guaranteed QoS, Non-Public Networks, millimeter wave frequencies, edge and cloud computing, etc. The on-going technical work in 5G-RECORDS to enable the three use cases will be then presented, another session concluded with an open panel discussion.

The list of presentations on behalf on the 5G-RECORDS project was:

[1] D. Gómez-Barquero, “Opening Remarks”, Workshop on 5G content production, IEEE BTS Pulse, February 2021. [Link]
[2] I. Wagdin, “5G in content production - the European perspective”, Workshop on 5G content production, IEEE BTS Pulse, February 2021. [Link]
[3] T. Lohmar, “5G Technology Enablers for Content Production – Part I”, Workshop on 5G content production, IEEE BTS Pulse, February 2021. [Link]
[4] P. Pérez, “5G Technology Enablers for Content Production – Part II”, Workshop on 5G content production, IEEE BTS Pulse, February 2021. [Link]
[5] P. Sunna, “5G Wireless Studio”, Workshop on 5G content production, IEEE BTS Pulse, February 2021. [Link]
[6] M. Pérez, “5G for Live Audio Production”, Workshop on 5G content production, IEEE BTS Pulse, February 2021. [Link]

3.1.2.2 Media Production over 5G NPNs in 5G-MAG

The 5G Media Action Group provides a framework for stakeholders to collaborate on a market-driven implementation of 5G solutions capable of meeting the requirements for the production and distribution of audiovisual media content and services. This group is a cross-industry organization gathering stakeholders across the media sector, including content and service providers, network operators, technology solution suppliers, equipment manufacturers, R&D organizations, regulators and policy makers [3].

The workshop, held on April 21st, 2021, and was organized in three sessions, which tackled different aspects of Media Production over 5G NPNs. An important part of the workshop was devoted to exchanging questions and answers allowing attendees to get involved in the discussion. In this interactive session the aforementioned 5G-RECORDS members acted as moderators.

On the first session, Ian Wagdin (BBC) and Thorsten Lohmar (Ericsson) presented the media production requirements (AVPROD and VIAPA) collected in TS 22.263 and TR 22.827; and the SA4 Study Item on “Media production over 5G NPN”, respectively. Further, María Dolores Pérez (Sennheiser) gave some valuable insights into the audio use cases.

The second session about initiatives in the media industry was hosted by Peter Brightwell (BBC), who presented the technology landscape that enable the transition towards IP media production. The thirds session consisted of 3 interactive sections, moderated by Ian Wagdin (BBC), Thorsten Lohmar (Ericsson), María Dolores Pérez (Sennheiser) and also Morten Brandstrup (TV2), in which the participants could ask questions and spark discussions about NPNs for media production for tier 1, 2 and 3 events, as well as Audio networks and production.

[1] I. Wagdin, “Media Production requirements (AVPROD and VIAPA)”, Workshop on Media Production over 5G Non-Public Networks, 5G-MAG, April 2021. [Link]
[2] T. Lohmar, “SA4 Study Item on Media Production over 5G NPN”, Workshop on Media Production over 5G Non-Public Networks, 5G-MAG, April 2021. [Link]
[3] P. Brightwell, “The technology landscape and the transition towards IP”, Workshop on Media Production over 5G Non-Public Networks, 5G-MAG, April 2021. [Link]
[4] I. Wagdin , T. Lohmar, “Interactive Session: 5G NPNs for Tier 1/2 Events: Sports, Music and large-scale deployments”, Workshop on Media Production over 5G Non-Public Networks, 5G-MAG, April 2021. [Link]
[5] M. Brandstrup, T. Lohmar, “Interactive Session: 5G NPNs for Tier 3 Events: News-gathering and small-scale deployments”, Workshop on Media Production over 5G Non-Public Networks, 5G-MAG, April 2021. [Link]
[6] M. Pérez, T. Lohmar, “Interactive Session: Audio Production and Audio Networks”, Workshop on Media Production over 5G Non-Public Networks, 5G-MAG, April 2021. [Link]

3.1.2.3 Non-Public Networks in EuCNC'21

The 2021 Joint EuCNC & 6G Summit, initiated this year, builds on putting together two successful conferences in the area of telecommunications: EuCNC, in its 30th edition of a series, supported by the European Commission and the 6G Summit, in its 3rd edition, originated from the 6G Flagship programme in Finland, one of the very first in its area. The conference is sponsored by the IEEE Communications Society and by the European Association for Signal Processing and focuses on all aspects of telecommunications ranging from 5G deployment and mobile IoT to 6G exploration and future communications systems and networks, including experimentation and testbeds, and applications and services. It brings together cutting-edge research and world-renown industries and businesses, attracting in the last years more than 900 delegates from all over the world, to present and discuss the latest results, and an exhibition space of more than 1.500 m^2 for demonstrating the technology developed in the area, namely from R&D programmes co-financed by the European Commission [1].

The first edition of the Workshop on Non-Public Networks (5G NPNs) took place on June 8th at the 2021 joint EuCNC and 6G Summit to provide a holistic view of NPNs, covering from vertical use cases, operation aspects, business models, trials and emerging technologies Around 70 attendees joined this full day workshop with four sessions, two in the morning and two in the afternoon. It was organized by the 5G-RECORDS project, its organizing committee was chaired by David Gómez-Barquero (UPV), Project Coordinator of 5G-RECORDS, and five other members of the project team were also involved in the organizing committee. The workshop gathered presentation from twelve 5G-PPP projects.

The 5G-RECORDS project was represented by Jordi Giménez (EBU) who presented an overview of the project:

[1] J. Giménez, "The role of 5G Non-Public Networks for Media Production", Workshop on Non-Public Networks, EuCNC 2021, 2021 Joint EuCNC & 6G Summit, Porto, Portugal, June 2021. [Link]

The rest of the presentations selected by the organizing committee were:

[2] X. An, "Shaping the Industrial 5G Revolution", Workshop on Non-Public Networks, EuCNC 2021, 2021 Joint EuCNC & 6G Summit, Porto, Portugal, June 2021. [Link]
[3] X. Li, "NPN Deployment Solutions & Industry 4.0 Pilot Examples", Workshop on Non-Public Networks, EuCNC 2021, 2021 Joint EuCNC & 6G Summit, Porto, Portugal, June 2021. [Link]
[4] N. König, "5G NPNs for Process Monitoring", Workshop on Non-Public Networks, EuCNC 2021, 2021 Joint EuCNC & 6G Summit, Porto, Portugal, June 2021. [Link]
[5] N. Tzanis, "Autonomous Edge 5G Private Network Requirements for Smart Factories", Workshop on Non-Public Networks, EuCNC 2021, 2021 Joint EuCNC & 6G Summit, Porto, Portugal, June 2021. [Link]
[6] M. Fuentes, "5G-enabled AGVs for NPN Production Lines in Manufacturing", Workshop on Non-Public Networks, EuCNC 2021, 2021 Joint EuCNC & 6G Summit, Porto, Portugal, June 2021. [Link]
[7] K. Noland, "5G for Military Use ", Workshop on Non-Public Networks, EuCNC 2021, 2021 Joint EuCNC & 6G Summit, Porto, Portugal, June 2021. [Link]
[8] K. Sun, "On the Role of 5G NPNs for Mission Critical Services", Workshop on Non-Public Networks, EuCNC 2021, 2021 Joint EuCNC & 6G Summit, Porto, Portugal, June 2021. [Link]
[9] J. Ordonez-Lucena, "Outlook for operator adoption of 5G Private Networks", Workshop on Non-Public Networks, EuCNC 2021, 2021 Joint EuCNC & 6G Summit, Porto, Portugal, June 2021. [Link]

[10] S. Gonzalez, “High-Tech and Affordable 5G Private Network Roll-Out to Every Corner”, Workshop on Non-Public Networks, EuCNC 2021, 2021 Joint EuCNC & 6G Summit, Porto, Portugal, June 2021. [Link]
[11] H. Lonsethagen, “Towards efficient 5G NPN Readiness and Testing, addressing the Industry 4.0 challenges of SMEs”, Workshop on Non-Public Networks, EuCNC 2021, 2021 Joint EuCNC & 6G Summit, Porto, Portugal, June 2021. [Link]
[12] S. Fletcher, “Operation of 5G NPNs: Industry Sector Considerations for Deployment and Sustainability”, Workshop on Non-Public Networks, EuCNC 2021, 2021 Joint EuCNC & 6G Summit, Porto, Portugal, June 2021. [Link]
[13] J. Costa,” Seamless integration of TSN into 5G NPNs for Industry 4.0”, Workshop on Non-Public Networks, EuCNC 2021, 2021 Joint EuCNC & 6G Summit, Porto, Portugal, June 2021. [Link]
[14] D. Munaretto, “Cloud Deployments of 5G NPNs: The Athonet Connectivity Platform”, Workshop on Non-Public Networks, EuCNC 2021, 2021 Joint EuCNC & 6G Summit, Porto, Portugal, June 2021. [Link]
[15] S. Robitzsch, “Cloud Native Service-Based Architecture Deployment Considerations for NPNs: An Evolution of NFV”, Workshop on Non-Public Networks, EuCNC 2021, 2021 Joint EuCNC & 6G Summit, Porto, Portugal, June 2021. [Link]
[16] D. Trossen, “Making (Virtualized) Service Interactions More Flexible Within and Across 5G Private Networks”, Workshop on Non-Public Networks, EuCNC 2021, 2021 Joint EuCNC & 6G Summit, Porto, Portugal, June 2021. [Link]

3.1.2.4 3rd COREnect workshop

On the 1st of February 2022, the workshop “Microelectronics and connectivity: Europe going forward” took place. It was organised by COREnec, with the NetworldEurope SME WG and the European DIGITAL SME Alliance. The main purpose of this workshop is to enhance the visibility of the European digital industry and to discuss about European connectivity and microelectronics matters.

European Core Technologies for future connectivity systems and components (COREnect) is a coordination and support action (CSA) project that brings major European stakeholders from both the telecommunication and microelectronics industries together, along with connectivity-enabled vertical industries. It is part of the 5G Public-Private Partnership. [17]

[1] M. Fuentes, “Showcasing the power of 5G devices for professional content production: the 5G-RECORDS approach”, Presentation on 3RD COREnect WORKSHOP, February 2022. [Link]

3.1.2.5 Radio Spectrum Policy Group (RSPG)

The Radio Spectrum Policy Group (RSPG) held a public workshop on 20 June 2022 in which 5G-RECORDS Project, represented by European Broadcasting Union, in collaboration with 5G Media Action Group (5G-MAG) presented the issue of spectrum access for 5G non-public networks used in professional content production.

[1] D. Ratkaj, “Spectrum access for 5G NPNs in professional content production”, Presentation on RSPG Stakeholder Workshop, June 2022. [Link]

3.1.3 Booth/Demos

3.1.3.1 EBU Network Technology Seminar

On 14-15 June 2022, the 5G-RECORDS Project participated in the European Broadcasting Union's Network Technology Seminar (NTS).

This seminar was a global reference point for the media industry on topics such as IP-based production infrastructures, a forum for users and providers to discuss requirements, standards and roadmaps, and an annual meeting point for experts to exchange experiences and best practices to deploy these technologies at scale [19].

NTS included demonstrations, and the project showed registration and discovery of media devices (cameras) in an integrated remote production scenario. The demo illustrated several capabilities of the Media and MOC Gateways such as media protocol adaptation (MQTT), browser-based confidence monitoring (WebRTC), resource management and NMOS, including registration, discovery and control.

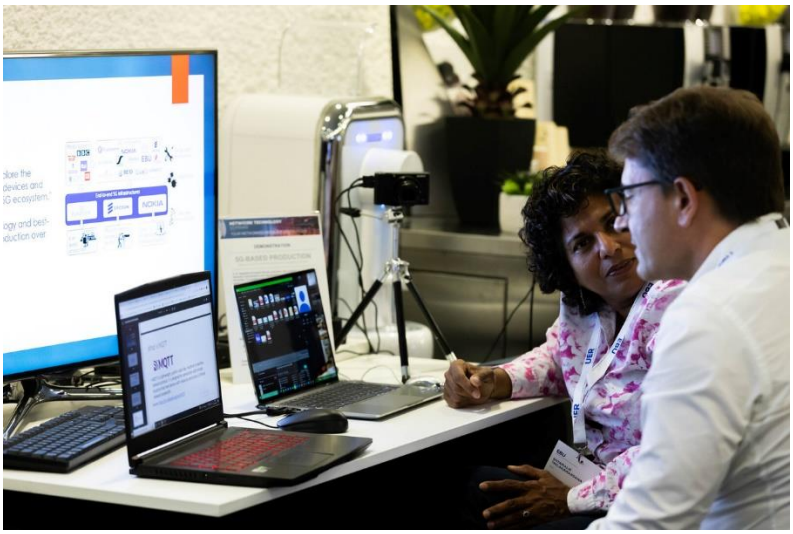

Figure 1. Demo of 5G-RECORDS Project on the media/control gateway.

3.1.3.2 IBC 2022

IBC is the world's most inspiring content and technology event. It draws together the global media, entertainment and technology industry for a compelling live experience that enables every attendee to gain critical insights, share expertise and unlock business opportunities. Created 'by the industry, for the industry' – a principle established on its founding in 1967 that carries through to today – IBC has continued to evolve with each new trend and technology over its 55-year history. Attracting representatives from 24 countries in its first year, IBC now welcomes exhibitors, speakers and visitors from more than 170 nations [20].

Figure 2. Pictures of the 5G RECORDS booths: Media Gateway (left) and dynamic configuration changes with the MOCG (right).

3.1.3.3 Ericsson's Innovation Days

The Ericsson Eurolab Innovation Days took place on 27th and 28th September, 2022 at the Ericsson premise in Herzogenrath, Germany. Around 150 representatives from Mobile Network Operators, industry partners, academia and press attended the event. 5G RECORDS presented the key findings of the project for both, the remote production and the local production sub-usecases, in line with use case 2.

For the event, a 5G SNPN was deployed within the event area (band n78). The 5G-RECORDS booth featured a presentation and a demo. The demo consisted of a Camera Interface Unit (CIU) that created an HEVC encoded live video at 20Mbps which was transmitted over the on-site 5G SNPN to the Media Gateway. The decoded video was rendered to a large screen at the booth and at times to other screens within the venue, emulating a gallery in an OB Van. Live video material from the event was used in the demo.

Figure 3. Demo at the Ericsson innovation Days.

Figure 4. 5G RECORDS Demo team.

3.1.4 Advisory Board meetings

On 25 October 2022, the project presented to the 5G-RECORDS advisory board the work done and the lessons learned in these two years.

Figure 5. Presentation of 5G-RECORDS Project to the Advisory Board by EBU.

During this online meeting, summaries of use cases were presented and fruitful discussions were held on the details of the technologies involved. The agenda was:

1. 5G RECORDS goals (EBU).
2. Use-case 1: Live audio production (Sennheiser).
3. Use-case 2: Live multi-cam production and contribution (TV2/BBC).
4. Use-case 3: Live immersive content production/FVV – Free Viewpoint View (NOKIA).
5. Q&A.

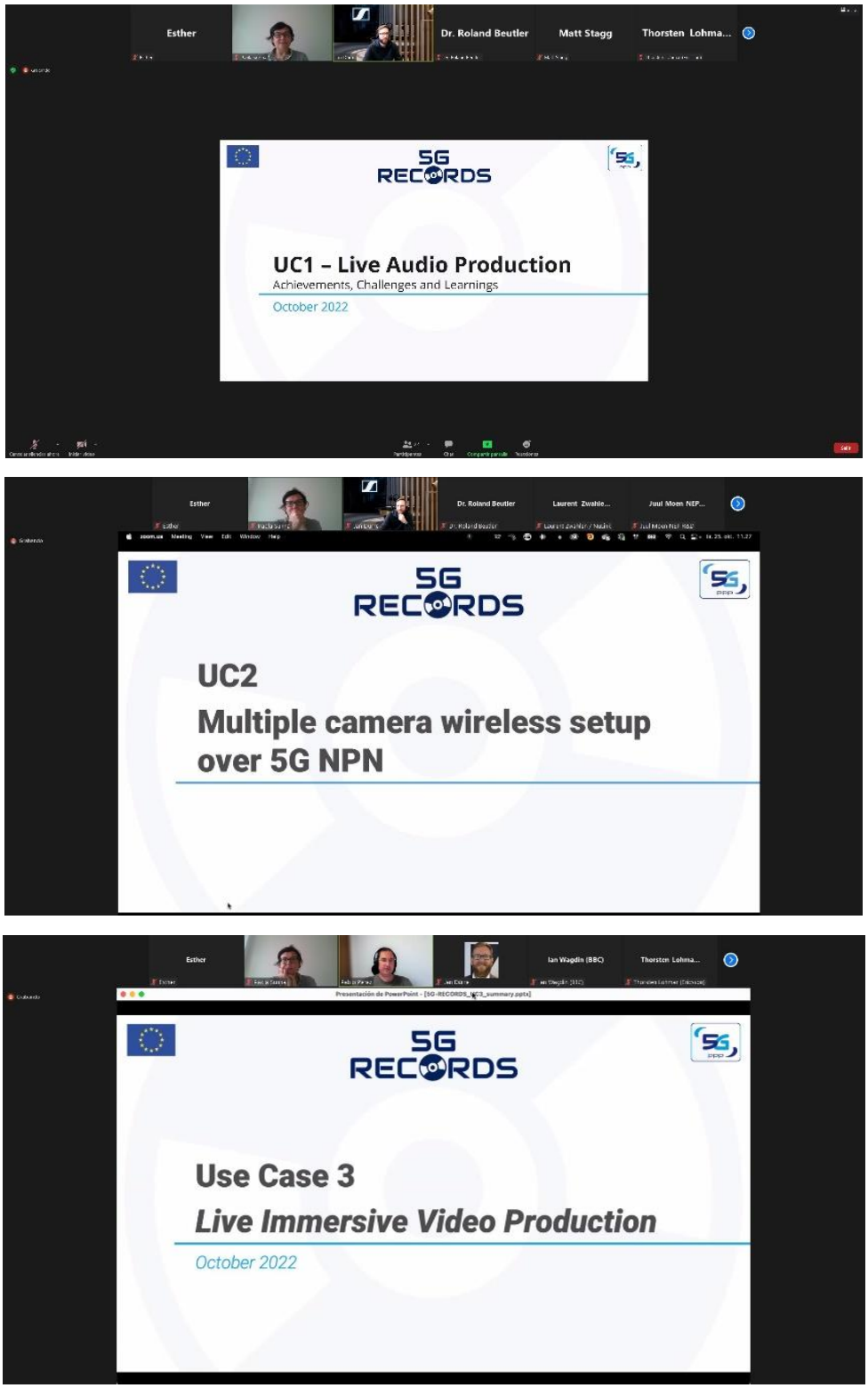

Figure 6. Pictures of presentations of 5G-RECORDS use cases to the Advisory Board by the use case leaders.

3.1.5 Persons reached

In this section, the estimated number of persons reached is specified, in the context of all dissemination activities in each of the following categories:

Table 7. Persons reached.

Events details		Persons Reached								
Name	**Date**	**Scientific community[4]**	**Industry**	**Civil society**	**General public**	**Policy makers**	**Media**	**Investors**	**Customers**	**Others**
After D6.3 in M12										
EBU Project group 5G in content production	Sept. 2021		>60							
EOT-Connect	Sept. 2021		5	75				5		
Danish Sound Cluster Webinar	Sept. 2021		20	70						Online
5G-IA, India TSDSI webinar	Sept. 2021									280
ONF Spotlight Talk	Sept. 2021									Around 30
PROAVEXPO	Oct. 2021			65				2		
4KHDR Summit	Nov. 2021			50						
EBU Forecast	Nov. 2021		220							
5G-MAG Working group Production	Nov. 2021		15							

[4] Higher education, Research.

/reveal/ b<>com	Nov. 2021									>350
DI Digital webinar	Jan. 2022									110
EBU PTS (Production Technology Seminar)	Feb. 2022									>500
ETSI RRS1	Feb. 2022			8			1			
NAB Broadcast	Apr. 2022		40							Online
IP Showcase	Apr. 2022		40							Online
EBU Network Technology Seminar	Jun. 2022									>500
RSPG	Jun. 2022		35			30				
IEEE BTS Pulse 2022	Jul. 2022									>750
SMPTE TC- Meetings										Around 40
IBC 2022	Sept. 2022									Around 10
Ericsson's Innovation Days	Sept. 2022									Around 150
SMPTE Media Technology Summit, 2022	Oct. 2022									Not available
EBU Tech Webinar on 5G-RECORDS	Oct. 2022	2	53		4					Online

Included in D6.3 in M12										
SMPTE Standards Community	Sept. 2020									>100
IEEE BMSB2020	Oct. 2020	44								
5GCP	Nov. 2020	5	15				30			
ETSI RRS	Nov. 2020	1	8			2				
Cambridge Wireless	Dec. 2020									>50
UK5G	Dec. 2020		20							
IEEE BTS	Dec. 2020	181								
VQEG	Dec. 2020	35	35				5			
IEEE BTS Pulse WS	Feb. 2021	50								
5G-PPP Webinar	Feb. 2021	60	60			5	10			
5G-MAG	Feb. 2021		6				1			
5G-PPP SME WG	Mar. 2021		25							
VSF	Apr. 2021									5
AMWA	Apr. 2021									5
5G-MAG WS	Apr. 2021	7	183							
SVG	May. 2021		60							
EOT-CONNECT	Jun. 2021		75							
V5G	Jun. 2021	40	30			5	15			
EuCNC & 6G Summit	Jun. 2021	80								

3.2 Dissemination documents

This section presents the scientific and technical documents containing project outcomes that have been presented elsewhere.

Table 8. Dissemination documents.

Category	Type	Target	Achieved (M12)	Achieved (M26)
Dissemination documents	Journal and conference papers	20	1	11
	Whitepapers		1	1
	Technical reports	---	1	2
	Posters/brochures/Industry Journal	---	2	6
	Tutorials	2	2	2

3.2.1 Journal and conference papers

[1] P. Carballeira, C. Carmona, C. Díaz, D. Berjón, D. Corregidor, J. Cabrera, F. Morán, C. Doblado, S. Arnaldo, M.M. Martín, N. García, "FVV Live: A real-time free-viewpoint video system with consumer electronics hardware", IEEE Trans. Multimedia, vol. 24, pp. 2378-2391, May 2021. 10.1109/TMM.2021.3079711

[2] D. Gomez-Barquero, Jordi G. Gimenez, Gabriel-Miro Muntean, Yiling Xu, Yiyan Wu, "Special Issue on 5G Media Production, Contribution and Distribution.", IEEE Trans. Broadcasting, vol. 68, no. 2, pp. 415-421, June 2022. 10.1109/TBC.2022.3163818

[3] P. Pérez, D. Corregidor, E. Garrido, I. Benito, E. González-Sosa, J. Cabrera, D. Berjón, C. Díaz, F. Morán, N. García, J. Igual, J. Ruiz, "Live Free Viewpoint Video in Immersive Media Production over 5G Networks", IEEE Trans. Broadcasting,vol. 68, no. 2, pp 439-450, June 2022. 10.1109/TBC.2022.3154612

[4] I. Kostiukevych, P. Kondratenko, T. Lohmar, M. Nabil, T. Kernen "Practicalities and analysis of using PTP over 5G systems with dedicated time synchronization support for media production", NAB BEIT, April 2022. [Link]

[5] J. Dürre, N. Werner, P. Matzakos, R. Knopp, A. Garcia, C. Avellán, "A Disaggregated 5G Testbed for Professional Live Audio Production", IEEE BMSB, June 2022. 10.1109/BMSB55706.2022.9828613

[6] P. Sunna, T. Lohmar, M. Nabil, M. Fuentes, A. Rodrigo, P. Ferreira, P. Brightwell, B. Altman, D. Desirello, G. Stante," A Multiple Camera 5G Wireless Studio for Professional Content Production Scenarios", IEEE BMSB, June 2022. 10.1109/BMSB55706.2022.9828740

[7] P. Pérez, L. Janowski, N. García, M. Pinson, "Subjective Assessment Experiments That Recruit Few Observers with Repetitions (FOWR)", IEEE Trans. Multimedia, vol. 24, pp. 3442-3454, July 2022. 10.1109/TMM.2021.3098450

[8] M. Brandstrup, P. Brightwell, D. Desirello, P. Ferreira, M. Fuentes, T. Lohmar, A. Rodrigo Castillo, P. Sunna, I. Wagdin, "5G S-NPN (Standalone Non-Public Network) for Professional Media Production", International Broadcasting Convention (IBC), 2022. [Link]

[9] P. Brightwell, P. Ferreira, T. Lohmar, P. Sunna "Media Gateway and Media Orchestration Control Gateway", SMPTE Media Technology Summit, October 2022.10.5594/M001981

[10] I. Kostiukevych, M. N. Ibrahim, P. Kondratenko, T. Lohmar, T. Kernen "Practicalities and Analysis of Using PTP over 5G systems with Dedicated Time Synchronization Support for Media Production", SMPTE Media Technology Summit, October 2022. 10.5594/M001966

[11] J. Usón, J. Cabrera, D. Corregidor, N. García, “Analysing Foreground Segmentation in Deep Learning Based Depth Estimation on Free-Viewpoint Video Systems”, IEEE Int. Conf. on Consumer Electronics Berlin, ICCE-Berlin 2022, September 2022. 10.1109/ICCE-Berlin56473.2022.9937087

[12] J. Gutiérrez, A. Galán, P. Pérez, D. Corregidor, T. Hernando, J. Usón, D. Berjón, J. Cabrera, N. García, “Subjective Study of the Impact of Compression, Framerate, and Navigation Trajectories on the Quality of Free-Viewpoint Video”, PIES-ME 2022: The First Workshop on Photorealistic Image and Environment Synthesis for Multimedia Experiments, ACM Int. Conf. on Multimedia. ACMMM 2022, Lisbon, Portugal, pp. 27-33, October 2022. 10.1145/3552482.3556553

[13] I. Kostiukevych, M. N. Ibrahim, P. Kondratenko, T. Lohmar, T. Kernen “Supporting Live Production Using Precision Time Protocol Over 5G systems with Dedicated Time Synchronization Support”, SMPTE Motion Imaging Journal, vol. 132, no. 1, pp. 25-39, January 2022. 10.5594/JMI.2022.3220738

3.2.2 Whitepapers

[1] 5G PPP Architecture Working Group, “View on 5G Architecture V4.0”, November 2021. [Link]

3.2.3 Technical reports

[1] P. Pérez, J. Ruiz, D. González, F. Adeyemi-Ejey, K. Brunnström, N. García, J. Gutiérrez, M. Martini, I. Wagdin, “Proposal for scope and use cases for G. QoE-5G”, ITU-T Study Group 12 meeting, contribution SG12-C519, May 2021. T17-SG12-C-0519/

[2] P. Pérez [Editor], ITU-T GSTR-5GQoE “Quality of experience (QoE) requirements for real-time multimedia services over 5G networks”, ITU Technical Report, June 2022. [Link]

3.2.4 Posters, brochures and industry journals

[1] D. Gómez-Barquero, I. Alepuz, C. Avellán, S. García, A. Rodrigo, E. Madejón, N. García, "5G-RECORDS 5G Key Technology Enablers for Emerging Media Content Production Services", Eur. Conf. on Networks and Communications, EuCNC 2021, 2021 Joint EuCNC & 6G Summit, Porto, Portugal, 2021. [Link]

[2] 5G-RECORDS Team, “5G-RECORDS, 5G Key Technology Enablers for Emerging Media Content Production Services”, The European 5G Annual Journal, 2021. [Link]

[3] H. Hoffmann, “5G-RECORDS: making 5G work for the storytellers”, EBU Tech-i magazine, 2021. [Link]

[4] B. Altman, “5G for media and entertainment: from theory to practical use cases”, IABM, 2020. [Link]

[5] B. Altman, “What 5G means for media and entertainment?”, TM Broadcast International, 2020. [Link]

[6] J. Düerre, T. Lohmar, “5G RECORDS: Professional AV-Production and 5G”, FKT Magazine, 2021. [Link]

3.2.5 Tutorials

There have been two tutorials one in the IEEE BTS PULSE and another one an internal tutorial for the 5G-RECORDS partners.

[1] I. Wagdin, “5G in content production - the European perspective”, IEEE BTS PULSE, Feb. 2021. [Link]

[2] T. Lohmar, “5G Technology Enablers for Content Production (Part I)”, IEEE BTS PULSE, Feb. 2021. [Link]

[3] P. Pérez, “5G Technology Enablers for Content Production (Part II)”, IEEE BTS PULSE, Feb. 2021. [Link]
[4] P. Sunna,” 5G Wireless Studio”, IEEE BTS PULSE, Feb. 2021. [Link]
[5] M. Pérez, “5G for Live Audio Production”, IEEE BTS PULSE, Feb. 2021. [Link]
[6] I. Kostiukevych, “PTP + network features influencing the PTP accuracy”, 5G-RECORDS online meeting, Jun. 2021. [Internal]

4 Communication Results

The key to the Communication plan was to disseminate all aspects of the project among the scientific community, professionals in the 5G sector and the general public. So, quantitative targets for measuring the success of these activities along the lifespan of the project were defined:

Table 9. Communication activities.

Category	Type	Target	Achieved (M12)	Achieved (M24)
Communication Results	Website	1	1	1
	Social networks	3	3	3
	Audiovisual resources	6	3	20
	Press releases	15	5	40

4.1 Website

The project website[5], managed by UPM, was unveiled in September 2020 at the beginning of the 5G-RECORDS project. The public portal comprises static contents (e.g. main project objectives, consortium, use cases, infrastructure, etc.) and dynamic contents (e.g. partners' news, videos, events, FAQs etc.).

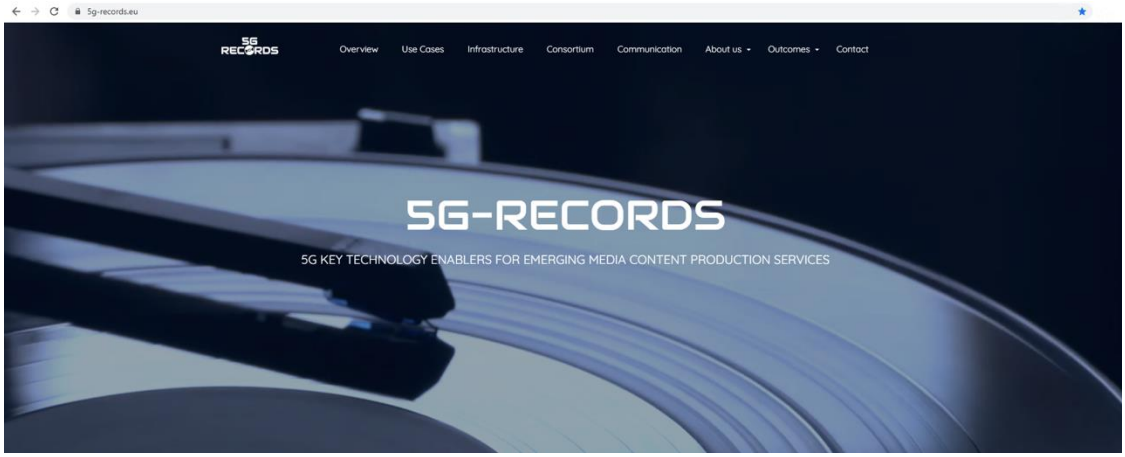

Figure 7. 5G-RECORDS website.

The website also includes a section[6] about dissemination activities where all of them are collected together with their respective references (e.g. scientific publications, presentations, public deliverables, etc.) in order to comply with the EC open access policies.

Figure 8. 5G-RECORDS outcomes.

[5] https://www.5g-records.eu/

[6] https://www.5g-records.eu/index.php/outcomes

The portal web is being regularly updated with all information facilitated by partners and contacts of the project with news about the project and relevant 5G topics.

Figure 9. 5G-RECORDS communication[7].

The partners' news published on the 5G-RECORDS website were:

[1] EBU, "5G in Content Production", December 2019. [Link]
[2] EBU, "EBU report concludes 5G can be made to work for media", June 2020. [Link]
[3] European Commission, "EU boosts investment in 5G", June 2020. [Link]
[4] COREnect, "New consortium to develop a 5G and beyond strategic roadmap for future European connectivity systems and components", July 2020. [Link]
[5] EBU, "The EBU has published its 'Technology Pyramid for Media Nodes' in the SMPTE ST 2110 ecosystem of LiveIP technology.", July 2020. [Link]
[6] UPM," The 5G-RECORDS project kick-off meeting", September 2020. [Link]
[7] LiveU, "5G for media and entertainment: from theory to practical use cases", September 2020. [Link]
[8] EBU, "5G for professional media production and contribution", October 2020. [Link]
[9] UPV, "Convergence of Broadcast and Broadband", October 2020. [Link]
[10] EBU, UPV, UPM, "NEW Deliverable", October 2020. [Link]
[11] EBU, "5G-RECORDS in the 5G in content production group", November 2020. [Link]
[12] LiveU, "What 5G means for media and entertainment", November 2020. [Link]
[13] LiveU, "5G for media and entertainment", November 2020. [Link]
[14] Red Technologies, "ETSI RRS WG1 #52 meeting", November 2020. [Link]
[15] UPV, "5G-RECORDS 2nd Plenary Meeting", December 2020. [Link]
[16] NOKIA/SENNHEISER, "5G Whitepaper", January 2021. [Link]
[17] UPV, "International Day of Women and Girls in Science", February 2021. [Link]
[18] UPV, "IEEE BTS Pulse 2021", February 2021. [Link]
[19] UPV, "5G-PPP Webinar", February 2021. [Link]
[20] EBU, "5G-RECORDS presentation to 5G-MAG", February 2021. [Link]
[21] UPM, "New Deliverable", February 2021. [Link]
[22] UPV, "Non-Public Networks", March 2021. [Link]
[23] Fivecomm, "5G-PPP SME WG meeting", March 2021. [Link]
[24] UPM, "5G-RECORDS 3rd plenary meeting", March 2021. [Link]
[25] EBU, "5G-RECORDS & VSF", April 2021. [Link]
[26] EBU, "5G-RECORDS & AMWA", April 2021. [Link]
[27] UPV, "5G-MAG Workshop", April 2021. [Link]
[28] LiveU, "NEXT GENERATION:5G, IP-bonding and the new world of production", April 2021. [Link]
[29] UPV, Telefonica. "Live 5G", May 2021. [Link]
[30] UPM. "New Deliverable", June 2021. [Link]
[31] UPM, "Connect to the tech future", June 2021. [Link]
[32] UPV, "V5G Day", June 2021. [Link]

[7] https://www.5g-records.eu/index.php/communication

[33] UPM, “Workshop on 5G-NPNs”, June 2021. [Link]
[34] UPM, “Poster paper at EUCNC | 6GSummit”, June 2021. [Link]
[35] UPM, “5G-RECORDS 4th Plenary Meeting”, June 2021. [Link]
[36] UPM, “Live Immersive Content Production”, July 2021. [Link]
[37] UPM, “New Deliverable”, July 2021. [Link]
[38] UPM, “New Deliverable”, July 2021. [Link]
[39] UPM, “New Deliverable”, August 2021. [Link]
[40] UPM/UPV, “5G-RECORDS 5th Plenary Meeting”, September 2021. [Link]
[41] LIVEU, “5GIA-TSDSI Webinar on 5G Tests & Pilots”, September 2021. [Link]
[42] SENNHEISER/TV 2 / UPM, “5G Technology in Pro Audio”, September 2021. [Link]
[43] FIVECOMM/UPM, “Fivecomm and its 5G modems”, October 2021. [Link]
[44] UPM, “New Deliverable”, November 2021. [Link]
[45] UPM, “New Whitepaper”, November 2021. [Link]
[46] UPM/UPV, “MID-TERM Review meeting”, November 2021. [Link]
[47] NOKIA/UPM, “4KHDR Summit”, November 2021. [Link]
[48] UPV/EBU/UPM, “EBU Forecast 2021”, November 2021. [Link]
[49] UPV/UPM, “5G-RECORDS 6th Plenary Meeting”, December 2021. [Link]
[50] UPV/UPM, “5G-RECORDS in the Production Technology Seminar held by EBU”, January 2022. [Link]
[51] UPV/UPM, “The 3rd COREnect workshop”, February 2022. [Link]
[52] UPM, “Newsletter 2: “Women in 5G-RECORDS””, February 2022. [Link]
[53] UPM/UPV, “5G-RECORDS 7th Plenary Meeting”, February 2022. [Link]
[54] EBU, “Disagreements Over Frequency Sharing Between Digital Broadcast And Mobile Ahead Of WRC-23”, March 2022. [Link]
[55] EURECOM/ACCELLERAN/UPM, “Mobile World Congress 2022”, March 2022. [Link]
[56] UPM, “IEEE Transaction on Broadcasting”, March 2022. [Link]
[57] ACCELLERAN/ EURECOM, “Accelleran and RED Technologies successfully perform 5G Shared Access Spectrum interoperability”, March 2022. [Link]
[58] NOKIA/UPM, “Another step forward in the integration of the use case 3”, April 2022. [Link]
[59] UPM, “New Deliverable”, April 2022. [Link]
[60] EBU, “Practicalities and analysis of using PTP over 5G systems with dedicated time synchronization support for media production”, April 2022. [Link]
[61] UPM/UPV, “5G-RECORDS 8th Plenary Meeting”, May 2022. [Link]
[62] LiveU/UPM, “LiveU”, May 2022. [Link]
[63] EBU/BBC/BISECT, “Network Technology Seminar” [Link]
[64] SENNHEISER/UPV/5G-MAG, “IEEE International Symposium on Broadband Multimedia Systems and Broadcasting 2022”, June 2022. [Link]
[65] EBU, “Radio Spectrum Policy Group Workshop”, June 2022. [Link]
[66] UPM/UPV, “5G-RECORDS 9th Plenary Meeting”, June 2022. [Link]
[67] EBU "TV2 Hosts EBU Members and Partners for 5G Live Production Tests in Copenhagen", July 2022 [Link]
[68] UPM, “New Deliverable”, July 2022. [Link]
[69] NOKIA/UPM, “Field Trial of Use case 3: Live Immersive Content Production”, July 2022. [Link]
[70] UPM, “New Deliverable”, September 2022. [Link]
[71] UPM, “New Deliverable”, September 2022. [Link]
[72] UPM, “5G-RECORDS 10th Plenary Meeting”, October 2022. [Link]
[73] UPM/EBU, “EBU Tech Webinar on 5G-RECORDS” October 2022. [Link]
[74] UPM/EBU, “5G-RECORDS Advisory Board meeting” October 2022. [Link]

4.2 Social Networks

The project has considered that online media are very effective to reach as much scientific and industrial community industry as a general public. Thus, three accounts on different social networks (YouTube[8], LinkedIn[9] and Twitter[10]) have been created and managed by UPM.

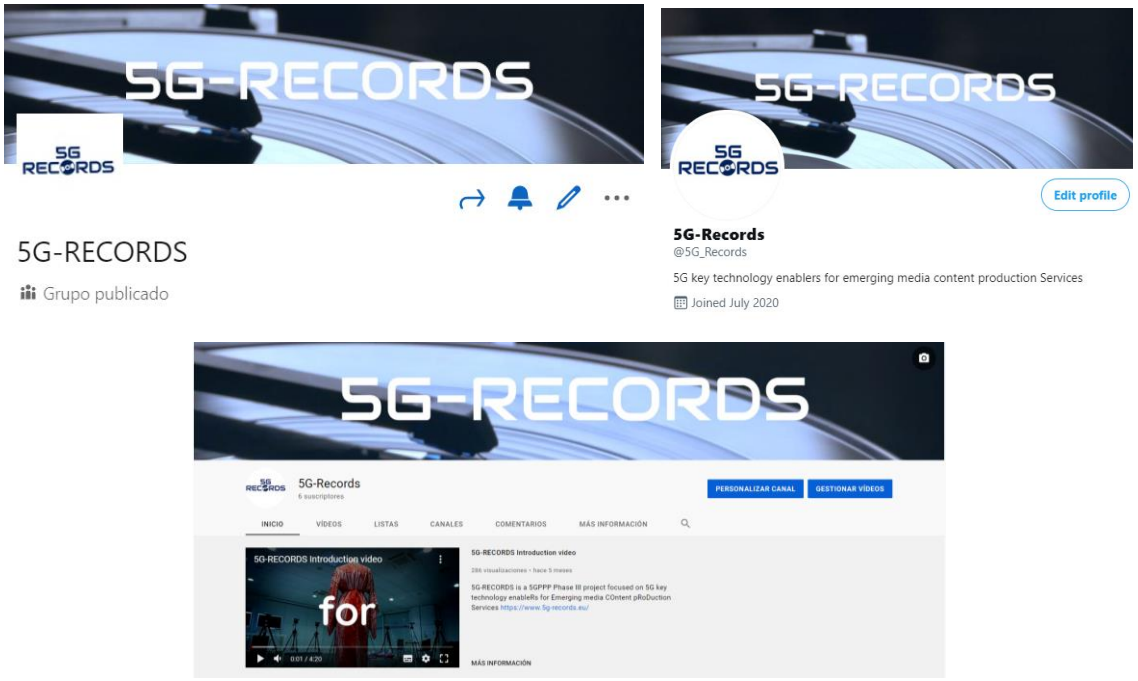

Figure 10. 5G-RECORDS social Networks.

Those social network accounts have been populated with the ongoing updates of the project and partner's news published on the website. During the second year of the 5G-RECORDS's lifetime and thanks to the active participation of the project's partners on the publication of their latest news, the project's social networks have earned a large number of followers and impressions, reaching a large number of audiences as can be seen in Table 10.

Table 10. Social Networks of 5G-RECORDS (Updated on 28 October 2022).

Category		Twitter (M12)	Twitter (M26)	LinkedIn (M12)	LinkedIn (M26)	YouTube (M12)	Youtube (M26)
Social networks	Followers	147	255	214	560	6	27
	News	126	220	126	235	3	17
	Impressions[11]	289	738	584	1609	327	1705

[8] https://www.youtube.com/channel/UCXIjFcm_Ee8sXzjmS3cJUJw

[9] https://www.linkedin.com/groups/8964293/

[10] https://twitter.com/5G_Records

[11] Clicks, likes, retweets, visualizations, etc.

4.3 Press Releases

In the Communication plan, a minimum number of press releases was defined (Table 11).

Table 11: Minimum list of press releases.

Type	Name	Leader	When
Overview	The key challenge of 5G-RECORDS	UPV	2020
Components Definition	5G microphones and IEM systems	Sennheiser	2021
	Spectrum sharing management technologies	RED Technologies	
	Compact 5G Core	Cumucore	
	Dynamic Profile Controller		
	dRAX platform	Accelleran	
	5G-enabled cellular bonding	LiveU	
	OAK module	Image Matters[12]	
	Edge computing platform	Telefónica	
	Free Viewpoint Video	UPM	
Use Cases	Live audio production	Sennheiser	2021
	Multiple camera wireless studio	BBC/TV2	
	Live immersive video production	NOKIA/UPM	
Outcomes	Achieved goals	UPV	2022
	Results	Nokia / Eurecom / Ericsson	

The number of press releases issued by project partners in relation to their work have exceeded the planned targets.

Some partners have had problems publishing their press releases on their own corporate websites, so several partners have teamed up and published on different websites, varying the number of press releases published per partner.

The press releases that were delivered by project partners were:

[1] N. García, “5G-RECORDS, 5G key technology enableRs for Emerging media COntent pRoDuction Services, European Commission”, Information Processing and Telecommunications Center (IPTC Review), October 2020. [Link]

[2] M. Fuentes, “5G-RECORDS: showcasing the real power of 5G for professional content production” Fivecomm, October 2020. [Link]

[3] Universitat Politècnica de València (UPV), “5G-RECORDS”, UPV, May 2021. [Link]

[4] eNEM, “5G key technology enableRs for Emerging media COntent pRoDuction Services, European Commission (5G-RECORDS)”, eNEM, May 2021. [Link]

[12] Image Matters left the 5G-RECORDS project in February 2022.

[5] I. Wagdin, “Trials and challenges: Unlocking the potential of 5G for sports broadcast production”, Sport Video Group Europe, July 2021. [Link]
[6] EBU, “EBU tests content production on private 5G networks in 5G-RECORDS project”, EBU website, February 2022. [Link]
[7] UPM, “5G-RECORDS: “Special newsletter for the Day of Women and Girls in Science”, 5G-PPP, February 2022. [Link]
[8] UPM, “El papel de las mujeres científicas en el desarrollo del 5G”, UPM, February 2022. [Link]
[9] UPM, “International Day of Women and Girls in Science” Grupo de Tratamiento de Imágenes (UPM), February 2022. [Link]
[10] UPM, “Día Internacional de la Mujer y la Niña en la Ciencia” ETSIT-UPM, February 2022. [Link]
[11] Accelleran, RED Technlogies, “Accelleran and RED Technologies successfully perform 5G Shared Access Spectrum interoperability”, PRNEWSWIRE, March 2022. [Link]
[12] LiveU, “LiveU Demonstrates the Combined Power of 5G Slices and Bonding for Remote Contribution”, LiveU, May 2022. [Link]
[13] LiveU, “LiveU tests 5G network slicing for remote production”, TVB EUROPE, May 2022. [Link]
[14] LiveU,” LiveU Demonstrates Combined Power of 5G Slices And Bonding For Remote Contribution”, TVNewsCheck, May 2022. [Link]
[15] LiveU,” LiveU Demonstrates the Combined Power of 5G Slices and Bonding for Remote Contribution”, SVG NEWS, May 2022. [Link]
[16] LiveU, “LiveU Demos 5G Slices and Bonding Combined for Remote Contribution”, Digital media world, May 2022. [Link]
[17] LiveU, “LiveU demos 5G network slicing, bonding in remote contribution”, Rapid TV News, May 2022. [Link]
[18] LiveU, “LiveU Tests How 5G Slices Can Serve Global Media Remote Production”, 4rfv.co.uk, May 2022. [Link]
[19] LievU, “LIVEU DEMONSTRATES THE COMBINED POWER OF 5G SLICES AND BONDING FOR REMOTE CONTRIBUTION”, Kitplus, May 2022. [Link]
[20] LiveU, “LiveU Demonstrates the Combined Power of 5G Slices and Bonding for Remote Contribution”, iamb, May 2022. [Link]
[21] LiveU, “LiveU Demonstrates the Combined Power Of 5G Slices And Bonding For Remote Contribution”, The Broadcast Bridge, May 2022. [Link]
[22] LiveU, “LiveU tests content streaming capability over 5G slices together with Ericsson and RAI”, TM Broadcast International, May 2022. [Link]
[23] LiveU, “LiveU Demonstrates the Combined Power of 5G Slices and Bonding for Remote Contribution”, In Broadcast, May 2022. [Link]
[24] LiveU, “LiveU Demonstrates the Combined Power of 5G Slices and Bonding for Remote Contribution”, Thefuture.tv, May 2022. [Link]
[25] LiveU, “LiveU Demonstrates the Combined Power of 5G Slices and Bonding for Remote Contribution”, Broadcast & Cablesat, May 2022. [Link]
[26] LiveU, “LiveU Demonstrates the Combined Power of 5G Slices and Bonding for Remote Contribution “, Digital studio, May 2022. [Link]
[27] LiveU, “LiveU demonstra fatiamento de rede 5G, ligação em contribuição remota”, UpLinkBr, May 2022. [Link]
[28] LiveU, “LiveU tested how 5G slices can serve global media remote production”, Broadcast Beat, May 2022. [Link]
[29] LiveU, “Remote contribution: LiveU to test 5G network capabilities”, FKT, May 2022. [Link]
[30] EBU, “Live Media Production with 5G – Testing a New Architecture for Multiple Wireless Cameras”, EBU website, May 2022 [Link]

[31] LiveU, “LiveU tests “network slicing” on 5G networks for remote TV production”, Archynewsy, June 2022. [Link]
[32] LiveU, “LiveU tests “network slicing” on 5G networks for remote TV production”, Venezuela Detail Zero, June 2022. [Link]
[33] LiveU, “LiveU teste le «network slicing» sur les réseaux 5G pour la production télévisée à distance”, News,dayFR, June 2022. [Link]
[34] LiveU, “LiveU prueba «network slicing» en redes 5G para la producción remota de TV”, Alta Densidad, June 2022. [Link]
[35] LiveU, “LiveU Demonstrates Combined Power of 5G Slices and Bonding”, Content Technology, June 2022. [Link]
[36] M. Brandstrup, “5G – fremtiden er sikret?”, PROAV magazine, June 2022. [Link]
[37] EBU, “Temporary, Nomadic and Cross-Border – EBU Explains Media Needs for 5G Non-Public Network Licenses at EU Forum”, EBU website, June 2022 [Link]
[38] EBU, ”TV 2 Hosts EBU Members and Partners for 5G Live Production Tests in Copenhagen”, EBU website, June 2022 [Link]
[39] M. Fuentes, “Fivecomm as key 5G enabler for professional content production” Fivecomm, July 2022. [Link]
[40] F. Pandolfi, G. Stante, “Rai CRITS experience in 5G-RECORDS EU Project”, Publication date: around 10/15 November 2022, [Link]
[41] L. Gaye, “5G RECORDS project Wrap-up: One step closer to media production over 5G”, [Link]

4.4 Audiovisual resources

The 5G-RECORDS Communication plan considered that audiovisual content delivery is a must for the project outreach. The table below lists the videos that should be produced throughout the project.

Table 12: Videos.

Type	Name	Leader	When
Overview	The key challenge of 5G-RECORDS	EBU/UPV/UPM	2020
Components Definition	5G microphones and IEM systems	Sennheiser	2021
	Spectrum sharing management technologies	RED Technologies	
	Compact 5G Core	Cumucore	
	Dynamic Profile Controller		
	dRAX platform	Accelleran	
	5G-enabled cellular bonding	LiveU	
	OAK module	Image Matters[13]	
	Edge computing platform	Telefónica	
	Free Viewpoint Video	UPM	
Use Cases	Live audio production	Sennheiser	2021
	Multiple camera wireless studio	BBC/EBU	
	Live immersive video production	NOKIA/UPM	

[13] Image Matters left the 5G-RECORDS project in February 2022.

Outcomes	Achieved goals	EBU/UPV/UPM	2022
	Results	Nokia / Eurecom / Ericsson	
Media	Media services orchestration	BBC/BISECT	2021
Broadcasters	RAI and 5GRecords	RAI	2021
	TV2 and 5GRecords	TV2	2021
	Red Bee and 5GRecords	Red Bee	2021

During the life of the 5G-RECORDS project, the following videos have been produced, increasing the expected figures:

[1] I. Wagdin, D. Gómez-Barquero, R. Ortíz, P. Pérez, M. Nabil, R. Knopp, P. Sunna, N. Werner, T. Lomar, I. Alepuz, E. Madejón, D. Corregidor, "RECORDS Introduction video", February 2021. [Link]
[2] J. Duerre, C. Avellán, E. Madejón, "Use Case 1: Live audio production", June 2021. [Link]
[3] M. Messaoudi, C. Le Thierry, "Use Case 1: Spectrum sharing management technologies", July 2021. [Link]
[4] P. Pérez, J. Cabrera, E. Garrido, "Use Case 3: Live immersive content production", October 2021. [Link]
[5] C. Cortés, C. Carmona, D. Corregidor, C. Doblado, F. Morán, E. Madejón "Use Case 3: Free Viewpoint video- FVV-Live", December 2021. [Link]
[6] A. García, M. Esawi, E. Madejón, "Use Case 1: dRAX", December 2021. [Link]
[7] B. Altman, E. Madejón, "Use Case 2: 5G-enabled cellular bonding", December 2021. [Link]
[8] J. Igual, E. Garrido, "Use Case 3: Edge Computing Platform", January 2022. [Link]
[9] I. Wagdin, "Use Case 2: Multiple camera wireless studio", April 2022. [Link]
[10] N. Werner, E. Madejón, "Use Case 1: Microphone and In Ear Monitoring", May 2022. [Link]
[11] J. Costa-Requena, E. Madejón, "Use Case 1: Network Slicing", June 2022. [Link]
[12] D. Desirello, E. Madejón, "Demonstration of camera control using NMOS and MQTT", June 2022. [Link]
[13] D. Corregidor, D. Berjón, J. Usón, J. Cabrera, E. Madejón, "Use Case 3: FVV-Live – Quality of Experience", July 2022. [Link]
[14] M. Garrido, E. Madejón, "Use Case 3 Trial: Line immersive content production", August 2022. [Link]
[15] M. Messaoudi, C. Le Thierry, "Use Case 1: Spectrum sharing management technologies (Phase 2)", September 2022. [Link]
[16] EBU, 5G-RECORDS: Orchestrator Designs, EBU website, September 2022 [Link]
[17] EBU, 5G-RECORDS: Media Gateway Designs, EBU website, September 2022 [Link]
[18] M. Brandstrup, "Use Case 2 Trial: Multiple camera wireless studio", October 2022. [Link]
[19] EBU, 4 video interviews, October 2022. [Link]
[20] L. Gaye, D. Gómez-Barquero, T. Lohmar, I. Wagdin, M. Brandstrup, T. Lohmar, P. Brightwell, J. Dürre, D. Ratkaj, "EBU Tech Webinar on 5G-RECORDS", October 2022. [Link]

Although the project ends on 31 October, videos will continue to be produced. A video on trial use case 1, a video on the 5G modem component and a final video, in which the partners talk about the project's achievements, are planned.

The project has also produced an interactive experience about the project which is already up and running on the website: https://www.5g-records.eu/index.php/communication/demos.

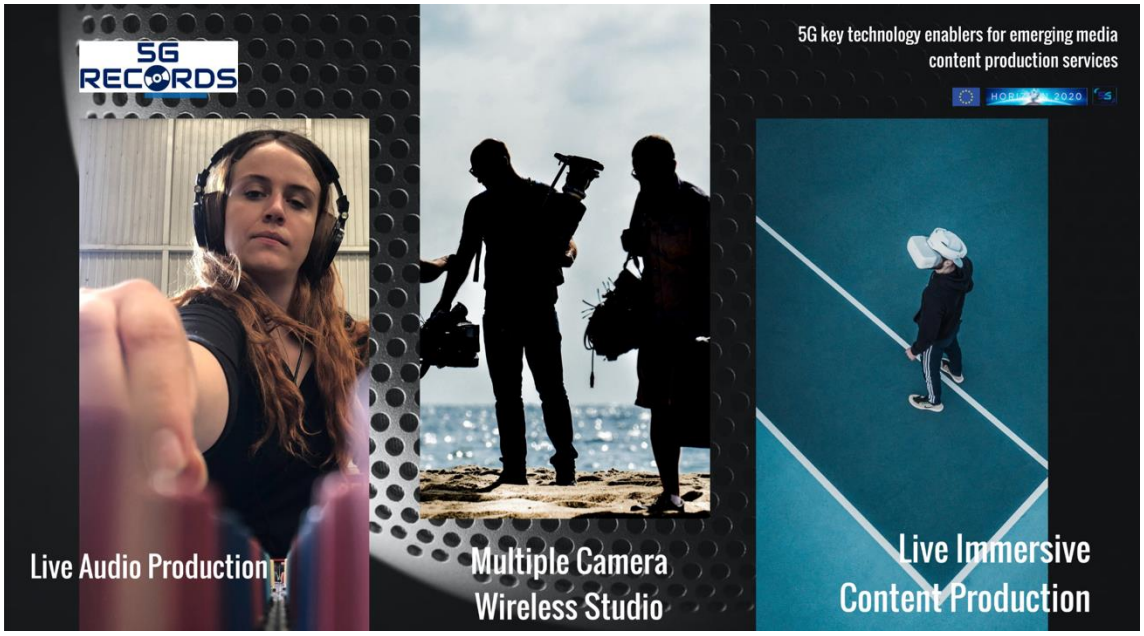

Figure 11. Online interactive experience.

4.5 FAQs

[1] L. Gaye, T. Lohmar, P. Sunna, I. Wadgin, M. Skarp, P. Brightwell, R. Berozashvili, P. Kondratenko, J. F. Nivart, P. Ferreira, A. Garcia, I. Hassan, I. Kostuikevych, P. Perez, M. N. Ibrahim, R. Ortiz Peña, M. Brandstrup, B. Altman, D. Ratkaj, J. Gimenez, S. Thompson, “FAQs on professional media production using 5G NPNs”, October 2022. [Link]

4.6 Newsletters

In the 5G-RECORDS communication plan, the project committed to distribute its own newsletter. Two newsletters have been published so far and one more is planned to be published after Use Case 2 Trial.

In total, one newsletter for each year of the project's life plus a special edition:

[1] D. Gomez-Barquero, E. Madejón,” 5G-RECORDS "5G Key Technology Enablers For Emerging Media Content Production Services", September 2021. [Link]
[2] D. Gomez-Barquero, E. Madejón, “5G-RECORDS Trials”, (Publication date: After the UC1 trial).

And the special one was to commemorate the International Day of Women and Girls in Science” with testimonials from women involved in research tasks within the 5G-RECORDS project.

[3] P. Sunna, I. Alepuz, R. Ortíz, E. Madejón, C. Avellán, N. Cilleruelo, M. Pérez, M. Messaoudi, T. Pardo, M. Assis, E. González, E. Sánchez, S. Thilakawardana, L. Gaye, “International Day of Women and Girls in Science”, February 2022. [Link]

5 Exploitation Results

5.1 Individual exploitation plans

The consortium members have targeted some of objectives listed in the following:

1. Enhance products and services portfolio
2. Speed-up the development
3. Validation and improvements of the current products and services
4. Influence business strategy decisions
5. Scaling up business and revenues
6. Planning alternative services related to content production complementing the existing workflows
7. Engaging with the industry partners and the regulators on issues beyond the technical aspects, i.e., 5G deployment models, business arrangements and regulatory conditions.
8. Developing software and hardware for future (public-domain) collaborative projects and by industry and academia around the world

5.1.1 Nokia

In 5G-RECORDS, Nokia has designed and validated a portable 5G end-to-end solution based on millimeter wave (mmW) technology, including RAN access, 5G core, MEC and specific VNFs to provide multimedia processing and KPI gathering. The target for this solution was to be exploited at three different levels: as a blueprint design for smart venues and similar venue-oriented deployments, as a test bed for 5G in mmW for several Nokia business units, and as a research platform for Nokia.

The blueprint design created in the project is already being used as the baseline for the deployment of two non-public-networks in Spain: a 5G island in mmW band to provide automation services in rural areas, to be deployed in a rural location in the province of Soria (Spain), and a deployment to provide health and communication services in the premises of *Fundación Juan XXIII* in Madrid (Spain). The lessons learnt from the results have also been disseminated to the Nokia team coordinating the technology demonstrations in the flagship smart venue Nokia Arena in Tampere (Finland).

The platform deployed in the project has been also used by Nokia Mobile Networks business unit to perform performance and coverage tests in FR2. Several measurement campaigns have been done, both in Madrid and Segovia trial sites.

The platform has been used as well for research purposes, beyond the scope of 5G-RECORDS. Several additional use cases have been tested on the deployment design in the project, such as streaming 360-degree video to provide immersive music therapy to elderly patients, or offloading XR algorithms to the MEC to provide richer immersive experiences.

From a broader perspective, 5G-RECORDS have been used to validate the possibility to use 5G networks to support immersive media processing pipelines, such as Free-Viewpoint Video or eXtended Reality. The project has served to find the capabilities of the existing generation of technology and to identify the next steps to improve. These results have been presented internally in the Advanced Technology Group in Nokia to influence business strategy decisions in core and mobile networks.

5.1.2 Fivecomm

Thanks to 5G-RECORDS, Fivecomm has designed from scratch, developed, and validated a 5G Release-15 modem to be integrated as part of the end-to-end infrastructure. The first phase of the project was dedicated to a first design of the modem,

completely compatible with both standalone and non-standalone networks, which works at most of the low- and mid-band frequencies available. Fivecomm designed the modem in a plug and play fashion, with an open graphical interface based on OpenWRT that permits any user to configure it and make changes in an easy manner. This device is now part of our main portfolio being commercialized, and it can be used for multiple verticals and applications.

In the second phase of the project, Fivecomm took this product and developed it further, with the final objective of providing a portable solution that could be easily attached to professional video cameras. One of the key features of this prototype is the delivery of streams produced by 5G-enabled wireless cameras to an IP production studio with minimum latency through a non-public 5G network.

The portable solution is formed by our 5G module, connected via USB to an NVIDIA Jetson Xavier, which acts as operative system and encoder. It is additionally connected to an SDI card that is used to capture the video from the camera. To make the solution portable and to be plugged into the professional camera, a 3D case was designed and printed. The case comes not only with an external button to power it up, but also with external SMA connectors for mid-band 5G antennas, 3 LEDs for monitoring the status of the 5G modem, and two V-locks that are used to plug an external battery and the entire solution to the camera.

This prototype was part of the wireless studio final trial, which took place in the Tivoli gardens in Copenhagen. It was a complete success and served us all to understand the great potential of 5G private networks for professional content production scenarios. From now on, Fivecomm plans to keep investigating on this subject and work towards a final product that can be used in the future.

5.1.3 UPM

UPM has evolved its real-time end-to-end Free Viewpoint Video system, FVV Live, to be able to operate on a 5G network. All four main modules of FVV Live, namely capture, transmission, rendering, and user control, have been updated and optimized for 5G and cloud environments. In addition, new components have been developed to enhance the system portability, ease its deployment, and improve its scalability. One of UPM's exploitation objectives was to improve its understanding of the new possibilities that 5G offers to alleviate the deployment, interconnection and transmission challenges associated with the stringent latency and data rate requirements of FVV systems. This objective has been fully fulfilled and UPM's findings and new knowledge are being adapted and included in its research activities and ongoing projects related to immersive communications.

Moreover, UPM has presented FVV Live at the *deep tech venture validation programme*, *UPM2T*, organized by ACTUA-UPM. The result has been very satisfactory: FVV-Live was awarded the second prize and included in the portfolio of UPM's exploitable technologies.

5.1.4 Accelleran

Accelleran has improved its cloud native and Open RAN dRAX commercial product offering in different fronts and with different levels of commercialisation:

- Accelleran dRAX CU enhancements – low latency

  Available as a GA customer release now, the Accelleran dRAX commercial CU component has been improved with enhanced performance and latency functionality as a result of the activities of the project to enable the lowest latency possible and highest performance in the CU UP component.

- Accelleran dRAX CU enhancements – Ethernet PDU Type

Ready to be part of a GA customer release once commercial UEs in the market are available for final end to end target testing. Accelleran dRAX commercial CU has been improved with the support of Ethernet Type PDUs that is a key functionality to support 5G LAN and Ethernet replacement in Industry 4.0. As soon as commercial UEs that can support Ethernet PDU Type are available in the market Accelleran will validate the feature end to end with those UEs and will make it part of the Accelleran dRAX GA customer release.

- Accelleran dRAX CU enhancements – QoS (DSCP)

Available as a GA customer release now, the Accelleran dRAX commercial CU component has been improved with traffic prioritization on NG and F1 interfaces based on DSCP markings for end-to-end QoS including transport resources.

- Accelleran dRAX Cloud Native and disaggregated RAN CBRS solution

Start of the productization of a Cloud Native and disaggregated RAN CBRS solution to be commercialized during 2023. This productization is still ongoing, but its Shared Access Spectrum client component has already been interoperability tested with RED Technologies SAS server as part of validation activities in the 5G-RECORDS project. This can lead to joint exploitation of commercial Shared Access Spectrum offerings with RED Technologies.

- Accelleran dRAX CU ecosystem diversification – OAI based DU/RU

The open RAN ecosystem supported by Accelleran dRAX CU has been diversified with the inclusion of the support of OAI as open-source platform for certain types of lab PoC customers requiring OAI based DU/RUs. The integration has been done for the F1 interface with dRAX CU. Future integrations will be done in the context of other projects in alignment to OAI roadmap for E2/O1 interfaces with dRAX RIC/SMO. This integration with OAI can lead to joint exploitation with OAI based DU/RUs.

- Accelleran dRAX CU ecosystem diversification – Cumucore based 5GC

The open RAN ecosystem supported by Accelleran dRAX CU has been diversified with the inclusion of the support of Cumucore 5GC. A specific commercial joint exploitation between Accelleran and Cumucore for a particular commercial customer field trial project is already ongoing as a result.

5.1.5 Sennheiser

Sennheiser has developed and validated a 5G-compatible audio system to evaluate and demonstrate the performance of 5G systems. A cloud-based proof-of-concept remote production software that allowed to perform measurements and trials without the need to be on-site is also part of that system. Through the work done in this project we were able to gain in-depth knowledge about the current state-of-the-art of 5G technology, ecosystem, and available implementations. We analyzed the impact of different network topologies (disaggregated/monolithic RAN) and deployments. Additionally, we were able to gain deep insight into future customer needs in the context of IP-based production scenarios. Furthermore, we were able to discuss and develop together with the project partners relevant business aspects that come with potential 5G production workflows. All this knowledge is of highest relevance so Sennheiser and is essential to support far-reaching strategic business decisions.

5.1.6 BISECT

5G-RECORDS helped BISECT develop the Media Gateway and build a Minimum Viable Product. This MVP is being used by a group of beta testers, namely broadcasters internal and external to the project. BISECT will receive their feedback and integrate any proposed changes into the Media Gateway, which will then be made available to the market as a product.

BISECT is currently extending the MG to support new transport protocols and codecs, as well as adding more advanced configuration and monitoring functionalities. Also, one of the most relevant features of the MG, the WebRTC monitoring components, are being licensed separately to manufacturers that wish to add low-latency monitoring to their products.

In addition to this, BISECT is leveraging the developments that have been made in the realm of 5G-RECORDS to develop a new platform, called Plateau, that can be used to build flexible pipelines for media processing, including real-time monitoring of video and audio, an open API for controlling processing parameters and centralized gathering of metrics, events and logs.

Both the Media Gateway and Plateau can be run in bare-metal, containerized or within a Kubernetes cluster.

5.1.7 TV2 Denmark

During the project period with lab test, and even during restrictions and lockdown, TV 2 was serval times part of the team in Eurolab Aachen, lab testing UC2. This gave valuable insight and understanding of 5G SA NPN, an understanding and knowledge brought back and share with the wider media industry.

Learnings and understanding of central 5G NPN technology have been taken into discussion and dialog with MNO, technology partners and potential service provider, to promote an understanding of the potential of business models and user case. This has raised an awareness and been a fruitful conversation, wish is expected to continue after 5G-RECORDS are finish as a project.

In the last phase of the project, TV 2 lead the trail production in TIVOLI Copenhagen, and this brought all UC 2 partners physical together for the first time. This trail was at the same time used as an option for the wider Danish and Nordic 5G industry, to have a closer look and demo of the project. More than 50+ professionals was visiting the trail studio and had an introduction to UC2 5G-RECORDS setup.

Figure 12. Guest visiting TIVOLI Trail production.

UC2 trail production in TIVOLI was used as a live insert to a “5G for professional usage” conference, hosted by the Danish regulator, The Confederation of Danish Industry (DI) and TV 2. With +120 telco professional participating, and Tour de France 2022 official

presentation as backdrop, 5G-RECORDS had an important footprint on the industry, with a clear user case and example of 5G usage. Collaboration with the Danish regulator during the trail production and the usage of n77 spectrum for temporary usage is an example of important dialog.

Figure 13. UC2 Trail production live to conference.

In October 2022 TV 2 was awarded with the Danish telco industry' TELE2022 award, given for the outstanding example and usage of 5G in Media Production. A clear message from the industry, that they recognise the work done in and around 5G-RECORDS.

Figure 14. TELE2022 award.

5.1.8 BBC

BBC R&D is developing prototypes for camera interface units based on work carried out in UC2, aimed at supporting future technology trials for BBC productions as well as providing tools for further 5G research. This includes designs based on the NVIDIA Jetson platform and the KRIA / Xilinx platform (also used by Image Matters). BBC has procured a S-NPN system to further address many of the areas that have been identified as important during 5G-RECORDS (e.g. latency, synchronisation and cell handover). We are working with a containerised version of Bisect's Media Gateway prototype as part of our wider investigation of automated and software-based live media production. The VPN and automation approaches developed in the project continue to be used in future work. The work on NMOS with H.265 is informing our input into ongoing specification work in AMWA, as does the work on MQTT-based discovery and configuration. As well as participation in the Tivoli trial, we also carried out trials at 2022 Commonwealth Games to further explore many of the technology areas related to UC2.

5.1.9 EBU

The EBU is an association of public service media providers, and facilitates collaboration between its members as well as with wider industry, SDOs and academia.
In 5G-RECORDS, part of UC2 was about testing live production using multiple 5G-enabled cameras and enabling a seamless connection between 5G and IP based production facilities.
This use-case was well aligned with a number of EBU activities such as the 5G for Content Production, 5G-MAG and the work conducted on IP studios.
The technical results (e.g., PTP performances over 5G networks, trials results), the 5G deployment models (e.g., business arrangements and regulatory conditions), the gateways (media and orchestration) design and implementation have allowed the EBU to gain an experience that will be used to assist its members in their strategic decisions for the adoption of 5G and the interaction with SMPTE ST 2110 IP based implementation projects. The EBU has already put in contact some EBU members with the partners involved in the development of the media gateways. The PTP performances evaluation carried out by the EBU and Ericsson is very valuable also for other projects. The considerations made in the WP2 working group led by the EBU on business models and regulatory issues and in particular those related to the Spectrum access for 5G non-public networks used in professional content production have been submitted and discussed at the RADIO SPECTRUM POLICY GROUP on Peer Review and Member State cooperation on authorisations and awards STAKEHOLDER WORKSHOP held in June 2022. These findings will also be the basis for submissions to CEPT work in response to the Commission's mandate on the shared use of the frequency band 3.8-4.2 GHz for local area networks. The work done by 5G RECORDS has reached hundreds of people representing EBU Members organizations, services and technology providers, standards organization during the EBU flagship conferences like the Production Technology Seminar and the Network Technology Seminar, as well as a dedicated EBU Tech Webinar about the project.

5.1.10 Ericsson

Ericsson has provided 5G Network connectivity initially for lab activities and later for trials and demonstrations of Use Case 2. During the tests and trial activities, a good understanding around the usage of 5G Technology within the Media Production (PMSE) industry vertical has been created. A number of relevant 5G System features have been identified and trialed: The Non-Public Networks feature has sub variants, i.e. dedicated networks with SNPNs or a share of a wide area public network using network slicing. The SNPN variant is specifically relevant for high quality media production, where equipment is deployed at an event. For the remote contribution scenario, specifically network slicing is relevant.

Usage of dynamic Quality of Service is relevant for both realizations (SNPNs and PNI-NPNs), e.g. to mitigate self-congestion and to separate different usages of 5G. A network exposure function is needed to enable sufficiently flexible access to this network function.

Precise time synchronization is specially needed for multi-camera productions, where the capturing process of all involved cameras needs to get synchronized. In the 3GPP specifications, time synchronization is defined as a part of Time Sensitive Communication.

Ericsson is sharing the gained knowledge leveraging demonstrations and presentations to partners. Specifically, the need for different kinds of connectivity, on Wide Area networks and within dedicated, confined areas. Ericsson will continue sharing its findings

specifically towards mobile operators. Several mobile operators are highly interested in the use cases and the results.

5.1.11 Telefónica I+D (TID)

Telefonica I+D (TID) is the innovation company of the Telefonica Group. It contributes to the Group's competitiveness and modernity through technological innovation. To achieve this, the company applies new ideas, concepts, and practices in addition to developing advanced products and services.

Telefonica plan to use 5G-RECORDS architecture and its approach to improve the solutions towards Media customers, leveraging our edge in the network. Our technology has been a key component to validate the media delivery end to end. With our QoS enabled edge solution, we´ve been able to capture the immense traffic coming from the 5G access network and deliver it to the Media processing in best conditions.

TID aim to build a value proposition over network slicing using programmable network and open platforms, with special focus on use cases of media distribution and immersive communication. We will integrate the results of 5G-RECORDS to improve our own innovations around the edge computing and make them more competitive and future proof, verifying the value to provide a network as a service with broadcaster and 3rd partners developers. We are offering commercial solutions for edge services.

One of the most notable achievements within the use case in which we have participated is the technological solution, which has proved to be flexible to integrate seamlessly solutions with three different video origins (Lab, Segovia and Nokia Center) and support the tests in all three set ups with minimal impact thanks to the SDN technology.

5GRecords has presented an interesting challenge to integrate a variety of technologies for access networks delivering media to our platform. We have learned and improved our solution to be flexible enough while maintaining the QoS capabilities key for the project.

The learnings from 5GRecords have been used in other projects in Telefónica (Pilotos 5G Madrid) and will help us shaping our commercial solutions to be competitive in the market.

5.1.12 UPV

Universitat Politècnica de València will exploit the results and experience gained from the project in further expanding their knowledge base in the field and staying competitive for future wireless media research initiatives, in enhancing their teaching scope and quality by introducing new project findings and cutting-edge technologies into the teaching and research syllabus at undergraduate, postgraduate teaching and research. UPV plays a central role in expanding the knowledge, teaching and training future engineers working in the fields of telecommunications and multimedia. They also have the leading role in disseminating research results in major scientific venues. UPV needed to expand its circle of competence and deepen its understanding of future wireless broadcast and multimedia challenges and 5G RECORDS did provide this chance.

5.1.13 Cumucore

Cumucore has been working with major Finnish media houses to exploit possibilities to use non-public networks in media productions. There is a concept developed and tested how to bring in needed infrastructure, power it up and use in media production. The work in RECORDS has enabled Cumucore to gain credibility in the industry and needed technical know-how.

Cumucore will continue developing wireless audio production capability over 5G infrastructure. Pushing delay under 1ms is our target and we will try to achieve that and add 5GLAN and add TSN capabilities in the solution. When this will be achieved, we'll have the solution that is not only capable of delivery low delay traffic but is also providing needed time synchronization over the air.

5.1.14 LiveU

LiveU experience with the 5G "guaranteed performance" and "best effort" slices, NPN, SMPTE and mmWave is intended to be used to plan pilots and tests with our customers in the remote production use case. The integration with the (non partner) Cyanview for the remote control of the camera shading may be used in additional trials with customers. We intend to conduct many such demos and trials with customers as 5G slices and NPN become more prevalent by cellular network vendors and operators. Our transmission solutions and SMPTE decoding-receivers will be used in such cases.

5.1.15 RED

In the context of the project, Accelleran and RED Technologies successfully performed Shared Access Spectrum interoperability testing between the cloud native Accelleran SAS client microservice part of Accelleran dRAX™ RIC platform and RED Technologies Spectrum Access System (SAS) in the cloud, enabling 4G / 5G devices to seamlessly operate on shared spectrum.

Users / operators owning a local license, or a lease were entitled to protection from interferences over the entire area of operation. The SAS guarantees at all times that this protection is enforced, using accurate radio propagation algorithms to determine the allowed transmission power for each registered device. for 5G RECORDS, the transmission power is determined upon license or lease creation, hence ensuring a guaranteed coverage area and quality of service for the entire duration of the local license / lease.

This makes shared spectrum suitable for professional usages, including for Live Audio Production. This feature can be leveraged on the 3.5 GHz CBRS band to enable 4G/ 5G operation within leases submitted to the FCC, across the entire US territory.

5.1.16 RAI

As a follow-up of the results achieved in the 5G-RECORDS Project relevant to exploitation of 5G technologies in the context of TV production, in particular in the "Multiple Camera Wireless Studio" scenario, where several cameras are used in wireless mode to achieve a "Full IP" production, RAI intends to continue studies and experimental trials in this area, with the target of achieving a 5G-based remote production with the required high reliability and QoS. To this purpose, RAI is currently involved in the Italian "5G Audiovisivo" Project, funded by the Ministry of Enterprises and Made in Italy and co-ordinated by Rai Way, where a 5G-based remote production is deployed and its performance is stressed also from an artistic point of view.

5.2 Use Case Trials

5.2.1 Use Case 1 (UC1) – Live Audio Production

Use case 1 demonstrated the end-to-end functionality of transporting audio in a private 5G network in a joint trial with UC2. The live TV production scenario of that context incorporated different KPI requirements with respect to latency while the network layer remains identical. The trial also made a proof-of-concept demonstration about the possibility of delivering wireless audio and video over the same private 5G network. During the trial a 15-minute live TV production was conducted over 5G.

Figure 15. Audio for live TV Production.

5.2.2 Use Case 2 (UC2) – Multiple Camera Wireless Studio

Hosted by Danish broadcaster TV 2's at its studio facility within the famous Tivoli amusement park in Copenhagen, the setup was centered around a 5G standalone non-public Network. The scenario used for the tests consisted of an interview setup with one host and two guests. Two 5G-enabled portable cameras and a microphone are connected via a private 5G network to a media gateway specifically designed and developed within the project. The production took place locally (TV2 gallery). The video streams (1080p50) were encoded in HEVC at 20 Mbps.

Figure 16. Trial UC2.

5.2.3 Use Case (UC3) - Live Immersive Media Production

Use Case 3 demonstrated an end-to-end field trial of live immersive media production. Two professional artists were recorded with 9 stereo cameras connected via 5G millimeter wave spectrum. The immersive content was rendered in real-time using Free-Viewpoint Video (FVV) at the edge, and the produced content was streamed with Quality of Service through Telefonica's transport network. The system was monitored end-to-end at platform and application level to generate KPIs that are valuable for analytic purposes.

The same set of cameras were used to render two parallel virtual views, one of them remotely controlled from a user in a distant location. This shows the capability of the system to scale horizontally and to provide services to content producers located remotely.

Figure 17. Trial UC3.

5.3 Standardization activities

Table 13. Standardization contributions.

Partner	QR	Title of the contribution	Date	SDO	Group	Document ID	Place
After D6.3 in M12							
RED	6	Spectrum Sharing for Live Audio Production	Feb 2022	ETSI	RRS WG1	Link	Online
EUR	6	Discussion on DMRS-less PUCCH for UL Coverage Enhancements	DEC 2021	3GPP	RAN	RP-212941	Online
EDD	7	TR 26.805	May 2022	3GPP	SA4	26-Series	online
From D6.3 (M12)							
EDD	3	Structure of the technical report (TR 26.805)	Apr 2020	3GPP	SA4	S4-210527	online
	3	Description of camera media flows in a Multi-Camera production	Apr 2020	3GPP	SA4	S4-210530	online
	3	Overview of NMOS functionality	Apr 2020	3GPP	SA4	S4-210528	online

	3	Addition of different production types and addition of more information about existing workflows.	May 2020	3GPP	SA4	S4-210823	online
	4	Clarification of Cloud vs Remote Production	Aug 2021	3GPP	SA4	S4-211162	online
	4	Proposal of Media Protocol related Key Issues	Aug 2021	3GPP	SA4	S4-211163	online
	4	Proposal of a Remote Camera Configuration Key Issue	Aug 2021	3GPP	SA4	S4-211164	online
	4	Proposal of two bitrate adaptation related Key Issues	Aug 2021	3GPP	SA4	S4-211165	online
	4	Proposal of a Key Issue around configurable audio channels	Aug 2021	3GPP	SA4	S4-211166	online
	4	Proposal of a new NPN usage related Key Issue	Aug 2021	3GPP	SA4	S4-211167	online
	4	Proposed Timeplan updates	Aug 2021	3GPP	SA4	S4-211168	online
	5	[FS_NPN4AVProd] Updated Timeplan	Nov 2021	3GPP	SA4	S4-211513	Online

	5	[FS_NPN4AVProd] QoS Separation	Nov 2021	3GPP	SA4	S4-211512	Online
	5	[FS_NPN4AVProd] Update of SRT and RIST description	Nov 2021	3GPP	SA4	S4-211511	Online
	5	TR 26.805 v0.4.0	Nov 2021	3GPP	SA4	S4-211600	Online
	6	[FS_NPN4AVProd]: Updated Time and Work Plan for FS_NPN4AVProd	Feb 2022	3GPP	SA4	S4-220280	Online
	6	TR 26.805 v1.0.2	Feb 2022	3GPP	SA4	S4-220279	Online
	6	LS to SA2 on NPN4AVPROD	Feb 2022	3GPP	SA4	S4-220278	Online
	6	[FS_NPN4AVProd] Proposed Exception Request	Feb 2022	3GPP	SA4	S4-220281	Online
	6	[FS_NPN4AVProd]: Summary of 5G MAG Workshops	Feb 2022	3GPP	SA4	S4-220144	Online
	6	[FS_NPN4AVProd]: Introduction to Candidate Solutions and updates to KI#2	Feb 2022	3GPP	SA4	S4-220143	Online
	6	[FS_NPN4AVProd]: Definition of Collaborati	Feb 2022	3GPP	SA4	S4-220142	Online

		on Scenarios					
	7	Considerations for completing the FS_NPN4AVProd study	Apr 2022	3GPP	SA4	S4-220565	Online
	7	[FS_NPN4AVProd]: KIX Device On Boarding	Apr 2022	3GPP	SA4	S4-220469	Online
	7	[FS_NPN4AVProd]: KI6 Interfacing Audio Channels	Apr 2022	3GPP	SA4	S4-220468	Online
	7	[FS_NPN4AVProd]: Description of KI#4 (Standby and Program Cameras), incl solutions	Apr 2022	3GPP	SA4	S4-220467	Online
	7	[FS_NPN4AVProd]: Proposal of a study conclusion clause	May 2022	3GPP	SA4	S4-220689	Online
	7	Updated SI on Media Production over 5G NPNs [SIDFS_5G_4_AVProd]	May 2022	3GPP	SA4	S4-220688	Online
RED	1	Presentation of 5G-RECORDS at ETSI	Nov 2020	ETSI	RRS WG1 #52 meeting	RRSWG1(20)052005r1	Online
	1	Spectrum sharing for PMSE; RED	Nov 2020	ETSI	RRS WG1 #52	RRSWG1(20)000002r1	Online

		Technologies SAS Server role and architecture was presented, as well as the 2 scenarios for PMSE explored in 5G RECORDS: (1) Access to shared spectrum through a local license and (2) Access to shared spectrum through a lease			meeting		
EUR	1	Low-PAPR Sequence-Based Approaches for PUCCH Coverage Enhancement	Nov 2020	3GPP	RAN WG1	R1-2009451	Online
	1	Limitations of NR short block-length codes for PUCCH coverage enhancement	Aug 2020	3GPP	RAN WG1	R1-2006880	Online
	1	Evolution for Coverage Enhancement in Rel-18	Jun 2021	3GPP	RAN	RWS-210507	Online

BBC	3	Study on Media Production over 5G NPN Systems	May 2021	3GPP	SA4	26805	Online

5.4 Standardization Work Study Items Proposals

Table 14. Standardization Work Study Items Proposals.

Partner	QR	Title of the work/study Item	Date	SDO	Group	Document ID	Place
After D6.3 in M12							
NOK	**3**	QoE requirements for real-time multimedia services over 5G networks	June 2022	ITU-T	SG12	T22-SG12-C-0005	Geneva
From D6.3 (M12)							
EBU	**2**	New Study Item on Media Production over 5G NPNs	Feb 2021	3GPP	SA4	S4-210326	S4#112e
	3	FS_NPN4AVProd	Apr 2021	3GPP	SA4	S4al211165	S4#113e
	3	FS_NPN4AVProd		3GPP	SA4	S4-210823	S4#114e
EDD	**2**	New Study Item on Media Production over 5G NPNs	Feb 2021	3GPP	SA4	S4-210326	online
NOK	**3**	New Work Item on QoE requirements for 5G services	May 2021	ITU-T	SG12	SG12-C519	online

5.5 Standardization support to other partners

Table 15. Standardization support to other partners.

Partner	QR	Title	Leading company	Date	SDO	Group	Document ID	Place
After D6.3 in M12								
BBC		Participation in the Architecture Review Group	BST		AMWA			Online
BBC		Adding support for HEVC, AVC and transports other than RTP on AMWA NMOS	BST		AMWA	BCP-006 NMOS Stream Mappings		Online
EBU, BST		Participation in AMWA Board, NMOS Steering, Architecture Review Group. Lead AMWA Networked Media Incubator and cloud testbed groups	BBC					Online
BST		Participation in VSF in JPEG XS and RIST group	BBC					Online
From D6.3 (M12)								
BBC, EBU, SEN, EDD	**3**	Draft of WID for study item	Ericsson	Apr 2021	3GPP	SA4	TR 26.805	online
EDD, BBC, EBU,SEN	**4**	Clarification of Cloud vs Remote Production	Ericsson	Aug 2021	3GPP	SA4	S4-211162	S4#115e
EDD, BBC, EBU,SEN	**4**	Proposal of Media Protocol	Ericsson	Aug 2021	3GPP	SA4	S4-211163	S4#115e

		related Key Issues						
EDD, BBC, EBU,SEN	**4**	Proposal of a Remote Camera Configuration Key Issue	Ericsson	Aug 2021	3GPP	SA4	S4-211164	S4#115e
EDD, BBC, EBU,SEN	**4**	Proposal of two bitrate adaptation related Key Issues	Ericsson	Aug 2021	3GPP	SA4	S4-211165	S4#115e
EDD, BBC, EBU,SEN	**4**	Proposal of a Key Issue around configurable audio channels	Ericsson	Aug 2021	3GPP	SA4	S4-211166	S4#115e
EDD, BBC, EBU,SEN	**4**	Proposal of a new NPN usage related Key Issue	Ericsson	Aug 2021	3GPP	SA4	S4-211167	S4#115e
EDD	**4**	Proposed Timeplan updates	Ericsson	Aug 2021	3GPP	SA4	S4-211168	WG4#114-e

5.6 Patents

Table 16. Patents.

Partner	Problem to be solved	Basic idea	Involved partners	Status
After D6.3 in M12				
EUR	"DEVICE AND METHOD FOR TRANSMITTING PAYLOAD DATA WITH REPETITIONS OF A CODED WAVEFORM"	"Transmission scheme for control data with repetitions. An outer coder generates a code for the data repetitions. A repetition unit spreads this information across the configured repetitions. The outer code is	EURECOM	EP21306923.0 December 2021

		combine with the waveform.”		
EUR	“OPTIMIZED DEVICE AND METHOD FOR TRANSMITTING CONTROL DATA”	“PUCCH transmission strategy where a binary coded sequence is interleaved and passed to an inner coded modulation unit. The output is then modulated with a single/multicarrier modulation scheme.”	EURECOM	EP21306922.2 December 2021
EUR	“DEVICE AND METHOD FOR TRANSMITTING CONTROL DATA WITH MODERATE LOW PEAK-TO-AVERAGE POWER RATIO”	“DMRS-less PUCCH transmission strategy using coded sequences with moderate PAPR to encode information in frequency domain. Those sequences are combined with classical codes in the time-domain.”	EURECOM	EP21306921.4 December 2021
From D6.3 (M12)				
EUR	“Improved Device and Method for Transmitting Control Data with Low Peak-to-Average Power Ratio”	“DMRS-less” PUCCH transmission strategy, medium payload (12-84 bits), combining binary codes (e.g. 3GPP polar) and low-PAPR sequences	EURECOM	European Patent Application, EP20306230.2, October 2020
	“Device and Method for Transmitting Control Data with Low Peak-to-Average Power Ratio”	“DMRS-less” PUCCH transmission strategy for short payload (11 bits or less), combining new and classical codes with low-PAPR sequences	EURECOM	European Patent Application, EP20306231.0, October 2020

		and low-complexity decoding		
RED	“Partage dynamique de spectre avec garantie de la puissance de transmission autorisée”	The present invention describes a method of creating a local license making it possible to mitigate these limitations, while guaranteeing, throughout the life of this local license, an authorized transmission power value for each radio base station, as well as " protection from interference at any point within the protection zone associated with this local license, up to a predefined interference threshold, independently of other local licenses created by the same process after this local license.	RED Technologies	French Patent Application, FR2102640, March 2021 This patent has been published by the French Patent office under N°3 121 002 on Feb 10th 2023.

5.7 Collaborations with other 5G-PPP projects

During the second year of the project, 5G-RECORDS has held several meetings with other 5G-PPPs in search of synergies.

5.7.1 5G-FUDGE Project

On 17th January 2022, the project invited Erik Vold from NRK and to have a meeting to discuss about potential collaborations between the two projects. The agenda was:

- Fudge 5G, use-cases and achievements.
- 5G-RECORDS, use-cases and achievements.
- Potential collaborations.

Figure 18. Collaborations with 5G-FUDGE Project.

During this first meeting, the 5G-FUDGE project expressed interest in learning about the performance of the Precision Timing Protocol (PTP) in 5G. On 4th May 2022 the two 5G-PPP projects met again to discuss about PTP measurements.

5.7.2 5G-TOURS Project

On the morning of 26 April 2022, the 5G-TOURS project and the 5G-RECORDS project shared their experiences in order to find possible future collaborations.

During the online meeting, summaries of both 5G-PPP projects were presented and fruitful discussions on their use cases were held. The agenda was:

- Introduction of the projects.
- Brief Use cases presentation (Media Production and distribution).
- Potential collaborations.

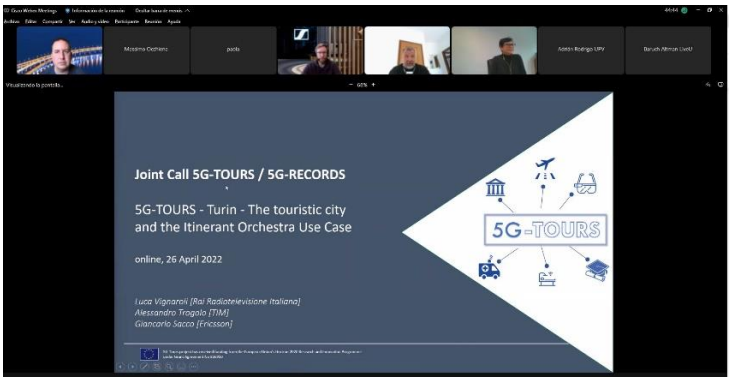

Figure 19. Collaborations with 5G-TOURS Project.

5.7.3 5G-VIRTUOSA Project

On 19th May 2022, the 5G-PPP projects: 5G-RECORDS Project and met to look for possible common ground between their research. During this online meeting, the 5G-VIRTUOSA project coordinator, Andrew Rayner from Nevion presented the work done by the 5G-VIRTUOSA project.

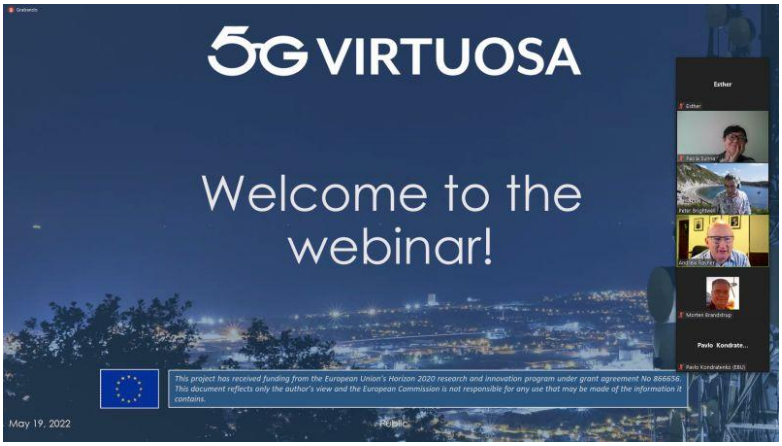

Figure 20. Collaboration with VIRTUOSA Project.

5.8 Collaborations with other industry partners

BBC: work with Neutral Wireless on S-NPN tests and trials; Neutral Wireless was used also for UC2 trial

5.9 Open-source repositories

The media operational control layer is being developed using an implementation of the AMWA Networked Media Open Specifications in C++, licensed under the terms of the Apache License 2.0 available here https://github.com/sony/nmos-cpp

6 Conclusions

The main goal of 5G-RECORDS was to understand if 5G private, standalone networks could be used for professional content production. The aim was to design, develop, integrate, test, and validate the components necessary to deploy three real-world use-cases: live audio production within the Eurecom OpenAir based network, multiple wireless cameras over the Ericsson network, multi views free to view video on in Nokia and Telefónica test bed.

Getting 4ms (round-trip) latency for the audio use-case, shortage and very long lead time for some components in UC2 (because of COVID) and syncronization on the device side (when multiple devices are operating) on a network operating as transparent clock, lack of modems capable of operating in standalone mmWave bands and unavailability of more powerful edge network for UC3 have been the major technological challenges faced by the project during the past two years.

Now as broadcasters, universities and industry partners we have a better knowledge of what is possible to achieve (e.g., bandwidth, latency, QoS) using 5G private network even if there is still some work to be done; the network providers, including also networks based on open-source such as Open Air Interface, have got a better knowledge of the requirements for professional media production; some SMEs have developed components that will be exploited in future projects and trials. In addition, thanks to different type of gateways developed in UC2 it has been possible to bridge 5G with IP based media facilities, on the media and orchestration side.

5G-RECORDS has been a great playground to explore 5G standalone networks for professional content production and understand its performance through multiple test sessions and trials and to realize that 5G is not only about technology availability and maturity but it's a quite complex ecosystem with many different stakeholders.

The dissemination and communication plan defined a set of objectives to ensure the success of dissemination, communication and standardization activities throughout the project.

This report summarizes the results of:

- Deliverables.
- Dissemination events.
- Dissemination documents.
- Communication activities.
- Individual exploitation results.
- Contributions to standardization.
- Patents.
- Open source repositories.

In view of the good results obtained, the dissemination and communication plan has succeeded in giving visibility to the project in all the communities active in the technologies, systems and services. The number of communication and dissemination activities by the partners has far exceeded the expected values.

One of the main objectives of the dissemination plan in the second half of the project was to encourage project partners to increase the number of scientific publications. In spite of a remarkable increase of 1.300% over the outcome of the first year, the expected results have not been achieved. Nevertheless, this is a great success.

In any case, due to the nature of the project and its high level of impact and innovation, publications will not stop after the end of the project, reaching their maximum success in the coming years.

A Annex

A brief description of the organizations 5G-RECORDS project has been involved with.

SMPTE Standards Community

SMPTE is an internationally recognized Standards organization, bringing order to the chaos of constantly evolving technologies with a high level of unbiased technical excellence. SMPTE's more than 800 engineering standards and guidelines are developed in a collaborative process with individuals and corporations to advance global interoperability of hardware and software [4].

IEEE BMSB

The IEEE BMSB symposium is the premier forum for the presentation and exchange of technical advances in the rapidly converging areas of multimedia broadcasting, telecommunications, consumer electronics, and networking technologies.

5G in Content Production

The EBU’s project group 5G in Content Production brings together broadcasters and the industry to identify requirements in content production that need to be met in the 5G context. The EBU also facilitates an ongoing dialogue with the wider industry on a range of issues related to 5G, including business arrangements amongst the stakeholders along the value chain [5].

Cambridge Wireless

CW is the leading international community for companies involved in the research, development and application of wireless and mobile, internet, semiconductor and software technologies [6].

UK5G Creative Industries Working Group

The UK5G Creative Industries Working Group will focus on developing the potential economic and social opportunities afforded by 5G in the UK [7].

IEEE BTS

Broadcasting is a one-to-many communication service in which the transmissions are intended for direct reception by the general public or a target audience, which may include audio, video and/or data services. The field of interest of the IEEE BTS shall encompass devices, equipment, techniques, and systems related to broadcast technology, including the production, distribution, wired and wireless transmission, propagation aspects and reception [8].

5G-PPP Webinar: New 5G Core Technologies Innovation Projects

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) [9].

5G-MAG Meetings

The 5G Media Action Group provides a framework for stakeholders to collaborate on a market-driven implementation of 5G solutions capable of meeting the requirements for the production and distribution of audiovisual media content and services [3].

5G-PPP SME WG

Since its inception, SME Working Group activities have been mostly focusing on promoting the skills and expertise of SMEs in the telecommunications domain, especially towards larger companies and research organizations, and on supporting the engagement of SMEs in collaborative projects and cooperation with those players, via networking and exchange of information amongst SME representatives [10].

AMWA

The AMWA focuses on the industry move to IP based architectures. To enable software based systems to recognize and exploit devices, the AMWA has developed the Networked Media Open Specifications (NMOS). These have been created in practical workshops by the Networked Media Incubator project. This activity complements the work of other well established technology associations, such as the Audio Engineering Society (AES), the European Broadcasting Union (EBU), the Society of Motion Picture and Television Engineers (SMPTE) and the Video Services Forum (VSF). The AMWA continues its support for the Media Exchange Format (MXF), the Advanced Authoring Format (AAF) and the Framework for Interoperable Media Services (FIMS). The organization maintains open membership and committee participation [11].

SVF

The VSF is an international association comprised of service providers, users and manufacturers dedicated to interoperability, quality metrics and education for media networking technologies. The organization's activities include providing forums to identify issues involving the development, deployment, operation, and security of media networking technologies, and promoting interoperability by contributing towards the development of Standards [12].

EOT-CONNECT

EOT is the fixed meeting place and knowledge hub for the electronics and technology industry, bringing together people, businesses and network to share knowledge and new ideas [13].

SVG

The SVG was formed in 2006 to support the professional community that relies on video, audio, and broadband technologies to produce and distribute sports content. Leagues, owners, teams, players, broadcasters, webcasters, and consumer technology providers have joined the SVG to learn from each other, turn vision into reality, implement new innovations, while sharing experiences that will lead to advancements in the sports production/distribution process and the overall consumer sports experience [14].

VQEG

VQEG was born from a need to bring together experts in subjective video quality assessment and objective quality measurement. The general motivation of VQEG is to advance the field of video quality assessment by investigating new and advanced subjective and objective methods for assessing quality. However, with the exception of some recent contributions on subjective assessment methods for multimedia, VQEG has focused, in the last few years, its effort on the validation of new objective quality metrics for standardization purposes [15].

RSPG

The RSPG is a high-level advisory group that assists the European Commission in the development of radio spectrum policy. The members of the Group are senior representatives from Member States' regulatory authorities and the ministries having responsibility for radio spectrum related matters, and the official representative of the European Commission. [18]

Danish Sound Cluster

The Danish Sound Cluster stimulates growth in the sound industry by strengthening collaboration between research and industry. 63[21]

5G-IA

The 5G-IA highlights its key role and new team to ensure European leadership in 5G global development and harmonization. the 5G-IA has issued new statutes and renewed its Board, leading to a clarified and simpler governance. The 5G-IA formally interacts with the European Commission through a partnership Board, and closely coordinates its Policy Work Groups with the 5G Initiative Projects and Technical Work Groups. As for the Networld 2020 Experts and Task Groups, they no longer formally belong to the 5G PPP organization, however it is planned to continue actively collaborating in relevant areas. [22]

TSDSI

The Indian Telecom Industry, comprising operators and manufacturers, Academia and R&D organizations came together to form Telecommunications Standards Development Society, India (TSDSI) on 7 January 2014, as an embodiment of the Govt.'s resolve, expressed in the National Telecom Policy 2012 (NTP 2012), to create an Indian Telecom Standards Development Organization (TSDO), for contributing to next generation telecom standards and drive the eco-system of IP creation in India, formally recognized by the Government. [23]

ONF Spotlight

ONF Spotlight is a new virtual series that will deliver the insights you need to stay on top of the fast growing open source movement for building next generation mobile and broadband infrastructures. This new forum incorporates a combination of virtual live and on-demand content that will be accessible from anywhere in the world enabling access to a broad audience. ONF Spotlight is designed to offer something for everyone and will span from coverage of industry level insights and perspectives to deep dive technical updates and open source-based demonstrations. [24]

PROAVEXPO

Since 2010, ProAV Expo has brought together Danish and international specialists, manufacturers, vendors and buyers within video, audio, lighting, streaming, videoconferencing, etc., and is Scandinavia's largest AV tradeshow. That's why it's thoroughly tested down to the smallest detail, so you can be absolutely sure that everything is working as it should. [25]

4KHDR Summit

We have always bet on the future and have become pioneers in new formats that have been on air for many years – on national and regional channels- and producing in different genres, such as docu-reality, travel show, live show, branded content, to name a few. [26]

EBU Forescast

FORECAST is our annual 2-day conference on the evolution of media distribution technologies, spectrum issues, regulation and associated business models. How are the technologies and user habits evolving, and how does this affect future distribution options for media organizations? FORECAST gives an in-depth view. [27]

/reveal/ b<>com

b<>com is a private Institute of Research and Technology that explores, designs, and provides innovations to companies that want to develop their competitiveness using digital tools. With a unique co-investment model, it generates technology, knowledge, and expertise. [28]

DI Digital

DI Digital is a business community in the Danish industry for IT, telecom, electronics and communication companies. We want to make sure that Denmark becomes the preferred country to operate technology companies to and from, to make Denmark richer. [29]

EBU Production Technology Seminar

The annual Production Technology Seminar focuses on recent and future developments in media production technology. It is a key industry event for those needing to make informed strategic decisions in the technical domain. PTS 2022 was run as a high-quality online event. Due to the ongoing Covid situation, EBU Members were able to join online free of charge. A limited number of attendees were also able to join us in person for PTS+, the on-site networking component at EBU HQ in Geneva, for discussions, catering, and a better experience. [30]

NAB Broadcast Engineering and IT Conference (BEIT)

The Broadcast Engineering & IT Conference (BEITC), part of the CONNECT track in the NAB Show Conference, is a renowned program designed for broadcast engineers and technicians, media technology managers, contract engineers, broadcast equipment manufacturers, distributors, engineering consultants and R&D engineers. [31]

IP Showcase

The IP Showcase is committed to educating attendees at major industry events on the business and creative potential of IP media solutions. Our ongoing focus is on market requirements as media operations move toward all-IP connectivity and content delivery to multiscreen platforms. The evolving SMPTE ST 2110 standards and the AMWA NMOS technology stack are improving media workflows for large and small deployments alike. Now that the transport layer is well established, we're focused on the next step – easing deployment for end users. [32]

EBU Network Technology Seminar

The EBU Network Technology Seminar is the annual rendezvous for experts dealing with IP-based media production infrastructure, IT networks and storage solutions for broadcast media content. NTS is a global reference point for media industry on topics such as IP-based production infrastructures, a forum for users and suppliers to discuss requirements, standards and roadmaps, and an annual meeting point for experts exchanging experience and best practice for deploying these technologies at scale. [33]

Media City Bergen

The Media Cluster HQ is located in Media City Bergen, a leading international hub for media and technology innovation, with the Media Lab and a startup lab forming the core of the innovation and research projects for the cluster and cluster partners. The cluster in total counts more than 100 companies, with eight major universities and research facilities among its members. The University of Bergen is a founding partner of the Media Cluster. Dept. of Information Science and Media Studies is co-located in MCB together with leading media and media technology companies. [34]

International Media Connectivity Group (WBU-IMCG)

International Media Connectivity Group (IMCG) is a committee of the World Broadcasting Unions (WBU). IMCG provides a global forum for members of the WBU to exchange information, outline requirements and resolve common operational problems. [35]

Future Media Hub

Established to support the production of creative content and to bring together international technology innovators. This hub aims to build an international network dedicated to the promotion, development and exchange of innovative media tools, mechanisms, strategies and workflows. More specifically, the Video Snackbar Hub is a community working on web video, live streaming, future broadcasts and other emerging formats. [36]

International Broadcasting Convention

IBC sits at the global crossroads of the media, entertainment and technology industries providing an informative, innovative and beneficial experience for all attendees. Established ‘by the industry for the industry’ in 1967, IBC has continued to evolve over its 53-year history serving the development of the Media, Entertainment & Technology industry. During this time new technologies have continued to emerge in a changing and converging world, that have influenced the development of IBC’s organisation and the evolution of the IBC event. [37]

EBU Tech Webinar on 5G-RECORDS

5G has the potential to greatly facilitate and possibly even revolutionize media content production. For the past 2 years, the EBU has been working with other partners in the 5G RECORDS project to understand better how 5G can be exploited for professional media applications. 5G RECORDS is an EU-funded project that explores possibilities brought to the 5G ecosystem in media, by new components and technologies. The main objective has been to integrate them into three use cases and evaluate their performance in the context of professional content production environments. [38]

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