5G RECORDS

5G-RECORDS:
Enabling 5G-based Media Content Production

November 17th 2021

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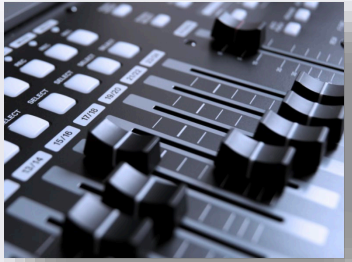
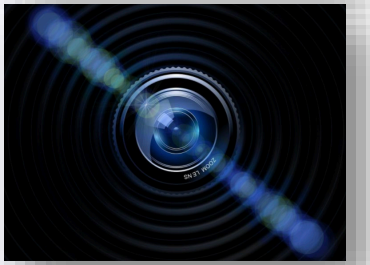
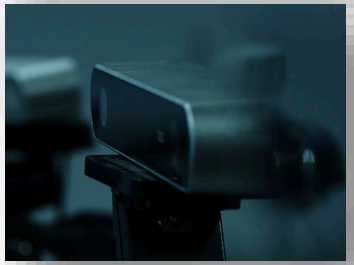
Universitat Politecnica de Valencia (Spain)

Contents

1. Project Motivation







5G-RECORDS is about the design, development, integration, validation and demonstration of **5G components** for **professional media content production**

Why 5G into Content Production?

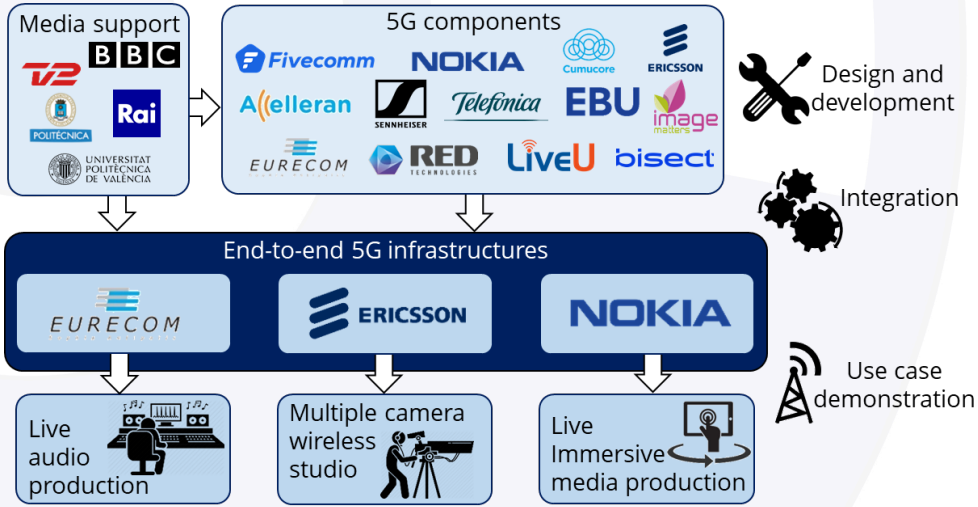
- Trend towards IP-Based CP
- Wireless capabilities inside and outside facilities
- Possibility of self-deployed networks (NPNs)
- KPIs assurance with QoS and Slicing
- Better performance than current mobile technologies
- Opportunities for standardization

1. Project Fact Sheet

- **Project type:** H2020 Innovation Action (**IA**)
- **Budget: 7.4 M€**
- **Consortium: 18 partners** with important 5G vendors, broadcasters and high-tech SMEs (11 countries)
  - Project coordination: UPV (Spain)
  - Technical coordination: EBU (Switzerland)
- **Project duration: 24 months**

  (Sep. 2020 – Aug. 2022)
- **5G components target TRL: TRL 7**

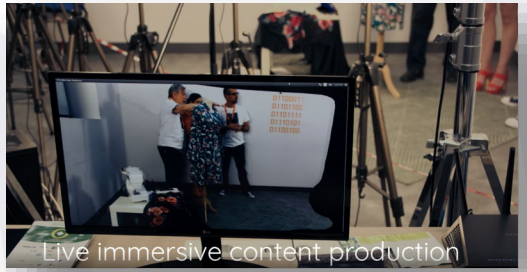
  System prototype demonstration in operational environment
- **Vertical use cases: 3 use cases**
  - **Live Audio Production**
  - **Multiple camera wireless studio**
  - **Live immersive media production**



1. Project Use Cases & Key Enablers

- Open and virtualized RAN
- SDR URLLC UE prototype
- URLLC air interface
- Dynamic Spectrum Access

- Non-Public Networks
- Timing and Synchronisation
- Network Slicing
- Media Orchestration



- mm-Wave Antennas/Devices
- Edge computing
- End-to-end slicing

Design
of 5G components for professional content production

Development
of state-of-the-art 5G prototypes

Integration
into end-to-end 5G infrastructures

Validation
in the context of real production use cases

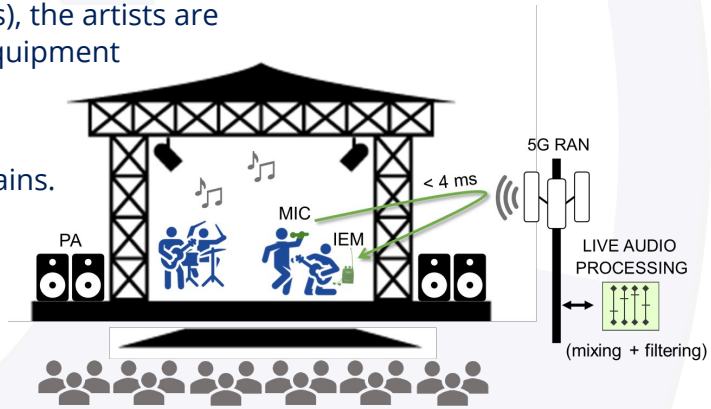
Demonstration
of the potential value to the sector

→ TRL 7

1. UC1 Live Audio Production

GOAL: To deploy a live audio production system, leveraging its connectivity with a 5G private local network using open-source software and disaggregated and open RAN components

- In a live audio production setup (e.g. music concerts, music festivals, TV shows), the artists are equipped with professional Programme Making and Special Events (**PMSE**) equipment
  - 5G wireless **microphones**
  - In-Ear Monitor (**IEM**) systems
  - **Control tools** and gateways between 5G and audio infrastructure domains.
- **4 main areas of work**:
  - Capturing of live audio data
  - Temporary spectrum access
  - Automatic setup of wireless equipment
  - Use of a local NPN
- **Requirements**:
  - End-to-end latency < 4 ms
  - User data rate ~500 kbps
  - Synchronization ± 500 ns



Leader

Media Components

Network Components

1. UC2 Multiple Camera Wireless Studio

GOAL: To develop a complete production system that takes advantage of 5G NPNs, QoS and time synchronization to fit remote, distributed production and remote contribution scenarios

- The best of an **IP studio** combined with the super-fast and highly reliable wireless 5G connections
- 5G will facilitate new types of **workflows** addressing 3 core requirements:
  - Flexibility and reduction cost in setting up productions
  - Scalability from small to large events
  - Shareability of content along the production chain and between creative stages
- **2 scenarios:**
  1. Multiple cameras in a wireless studio. Wired/wireless functionalities will be combined using a fully IP system
  2. Outdoor production scenario with 2 or more 5G-enabled cameras and sound capture devices connected to NPN
- **Requirements:**
  - Bandwidth: 35-50 Mbps per camera
  - Latency: less than 100ms
  - High reliability is expected

UC2 WP3 leader

Media Entities and Components

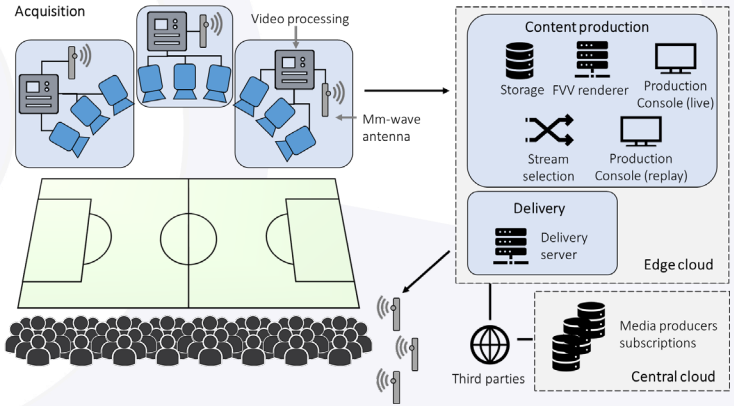
Leader

Network Components

1. UC3 Live Immersive Media Production

GOAL: To provide real-time immersive capture, contribution, delivery and visualization of events through cameras connected via 5G millimeter waves

- Real-time end-to-end free-viewpoint video (**FVV**) system that includes capturing, 5G contribution, virtual view synthesis on an edge server, 5G delivery and visualization on user terminals.
- **Video workflow in 3 stages**:
  - Capturing
  - Encoding and transmission
  - Synthesis and visualization
- **Requirements**:
  - Media acquisition: up to 100 Mbps per camera
  - Radio uplink speeds of 20-200 Mbps
  - Downlink speeds of 2-20 Mbps per user
  - Connected end-users: 10-100 per 1000 m^2
  - Reliability: 1 error every 10 min



POLITÉCNICA

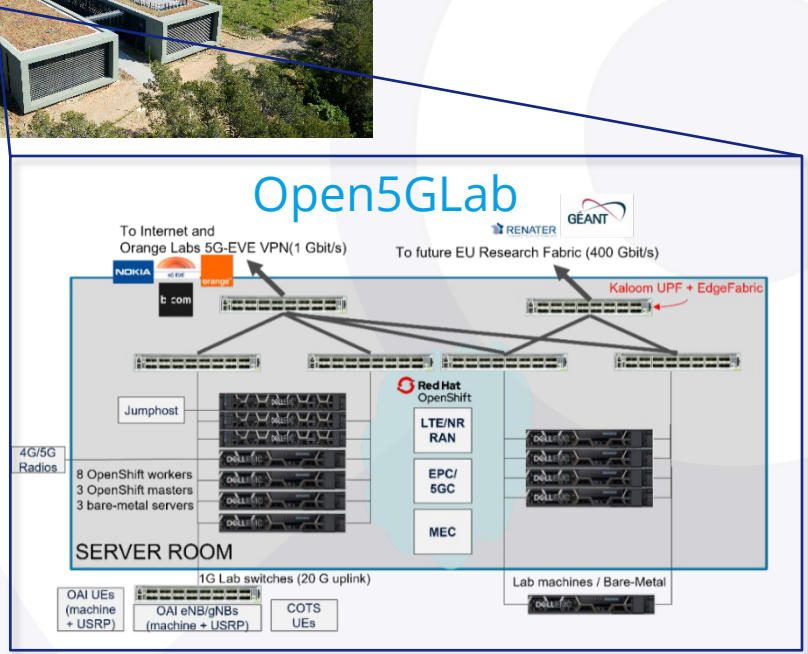
Media Components

Telefónica

Leader NOKIA

Network Components

3. Main Results so far:
UC1 5G Test-Bed



- RedHat OpenShift k8s (real-time cluster)
- High-speed Switching Fabric Bare-metal servers for testing radio
- Several radio units (USRP and COTS RRU)

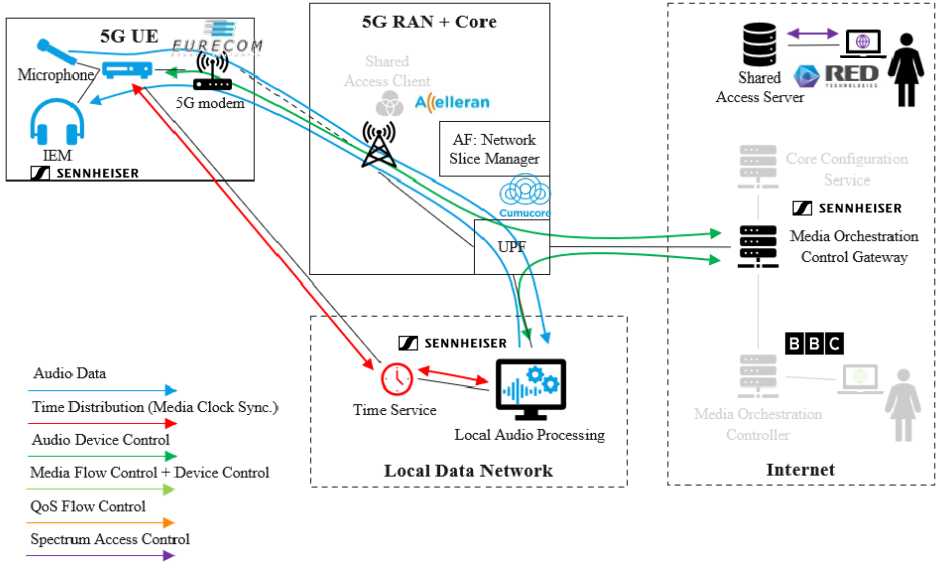
(n78 - 3.3 or 3.4 GHz indoor, testing on 40,50,60 MHz channel in lab environment)

- New RU/RRH coming soon (Q1 2022)

3. Main Results so far:
UC1 Test-Bed Integration

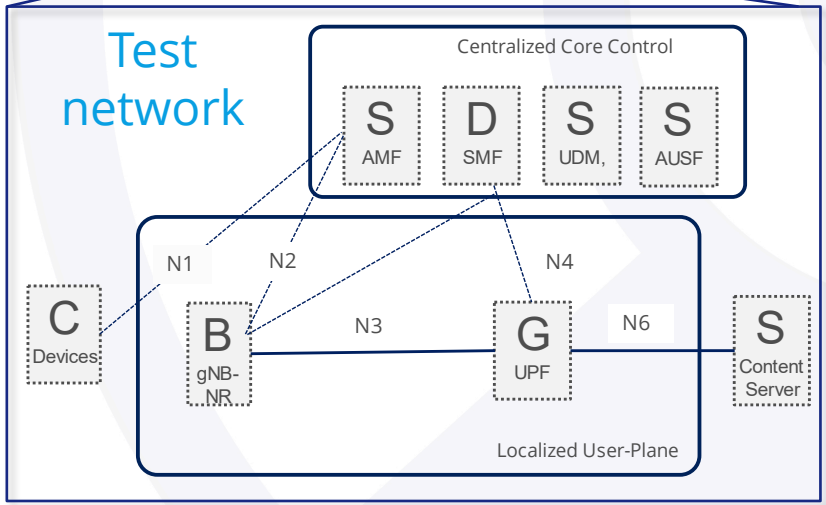
The **first phase** of deployment has been addressed within the first year with a simplified architecture

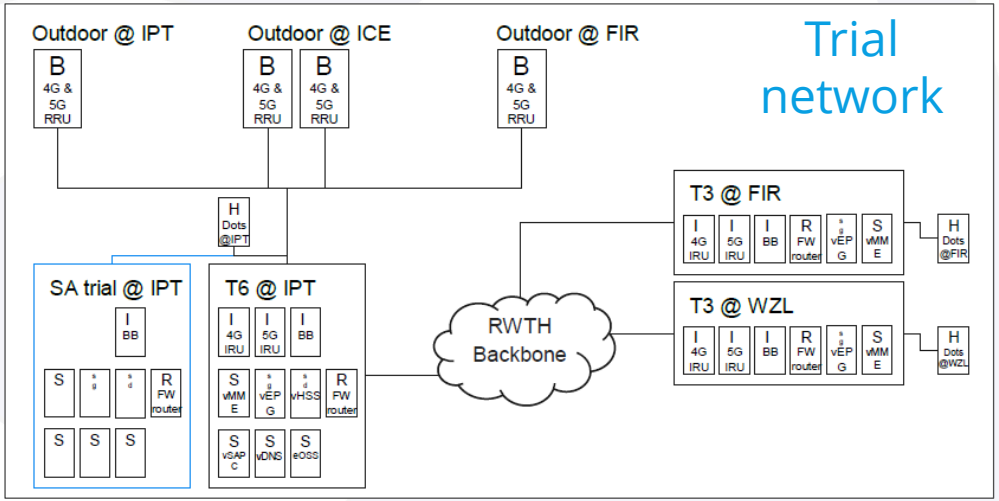
Elements	Partner
Rel15/16 UEs with prototype audio equipment	SENNHEISER, EURECOM
RAN (DU/UE)	OPEN AIR INTERFACE
RAN (CU-U, CU-C)	Accelleran
5GC	Cumucore
RIC	Accelleran
DSA client	Accelleran
DSA server	RED TECHNOLOGIES



Task	Item	State
E2E audio application	**UL & DL traffic**	• Integration of COTS UE + SEN prototype audio equipment done • UL and DL streaming lab tests done
	KPIs	• KPIs (latency/jitter) from the tests obtained
	Orchestration control gateway	• First version deployed • Remote control from SEN premises operational
ACC CU + EUR DU	**Integration**	• Interoperability testing performed and almost complete
CMC 5GC	**Integration**	• Deployment of CMC (VM) at EUR network operational • Integration of CMC 5GC with OAI RAN tested

3. Main Results so far:
UC2 5G Test-Bed





Test network deployment done. Upgrade to 5G Rel. 16 might be available later in the project

3. Main Results so far:
UC2 Test-Bed Integration

Aachen, Germany

ERICSSON

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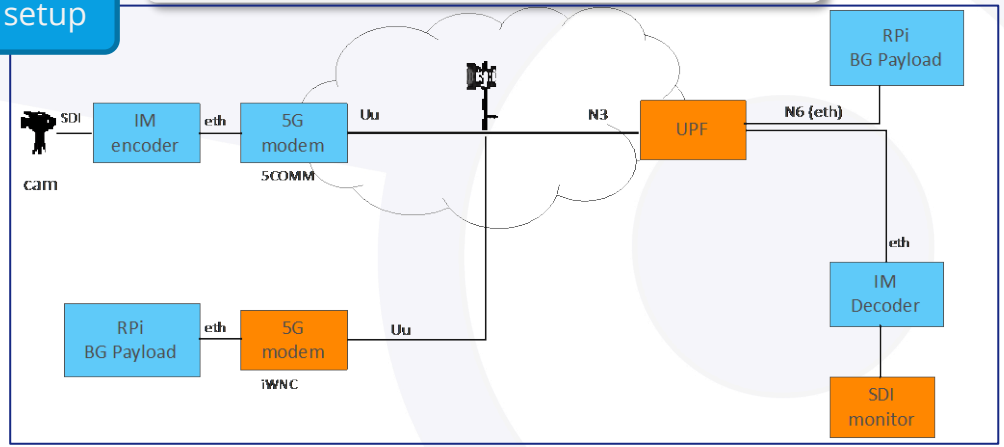
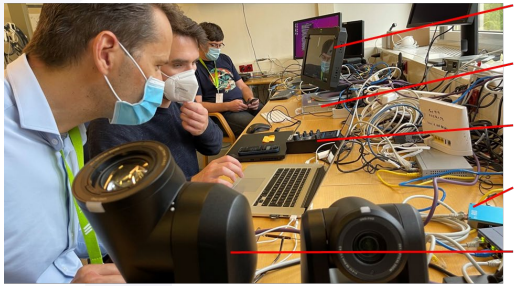
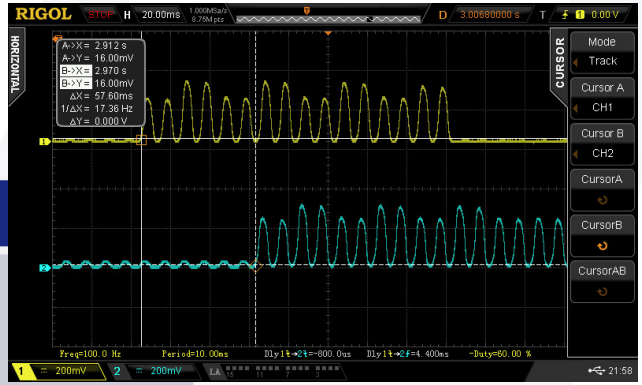
Second round of tests in Aachen

Test setup







Glass-to-Glass latency measurements

Item	Description
Integration of components	• Integration of LiveU components and already available cameras, mixers etc. in the test network. • Integration of Fivecomm modem is done • Integration of IM encoder/decoder with basic functionality is done
Testing	Two round of tests has been done, focusing on network capabilities, interoperability, PTP performance, encoders and modem, etc. **Test results are currently being analyzed**

3. Main Results so far:
UC3 5G Test-Bed

Madrid, Spain

NOKIA

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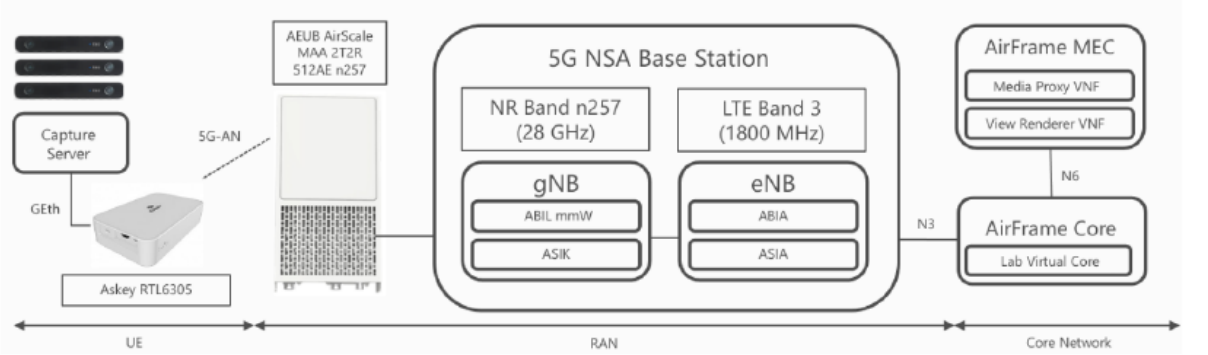
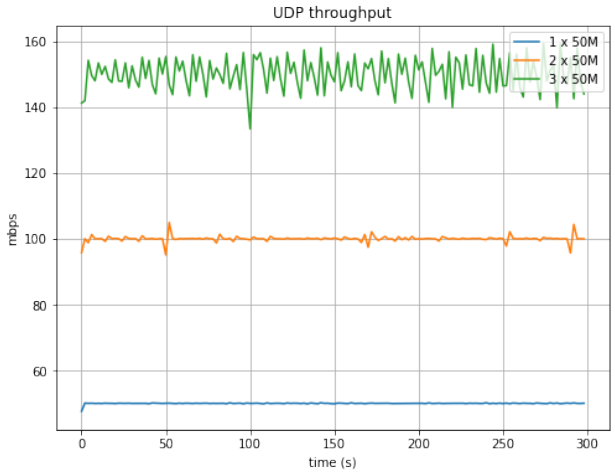




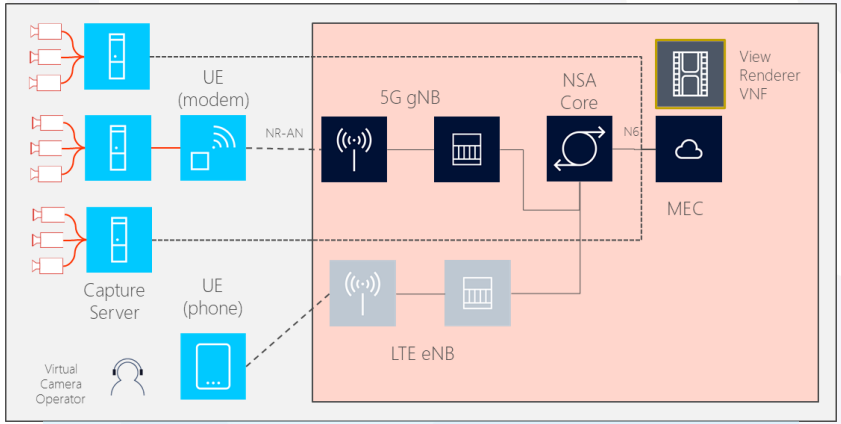
- 5G NSA mmW n257
  - 6x100 MHz DL
  - 2x100 MHz TDD DL/UL
  - 2x2 MIMO

- 150/170 Mbps UL
- >4 Gbps DL
- Average PLR <0.01%
- Peak PLR (in 2s windows) ~0.2%

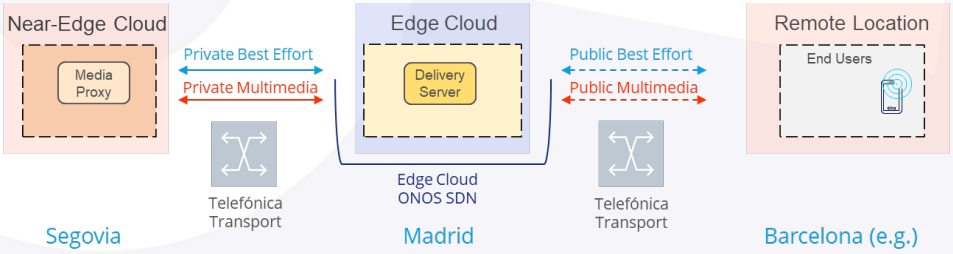
3. Main Results so far:
UC3 Test-Bed Integration

Nokia 5G network is ready and the first tests and integration is in progress

Task	Item	State
Capture + Production	Capture Server and View Renderer	Integrated
	CPE + gNB + 5GC + MEC	Integrated
Transport + Delivery	SDN + Network Slices + Slice Selector + DNS + Backend/Monitoring	Integrated
	Video Player + Delivery Server	Integrated



Capture + Production tests have been done with this architecture and KPIs have been obtained



Delivery + slicing tests have been done with this architecture and KPIs have been obtained

3. Main Results so far:
UC3 End-to-End Test

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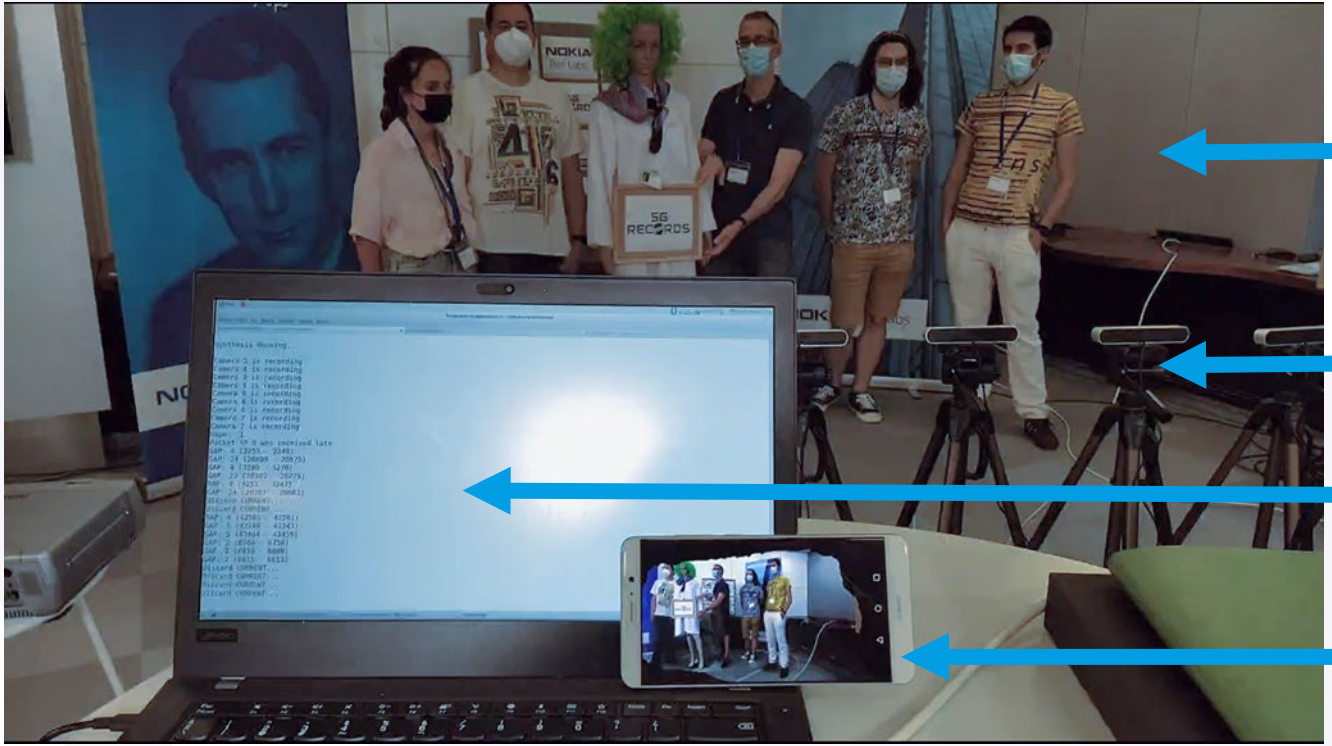


Live scene

9 cameras

View renderer VNF

Camera control
(w/ rendered view)

3. Main Results so far:
Standardization Impact

- 5G-RECORDS partners are active in 3GPP and ITU-T, NMOS, VQEG, AMWA SMPTE and MPEG.

- **Nokia: new work item defined in ITU-T GSTR 5GQoE**

Final version: May/June 2022. Contributions from: UPM, BBC, EBU

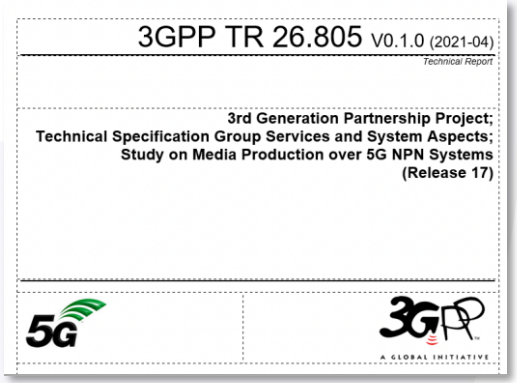
- **Ericsson (Rapporteur): 3GPP Study Mission FS_NPN4AVProd.**

The intention of the study is to identify standardization needs and potential standards gaps when using 5G Systems including NPNs (both Standalone NPN and Public Network Integrated NPN) for media production. End: Feb 22. Supported by: BBC, EBU, SEN

5G-RECORDS Summary Standardization contributions :

- 8 Admin contributions
- 16 Tech Contributions
- Study Item Proposal

Category	Type of activity	Target	Achieved
Exploitation	Standardization contributions	40	16
Others	Filed patents	5	3
	Open source repositories	2	2
	Collaborations with other research projects	4	0


3GPP TR 26.805 V0.1.0 (2021-04)
Technical Report

3rd Generation Partnership Project;
Technical Specification Group Services and System Aspects;
Study on Media Production over 5G NPN Systems
(Release 17)

3GPP SA4 Study Item (SI) on media production over 5G NPN Systems (FS_NPN4AVProd)

4. Next steps & Expected results

UC1 – Live Audio Production

- **Performance** enhancements to reduce latency, jitter and increase stability
- Support some Rel-16 **URLLC features** for live audio production
- Integration of second round of **components**: ACC Shared Access Client, RED Shared Access Server and the Media Orchestration Controller
- Support for **multiple end devices**

UC2 – Multiple camera wireless studio

- First prototype of the **Media Gateway (MG)**
- Completing **interoperability** between **MG** and **IM encoder** board
- First prototype of **Media Orchestration Control Gateway (MOCG)**
- IM Encoder with genlock and **PTP** capabilities
- Integrate the new developed **components** into the Ericsson test-bed infrastructure

UC3 – Live Immersive Media Production

- Design a **portable** 5G NSA setup
- Deployment of a **new trial location**, based on the portable setup in Madrid (Nokia premises)
- Complete de foreseen production functionality for the **FVV system**, developing the pending elements
- Integration the **E2E slicing** solution into the access network
- Performing subjective **QoE evaluation** with users

Target events for final trials and demonstrations (yet to be confirmed)

Thanks for your attention!

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Any questions?

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 957102

1. Consortium

x7 high-tech SMEs

Accelleran, Image Matters
Cumucore, RED Technologies
Fivecomm, LiveU, Bisect

x2 5G infrastructure providers

Ericsson, Nokia

x1 PMSE vendor

Sennheiser

x3 research centres & universities

UPM, UPV, EURECOM

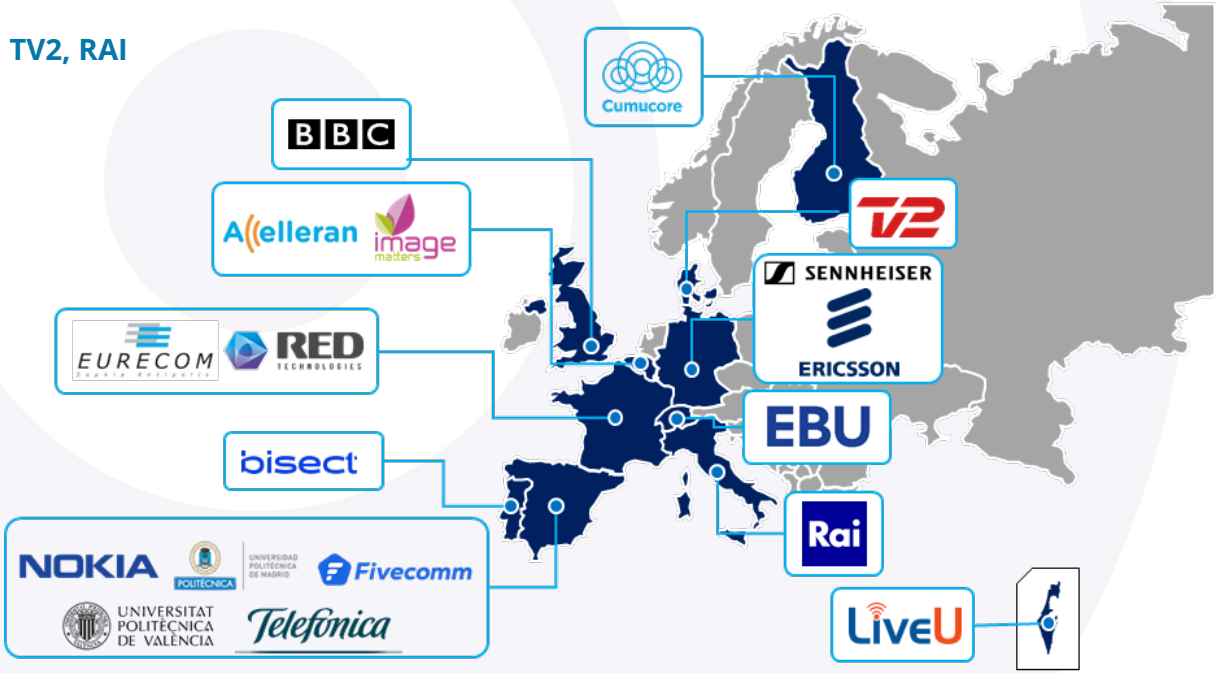
x4 broadcasters

EBU, BBC, TV2, RAI

x1 MNO

Telefonica

18 partners **11 countries**



2. Main Results so far:
Project Component Portfolio UC1

UC1 Components	New/ Enhanced	State
Local Audio Processing	Enhanced	**Ready** (PTP client, audio mixer, network audio source/sink, audio device control client)
Audio User Terminal	Enhanced	**Basic functionality available** (Audio Device Control Client, Network Audio Source/Sink, PTP Client)
Media Orchestration and Control Gateway	New	**Basic functionality available** (Audio Device Control Server, Core Config Service)
5G RAN (inc. Shared Access Client)	Enhanced	**Some functionality available** (5G CU/DU, 5G Shared Access Client, OAI E2E Rel-15 SA support, remote access, latency improvements on the protocol stack)
5G Core	Enhanced	**Ready** (Slicing management including external API, slicing functionality in 5G core, PCF)
Shared Access Server	Enhanced	**Basic functionality available** (Lease creation, Protection of leases, Synchronization with leases database, Leases visualization)
Time Service	New	**Basic functionality available** (Local PTP Server)
Media Orchestration Controller	New	**Delayed** to late Q1 2022 (1st PoC)

2. Main Results so far:
Project Component Portfolio UC2

UC2 Components	New/ Enhanced	State
Media gateway (EBU, bisect)	New	**Delayed** to December 2021 (Currently available: RESTful API, graphical user interface, Gstreamer pipelines, NVIDIA integration, Rivermax integration in the Gstreamer pipelines, RIST libraries integration, configuration of the NVIDIA Jetson based image)
Media Orchestration and Control Gateway (BBC, bisect)	New	**Delayed** to late Q1 2022 (1st PoC). (Currently available: general architecture, enhancements to nmos-cpp and nmos-js to additional functionality, i.e., registration and connection of device "through the gateway" and compressed stream types, carriage of camera control information in IS-07)
Network slice management/NEF (ERICSSON)	Enhanced	Defining how the QoS functionality to be implemented.
5G network (ERICSSON)	Enhanced	**Ready** (SA test network, reference setup including prototype 5G modem for network evaluation)
5G modem (Fivecomm)	New	**Ready** (5G Ethernet/USB board for broadband communications, 5G Rel-15 SA modem, 4x4 MIMO antennas, SIM card, microprocessor)
Encoder and decoder (image masters)	New	**Basic functionalities ready** (Origami Square Carrier board for Broadcast Camera I/O, ZCU-106 IO board for Broadcast Camera)
Media Master Control Room (MCR) (EBU)	Enhanced	**Red Bee → EBU** (Public cloud E2E "MCR" chain, i.e., signal contribution (JPEG-XS), processing (AWS-Cloud Digital Interface, CDI) and signal egress)
LU800 (LiveU)	Enhanced	**Ready** (bitrate enhancements, added Sierra 5G module with external antenna connectivity for 5G SA, enhanced IP pipe for the remote control of IP A/V equipment)
LU2000-SMPTE (LiveU)	Enhanced	**Ready** (Multi-sub-networks support, tighter SMPTE compliance, enhancements for the IP pipe for remote control of the AV equipment)

2. Main Results so far:
Project Component Portfolio UC2

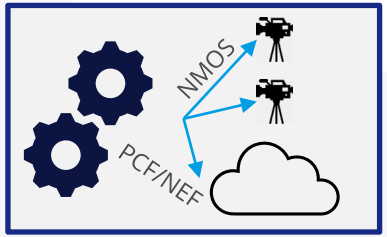
- In the proposal, a new component was identified to translate professional media production formats over 5G and to control media devices over 5G networks: SMPTE2110-5G Gateway
- Once the project started, the SMPTE2110-5G GW was divided into two to solve logistic issues of the IP-based 5G production workflow

5G-enabled Media Gateway (MG)

Does media codec/format/protocol conversion

Designed and developed from scratch

Media orchestration and control Gateway (MOCG)



Does device/network management

2. Main Results so far:
Project Component Portfolio UC3

UC3 Components	New/ Enhanced	State
Capture Server	Enhanced	**Ready** (Capture simulation module for transmitting pre-recorded FVV sequences, RTP traffic smoother, Configurable MTU size)
Production Console	Enhanced	Planned for **Phase 2**
User Terminal	**New**	**Ready** (HTML5 web player based on videojs to serve the video and collect metrics)
View Renderer	Enhanced	**Ready** (Offline version that works reading pre-recorded video file, RTP packet reordering capability, Single-GPUworking mode, Logging statistics generation during execution, integration in MEC)
Stream selector & Storage	**New**	Planned for **Phase 2**
Media Proxy & Delivery Server	**New**	**Ready** (Integration of adaptive streaming server, modules for RTP video processing, transcoding configuration, monitoring tools)
5G mmWave RAN	Enhanced	**Ready** (Modem configuration and position, mmW equipment (antenna, baseband, controllers) integration in n257, fine-tuned radio options for performance)
Edge MEC	**New**	**Ready** (New hardware platform acquired and integrated, OpenStack configuration, Availability of GPU within OpenStack VM)
Delivery cloud	Enhanced	**Ready** (tenant configuration in Telefonica Edge solution, to ensure compute, storage and network capacity for the required deployments in order to guarantee UC3 needs.)
E2E SDN	Enhanced	**Ready** (Conditional DNS, Slice selector, Monitoring elements, New edge cloud tenant)

3. Main Results so far: Dissemination Impact

Category	Type of activity	Target	Achieved
Dissemination	Public deliverables	15	10
	Journal papers, whitepapers and international conference papers	20	4
	Keynotes, presentations and panels in major conferences	15	32
	Participation in events and forums in Europe and worldwide	10	
	Workshops in major IEEE conferences	4	3
	Tutorials, Summer schools, Training	2	2 (6)
Communication	Website	1	1
	Press releases	15	5
	Social networks	3	3
	Audiovisual resources	6	4

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