Towards a comprehensive 5G-based toolbox for live media production

This report focuses on the use of 5G technologies in media production and contribution workflows. With reference to three live production deployment scenarios of evolving complexity, it provides:

- a brief description of the **current state of the art** for equipment and technologies;
- an overview of the **features that 5G would ideally support** for each scenario;
- and an initial inventory of **potential solutions available in the 5G specifications currently under development**.

The annexes provide further background information and definitions of key terms, along with additional details on the parameter ranges for media-related data streams that the 5G network would transport.

Contents

Introduction

Looking specifically at media production and contribution, some key processes can be highlighted [1], as shown in *Figure 1*:

- **Content acquisition**: involves the acquisition equipment used to capture an event; see a non-exhaustive list in Annex B.
- **Data processing**: content is processed (e.g. encoding, mixing, inclusion of graphics, etc) to create the programme output.
- **Production control:** involves the use of control surfaces to manage equipment and/or data processes.
- **Contribution**: refers to the transport of media assets from the event location to the production facility or **production hub** (usually the production company headquarters or a cloud-based facility).
- **Auxiliary communication systems**: various communication systems that are required by the individual parts of a production and that are used for planning and coordination.

Where processes happen

Depending on the nature of the scenario, some processes (either data, control or both) may be co-located with the event (**on-site**) while others may take place in a **remote** location.

5G-enabled production and contribution equipment

5G-enabled equipment includes devices to generate/receive media data; equipment for auxiliary operations and control; and network equipment.

This document refers to media-related connected equipment/devices as **5G UE (user equipment)**. In addition to the main data stream transporting audio and video, these devices may generate other signals (e.g. remote control, telemetry, etc.). All such data streams are considered part of the **5G user plane (UP)** and should not be confused with the **5G control plane (CP)**, whose data streams relate to network connectivity.

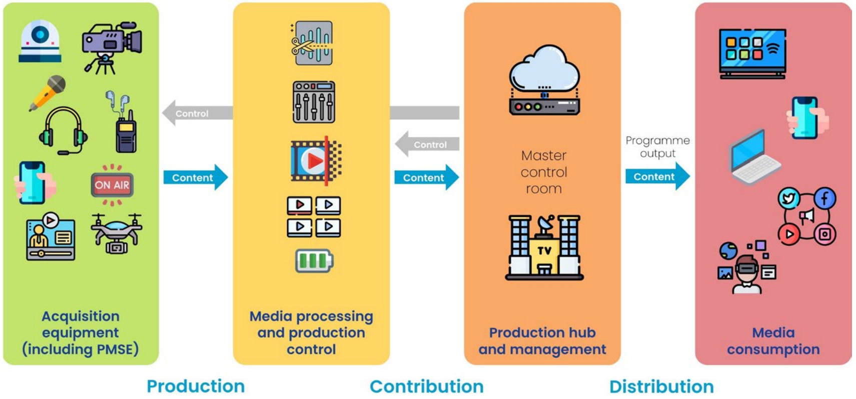

Figure 1: Processes involved in the creation and consumption of content

Deployment scenarios: expectations and solutions

This section considers three remote media production scenarios in order of increasing complexity:

1. **Electronic newsgathering (ENG) and uplink contribution** – coverage of an event in the field where audiovisual content (audio, video, and auxiliary data) is up- and down-streamed over the air.
2. **Live audiovisual production using a fixed or nomadic installation** – such as the coverage of an event in a sports stadium, a race with mobile equipment to capture the action, a conference, or a concert in a theatre.
3. **Live audiovisual production using a multi-tenant installation** – such as a music festival at which a generic installation (a seasonal stage) is built to host different performances, also involving the temporary connection of diverse equipment

For each scenario, an introductory section outlines the on-site and off-site elements that would be used in the context of a 5G-based deployment. The current state of the art regarding the technology used in this scenario is then described.

Next, we set out the features that 5G networks and systems would ideally support for the scenario in question. These 'shopping lists' of features reflect the support of a mixture of different applications in one network.

Depending on the scenario and the application, network requirements may differ, for example from low data rate and very low latency (audio) to very high data rate and medium latency (video). The requirements derived are based on practical assumptions and may only be a subset of those in [2].

Finally, we provide an initial inventory of potential solutions offered within the 5G ecosystem to support the given scenario, some of which have been proposed for study in 3GPP TR 26.805 [3].

Scenario 1. Electronic newsgathering (ENG) and uplink contribution

This scenario refers to the coverage of an event in the field that requires the up- and down-streaming of audio, video and auxiliary data over the air.

Connectivity is made available on-site by public or non-public networks. Audiovisual content is transferred to the production hub, where the programme output for the audience is generated.

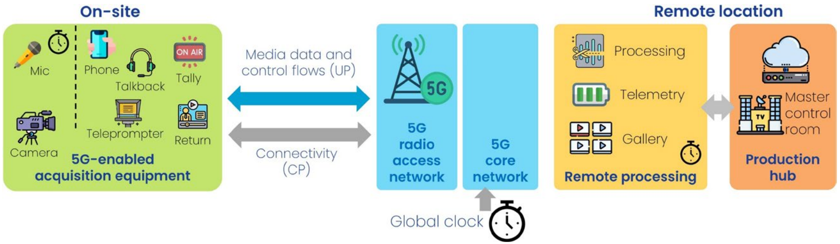

Figure 2: Electronic newsgathering scenario based on a 5G network deployment

Figure 2 shows the scenario based on 5G network components with bi-directional communication between 5G-enabled equipment and the 5G network. User data generated by microphones and cameras are synchronized to a global clock fed into or provisioned over the 5G system.

For small ENG setups, with less equipment required, it may be more convenient to use device-to-device (D2D) links to connect equipment to a local processing unit (see *Figure 3*). Here, user data provided by microphones and cameras are also synchronized to a global clock.

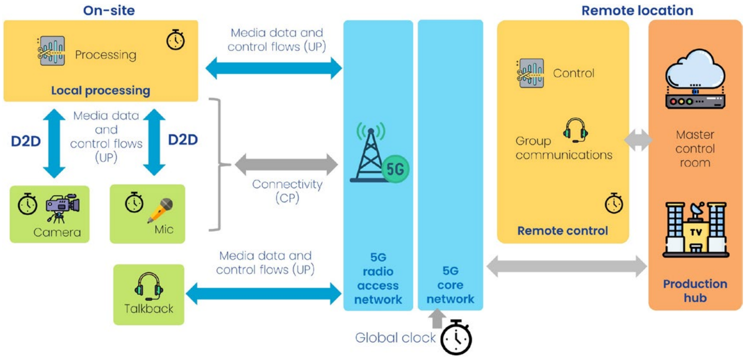

Figure 3: High-level view of a scenario using D2D connections

Current practices for Scenario 1

Guaranteed network performance

Managed or uncontended networks with high SLA (service level agreement) targets (e.g. predictable data rate, jitter, packet loss, reliability). Examples include dedicated capacity over satellite or fibre links (e.g. SMPTE 2022-6).

Best-effort and cellular bonding in unmanaged networks

Protocols for cellular bonding and transport over the public internet are a pragmatic solution against the lack of QoS over unmanaged networks. These implement redundancy paths, packet re-ordering or error correction, at the expense of additional latency. Examples are SRT, RIST, SST, LRT, Zixi ...).

Desired feature support for Scenario 1

5G may bring the opportunity to transition from best-effort unmanaged networks towards managed and guaranteed network performance. Networks and systems would ideally support the following features.

Quality of Service (QoS) management and prioritization, enabling:

- network performance tailored to data stream requirements (e.g. data rate, latency, reliability, etc.)
- priorities between streams in case of contention (e.g. video quality for return less critical than video quality for live camera).

Simultaneous handling of different data streams per device with different characteristics, protocols and QoS KPIs. In particular, the following QoS profiles (see Annex A):

- Profile A1: Voice Quality Audio, for audio streams delivered by equipment used for talkback and/or pure voice applications such as presentation, on-site or remote (e.g. microphone, talkback);
- Profile V1: ENG Quality Video, for video with high degree of compression (e.g. camera output);
- Profile V5: Return Quality Video, for video streams used for monitoring and preview (e.g. return video);
- Profile AV: Production Quality Audio with Video, for streams from the same source (camera and microphone from same speaker);
- Profile C1: Signalling, for non-latency-critical data (e.g. tally light, telemetry).

Dynamic adjustment of different QoS levels according to the changing network capacity/performance, including network-aware encoding.

Network QoS and SLS monitoring by means of exposure of network QoS parameters to sources/devices and service-level specification monitoring to service providers.

Ad-hoc set-up, deployment and release of equipment and related network functionalities within the 5G system in order to decrease set-up time and minimize pre-configuration steps. In particular:

- Scalability of the number of connected UEs;
- Identification of type of UE (mic, talkback, video, …);
- Assignment of QoS associated per data stream.

Ease of UE on-boarding and provisioning by means of pre-configuration or new registration into the network. The following devices are considered:

- UEs with subscriber identifier and credentials, including a physical SIM card;
- UEs without physical SIM-card (e.g. with an eSIM or alternative);
- UEs without human interfaces (no touchscreen, keyboard).

Timing and synchronization by the support of a global clock across connected devices, in particular for programme-output-related data coming from different audio and video sources.

Device-to-device communication to establish direct communication between mobile devices without the need for a network in between.

Potential 5G solutions for Scenario 1

Within the generic 5G System architecture, these are specific potentially beneficial solutions that 5G-MAG members consider worthy of study.

Uplink enhancement and aggregation of uplink bandwidth resources are part of the 3GPP specifications since Rel. 15, considering carrier aggregation (CA), supplemental uplink (SUL), dual connectivity (DC) and dynamic TX switching [4][5][6]. How these techniques can be applied to maximize spectral efficiency is to be analysed.

Device on-boarding and network management for NPNs. A deployment option may consist of provisioning an ad-hoc Standalone Non-Public Network (SNPN) covering the content-acquisition location. As an evolution of the current best-effort use of public networks for ENG and contribution scenarios, the use of Public-Network-Integrated Non-Public Networks (PNI-NPNs) is also a possibility. Solutions to manage QoS, device on-boarding and security aspects within NPNs are part of the 3GPP specifications [7].

UE aggregation and multipath via ATSSS (Access Traffic Steering, Switching and Splitting) is part of the 3GPP Rel. 16 specifications. ATSSS introduces the notion of a Multi Access PDU session where data traffic can be served over one or more concurrent accesses [8]. The extent to which these features are applicable for more efficient cellular bonding is to be studied.

Reliability mechanisms to increase reliability should be studied in relation to:

- Physical layer FEC, ARQ, frame repair, packet reordering, etc.;
- Exposure of network state information towards stream sources.

Enhanced video encoding with 5G Media Streaming Architecture, which has been developed to enable collaboration and deployment models involving operators and media service providers [9][10]. The architecture supports uplink and downlink streaming with a series of functions to interact with the 5G system and exposed APIs, enabling end-to-end application services. Its applicability to cover the following functionalities is relevant:

- Support of dynamic and adaptive bitrate encoding and QoS flows;
- Network-awareness to adapt encoding to network conditions;
- Policies and network slice management.

Latency reduction and lightweight transport protocols. The impact in latency reduction when applying relevant 5G features should be investigated. In particular, the possibility for guaranteed network performance and reliability may enable the introduction of lightweight protocols enabling a substantial latency reduction.

Sidelink and device-to-device communication. Sidelink has been specified in 3GPP Release 16 in the domain of vehicular communications. Its applicability to other uses is to be studied.

Synchronization of UEs with a global clock. Timing and synchronization is part of the 3GPP specifications [7]. Two cases for media are identified: alignment of user data at the application layer, leveraging the IEEE TSN standards [11] to expose 5G system timing to applications; and latency optimizations by time alignment between application and transport to reduce or eliminate buffering, thus reducing overall latency.

Scenario 2. Live production using a fixed or nomadic installation

This scenario supports media and entertainment use cases such as the production of sport events, conferences, concerts in venues or outdoors, etc.

The scenario is enabled by on-site local area connectivity with multi-source audiovisual equipment including wireless cameras and microphones, talkback, monitors for return video, teleprompters, tally lights, intercom, or robotics; each with various data streams. Integration with wired networks and devices may also be required.

Key features are timing and synchronization between different sources and between video and audio streams with a common origin. Auxiliary communications (e.g. group, intercom) may also be considered.

Figure 4 shows examples of 5G-enabled equipment and three different options for media processing and control [1]:

A) **Local production** – acquisition, media processing and control deployed on-site. Outputs are transported to the production hub.

B) **Remote Control** (surfacing) – media processing remains on-site, but control surfaces are remote and managed at distance.

C) **Remote Production** (remote processing and surfacing) – media processing is located remotely. Control surfaces may be co-located with the processing (e.g. at the production hub) or distributed across multiple sites (e.g. in cloud facilities).

In remote control and remote production scenarios, real-time response is critical. Discoverability of equipment connected to the network is needed.

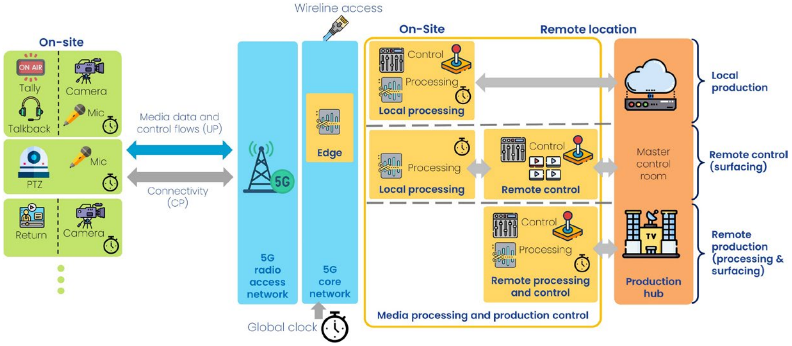

Figure 4 : High-level view of a media production scenario using a fixed or nomadic installation

Current practices for Scenario 2

Media production facilities are evolving towards IP- and software-based solutions. Wired networks are typically deployed with high-end quality requirements (e.g fibre-based studios may use 3–24 Gbps per camera). Wireless solutions are obviously limited given mobile radio conditions.

Cameras typically rely on dedicated uni-directional OFDM links with data rates between 5 and 30 Mbps for DVB-T or around 40 Mbps for DVB-T2. Microphones use dedicated uni-directional links over a short distance.

Desired feature support for Scenario 2

Mobile bi-directional connectivity creates opportunities to transition from OFDM into connected IP solutions. In addition to those described in Scenario 1, these are features that networks and systems would ideally support.

Simultaneous handling of different data streams per device with different characteristics, protocols and QoS KPIs. In particular, the following QoS profiles, in addition to those of Scenario 1 (see Annex A):

- Profile A2: High Quality Audio, for audio streams for data capturing and playback for content creation (e.g. microphone output, IEM, …);
- Profile V2: Production Quality Video, for video streams intended to be part of the programme output (e.g. camera video output);
- Profile V3: Ultra-Low-Latency Quality Video (e.g. camera output with lower degree of compression);
- Profile V4: Preview Quality Video, for video streams for monitoring (e.g. return video, monitoring, stand-by cameras, etc.);
- Profile C2: Remote Control, for equipment controlled remotely or for near-real-time operations (e.g. robotics, PTZ and remote control).

Network architecture, connectivity and security features to support:

- Low-latency processes, (e.g. closed-loop audio for IEM);
- Local area network (LAN) configurations for signal routing among on-site acquisition equipment and related processes;
- Positioning information (e.g. positioning accuracy for spotlight following, ~0.5m, or positioning data for immersive applications);
- LAN security while providing support for remote access and control.

Group communication for talkback/intercom applications.

Potential 5G solutions for Scenario 2

In addition to those identified under Scenario 1, these are specific potentially beneficial solutions that 5G-MAG members consider worthy of study.

Support of IP hand-off across networks and the roles of Network Address Translation (from network address range to production address range), monitoring, demarcation, and security aspects including firewalls.

5G Local Area Network and Local Breakout support are part of the 5G specifications [7] and should be studied for the provision of local area connectivity for media equipment.

Prioritization and source adaptation with 5G Media Streaming [9], in particular the following is potentially relevant:

- Dynamic control of data rates between production and preview or even idle sources, to maximize effective capacity usage;
- Traffic segregation and prioritization to treat media streams with different priorities, even grouping those with similar requirements.

Group communications for intercom purposes are part of the 3GPP specifications (e.g. mission critical comms, PTT, IMS, etc.). The application of multicast for group communications should also be considered.

Edge computing capabilities are part of the 5G specifications [12]. Enablers are addressed in the extensions to 5G Media Streaming Architecture [13].

High precision positioning, addressed in 3GPP Release 17, with relevant features applicable to the positioning of users and devices across localized outdoor or indoor environments.

Scenario 3. Live production using a multi-tenant installation

This scenario extends the previous one, adding specificities of a music festival taking place in a generic installation built to host different performances, with temporary connections and diverse equipment from multiple tenants.

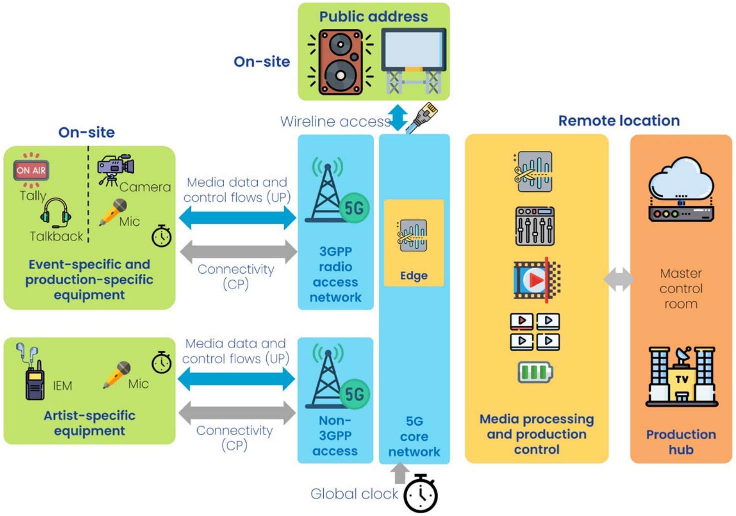

Figure 5: High-level view of the multi-tenant installation scenario highlighting the incorporation of equipment not based on a 3GPP RAT

The novel operational aspect of this scenario relates to the provision of live sound to performers on the stage by means of in-ear monitors (IEMs) and/or to on-site audiences by means of public address (PA) systems. These systems are key as they impose stringent latency requirements (e.g. mouth-to-ear latency for IEMs).

The scenario considers the possibility of providing 5G connectivity to devices based on a non-3GPP RAT (radio access technology), in particular when 5G-NR is not able to meet certain requirements (e.g. low latency for IEM).

Figure 5 depicts the proposed set-up and technologies:

- Pre-installed on-site 5G network to temporarily connect 5G-enabled equipment specific to the event and its production needs;
- Artist-specific equipment based on a non-3GPP RAT temporarily integrated into the on-site 5G network.

Current practices for Scenario 3

Today, audio PMSE links are established using a dedicated transmitter/receiver pair, with devices from different manufacturers generally incompatible. Therefore, artist-specific equipment always includes a complete RAT. This results in a huge number of receivers (for wireless microphones) and transmitters (for IEMs) being connected to the audio production network, if digital output/input is provided (e.g. DANTE), or in every receiver/transmitter being connected separately to the production mixing console.

Desired feature support for Scenario 3

These are features that networks and systems would ideally support In addition to those described for Scenarios 1 and 2.

Scalability of the 5G core to support the following configurations:

- 3GPP RAT (5G-NR);
- 3GPP RAT (5G-NR) plus an additional IMT-2020 RAT;
- 3GPP RAT (5G-NR) plus an additional user-specific RAT.

Support of non-3GPP access and devices (e.g. legacy equipment and equipment based on Wi-Fi, DECT, etc.) as required for certain scenarios. This integration is foreseen on short timescales and being automatic and easy.

Dual connectivity between different accesses (e.g. Wi-Fi and 3GPP).

Ethernet-based wireline access to the network, in particular when the production network uses wireless and wireline equipment.

Ease of equipment/device on-boarding and release in non-public networks. In particular for "bring your own device" applications, in which a 5G non-public network (radio access and core) is provided by the venue owner as a network service. Some PMSE production devices may be present and already authorized by the network while shows/artists/productions can bring their own PSME devices for a given performance.

Handling of ultra-low latency communication for IEM according to Profile A2 in Annex A, as IEM requires a mouth-to-ear latency below 4 ms.

Potential 5G solutions for Scenario 3

In addition to those identified for Scenarios 1 and 2, these are specific potentially beneficial solutions that 5G-MAG members consider worthy of study.

Interworking with wired/wireline access. Involves the possibility of integrating wireline (Ethernet-based) access within the 5G network for those scenarios where wireless and wired devices operate in the same network [7]. Devices connected to both types of access may also require connectivity to edge computing resources. The 3GPP specifications support Ethernet PDU (protocol data unit) sessions, multi-access PDU sessions and ATSSS.

Interworking for non-3GPP access. The 3GPP specifications define interworking between 3GPP and non-3GPP access, including support for trusted non-3GPP access networks [14]. The extent to which the current specifications enable interworking with a diverse range of non-3GPP RATs is to be investigated.

Device on-boarding. Consideration for device on-boarding as part of non-public networks (both SNPN and PNI-NPN) are part of the 3GPP specifications [7]. The opportunities to manage registration of devices without physical SIM cards are to be studied. Additionally, device off-boarding mechanisms are needed to ensure the privacy of data. The extent to which the specifications can support such needs requires clarification.

Annexes

A) QoS profiles

The tables in this annex set out expected requirements for media and data streams in the scenarios of this report. These are classified in profiles according to the nature of the data. Ranges indicate a certain flexibility depending on the application. See Annex C for definitions.

Note that data rates for video are directly linked to the quality/compression of the content. Some values may be revisited for new generations of video codecs. In other cases, they refer to what current technologies support.

A note on bitrates for media streams

The video profile data rates may vary when compression is applied, adapting the video signal to the available data rates. The upper values correspond to data rates offered by typical compression technologies (e.g. JPEG XS with HD 720p60 or HD 1080i60/p30 offer bitrates in the range of 70-195 Mbps; NDI streams with HD 1080p60 offer bitrates up to 150 Mbps per stream; H.264, HEVC or VVC encoders may bring greater data rate savings.

A note on latencies for media streams

Latencies below 100 ms in wireless multi-camera systems are expected, as already achieved with OFDM systems. Considering a highly performant, low RTT (round-trip time) network, a sub-frame latency encoder and efficient decoding, with proper compensation of jitter and clock skews, latency expectations around 3 or 4 frames may be considered. For reference, at 50 fps, a latency of 3–4 frames would correspond to around 60–80 ms.

A note on latencies for signaling and remote control

A distinction is made between signaling and remote control Signaling refers to latency requirements for non time-critical signals transported from the equipment at the acquisition site to a remote location or vice-versa. Optimizations to reduce latency are beneficial but do not compromise operations. Remote control (surfacing) refers to latency requirements for highly time-sensitive operations which target near-real-time performance.

Profile AV: Production Quality Audio with Video

Parameter	Unit	Value
Audio–video stream synchronization (lipsync) (Note 1)	ms	-20 to +50

Note 1: Lipsync values compare the delay of audio with respect to video (a negative value indicates that audio is ahead of video).

Profile C1: Signalling and telemetry

Parameter	Unit	Value
Latency (Note 1)	ms	500–5000
User experienced data rate (per link) – *UL & DL*	Mbit/s	<1

Note 1: Latency is defined between the transmission and reception of the signal.

Profile C2: Remote Control (Surfacing)

Parameter	Unit	Value
Latency (application user data)	ms	40–100
User experienced data rate (per link) – *UL & DL*	Mbit/s	<1

Audio Profiles A1 and A2

Parameter	Unit	Audio Profiles and Values	
		A1: Voice Quality	A2: High Quality
Latency (application user data)	ms	<10	<1
Latency (application control data)	ms	<100	<100
User experienced data rate (per link) – *UL & DL*	kbit/s	32–500	100–5000
Control data rate	kbit/s	<50	<50
Reliability	%	<99.99	<99.9999
Communication service availability	%	<99.9999	<99.9999
Service area times height	m³	<10000 x 10	<10000 x 10
Synchronicity	μs	1–10	1–10
# of audio links		2–20	5–300
Operation time of mobile devices	h	6–12	6–12
UE speed	km/h	<5	<50

Video Profiles V1, V2, V3, V4 and V5

Parameter	Unit	Video Profiles and Values				
		V1: ENG Quality	V2: Production Quality	V3: Ultra-Low-Latency	V4: Preview	V5: Return
Latency (application user data) (Note 1)	ms	500–5000	200–500	<100	100–500	500–5000
User experienced data rate (per link, HD) – *UL & DL*	Mbit/s	0.2–20	0.2–20	20–50	0.2–6	0.2–6
User experienced data rate (per link, UHD) – *UL*	Mbit/s	2–80	2–80	50–150	N/A	N/A
UE speed (Note 2)	km/h	<5	0–120	0–120	<5	< 5

Note 1: Latency is defined between the input video encoder to output video decoder (typically SDI output) including transmission.

Note 2: The value of UE speed considered here reflects requirements from static (e.g. commentator set, fixed camera, etc.) to mobile scenarios (e.g. sport, racing, etc.). It should be noted that some scenarios may deploy a mobile base station (e.g. located on a motorbike or helicopter). The value indicated in this table only considers the absolute speed of the UE, whereas in reality the relative speed between the UE and the base station may be lower.

B) Examples of 5G-enabled equipment

Equipment for acquisition, control, monitoring and auxiliary processes:

Wireless camera: handheld or mounted cameras with additional power packs, transceiver and antennas. It generates uplink video traffic, generally compressed by means of a video encoder. Camera processes may also be control remotely (e.g. pan-tilt-zoom or PTZ, robotics, focus control, ...) through a camera control unit (CCU). Telemetry may also be provided.

Wireless microphone: handheld or body-worn microphone that generates uplink audio traffic. The portable part of the device can be controlled remotely (e.g. audio gain and mute controls). Telemetry may also be provided (e.g. battery status).

IEM (in-ear monitor): transmitter and one or more bodypack receivers with earpieces for personal monitoring of single- or dual-channel sound [15]. IEM units can also be controlled remotely, e.g. to adjust audio parameters. Note that IEM may impose critical quality given its direct impact on the artist.

PA (public address): a music or sound system that amplifies audio signals for human perception by means of loudspeakers.

Talkback/intercom: wireless (or wired) system used to provide group communications (multi or single channel) among staff participating in a media production scenario to ensure a safe and error-free running audio/video production [15].

IFB (interruptible foldback): unidirectional audio communication to staff members from the production hub or for return audio (e.g. for interviews).

Monitor for video return: used to show live video from the production hub (e.g. output programme delivered to audiences, live video for interviews, ...).

CCU (camera control unit): refers to a range of equipment and operations related to remote control of camera functions.

Teleprompter: used to receive and project the speaker's script on-site.

Tally light: indicates that the content being captured by the wireless camera is ready to be, or is already, inserted into the live programme.

Robotic camera system: enables smooth movements for a camera mounted on it. These can be managed remotely and automated.

Network equipment:

Smartphones, tablets and mobile journalism equipment: may be introduced as a lightweight alternative to cameras and microphones (including lens, encoder, modem and RF parts). They may also be used for return video, editing purposes or talkback and intercom services.

Camera interface unit and/or backpack: an integrated solution combining camera controls, intercom, tally and other signals. It may integrate modems, slots for SIM cards and related RF parts. It may act as a point for media processes or as intermediate point between the network where equipment is connected and the network that provides connectivity towards the internet.

Media processing tools

A series of software applications may be used for encoding, editing, insertion of captions, video gallery, metadata processing, video management platforms for integration with social media, etc.

C) Definitions and terminology for QoS profiles

End-to-end latency: the time that takes to transfer a given piece of information from a source to a destination, measured at the communication interface, from the moment it is transmitted by the source to the moment it is successfully received at the destination [16].

Latency: sum of end-to-end latency and time for additional user data processing such as analogue to digital conversion and vice versa, audio encoding/decoding, frame realignment, jitter buffer. For example, end-to-end latency would be measured between a microphone input as source and a data processing unit as destination.

User experienced data rate: the minimum data rate required to achieve a sufficient quality experience, except for scenarios for broadcast-like services, where the given value is the maximum that is needed [16].

Control data rate: the minimum data rate required to achieve error-free operation. The value is specified per link (audio/video) and refers to application control feasibility.

Reliability: the probability that an application can perform a required function under agreed conditions for a given time interval. Reliability will be evaluated by the success probability of the transmission with a certain data rate and within a certain delay. Both data rate and delay are specific to the use case. It is defined as 1- PER for a packet size corresponding to 1 ms of audio data. Note this contrasts with the definition within 3GPP [16] where reliability is defined as: in the context of network layer packet transmissions, percentage value of the packets successfully delivered to a given system entity within the time constraint required by the targeted service out of all the packets transmitted.

Communication service availability: percentage value of the amount of time in which the end-to-end communication service is delivered according to an agreed QoS, divided by the amount of time the system is expected to deliver the end-to-end service according to the specification in a specific area [16].

Service area: geographic region where a 3GPP communication service is accessible. The service area can be indoors. For some deployments, the vertical dimension of the service area can be considerable [2]. It also includes non-3GPP communication services

Synchronicity (or clock synchronicity): the maximum allowed time offset within a synchronization domain between the sync master and any sync device. NOTE: Clock synchronicity (or synchronicity) is used as a KPI of clock synchronization services. Clock synchronicity is also referred to as clock (or time) synchronization precision [17].

# of audio/video links: typical number of simultaneous links which must be supported by the production network in uplink and downlink.

Operation time of mobile device: total time in which the mobile device transmits or receives audio/video data.

Direct device connection: the connection between two UEs without any network entity in the middle [16].

D) References and related 3GPP specifications

[1] Live Remote Production, DPP Whitepaper, April 2021
[2] 3GPP TR 22.827: “Study on Audio-Visual Service Production; Stage 1 (Release 17)”
[3] 3GPP TR 26.805: “Study on Media Production over 5G NPN Systems (Release 17)”
[4] 3GPP TS 38.101-1: "NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone(Release 17)”
[5] 3GPP TS 38.213: "NR; Physical layer procedures for control (Release 17)”.
[6] 3GPP TS 38.214: "NR; Physical layer procedures for data (Release 17)”
[7] 3GPP TS 23.501: "System architecture for the 5G System (5GS)" (Release 17)”
[8] 3GPP TS 24.193: “5G System; Access Traffic Steering, Switching and Splitting (ATSSS); Stage 3 (Release 17)”
[9] 3GPP TS 26501: “5G Media Streaming (5GMS); General description and architecture (Release 17)”
[10] 3GPP TS 26512: “5G Media Streaming (5GMS); General description and architecture (Release 17)”
[11] IEEE 1588-2008: "Precision Time Protocol"
[12] 3GPP TS 23.558: “Architecture for enabling Edge Applications (Release 17)”
[13] 3GPP TR 26.803: “Study on 5G Media Streaming Extensions for Edge Processing (Release 17)”
[14] 3GPP TS 24.502: “Access to the 3GPP 5G Core Network (5GCN) via non-3GPP access networks (Release 17)”
[15] ETSI TR 102 546: “System Reference document (SRdoc); Technical characteristics for Audio PMSE equipment (V2.1.1)”
[16] 3GPP TS 22.261: “Service requirements for the 5G system; Stage 1 (Release 19)”
[17] 3GPP TS 22.104: “Service requirements for cyber-physical control applications in vertical domains; Stage 1 (Release 18)”

www.5g-mag.com

Published by 5G-MAG | December 2022

5G Media Action Group (5G-MAG) Association
17A L'Ancienne-Route
1218 Grand-Saconnex (Switzerland)

info@5g-mag.com • www.5g-mag.com