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Contents

Foreword

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- z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The scope of the present document is to support the generation of a technical specification which defines a limited set of operation points for TV services in order to enable a consistent service offering within 3GPP. For this purpose the present document collects relevant information from other organizations and summarizes and consolidates these findings. Additional 3GPP specific aspects on TV profiles (such as existing and emerging UE capabilities, delivery enablers, or specific service aspects) are collected and put in context.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
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- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document.*

[1] 3GPP TR 21 905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 26.234: "Transparent end-to-end Packet-switched Streaming Service (PSS); Protocols and codecs".

[3] 3GPP TS 26.346: "Multimedia Broadcast/Multicast Service (MBMS); Protocols and codecs".

[4] 3GPP TS 26.247: "Transparent end-to-end Packet-switched Streaming Service (PSS); Progressive Download and Dynamic Adaptive Streaming over HTTP (3GP-DASH)".

[5] DVB ETSI TS 101 154 v2.2.1 (2015-06): "Digital Video Broadcasting (DVB); Specification for the use of Video and Audio Coding in Broadcasting Applications based on the MPEG-2 Transport Stream ".

[6] ETSI TS 103 285 v1.1.1 (2015-05):: "Digital Video Broadcasting (DVB); MPEG-DASH Profile for Transport of ISO BMFF Based DVB Services over IP Based Networks".

[7] ETSI EN 300 468 V1.14.1 (2014-05): "Specification for Service Information (SI) in DVB systems".

[8] ETSI EN 300 743 V1.5.1 (2014-01): "Digital Video Broadcasting (DVB); Subtitling systems"

[9] ETSI TS 101 211 V1.12.1 (2013-12): "Guidelines on implementation and usage of Service Information (SI)"

[10] DASH-IF, "Guidelines for Implementation: DASH-IF Interoperability Points", version 3.0.

[11] ISO/IEC 23001-8:2013, "Information technology -- MPEG systems technologies -- Part 8: Coding-independent code points".

[12] ISO/IEC 14496-12:2015: "Information technology -- Coding of audio-visual objects -- Part 12: ISO base media file format".

[13] ITU-T Recommendation H.264 (01/2012): "Advanced video coding for generic audiovisual services" | ISO/IEC 14496-10:2010: "Information technology – Coding of audio-visual objects – Part 10: Advanced Video Coding".

[14] ISO/IEC 14496-15:2014/Cor 1:2015: "Information technology -- Coding of audio-visual objects -- Part 15: Carriage of network abstraction layer (NAL) unit structured video in ISO base media file format".

[15] ITU-T Recommendation H.265 (07/2013): "Advanced video coding for generic audiovisual services" | ISO/IEC 23008-2:2013: " High Efficiency Coding and Media Delivery in Heterogeneous Environments – Part 2: High Efficiency Video Coding".

[16] ISO/IEC 23009-1:2014/Cor.1:2015/Amd.1:2015: "Information technology -- Dynamic adaptive streaming over HTTP (DASH) -- Part 1: Media presentation description and segment formats".

[17] ATSC A/53, Part 4:2009: "MPEG-2 Video System Characteristics".

[18] ATSC A/72 Part 1 & 3: "Video System Characteristics of AVC in the ATSC Digital Television System" & "Video and Transport Subsystem Characteristics of MVC for 3D-TV Broadcast in the ATSC Digital Television System".

[19] ATSC A/153 Part 7:2012, "AVC and SVC Video System Characteristics".

[20] ANSI/SCTE 128-1 2013: "AVC Video Constraints for Cable Television, Part 1 – Coding".

[21] ETSI TS 101 211 V1.12.1 (2013-12): "Basic Parameter Values for the HDTV Standard for the Studio and for International Programme Exchange".

[22] SMPTE 170M: "Television – Composite Analog Video Signal – NTSC for Studio Applications".

[23] DECE: "Common File Format & Media Formats Specification" v2.0.1 Dec.2014

[24] Recommendation ITU-R BT.601-7 (2011): "Studio encoding parameters of digital television for standard 4:3 and wide screen 16:9 aspect ratios".

[25] Recommendation ITU-R BT.1700 (02/2005): "Characteristics of composite video signals for conventional analogue television systems".

[26] 3GPP TS 26.244: "Transparent end-to-end packet switched streaming service (PSS); 3GPP file format (3GP)".

[27] void

[28] Recommendation ITU-R BT.2022 (2012): "General viewing conditions for subjective assessment of quality of SDTV and HDTV television pictures on flat panel displays".

[29] ISO/IEC 14496-3: "Information technology -- Coding of audio-visual objects -- Part 3: Audio".

[30] ETSI TS 102 366 V1.2.1 (2008-08): "Digital Audio Compression (AC-3, Enhanced AC-3) Standard".

[31] ANSI/SCTE 128-2: "AVC Video Constraints for Cable Television, Part 1 – Transport".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply.
An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

ARIB Association of Radio Industries and Business
ATSC Advanced Television Systems Committee
CDN Content Delivery Network

CICP	Coding-independent code points
DASH	Dynamic Adaptive Streaming over HTTP
DASH-IF	DASH Industry Forum
DECE	Digital Entertainment Content Ecosystem
DVB	Digital Video Broadcasting
DTT	Digital Terrestrial TV
EBU	European Broadcast Union
GOP	Group of Pictures
IRD	Integrated Receiver-Decoder
ISO BMFF	ISO Base Media File Format
HbbTV	Hybrid broadcast broadband TV
HD	High Definition
HEVC	High Efficiency Video Coding
HRD	Hypothetical Refence Decoder
LTE	Long Term Evolution
MBMS	Multimedia Broadcast/Multicast Service
MBSFN	Multicast-Broadcast Single Frequency Network
MNO	Mobile Network Operator
MPD	Media Presentation Descriptor
PSS	Packet-switched Streaming Service
RAP	Random Access Point
SAP	Stream Access Point
SCTE	Society of Cable Technology Engineers
SD	Standard Definition
SEI	Supplemental Enhancement Information
TV	TeleVision
UHD	Ultra-High Definition
VoD	Video on Demand
VUI	Video Usability Information

4 Background and Context

4.1 Introduction

Linear TV services can be made available on 3GPP networks via MBMS [3] and PSS [2] user services (over RTP or 3GP-DASH [4]).

- 3GP-DASH aims at offering the best quality of experience as possible by adapting to the UE capabilities and dynamically to the network conditions. Linear TV and on-demand services are already identified as major use cases for 3GP-DASH delivery format.

- (e)MBMS user services offer the possibility to offload the network when the same content is consumed simultaneously by many UEs. This typically happens when a large audience accesses the same content concurrently, such as a popular football match, the Olympic Games, a political debate, breaking news, etc. For this reason, the access to live broadcast TV services is a major use case for eMBMS.

For traditional linear TV distribution, TV services accessed through Satellite, Digital Terrestrial TV (DTT), cable or IPTV obey to requirements on the video profiles to ensure a consistent quality of experience while accessing different channels within a TV bouquet.

On-demand video services, via streaming or downloading, generally obey to the same requirements.

Up to Release-12, 3GPP specifications are missing detailed definitions of distribution formats (such as spatial and temporal resolutions, aspect ratios, random access points, etc.) for which operators and service providers can provide guarantees in terms of quality of experience. Typically, 3GPP service specifications only define profiles and levels of video codecs.

Therefore, additional requirements/guidelines on video formats (frame rate, resolution, aspect ratio, colorimetry, bit depth…) and codecs (random access point period, SEI messages…) for linear TV and video-on-demand services need to be documented. The definition of a limited set of operation points (e.g. SDTV, HDTV…) provides confidence to

content providers/broadcasters on the quality of experience offered by 3GPP services when used for TV-like distribution.

In addition, in the context of DASH operations, not only the main distribution format is of relevance, but at least also a subset of spatial and temporal resolutions. In order to minimize testing for seamless switching experience, suitable lower resolutions of distribution formats are important for consistent service offerings. Furthermore, to compensate congestion situations, a minimum service quality should be defined in order to provide service continuity.

Note that a TV service typically not only includes video components, but also other audio and supplementary components, such as subtitles. These aspects are also considered in the present document.

Such consolidated operation points are particularly useful for second screen applications as well as hybrid broadcast broadband services. Traditional broadcasters and service providers are keen to provide a unified service offering to mobile devices without requiring adapting content encoding to a multitude of different device capabilities. Input from such organizations on main distribution formats for traditional distribution is relevant.

In order to address different device classes and distribution formats, a limited set of operation points for a TV profile definition are expected to be defined.

The objective of the present document is to support the generation of a technical specification which defines a limited set of operation points for TV services in order to enable a consistent service offering within 3GPP, but also across different access networks including traditional distribution systems.

Therefore, the present document addresses the collection of the following information:

- Relevant established and emerging traditional distribution formats.
- Parameters assigned to an operation point including but not limited to: spatial and temporal resolutions, bit depth, color space, etc.
- Small subset of relevant distribution formats independent of the service.
- Operation points from a video codec point of view (signaling of SEI messages…).
- Enablers in different 3GPP services (MBMS, PSS, DASH) to map such parameters to 3GPP services, including service specific requirements, e.g. adaptive resolution switching in DASH. etc.
- Non-video relevant aspects.

4.2 Scenarios and Deployment Cases

4.2.1 Scenario

In the context of the present document, the provisioning of TV-like services to 3GPP UEs is considered. Figure 1 provides a high-level context of a possible scenario. The scenario is not considered being complete or comprehensive, but only highlights the context. The present document also does not consider the role of the mobile network operator (MNO), whether it is a content/service provider itself, or it collaborates with a content provider to distribute the content. Nevertheless, in any case it is the desire of the content provider to provide a realistic and possibly controllable quality to different end devices that are connected through a 3GPP network and include a 3GPP UE with PSS and/or MBMS client.

On the left hand sources that contribute to the generation of a TV program are provided. Such sources may for example be satellite feeds, terrestrial broadcast feeds, cable or other contribution links. These feeds typically carry content that is encoded and distributed using formats such as defined by DVB, ATSC, SCTE or other broadcast organizations. Examples for video formats are SD content, HD content, full HD content or UHD content. The content may have different properties to support the service, for example display instructions, random access point frequencies and so on. At the same time, the content may be augmented with program that is available On-demand, for example VoD assets or ad content. The content is expected to be received by 3GPP UE with PSS and/or MBMS client. Such receivers may be heterogeneous in terms of capabilities, for example in terms of display resolutions, decoding capabilities, audio rendering capabilities and many other aspects.

An important scenario is the adaptation and provisioning of the content originating from a multitude of sources to a heterogeneous receiver population (equipped with a 3GPP UE functionality) through a 3GPP network. This work is not expected to cover all flavors of such a complex service offering, but focusses on the media-format related challenges in such a scenario that motivate the definition of operation points in the context of TV Video Profiles.

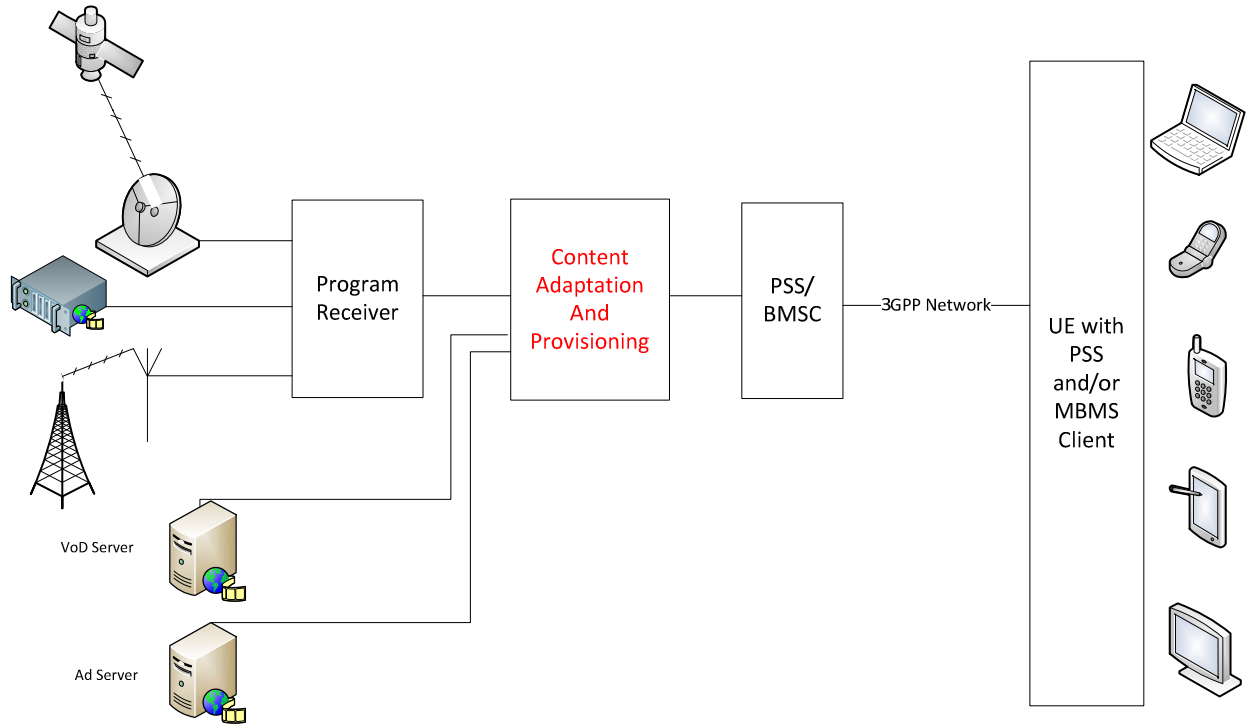

Figure 1: Scenario for Distributing TV Content to Mobile Devices

4.2.2 Media-Format Related Challenges

In the following a few media-format related challenges are provided that motivate the definition of TV Video Profiles.

1) On the Contribution Formats:

   a) The live contribution formats may be different depending on the contribution link, the applied standard or the location/region. Different content sources need to be taken into account, for example different broadcast standards such as DVB or ATSC, different contribution links, as well as formats that are used in different regions. It is expected that a 3GPP-based set of TV profiles enables to distribute formats in different regions of the world distributed with different standards.

   b) Legacy and new formats: Broadcast quite often needs to maintain legacy distribution in order to ensure compatibility to an installed base. At the same time advanced formats with better quality of experience are distributed to newer devices. It is expected that a 3GPP-based set of TV profiles enables to distribute new and emerging formats whereas legacy Broadcast TV formats are of less relevance.

   c) VoD Assets and Ads may be in different content formats. For example movies are quite often provided in formats defined by MovieLabs, DECE or Bluray Disk Association (BDA). It is expected that a 3GPP-based set of TV profiles enables to distribute movies in commonly used formats.

   d) Content industry generates new formats to enable new experiences, for example wider colour gamut, higher dynamic ranges, etc. It is expected that a 3GPP-based set of TV profiles may be updated in the future to add such new formats as interoperable options.

   e) Contribution formats may contain certain properties (random access points, encryption) or may carry specific metadata or auxiliary information (subtitles, etc.). It is expected that a 3GPP-based set of TV profiles enables to maintain relevant properties and metadata.

2) On Consuming Devices

   a) Consuming Devices are heterogeneous including different display resolutions and capabilities. It is expected that a 3GPP-based set of TV profiles enables to provide TV-like contents to a collection of different device classes in a controllable and consistent manner. In addition, it is expected that consuming devices would be able to select a content that fits their capabilities. However, it is not expected that a 3GPP-based set of TV profiles would cover all capabilities of existing mobile devices, but would provide an ability that, in the future, consuming devices would consistently implement 3GPP TV profiles to reduce fragmentation.

   b) Higher-end 3GPP UEs already provide media capabilities that may be suitable for consuming TV-like services. Therefore it is expected that at least one TV profile would be defined that would enable content distribution with higher-end capabilities than those already deployed UEs.

   c) Mobile devices provide new capabilities to enable new media experiences, for example wider colour gamut, higher dynamic ranges, higher resolution, etc. It is expected that a 3GPP-based set of TV profiles may be updated in the future to add such new formats as interoperable options.

3) On Content Distribution

   a) Efficient distribution is of utmost relevance for 3GPP-based distribution. It is expected that a 3GPP-based set of TV profiles would enable the efficient distribution of video formats to different devices. In particular it is expected that options would be provided that would enable the use of latest advances in compression efficiency.

   b) In order to enable cost-efficient distribution, scalable delivery is important. This could enable for example the use of broadcast distribution (either directly or using MBMS-on-Demand) and/or CDN architectures for efficient caching. It is expected that a 3GPP-based set of TV profiles would support scalable distribution of content.

   c) In order to react to throughput changes, for example due to mobility, congestion, handovers and other mobile variability, rate and quality adaptive distribution is relevant for consistent quality and service continuity. It is expected that a 3GPP-based set of TV profiles would support adaptive distribution of content, in particular 3GP-DASH.

4) On Content Adaptation and Provisioning

   a) It is expected that different types of content will be made available in a service offering, for example by content splicing at the sender (program mix) or also in the receiver (targeted ad insertion). It is expected that a 3GPP-based set of TV profiles would support different types of content, and also the change and update of the format in a linear program.

   b) The processing requirements in content adaptation should be manageable. It is expected that a 3GPP-based set of TV profiles would support content adaptation in a processing-manageable manner.

   c) Content adaptation may lead to quality degradation, for example due to transcoding, distribution format change, frame rate adaptation, cropping, subsampling, aspect ratio adaptation and so on. It is expected that a 3GPP-based set of TV profiles would enable content adaptation such that quality degradations due to content adaptation are avoided or at least minimized. In particular, TV profiles should have capabilities that result in frame rate conversion being avoided for the large majority of content.

Based on these initial considerations, some functions that are relevant for content adaptation and provisioning are documented below.

4.2.3 Content Adaptation and Provisioning Functions

Based on the discussions in clauses 4.3.1 and 4.3.2, at least the following content adaptation and provisioning functions are considered relevant and are expected to be considered to enable the distribution of common media formats with 3GPP TV profiles:

- Mapping of typical broadcast distribution formats to 3GPP TV Profiles
- Mapping of typical VoD and Ad content formats to 3GPP TV Profiles
- Mapping of relevant properties and metadata of broadcast and movie formats to 3GPP TV Profiles

- Provisioning of content for different device classes with different decoding and rendering capabilities
- Provisioning of new media formats
- Encoding/transcoding such that efficient distribution is enabled
- Mapping to 3GP-DASH formats

5 Traditional Distribution Formats

5.1 Overview

In order to collect relevant traditional TV distribution formats, several broadcast TV related groups have been identified and an analysis was conducted in order to provide an overview of existing and emerging TV distribution formats. Details on the methodology are provided in clause 5.2, the collected information of responding organizations is in clause 5.3 and clause 5.4 provides a summary.

5.2 Methodology

In order to collect relevant information of existing TV distribution formats, communication was initiated with a number of Broadcast-related organizations such as :the Advanced Television Systems Committee (ATSC), the DASH Industry Forum (DASH-IF), the Digital Entertainment Content Ecosystem (DECE) and the Digital Video Broadcasting (DVB) Project.

The objective was to get an overview of the relevant parameters that are constrained in the context of the live and on-demand TV distribution.

The analysis was conducted by identifying the specifications that contain TV video profiles where the relevant parameters were listed with their constrained values. Video and non-video related requirements were collected together with their context of application (type of service considered).

Such parameters are depicted in theTable 1a below with two sets of values as example.

Table 1a: Parameters for TV profiles

Parameter	Operation Point #1 (example)	Operation Point #2 (example)
Picture Resolution	1920 x 1080	352 × 288 ('CIF')
Picture Aspect Ratio	16:9	4:3
Chroma Format	YCbCr	YCbCr
Sub-sampling format	4:2:2	4:2:0
Sample aspect ratio	1:1 ('square')	11 x 10
Bit Depth	10	8
Color Primaries	BT.2020	709
Transfer function (SDR or HDR)	SMPTE ('PQ')	709 (SDR)
Frame rates (Hz)	60	24

Parameter	Operation Point #1 (example)	Operation Point #2 (example)
Video coding format	AVC aka H.264	H.263
Video Codec Profile Level	HEVC Main Tier MP level4.1	
Audio Channel Count	5,1	1
Audio Codec	AAC LC 5.1ch	AMR
Transport Layer	MPEG-2 TS	RTP
Closed Captioning	CEA-708 inband	3GPP Timed Text
SEI messages	Picture Timing SEI Message	
VUI parameters	Aspect Ratio Information	
Random Access Point Definition		
Bar data handling (aka letterbox etc.)	AFD	

5.3 Collected Information

5.3.1 DVB

5.3.1.1 Introduction

The main specification defining TV profiles in DVB is the ETSI TS 101 154 v2.1.1 [5]. This specification defines, among others, video profiles based on H.264/AVC [13] (in SD and HD) and H.265/HEVC [15] (in HD and UHD). The TS 101 154 defines additional profiles, including for example MPEG-2 video as well as formats with interlaced video. All the profiles are defined in TS 101 154 in the context of the MPEG-2 TS.

In addition, the DVB-DASH profile using MPEG DASH and ISO Base Media File Format for encapsulation is defined in the ETSI TS 103 285 v1.1.1 [6] This specification defines certain extensions to video profiles in the context of DASH, but still refers to TS 101 154 for the core video profiles.

DVB Service Information is provided in ETSI EN 300 468 [7]. This document also defines signaling related to TV Video profiles.

5.3.1.2 Video codec profiles and levels

The video profiles defined by the specification TS 101 154 that are considered of interest for 3GPP SA4 are:

- H.264/AVC Main Profile at Level 3 is used for H.264/AVC SDTV,
- H.264/AVC High Profile at Level 4 is used for 25 Hz and 30 Hz H.264/AVC HDTV,
- H.264/AVC High Profile at Level 4.2 is used for 50 Hz and 60 Hz H.264/AVC HDTV,
- HEVC Main Profile at Level 4.1 is used for HEVC HDTV 8-bit IRDs,
- HEVC Main 10 Profile at Level 4.1 is used for HEVC HDTV 10-bit IRDs,
- HEVC Main 10 Profile at Level 5.1 is used for HEVC UHDTV.

5.3.1.3 Defined parameters for video profiles

The TS 101 154 defines video related parameters provided in the Tables below (focusing on progressive formats only), specifically:

- H.264/AVC SDTV IRDs and Bitstreams in Table 1
- H.264/AVC HDTV IRDs and Bitstreams in Table 2
- HEVC IRDs and Bitstreams in Table 3

Table 1: H.264/AVC SDTV IRDs and Bitstreams

Profile	**25 Hz H.264/AVC SDTV (clause 5.6.2)**	**30 Hz H.264/AVC SDTV (clause 5.6.3)**
Picture Resolution	720 × 576, 544 x 576, 480 x 576, 352 x 576, 352 x 288	720 × 480, 640 × 480, 544 × 480, 480 × 480, 352 × 480, 352 × 240
Picture Aspect Ratio	4:3 or 16:9	
Chroma Format	YCbCr	
Sub-sampling format	4:2:0	
Sample aspect ratio	Provided in Table 8 signaled by aspect_ratio_idc	Provided in Table 10 signaled by aspect_ratio_idc
Bit Depth	8 bit	
Color Primaries and Transfer Function	Recommended to use BT.1700 Part A **colour_primaries=5 transfer_characteristics=5 matrix_coefficients=5**	Recommended to use BT.1700 Part A **colour_primaries**=6 **transfer_characteristics**=6 **matrix_coefficients**=6
Frame rates (Hz)	25	24 000/ 1 001, 24, 30 000/ 1 001, 30
Video coding format	H.264/AVC	
Video Codec Profile Level	Main Profile Level 3	

Table 2: H.264/AVC HDTV IRDs and Bitstreams

Profile	**25 Hz (clause 5.7.2)**	**30 Hz (clause 5.7.3)**	**50 Hz (clause 5.7.4)**	**60 Hz (clause 5.7.5)**
Picture Resolution	1920 × 1080, 1440 × 1080, 1280 × 1080, 960 × 1080, 1280 × 720, 960 × 720, 640 × 720			
Picture Aspect Ratio	16:9			
Chroma Format	YCbCr			
Sub-sampling format	4:2:0			
Sample aspect ratio	Provided in Table 11 signaled by aspect_ratio_idc			
Bit Depth	8 bit			
Color Primaries and Transfer Function	Recommended to use either BT.709: **colour_primaries=1, transfer_characteristics=1, matrix_coefficients=1** or IEC 61966-2-4 (xvYCC) **colour_primaries=1, transfer_characteristics=11, matrix_coefficients=1**			
Frame rates (Hz)	25	24 000/1 001, 24, 30 000/1 001, 30	25 or 50	24 000/1 001, 24, 30 000/1 001, 30, 60 000/1 001 or 60
Video coding format	H.264/AVC			
Video Codec Profile Level	High Profile Level 4		High Profile Level 4.2	

Table 3: HEVC IRDs and Bitstreams

Profile	HEVC HDTV 8-bit (clause 5.14.2)	HEVC HDTV 10-bit (clause 5.14.2)	HEVC UHDTV (see clause 5.14.3)
Picture Resolution	1920 × 1080, 1440 × 1080, 1600 × 900, 1280 × 720, 960 × 720, 960 × 540		3840 x 2160, 2880 x 2160, 3200 x 1800, 2560 x 1440, 1920 × 1080, 1440 × 1080, 1600 × 900, 1280 × 720, 960 × 720, 960 × 540
Picture Aspect Ratio	16:9		
Chroma Format	YCbCr		
Sub-sampling format	4:2:0		
Sample aspect ratio	Provided in Table 20 signaled by aspect_ratio_idc		Provided in Table 21 signaled by aspect_ratio_idc
Bit Depth	8 bit	10 bit	8 and 10 bit
Color Primaries and Transfer Function	BT.709: **colour_primaries=1, transfer_characteristics=1, matrix_coefficients=1** or optionally IEC 61966-2-4 (xvYCC) **colour_primaries=1, transfer_characteristics=11, matrix_coefficients=1**		BT.709 **cp** = 1, **tc**=1, **mc** =1 or BT.2020 (NCL) **cp** = 9, **tc**=14, **mc** =9 Note: displays may not support BT.2020, but are expected to handle the signaling.
Frame rates (Hz)	24 000/1 001, 24, 25, 30 000/1 001, 30, 50, 60000/1 001 or 60 Hz Note: two types of decoding capabilities are defined (50Hz and 60 Hz family)	24 000/1 001, 24, 25, 30 000/1 001, 30, 50, 60000/1 001 or 60 Hz Note: two types of decoding capabilities are defined (50Hz and 60 Hz family)	24 000/1 001, 24, 25, 30 000/1 001, 30, 50, 60000/1 001 or 60 Hz
Video coding format	HEVC		
Video Codec Profile Level	Main Profile, Level 4.1	Main-10 Profile, Level 4.1	Main-10 Profile, Level 5.1

5.3.1.4 Video coding parameters for broadcast distribution

TS 101 154 provides detailed requirements on the following parameters:

- Random Access Point Definition and Frequency
- Signalling in the VUI information
- Constraints in the Parameter Sets (High-Level Syntax)
- Supported SEI messages
- Scalability (for example for forward compatibility)
- Seamless splicing
- Signalling for additional information
  - Auxiliary Data in the Video Elementary Stream
  - Discusses Active Format Descriptors (AFD) and Bar data handling

5.3.1.5 Audio related Parameters

DVB defines a toolbox for codecs and audio and video are not combined in a single profile. It is up to the service provider to choose the appropriate combination of video and audio interoperability points.

For audio, the following codecs are referenced:

- MPEG-1 Layer I, MPEG-1 Layer II, MPEG-2 Layer II backward compatible,

- AC-3, Enhanced AC-3 [30],
- DTS, DTS-HD,
- MPEG-4 AAC, MPEG-4 HE AAC or MPEG-4 HE AAC v2 audio.

From the toolbox of codecs only some of the options are in common use: MPEG-1 Layer II, AC-3, MPEG-4 AAC, HE-AAC, and E-AC-3. Some of these are considered legacy codecs, and only a subset of these codecs with relevant efficiency are commonly used for new DVB broadcast services.

The relevant parameters for commonly used audio codecs are summarized in Table 4.

Table 4: Relevant parameters for commonly used audio codecs

audio codec	MP1L2	AC-3	EAC-3	AAC	HE-AAC
codec signaling stream_type, stream_id		0x6, 0xBD, Refer to TS 101 154, clause 4.1.6.1	0x6, 0xBD Refer to TS 101 154, clause 4.1.6.1	0x11, 0b110x xxxx Refer to TS 101 154, clause 4.1.6.1	0x11, 0b110x xxxx Refer to TS 101 154, clause 4.1.6.1
codec specific descriptor tag for PMT		0x6A Refer to TS 101 154, clause 4.1.8.23	0x7A Refer to TS 101 154, clause 4.1.8.23	0x7C Refer to TS 101 154, clause 4.1.8.26	0x7C Refer to TS 101 154, clause 4.1.8.26
intermediate wrapping	not required	not required	not required	LATM/LOAS Refer to TS 101 154, clause 6.4.1 and ISO/IEC 14496-3	LATM/LOAS Refer to TS 101 154, clause 6.4.1 and ISO/IEC 14496-3
Specific PES constraints	n.a.	yes, refer to TS 101 154, clause 6.2.1	yes, refer to TS 101 154, clause 6.2.1	no	no
recommended STD audio buffer size		5696 bytes Refer to TS 101 154, clause 4.1.8.20	5696 bytes Refer to TS 101 154, clause 4.1.8.20	3584 bytes (L2), 8976 bytes (L4) Refer to TS 101 154, clause 4.1.8.20	3584 bytes (L2), 8976 bytes (L4) Refer to TS 101 154, clause 4.1.8.20
DVB SI component descriptor required		Yes	Yes	yes	yes
RAP necessary	not required	not required	not required	Yes Refer to TS 101 154, clause 6.5	Yes Refer to TS 101 154, clause 6.5
sampling rates		32 kHz, 44.1 kHz, 48 kHz, Refer to TS 102 366, Annex A	32 kHz, 44.1 kHz, 48 kHz, Refer to TS 102 366, Annex A	32 kHz, 44.1 kHz, 48 kHz, refer to ISO/IEC 14496-3	32 kHz, 44.1 kHz, 48 kHz, refer to ISO/IEC 14496-3
channel configs		up to 5.1 Refer to TS 101 154, clause 6.2.1.1	up to 7.1 Refer to TS 101 154, clause 6.2.1.1	up to 5.1, refer to ISO/IEC 14496-3	up to 5.1, refer to ISO/IEC 14496-3
codec levels, compatibility indication*		not required	not required	up to stereo = L2, up to 7.1 = L4, refer to TS 101 154 clause 6.4.2.1 and ISO/IEC 14496-3	up to stereo = L2, up to 7.1 = L4, refer to TS 101 154 clause 6.4.2.1 and ISO/IEC 14496-3
audio control MD (DRC and loudness)		yes, refer to TS 102 366, clause 6	yes, refer to TS 102 366, clause 6	optional, refer to TS 101 154 Annex C5 and ISO/IEC 14496-3	optional, refer to TS 101 154 Annex C5 and ISO/IEC 14496-3
associated audio mixing	yes	Yes, Refer to TS 102 366, clause 6	Yes, Refer to TS 102 366, clause 6	yes, Refer to TS 101 154, Annex E	Yes, Refer to TS 101 154, Annex E
ISO 639 Language Descriptor	yes	yes	Yes	yes	yes

5.3.1.6 Parameters for special services (supplementary streams, DASH sub-resolutions, etc.)

For auxiliary video services, TS 101 154 does not provide any specific aspects.

However, DVB DASH as defined in TS 103 285 [6] provides additional information and restrictions, namely:

- Luminance Resolutions and Frame Rates for DASH-based distribution, more resolutions are permitted to enable seamless adaptive switching
- Video Switching Between Different Representations in the same Adaptation Set
- Restrictions on carriage of Parameters Sets inband and Initialization Segments
- Trick Mode considerations

For auxiliary audio services, the following is defined

- TS 101 154, Supplementary Audio Services for MPEG-1 layer II. Other codecs define supplementary services as part of their codec specifications.
- TS 103 285, Using the Role Scheme to Distinguish Between Different Adaptation Sets
- EN 300 468 [7] DVB SI contains descriptors

In terms of DASH specific restrictions for audio, DVB DASH TS 103 285 defines the following:

- Audio behavior in case of adaptive switching include seamless switching performance
- Service Continuity Considerations
- Bitrate recommendations for codecs in case of multiple Adaptation Sets

For subtitles, TS 101 154 does not provide any information. However, ETSI EN 300 743 [8] defines DVB subtitling based on bitmaps. Furthermore, the DVB-DASH specification TS 103 285 provides information on DASH Specific Aspects for Subtitles including a reference to EBU-TT, the provisioning of metadata to annotate subtitles as well as how to use downloadable fonts. In addition, usage guidelines are defined in clause 10.7.

5.3.1.7 Any implementation guidelines

DVB provides a certain amount of implementation guidelines in:

- ETSI TS 101 211 [9]: Guidelines on implementation and usage of Service Information (SI)
- As part of ETSI TS 102 385 in the DVB DASH specification

5.3.1.8 Deducted Information on Random Access Points

The DVB specification TS 101 154 [5], defines RAP frequency requirements for AVC and HEVC bitstreams. H.264/AVC and HEVC RAPs in the video elementary stream appear at least once every 5 s with a recommendation of aa average of at least every 2 s. Where rapid channel change times are important 500 ms is also recommended for H.264/AVC and 1 s for HEVC . The time interval between successive RAPs is measured as the difference between their respective DTS values.

5.3.2 ATSC

5.3.2.1 Introduction

The ATSC relevant specifications for video related parameters are:

- ATSC A/53, Part 4:2009, "MPEG-2 Video System Characteristics" [17]

- ATSC A/72 Part 1 & 3, "Video System Characteristics of AVC in the ATSC Digital Television System" & "Video and Transport Subsystem Characteristics of MVC for 3D-TV Broadcast in the ATSC Digital Television System" [18]

- ATSC A/153 Part 7:2012, "AVC and SVC Video System Characteristics" [19]

the information in this clause is collected.

5.3.2.2 Colorimetry aspects

The ATSC standard for H.264/AVC [19] defines the possible input formats of 3 types:

- SMPTE 274M corresponding to the full HD resolution (1920x1080)

- SMPTE 296M corresponding to the 720p HD resolution

- ITU-R BT.601-5 corresponding to NTSC SD resolution (720x480)

For H.264/AVC, the color transfer function characteristics are conveyed within the VUI message, inside the SPS.

For the VUI-related constraints, the ATSC refers to the SCTE specification on AVC video constraints for Cable TV [20] which states that even if all the allowed values by the H.264/AVC standard may be used for ***colour_primaries***, ***transfer_characteristics***, and ***matrix_coefficients***, the preferred values are the ITU-R BT.709 [21] for 720p HD and Full HD inputs; and SMPTE 170M [22] for the NTSC SD input.

5.2.2.3 Frame rate aspects

Focusing only on the HDTV formats all the following frame rates are supported: 23,97 Hz (24/1 001); 24 Hz; 29,97 Hz (30/1 001); 30 Hz; 59,94 Hz (60/1 001); 60 Hz; 25 Hz and 50 Hz.

One exception is made for the 720p format that is not required to support: 29,97 Hz; 30 Hz and 25 Hz.

5.2.2.4 RAP period in ATSC

The ATSC standard for H.264/AVC [19] applies the requirements from the SCTE 128-2 [31] specification. For applications where fast channel change or random access is important, the maximum time interval between the decoding time stamp of successive SRAP Pictures is less than or equal to 1 second for integer frame rates, with appropriate adjustment (less than two pictures) for (1) non-integer frame rates and (2) small variabilities associated with scene change detection during encoding.

5.3.3 DECE

5.3.3.1 Introduction

The DECE Common File Format & Media Formats Specification" [23] contains requirements related to colorimetry, frame rate and random access point period aspects as depicted in the following sub-clauses.

5.3.3.2 Colorimetry aspects

- PD (portable device) Media profile: Video streams conforming to this Media Profile are encoded using the color parameters defined by BT.709 [21].

- SD (Standard Definition) Media Profile: Video streams conforming to this Media Profile are (i) preferably encoded using the color parameters defined by BT.709 [21]; and (ii) encoded with the following color parameters:

  - for 24 Hz, 30 Hz & 60 Hz content: the color parameters defined by BT.709 [21], or the color parameters defined for 525-line video systems as per BT.601 [24]; or

  - for 25 Hz & 50 Hz content: the color parameters defined by BT.709 [21], or the color parameters defined for 625-PAL video systems as per BT.1700 [25].

- High Definition (HD) and High Definition High bitrate (xHD) Media Profiles: Video streams conforming to this Media Profile are encoded using the color parameters defined by BT.709 [21].

5.3.3.3 Frame rate aspects

The specification on Common File Format & Media Formats [23] defines a set of media profiles in annex B for which the maximum frame rates are indicated. Delivery targets are defined where only the Multi-track delivery target provides additional constraints on frame rates.

- PD (portable device) Media profile:
  - Maximum frame rate is 30 Hz
  - The following frame rates are supported: (i) for 24 and 30Hz contents: 23.97; 24; 29.97 and 30 Hz, (ii) for 25 Hz contents: 25 Hz
- SD (Standard Definition) Media Profile:
  - Maximum frame rate is 60 Hz
  - The following frame rates are supported: (i) for 24, 30 Hz and 60 Hz contents: 23.97; 24; 29.97; 30; 59.94 and 60 Hz, (ii) for 25 and 50 Hz contents: 25 and 50 Hz
- High Definition (HD) Media Profile:
  - Maximum frame rate is 60 Hz
  - The following frame rates are supported: (i) for 24, 30 Hz and 60 Hz contents: 23.97; 24; 29.97; 30; 59.94 and 60 Hz, (ii) for 25 and 50 Hz contents: 25 and 50 Hz
- High Definition High bitrate (xHD) Media Profile:
  - Maximum frame rate is 60 Hz
  - The following frame rates are supported: (i) for 24, 30 Hz and 60 Hz contents: 23.97; 24; 29.97; 30; 59.94 and 60 Hz, (ii) for 25 and 50 Hz contents: 25 and 50 Hz

5.3.3.4 RAP period in DECE

The specification on Common File Format & Media Formats [23] defines common requirements for AVC and HEVC on random access point period as being an occurance of RAP every 3.003 seconds or less.

5.3.4 Response from DASH-IF

DASH-IF does not define content profiles but focuses on transport and codec interoperability. However, relevant information on constraints in DASH-based content offerings is defined in "DASH-IF Implementation Guidelines. Interoperability Points" [10] including video, audio and subtitles.

5.4 Summary

5.4.1 Overview

This clause provides a summary of the relevant aspects extracted from the clause 5.3 and a recommendation on how to make use of this information in the context of 3GPP TV Video Profiles.

Specifically the following aspects are considered of relevance:

- Spatial Resolutions
- Frame rate aspects

- Colormetry Aspects
- Random Access Points periods
- Video Codecs and Related Parameters

5.4.2 Spatial Resolution

This clause presents the different constraints on spatial resolutions to be supported for the delivery of video contents in the Broadcast and the On-demand delivery environments.

As a summary:

- Spatial resolutions typically define profiles and operation points.
- For any advanced format, the committed aspect ratio is 16:9. For legacy, still 4:3 exists.
- The following relevant content formats are identified:
  - UHD: 3 840 x 2 160
  - HD: 1 920 x 1 080, 1 280 x 720
  - SD: 640x480, 854x480, 720x576
- The following relevant distribution formats are identified:
  - For UHD: 3 840 x 2 160, 3 200 x 1 800, 2 560 x 1 440, 1 920 × 1 080, 1 600 × 900, 1 280 × 720, 960 × 720, 960 × 540
  - For HD: 1 920 × 1 080, 1 600 × 900, 1 280 × 720, 960 × 540
  - For SD: 640x480, 854x480, 720x576

It is understood that content nowadays is available almost exclusively in HD formats or beyond, but for distribution a subsampled version may be used in order to address specific device classes or bitrate constraints. SD formats are maintained for legacy in TV broadcast standards, but of decreasing relevance.

Therefore, the 3GPP TV Video Profile may be the right place and time to deprecate SD formats, by at least not adding those to the recommended video profile operation points.

Based on this, the following subset of spatial resolutions may be considered as most relevant:

- Content formats: 3 840 x 2 160, 1 920 x 1 080, 1 280 x 720
- Distribution formats: 3 840 x 2 160, 3 200 x 1 800, 2 560 x 1 440, 1 920 × 1 080, 1 600 × 900, 1 280 × 720, 960 × 540

It is expected that sufficient tools would be available to convert content into one of the above distribution formats, for example by the use of letter boxing, cropping etc.

In addition the following aspects are relevant to be considered:

- It needs to be checked if for mobile distribution, a lower spatial resolution than 960 x 540 for distribution may be considered.
- For DASH services Adaptation Sets may be provided in different resolutions. If the above spatial resolutions are applied, then seamless switching across different spatial resolutions is expected to be straight-forward.

5.4.3 Frame Rates

This clause presents the different constraints on frame rates to be supported for the delivery of video contents in the Broadcast and the On-demand delivery environments.

As a summary:

- ATSC and DECE require the support of **23.97** (24/1 001); **24**; **29.97** (30/1 001); **30**; **59.94** (60/1 001); **60**; **25** and **50** Hz.
- DVB requires the support of
  - **25** and **50** Hz for 25Hz HDTV systems
  - **23.97** (24/1 001); **24**; **29.97** (30/1 001); **30**; **59,+.94** (60/1 001); **60** Hz for 30Hz HDTV systems
  - UHDTV systems require all the above-mentioned frame rates to be supported.

It is understood that globally two families of frame rates are of major relevance

- Fractional frame rates (30/1 001) and (60/1 001)
- Frame rates of 25 and 50 Hz

Fractional frame rates are still quite frequently used by broadcast distribution systems. In order to enable distribution of existing video format in 3GPP TV Video Profiles it seems unavoidable to include also fractional frame rates into the video formats.

Based on this discussion, it is proposed that a video operation point in 3GPP TV Video Profiles is expected to support the following frame rates: **24**; **25**; **30; 50 and 60 Hz.** The following fractional frame rates are beneficially also be supported: **24/1.001, 30/1.001, 60/1.001 Hz**.

It is expected that sufficient tools would be available to convert content into one of the above frame rates.

In addition the following aspects are relevant to be considered:

- A frame rate cannot be associated with a specific video format (resolution).
- For DASH services provisioning Adaptation Sets with frame rates restricted in one family (24 Hz, 25 and 50 Hz, 30 Hz and 60Hz, 30/1.001 and 60/1.001 Hz) may simplify switching between representations without complex frame rate adaption.

5.4.4 Colorimetry Formats

This clause presents the different constraints on colorimetry formats for the delivery of video contents in the Broadcast environment and the On-demand delivery area.

As a summary:

- ATSC defines the support of *BT.709* for HD and Full HD inputs; and *SMPTE 170M* for the NTSC SD input.
- DVB defines the support of *BT.1700* for the delivery of conventional SDTV and *BT.709* for HDTV and HD sub-resolutions (DASH) and *BT.2020* for HEVC HDTV and UHDTV.
- DECE defines the support of *BT.709* for types of content plus *BT.601* and *BT.1700* for traditional SD contents.

From this collection of information and given the approach to only consider contents from an HD delivery workflow in the TVProf Work Item, BT.709 and BT.2020 are considered most relevant.

Furthermore, it is observed that in many cases it is expected that the receiving and rendering device can support BT.2020 signalling and the device is responsible to map the provided signal to the color space of the device. Based on this observation, the following is proposed for the TV Video Profiles:

- Operation Points for 3GPP may either signal BT.709 or BT.2020
- If no signal is provided for the color space, BT.709 should be assumed as default color space
- Receiving devices are expected to support BT.2020 signalling and provide an appropriate mapping of the signal to the supported color space of the device

In addition the following aspects are relevant to be considered:

- A color space cannot be associated to a specific video format (resolution).
- For DASH services Adaptation Sets being provided in a unique color space may be considered beneficial in order to be able to switch between representations without color variations.

5.4.5 Random Access

This clause presents the different constraints on random access point period for the delivery of video contents in the Broadcast environment and the On-demand delivery area.

As a summary:

- ATSC mandates a RAP period less than 1 second.
- DVB mandates a RAP period less than 5 seconds, recommends 2 seconds and optionally 0.5 second for AVC and 1 second for HEVC.
- DECE mandates a RAP period less than 3.003 seconds.

Defining a random access point period of N seconds is typically equivalent to define a channel change time or a channel access time to be on average roughly equal to N/2 seconds.

In general, the numbers from above should be taken into account in order to provide random access in TV-like services. Details how to achieve this may depend on the distribution formats, the service configuration, and many other aspects.

5.4.6 Video Codecs and Other Video Parameters

Video codecs in all standards consistently use 16:9 aspect ratio, YCbCr as the Chroma Format and 4:2.0 for color sub-sampling.

Despite the fact that there are still profiles for interlaced video signals, progressive formats are more and more relevant with the introduction of UHD productions. 3GPP TV Video profile is the right time and place to deprecate interlaced formats, by not adding those to the recommended video profile operation points.

On video codecs, the following codec profiles are considered relevant in today's TV services:

- H.264/AVC High Profile
- H.265/HEVC Main Tier Main Profile
- H.265/HEVC Main Tier Main-10 Profile

The levels depend on the supported video formats and range up to level 5.1 for H.265/HEVC Main Tier Main-10 Profile.

As a summary, the following video codec capabilities are worthwhile to be considered to support certain amount of service and classes of potential interest:

- Consistent use of 16:9 aspect ratio, YCbCr as the Chroma Format and 4:2.0 for color sub-sampling
- H.264/AVC High Profile level 4.1 to support consistent HD services
- H.265/HEVC Main Tier Main Profile level 4.1 to support consistent HD services
- H.265/HEVC Main-10 Tier Main Profile level 5.1 to support consistent UHD services

In addition, TV services may also be supported with the capabilities defined in TS26.234 [2] and TS 26.346 [3] using 720p and H.264/AVC Progressive High Profile Level 3.1 or H.265/HEVC Main Profile Main Tier Level 3.1.

5.4.7 Non-Video Related Parameters

For a consistent TV experience, other aspects such as audio, subtitling, closed captioning as well as metadata are of relevance and are likely to be addressed in the future. However, in the context of the present document, the focus is on video related aspects only.

6 Video Operation Point Parameters

6.1 Video resolution

6.1.1 Introduction

Mobile terminals (smartphones, tablets) have display capabilities that are increasing over time. This is enabled by greater screen sizes as well as increasing pixel density.

Table 5 below presents a list of the main resolutions available in the market place as of mid-2014, including the picture aspect ratio:

Table 5: Main screen resolutions for mobile terminals

Resolution	Pixel Width	Pixel Height	Aspect ratio
HVGA	480	320	1.5
WVGA	800	480	1.67
qHD	960	540	16:9
DVGA	960	640	1.5
WSVGA	1024	600	1.71
XGA	1024	768	4:3
iPhone5	1136	640	16:9
WXGA*	1280	768	1.67
720p	1280	720	16:9
iPhone6	1334	750	~16:9
WXGA*	1280	800	1.6
1080p	1920	1080	16:9
4XGA	2048	1536	4:3

6.1.2 Working assumptions

With the generalization of High Definition in residential TV services, production environments mainly use the HD format (in 720p or 1080p) and increasingly also UHD and set the 16:9 picture aspect ratio as the main layout of video services.

When the aspect ratio of the video and the display do not match, some mobile terminal implementations offer the capability to zoom the video so as to fill otherwise black areas of the screen. But, for non-technical reasons, unless there is an agreement with the content provider, the network operator/service provider is not allowed to crop the video so as to fit with particular device capabilities.

Based on this the following working assumptions are established:

- the picture aspect ratio of the TV services over 3GPP services is 16:9;
- the video is displayed by default in letter-box mode when the UE display resolution is not 16:9.

6.1.3 Video profile resolution definition

Based on the working assumptions in clause 6.1.2, and from Table 1, it is then possible to define the 16:9 picture resolutions that best fit in each display resolution as shown in Table 2:

Table 2: 16:9 letter-box formats for each display resolution

Resolution	Pixel Width	Pixel Height	LetterBox 16:9 resolution		
			Width	Height	Number of pixels (in thousands)
HVGA	480	320	480	270	129.6
WVGA	800	480	800	450	360
qHD	960	540	960	540	518.4
DVGA	960	640	960	540	518.4
WSVGA	1024	600	1024	576	589.824
XGA	1024	768	1024	576	589.824
iPhone5	1136	640	1136	639	725.904
WXGA	1280	768	1280	720	921.6
720p	1280	720	1280	720	921.6
iPhone6	1334	750	1334	750	1000.5
WXGA	1280	800	1280	720	921.6
1080p	1920	1080	1920	1080	2073.6
4XGA	2048	1536	2048	1152	2359.296
QHD	2560	1440	2560	1440	3684.4
WQXGA	2560	1600	2560	1440	3684.4
UHD (production)	3840	2160	3840	2160	8294.4

Legend
The last column of gives the number of pixels for all of the 16:9 formats.
The greyscale background intends to group similar formats so as to minimize the number of final resolutions

The last column of Table 2 gives the number of pixels for all of the 16:9 formats. The greyscale background intends to regroup the similar formats so as to minimize the number of final resolutions.

Based on Table 2, for each identified group, only the smallest resolution is kept as presented in Table 3. The last column of Table 3 names these resolutions explicitly as they are used in the remainder of this specification.

Table 3: Selected 16:9 format and labelling

Resolution	Pixel Width	Pixel Height	LetterBox 16:9 resolution		Resolution Name
			Width	Height	
HVGA	480	320	480	270	qSD
WVGA	800	480	800	450	SD
qHD	960	540	960	540	qHD
DVGA	960	640	960	540	
WSVGA	1024	600	960	540	
XGA	1024	768	960	540	
iPhone5	1136	640	960	540	
WXGA	1280	768	1280	720	720p HD
720p	1280	720	1280	720	
iPhone6	1334	750	1280	720	

WXGA	1280	800	1280	720	
1080p	1920	1080	1920	1080	Full HD
4XGA	2048	1536	1920	1080	
QHD	2560	1440	2560	1440	
WQXGA	2560	1600	2560	1440	
UHD	3840	2160	3840	2160	UHD

6.1.4 Selection of video profile resolutions for operation points

Finally, Table 4 summarizes the selected resolutions and highlights the increment factor between 2 consecutive formats:

Table 4: Summary of selected resolutions (option 1)

Format name	Format definition	Increment factor
qSD	480x270	-
SD	800x450	2.78
qHD	960x540	1.44
720p HD	1280x720	1.78
Full HD	1920x1080	2.25
Beyond HD	2560 x 1440	1.77
UHD	3840 x 2160	2.25

In order to limit the number of resolutions to be selected for the definition of operation points, the qHD format could be removed thus providing a reasonably consistent table in terms of increment factors (around 2.5) as presented below in Table 5.

Table 5: Summary of selected resolutions (option 2)

Format name	Format definition	Increment factor
qSD	480x270	-
SD	800x450	2.78
720p HD	1280x720	2.56
Full HD	1920x1080	2.25
UHD	3840 x 2160	4.00

NOTE: Although the Release12 3GPP specifications are limited to 720p resolutions, 1080p and beyond resolution is kept for information and might be referred to in the future.

6.2 Viewing Distance and Resolution

6.2.1 Introduction

Higher spatial resolution is relevant in order to avoid artefacts such as pixilation of the video. However, pixilation also depends on the viewing distance and possibly also on the applied upsampling filters So this clause provides a very brief overview on the relation of spatial resolutions and the viewing distance.

The following parameters are of relevance:

- Pixel Density: Pixels per inch (PPI) is a measurement of the pixel density (resolution) of an electronic image device, such as a computer monitor or television display, or image digitizing device such as a camera or image scanner. Pixel density can be computed as $\texttt{sqrt(wp}^2 + \texttt{hp}^2\texttt{)/di}$ with `wp` and `hp` the vertical and horizontal pixel size, respectively, and `di` the diagonal size of the screen in inches,

- Visual Acuity (VA) commonly refers to the clarity of vision. Visual Acuity is dependent from optical and neural factors, i.e. (i) the sharpness of the retinal focus within the eye, (ii) the health and functioning of the retina, and (iii) the sensitivity of the interpretative faculty of the brain. Normal visual acuity is commonly referred to as

20/20 vision: At 20 feet, a human eye with nominal performance is able to separate contours that are approximately 1.75 mm apart. Vision of 20/40 corresponds to lower than nominal performance; vision of 20/10 corresponds to better performance.

- Optimum Viewing Distance (OVD): Optimum viewing distance is the distance that provides the viewer with the optimum immersive visual experience. Note that the actual viewing distance may be larger than OVD without impacting the pixelation quality the OVD can be computed as follows:

```
OVD = 1/(PPI * 2 * tan(1/120*VA))
```

6.2.2 Optimum Viewing Distance

In the following, the normal VA of 20/20 is assumed. Figure 2 shows the optimum viewing distance in inches for different screen resolutions in ranges that are typical for mobile devices in the market at the time of the generation of the report for different spatial resolutions as documented in Table 4 above. Screen resolutions of 3" to 11" are selected.

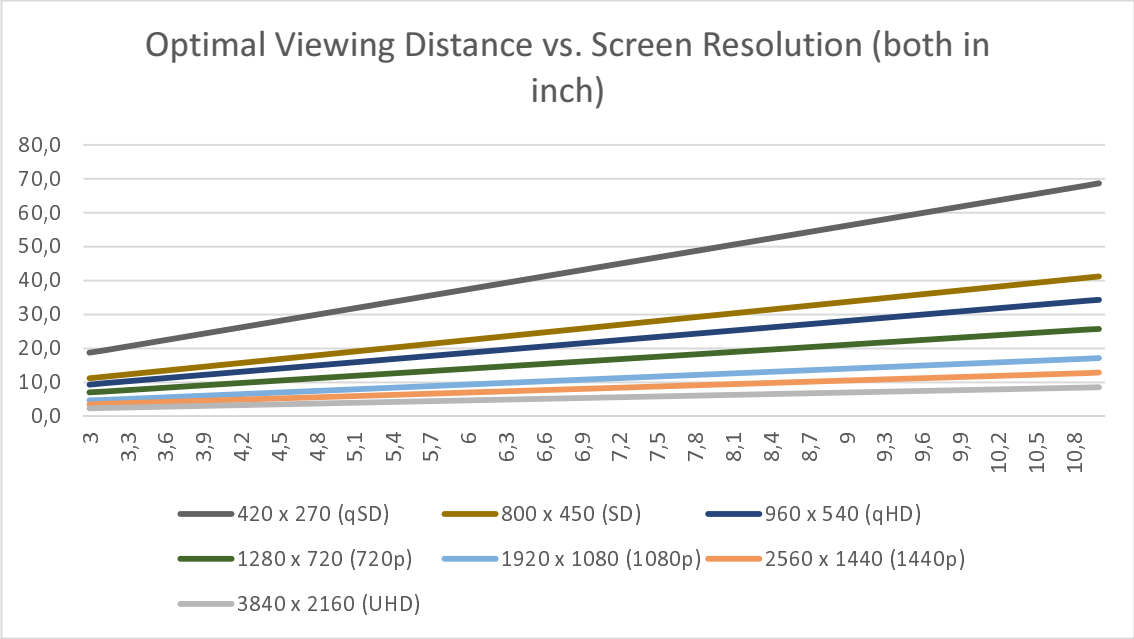

Figure 2: Optimum Viewing Distance vs. Screen resolution for typical mobile device screen sizes

Figure 3 shows the optimum viewing distance in inches for different screen resolutions in ranges that are typical for TV screens in the market at the time of the generation of the report for different spatial resolutions as documented in Table 4 above. Screen resolutions of 11" to 100" are selected.

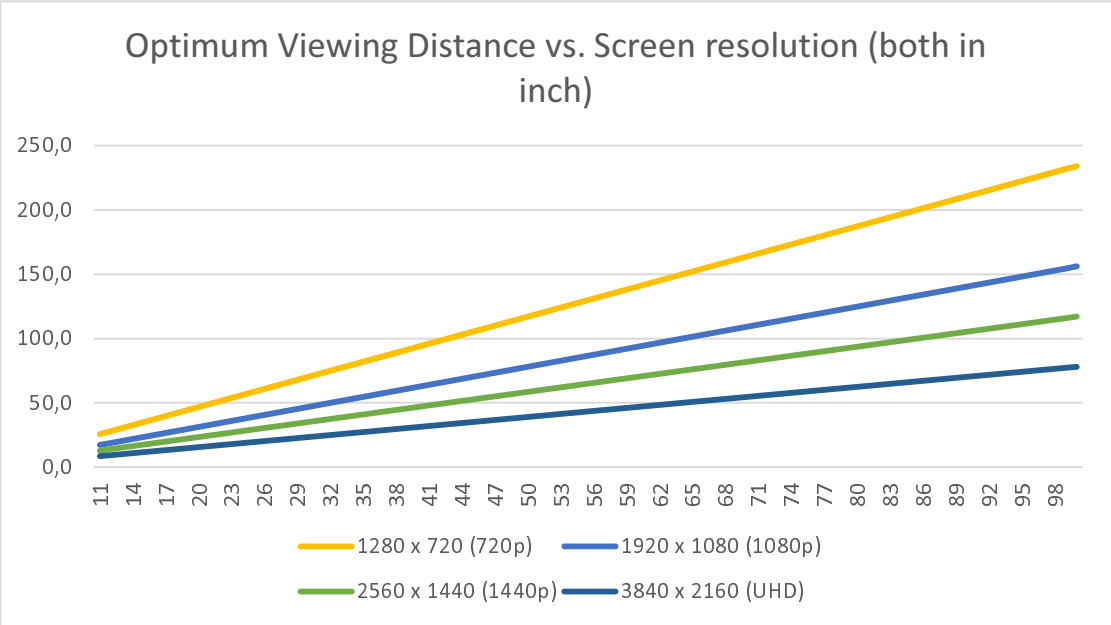

Figure 3: Optimum Viewing Distance vs. Screen resolution for typical TV set screen sizes

In a similar fashion, ITU-R BT.2022 [28] provides information on the optimal viewing distance depending on the picture height for different image systems. The key image systems as documented in ITU-R BT.2022 [28], Table 1, are summarized in Table 6. The ITU-R BT.2022 [28] confirms the model introduced in clause 6.2.1.

Table 6: Optimum Viewing Distance as function of picture heights (H) and screen resolution (S)

Format name	Resolution	Optimum Viewing Distance (H)	Optimum Viewing Distance (S) BT.2022	Optimum Viewing Distance (S) according to 6.2.1
VGA	640 x 480	7 H	4.2 S	n/a
SD	720 x 576	6 H	3.6 S	n/a
720p HD	1280x720	4.8 H	2.4 S	2.3S
Full HD	1920x1080	3.2 H	1.6 S	1.6S
UHD	3840 x 2160	1.6 H	0.8 S	0.8S
8K	7680 x 4320	0.8 H	0.4 S	n/a

6.2.3 Conclusions

Based on the data and discussion in clause 6.2.2, the following conclusions are drawn:

- Spatial resolutions of 720p are essential to provide highest picture quality at regular viewing distances with phones of screen size as available today.
- Spatial resolutions of 1080p are very desirable to provide highest picture quality at regular viewing distances with phones of screen size as available today If other form factors are added such as tablets, then such spatial resolutions are essential.
- If other form factors, such as TV screens are of relevance, then 720p and 1080p are absolutely essential and 1440p and UHD are desirable formats to be added as well.

7 Non-video related aspects

For a consistent TV experience, other aspects such as audio, subtitling, closed captioning as well as metadata are of relevance and should be addressed in the future. However, in the context of the present document, the focus is on video related aspects only.

8 Enablers for different 3GPP services

8.1 Introduction

This clause provides an overview on the enablers in different 3GPP services (MBMS, PSS, DASH) to map parameters to 3GPP services, including service specific requirements, e.g. adaptive resolution switching in DASH. etc.

8.2 DASH Signalling Enablers

8.2.1 Relevant Signaling Parameters

The relevant parameters for video property signaling according to clause 5.3.1 are:

- Picture Resolution
- Picture Aspect Ratio
- Chroma Format
- Sub-sampling format
- Sample aspect ratio
- Bit Depth
- Color Primaries and Transfer Function
- Frame rates (Hz)
- Video coding format
- Video Codec Profile Level
- Random Access Point

Parameters for other media types are not considered in this context. .

8.2.2 DASH Signaling Background

8.2.2.1 Representations in one Adaptation Set

In order to understand the relevant signaling aspects in DASH, a processing model for Representations in one Adaptation Set is provided in the Figure 5 below. In this case, original video in a certain format (e.g. any of those documented in the TR) may be preprocessed, for example by temporal and/or spatial subsampling. Afterwards, the signal is encoded, possibly in different bitrates such that adaptive switching across the provided Representations is permitted. After delivery, the receiver decodes and processes the data to display the data. Different video formats may be offered to the client and the video format may be differentiated on selection or on adaptation level.

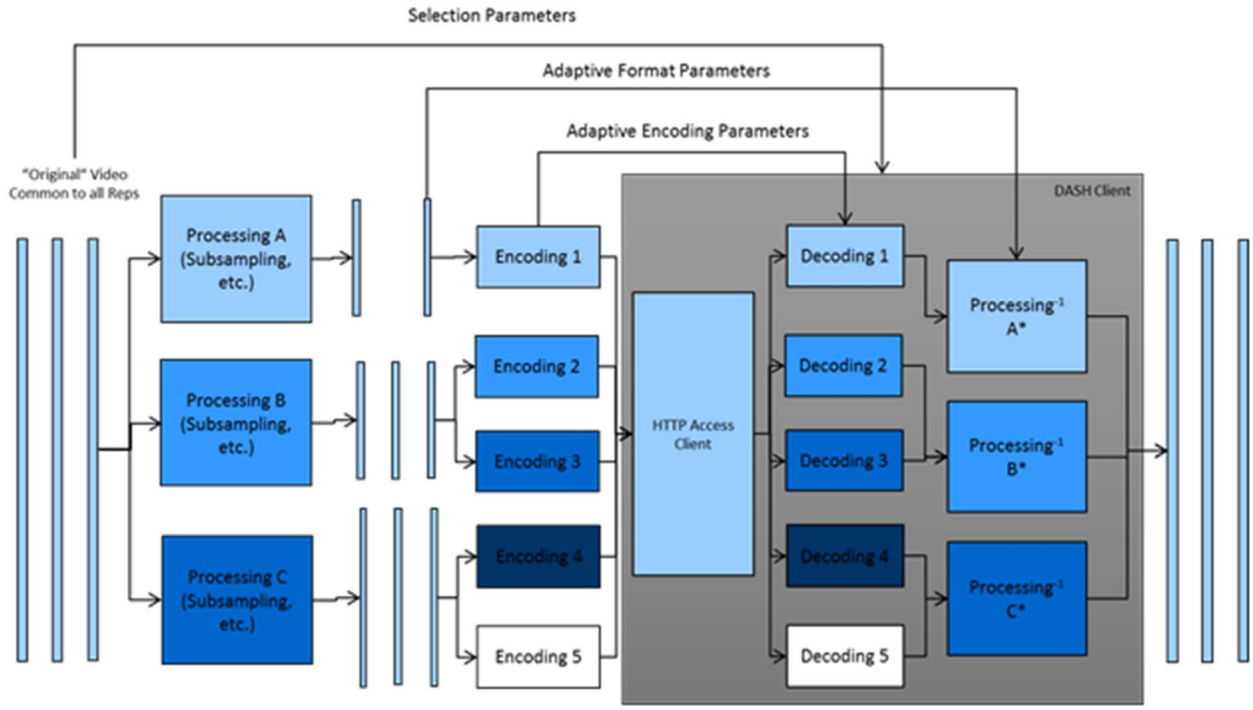

Figure 5: End to end Processing model for one Adaptation Set

8.2.2.2 Receiver Processing Model

It is relevant that the video signal is processed in multiple instances in the receiver in a DASH-based model. This is shown in Figure 6. The DASH client provides the downloaded information to an ISO BMFF [12] processing engine that consumes the downloaded data and provides the elementary streams to the video decoder and to the display. The parameters as documented in clause 8.2.1 may be available and required in different levels of the processing chain, namely in the DASH client (i.e. MPD), the ISO BMFF parser (i.e. in the movie fragment header), in the video decoder (i.e. in the elementary stream) or for the display (i.e. in VUI and/or SEI parameters).

The purpose and consistency of the parameters is important.

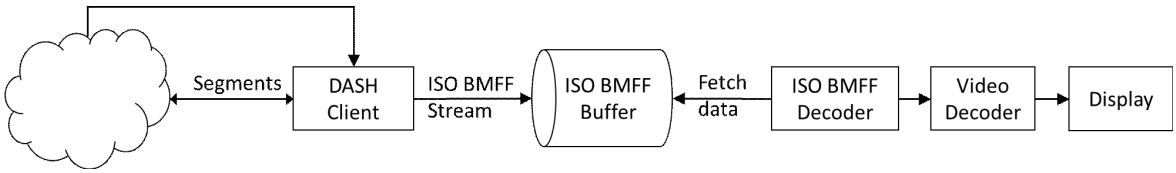

Figure 6: Receiver reference model for DASH based streaming

8.2.2.3 Signaling Framework and Options

In DASH, the following signaling options are available for the different parameters and also some constraints are mentioned:

- Picture Resolution
  - Adaptation Set Parameters `@maxWidth` and `@maxHeight`
    - Note in [6] and [10]: The attributes `@maxWidth` and `@maxHeight` are recommended to be used such that they describe the target display size. This means that they may exceed the actual largest size of any coded Representation in one Adaptation Set.
  - Common Adaptation Set or Representation Parameters `@width` and `@height`

    - Note in [6] and [10]: `@width`, `@height`, and `@sar` attributes are recommended to be used so as to indicate the vertical and horizontal sample count of encoded and cropped video samples, not the intended display size in pixels.

    - Requirement in [6] and [10]: Only the active video area is required to be encoded so that devices can frame the height and width of the encoded video to the size and shape of their currently selected display area without extraneous padding in the decoded video, such as "letterbox bars" or "pillarbox bars".

  - Width and height in track header box of the ISO BMFF

    - Requirement in [12]: the width and height values in the track header box has the nominal display size in square pixels after decoding, H.264/AVC cropping, and rescaling.

- Picture Aspect Ratio

  - The Adaptation Set parameter `@par`

    - Requirement in [15]: the picture aspect ratio as specified by this attribute is the same as indicated by the values of `@width`, `@height`, and `@sar`, i.e. it expresses the same ratio as (`@width` * `sarx`): (`@height` * `sary`), with `sarx` the first number in `@sar` and `sary` the second number.

- Chroma Format

  - Signaling in Coding-Independent Code Points (CICP) ISO/IEC 23001-8 [11] through the matrix coefficients code point

    - Defines the URN format urn:mpeg:mpegB:cicp:MatrixCoefficients

    - Defines the allowed values in Table 4 of ISO/IEC 23001-8 [11].

  - In DASH the Essential or Supplemental Descriptor may be used to signal the value using the CICP scheme and values

  - In the ISO BMFF [12], the `ColourInformationBox` may be used to signal the matrix coefficients code point

  - Signaling through VUI information in the `matrix_coeffs`

- Sub-sampling format

  - No signaling in DASH, but through `@codecs` parameter (see below)

  - No explicit signaling in ISO BMFF, but through the sample entry

  - Signaling in elementary stream through `chroma_format_idc`

- Sample aspect ratio

  - Common Adaptation Set or Representation Parameters `@sar` in DASH

    - Note in [6] and [10]: `@width`, `@height`, and `@sar` attributes are recommended so as to indicate the vertical and horizontal sample count of encoded and cropped video samples, not the intended display size in pixels.

  - `PixelAspectRatioBox` in the ISO BMFF [12]

- Bit Depth

  - No signaling in DASH, but through `@codecs` parameter (see below)

  - No explicit signaling in ISO BMFF, but through sample entry

  - Signaling in HEVC elementary stream [15] through `bit_depth_luma_minus8` and `bit_depth_chroma_minus8`.

- Color Primaries and Transfer Function

- Signaling in CICP ISO/IEC 23001-8 through the colour primaries and transfer characteristics code point
  - Defines the URN format urn:mpeg:mpegB:cicp: ColourPrimaries and urn:mpeg:mpegB:cicp:TransferCharacteristics
  - Defines the values in Table 4 of ISO/IEC 23001-8 [11].
- In DASH the Essential or Supplemental Descriptor may be used to signal the value using the CICP scheme and values
- In the ISO BMFF [12], the `ColourInformationBox` may be used.
- Signaling through VUI information in the elementary stream [14] and [15].

- Frame rates (Hz)
  - Adaptation Set Parameter `@maxFrameRate`
  - Common Adaptation Set or Representation Parameter `@frameRate`
  - The `frar` parameter in the Track Selection box of the user Data in the ISO BMFF [12]. This is driven by decoding and composition times in the ISO BMFF.
  - No explicit signaling of the frame rate is possible in the elementary stream. Note that in the HRD parameters, this may be implicitly defined.
- Video coding format and Video Codec Profile Level
  - Common Adaptation Set or Representation Parameter `@codecs` in MPEG-DASH
  - In the Visual Sample entry in the ISO BMFF [12]
- Random Access Point
  - In DASH this can be signaled by segment durations and `@startsWithSAP` signaling being 1, 2 or 3.
  - In the ISO BMFF [12], Random access points can be signaled with the Segment Index and the sync sample table.

8.2.2.4 Open Questions and Potential Answers

In order to consistently support the formats in DASH based environments, at least the following questions need be answered by for video profiles in the context of DASH. Based on the considerations in clauses 5 and 6, initial answers to the questions are collected.

- What are the relevant Signal Parameters for 3GPP to support the TV Profile parameters?
  - (Display) Picture Resolution: see Table 4 and 5: 3840 x 2160, 1920 x 1080, 1280 x 720, 800x450, 480x270
  - (Encoded) Picture Resolution: 3840 x 2160, 3200 x 1800, 2560 x 1440, 1920 × 1080, 1600 × 900, 1280 × 720, 960 × 540, 800x450, 480x270
  - Frame rates (Hz): 24; 25; 30; 50 and 60Hz. Addition of fractional frame rates is currently not considered relevant.

  Video Codec Profile and Level:

  - H.264/AVC High Profile level 3.1
  - H.265/HEVC Main Tier Main Profile level 3.1
  - H.264/AVC High Profile level 4.1
  - H.265/HEVC Main Tier Main Profile level 4.1
  - H.265/HEVC Main-10 Tier Main Profile level 5.1

- Random Access Point: values between 0.5 to 5 seconds.
- Color Primaries and Transfer Function: BT.709 and BT.2020
- Video coding format: progressive (no signaling necessary, if not present this default value is used)
- Picture Aspect Ratio: 16:9 (no signaling necessary, if not present this default value is used)
- Chroma Format: YCbCr (no signaling necessary, if not present this default value is used)
- Sub-sampling format: 4:2:0 (no signaling necessary, if not present this default value is used)
- Sample aspect ratio: 1:1 (no signaling necessary, if not present this default value is used)

- What are relevant selection parameters for video Adaptation Sets, i.e. which parameters may be placed on Adaptation Set level?
  - Frame rates (Hz)
  - Video Codecs and Video Codec Profile
  - Random Access Point
  - (Display) Picture Resolution
  - Color Primaries and Transfer Function
- What are relevant adaptation parameters for video Adaptation Sets, i.e. which parameters may be placed on Representation level?
  - (Encoded) Picture Resolution: Any decimated resolution of the (Display) Picture resolution
  - Frame rates (Hz): only within family, i.e. 25/50, 30/60. Video Codec Level
- What are parameters not to be changed within one Adaptation Set?
  - (Display) Picture Resolution, if signaled at all
  - Color Primaries and Transfer Function
  - Video codecs
  - Video codec Profiles
- What parameters are expected to be signaled on what level?
  - Adaptation Set level:
    - (Display) Picture Resolution: see Table 4 and 5: 3840 x 2160, 1920 x 1080, 1280 x 720, 800x450, 480x270, if signaled at all
    - Frame rates (Hz): 24; 25; 30; 50 and 60Hz.
    - Video Codec Profile Level:
      - H.264/AVC High Profile level 3.1
      - H.265/HEVC Main Tier Main Profile level 3.1
      - H.264/AVC High Profile level 4.1
      - H.265/HEVC Main Tier Main Profile level 4.1
      - H.265/HEVC Main-10 Tier Main Profile level 5.1
    - Random Access Point: values between 0.5 to 5 seconds.
    - Color Primaries and Transfer Function: BT.709 and BT.2020

- Representation level
  - (Encoded) Picture Resolution: 3840 x 2160, 3200 x 1800, 1920 × 1080, 1600 × 900, 1280 × 720, 960 × 540, 800x450, 480x270
  - Frame rates (Hz): 25 or 50, 30 or 60Hz.
  - Video Codec Level:
    - H.264/AVC High Profile: level 3.1 or level 4.1
    - H.265/HEVC Main Tier Main Profile level 3.1 or level 4.1
  - Random Access Point: values between 0.5 to 5 seconds.
- If parameters are available on different levels, how do they relate? Can they differ? Which one takes precedence?
  - Typically no, but for example the Adaptation Set may provide the maximum of:
    - Frame rate
    - Codec level
    - Spatially encoded resolution
- What are the signaling methods to provide the parameters?
  - See clause 8.2.2.3

8.2.2.5 Gap Analysis on DASH-based signalling

Based on the discussions in clauses 8.2.2.2, 8.2.2.3 and 8.2.2.4 and the analysis of 3GP-DASH [4] and 3GPP File format [26] up to Release 12, at least the following gaps are identified:

- Interpretation of the `@maxWidth` and `@maxHeight` in DASH needs to be clarified according to [6] and [10].
- Interpretation of the `@width`, `@height`, and `@sar` in DASH needs to be clarified according to [6] and [10].
- Interpretation of width and height in track header box of the ISO BMFF needs to be clarified according to [12].
- Addition of Picture Aspect Ratio to TS 26.247 with some restricted values.
- Enable signaling of CICP parameters for Matrix Coefficients, Colour Primaries and Transfer Functions in DASH and ISO BMFF.
- Enable a frame rate signaling in DASH.
- Provide signaling for the defined parameters and options in the TV Profile Specification addressing the questions in clause 8.2.2.4.
- Define default parameters if certain signaling is not present.

9 Information from Example Deployments

9.1 Description of Linear / Live TV using MBMS

MBMS allows the carriage of linear TV services over MBMS bearers as well as using unicast bearers. The access information for unicast TV content acquisition is provided together with the MBMS metadata.

The following DASH format description is often used in MBMS deployments and provides additional details and examples following the recommendations from the TS 26.346 Annex K [3].

MBMS bearers offer a constant and guaranteed bitrate service. Although 3GP DASH is an adaptive bitrate format, only a single video representation is offered over an MBMS bearer in a single MBSFN (if the service is a video service). The used resolution is in the area of WVGA (854x480) and HD (1280x720). The service may also include one or more audio tracks (multi-language) and other components (e.g. timed text) in the offering.

Many DASH players today support playback of multiplexed segments (i.e. audio, video and other components are multiplexed into the same segment). Some deployments use multiplexed segments, with the intent to increase the spectral efficiency on wireless systems. A higher spectral efficiency allows for more simultaneous MBMS sessions or reduces the capacity need (in terms of allocated LTE subframes) for the service.

For services over MBMS Bearers, the DASH media segment duration is in range of 1 sec to 2 sec. Short segment durations are selected with the intent of having a reasonable tune-in delay at still a reasonably good application layer FEC efficiency. Each DASH Media segment contains only a single ISO BMFF movie fragment.

Each segment contains at least one SAP that is placed at the beginning of the segment. Each segment can act as random access point into the stream. Note, DASH profiles allow segments without a SAP, which are beneficial for low delay operations. For instance, when working with 500 ms DASH Segment durations, not each segment should contain a SAP in order to keep a reasonable video compression efficiency. The DASH Media Presentation Description (MPD) is valid for a long time. An initial MPD is provided with service announcement before the actual Live DASH session starts and is typically valid for the entire Live session. The segment duration is constant on average during the session. For video representations, each segment contains the same number of video samples at constant framerate. For other media components such as audio, the number of samples per segment may vary around an average (+/- 1 sample per segment).

The DASH Initialization Segment is sent with the MBMS service announcement prior to the Live session and is not updated during the session.

The system can send MPD updates, for instance to add the media presentation duration. The MPD may also be updated with additional periods or old periods may be removed. For service offerings over MBMS bearers, an updated MPD with the new set of Periods is provided sufficiently in advance, so that the DASH Player receives the updated MPD in time, i.e. latest at the start of the new period.

Segment size variations: Segment sizes varies due to the content jitter. Transmission duration over MBMS bearers may vary accordingly. Often the rate control works with a content jitter buffer in the area of 2sec. Live Encoders use a rate control to shape variable bitrate content into a constant bitrate stream to provide a higher video quality at the same bitrate. The player follows the value of `@minBufferTime` since this expresses the shaping window of the rate control. Note, the value of `@minBufferTime` may be longer than segment duration (e.g. MBT = 2sec while `@duration`=1sec).

Open GOP structures: Only a single video quality is offered over MBMS bearers. Players do not need to switch Representations (unless a transition to unicast happens). Therefore, using Open GOP structures (i.e. SAP type 3) may be preferable, at least when offering services only over MBMS Bearers. In case of MBMS Services offerings over unicast and broadcast offerings (allowing for service continuity), the service over unicast may be offered with multiple video quality representations using closed GOP (SAP Type 1 or 2).

MBMS clients keep the DASH segments for some duration in local memory in order to offer local timeshift capabilities. This allows users to pause the stream for a short while still receiving the broadcast stream. Often, the duration of the local timeshift capability is in order of 5 min. When the MBMS client establishes the timeshift buffer from the broadcast stream, then the full timeshift buffer depth is not available after tune-in. The full timeshift buffer is only available after the client has received data for the timeshift buffer duration from the stream. Example: when the timeshift buffer value in the MPD is set to 5 min, then the client will receive data from the broadcast stream for at least 5 min to have the full timeshift buffer depth.

Full timeshift buffer after tune-in: When the MBMS service is offered over unicast and broadcast, then the client may fetch DASH segments using unicast for the time until the timeshift buffer is established for broadcast.

10 Conclusions and Recommendations

Based on the discussion and material provided in the present document, the following conclusions and recommendations are drawn.

It is recommended that typical formats available for broadcast distribution, VoD and Ad content as well as their relevant metadata should be easily delivered within the formats defined for 3GPP TV Profiles. Encoding/transcoding should be enabled such that efficient distribution is enabled and at least a mapping to 3GP-DASH formats should be defined.

Based on clause 5 and the analysis of established Broadcast TV distribution, the following conclusions and recommendations can be drawn:

- TV Video Profile specification should define operation points to support the spatial resolution of content and distribution formats as defined in clause 5.4.2, namely:
  - Content formats: 3840 x 2160, 1920 x 1080, 1280 x 720
  - Distribution formats: 3840 x 2160, 3200 x 1800, 2560 x 1440, 1920 × 1080, 1600 × 900, 1280 × 720, 960 × 540. Smaller resolutions may be added for service continuity.
- TV Video Profile specification should define operation points to support frame rates as defined in clause 5.4.3, namely 24; 25; 30; 50 and 60Hz. The following fractional frame rates are beneficially also be supported: 24/1.001, 30/1.001 and 60/1.001 Hz.
- TV Video Profile specification should define operation points to support colorimetry formats as defined in clause 5.4.4, namely BT.709 or BT.2020. Receiving devices are expected to support BT.2020 signalling and provide an appropriate mapping of the signal to the supported color space of the device.
- TV Video Profile specification should enable the random access period numbers as outlined in clause 5.4.4, specifically the DVB recommendations.
- TV Video Profile specification should enable the following video related parameters:
  - Consistent use of 16:9 aspect ratio, YCbCr as the Chroma Format and 4:2.0 for color sub-sampling
  - H.264/AVC High Profile level 4.1 to support consistent HD services
  - H.265/HEVC Main Tier Main Profile level 4.1 to support consistent HD services
  - H.265/HEVC Main-10 Tier Main Profile level 5.1 to support consistent UHD services
  - In addition, TV services may also be supported with existing capabilities in TS26.234 [2] and TS26.346 [3].
- Based on clause 6.1.2, it is recommended that:
  - the picture aspect ratio of the TV services over 3GPP services is 16:9.
  - the video is displayed by default in letter-box mode when the UE display resolution is not 16:9.
- Based on clause 6.1.3, the specification should define operation points to support the spatial resolution formats 480x270, 800x450, 960x540 1280x720, 1920x1080, 2560 x 1440, and 3840 x 2160.
- Based on clause 6.2.3, the content formats as recommended in clause 5.4.2 are confirmed.
- Based on clause 7, for a consistent TV experience, other aspects such as audio, subtitling, closed captioning as well as metadata are of relevance and should be addressed in the future. However, in the context TV Video Profile, the focus is on video related aspects only.
- Based on clause 8, it is recommended to define the DASH-based signalling to support the TV video profiles taking into account the signalling in the video elementary stream, VUI parameters, the ISO base media file format as well as the DASH MPD.

This report provides in clause 4 the considered scenario that is of relevance for the TV video profile. The key issues are summarized:

- The content provider would like to provide content from a multitude of sources to a multitude of device classes.
- It is relevant to define a reduced and constrained amount of content formats that can target a wide variety of device classes, but the device classes are able to decode and render the content formats.

Figure 7 provides an overview of the expected specification work for TV Video Profile. Operation Points are defined by a collection of tools that may be used by the one generating the service offering to generate a "bitstream". Note that the

term "bitstream" is used, despite the data may be delivered not in a bitstream mode, it may be packetized in segments or in packets. However, the intention is to initially address the use of media coding tools and generating media bitstreams. The system level signaling is a derived aspect and should not influence the definition of the operation points.

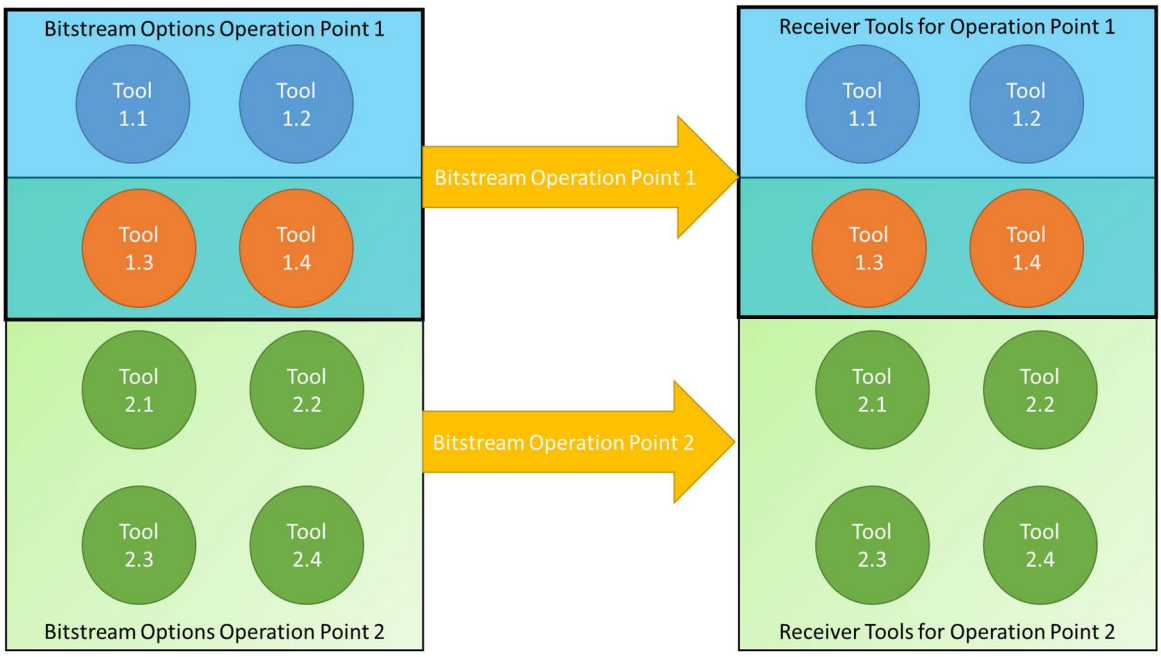

Figure 7: Overview of the expected specification work for TV Video Profile

The specification of a TV Profile operation should include the following aspects:

- Definition of an Operation Point: A collection of discrete combinations of different content formats including spatial and temporal resolutions, color mapping, transfer functions, etc. and the encoding format.
- The bitstream: If a bitstream conforms to a certain operation point, it includes features that are included in the operation point. There should be a signalling on delivery system level that indicates to what operation point the bitstream is conforming.
- The receiver: If a receiver conforms to a certain operation point, it includes all necessary tools to decode and render a bitstream that conforms to an operation point.
- The bitstream and client requirements handling includes usage VUI messages.
- The specification should document the requirements for the bitstream and the receiver.
- A bitstream may conform to one or multiple operation points.
- A receiver may conform to one or multiple operation points.
- The specification needs to be extensible to new operation points for future releases and to other media types.
- The number of operation points should be small and be justified by different deployment cases and/or device classes.
- Operation Points should have catchy names.
- The specification should be written such that operation points can be referred from outside.
- Operation Points should provide an overview on compatibility to other operation points.
- Operation Points should include the relevant aspects identified in the present document.
- An operation point may be delivered by a delivery system, for example DASH. For each operation point, the delivery specific aspects for the sender and the receiver should be defined. Specific aspects such as DASH signalling should be included.

Such a specification will then be useful as:

- It allows to generate bitstreams that conform to operation points.
- It allows receivers to be tested by being able to process bitstreams that conform to a certain bitstream.
- It allows to also to test delivery systems that deliver certain operation points.

Annex A:
Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
09-2015	SA#69	SP-150444			Presented to TSG SA #69 (for information)		1.0.0
12-2015	SA#70	SP-150648			Presented to TSG SA #70 (for approval)	1.0.0	2.0.0
12-2015	SA#70				Approved at TSG SA #70	2.0.0	13.0.0

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Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
09-2016	SA#73	SP-160591	0003	1	F	Alignment with TS 26.	13.1.0
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