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Speech and multimedia Transmission Quality (STQ);
QoS aspects of TCP-based video services like YouTube™

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Speech and multimedia Transmission Quality (STQ).

Modal verbs terminology

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Introduction

There are a variety of popular TCP-based video services available on the internet, on which users can upload, view and share videos. These services use mainly Adobe® Flash® Video but also RealPlayer® and QuickTime® and lately HTML5 technology to display a wide variety of video content, including movie clips, TV clips, and music videos, as well as amateur content such as video blogging and short original videos.

NOTE 1: Adobe® Flash® is the trade name of a product supplied by Adobe. This information is given for the convenience of users of the present document and does not constitute an endorsement by ETSI of the product named. Equivalent products may be used if they can be shown to lead to the same results.

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These services have become very popular and have a major share of the internet traffic worldwide. Due to its high popularity in general and its use over mobile internet its availability and quality is of key interest of the provider of mobile internet access, which makes the services a matter for benchmarking. The down-stream scenario, the probability to access and see a desired video and the quality of the video is the subject of measurement method laid out in the present document.

Any video content is accessed via a link that is provided by the service on a web page. The actual linked videos need to be qualified however e.g. YouTube™ provides different quality profiles of the same video content e.g. a music video clip.

NOTE 4: YouTube™ is the trade name of a product supplied by Google. This information is given for the convenience of users of the present document and does not constitute an endorsement by ETSI of the product named. Equivalent products may be used if they can be shown to lead to the same results.

The individual quality profiles can differ in resolution (e.g. 240p, 360p, 480p, HD720p, HD1080p), in the data-rate and other aspects. Since these differences of clips have an impact on their size and thus on the reproduction speed and quality, a fair comparison can only be provided if actually the same clips are streamed over different networks. On the other hand the clips not need to come physically from the same server since mobile operators employ proxies in order to move the content closer to their subscriber and the downlink bandwidth is often controlled primarily by the video service. Therefore the clips need to be streamed from the actual live network and may not be streamed from a dedicated server.

For cases in which the video content is compressed during the transfer by a proxy hence the content arriving at the subscriber is not identical, the compression ratio may be indicated to show that possible advantages in performance are achieved by reducing the amount of data to be transferred. Whether this enhancement was achieved at the cost of the general quality of the content could be determined by an objective video quality assessment.

The TCP-based videos can be received either on Smartphone or a PC connected via mobile network to the internet. For the Smartphone the way the content is provided can differ significantly with the type and the OS the phone is using. In the present document content delivery for special Apps, RealPlayer® and QuickTime® is not taken into consideration but only the streaming over TCP as e.g. used by YouTube™ with a Browser on a PC or Smartphone with the respective player.

1 Scope

The present document focuses on Quality of Service (QoS) measurements for TCP-based video services where downloading and viewing takes place in parallel. In principle the presented measurement approach can be used for all video services, where the video is embedded in a HTML context as of video on demand services like e.g. YouTube™. Similar applications are also available on social networks.

In the following, QoS parameters to be used for such video service measurements are presented. The underlying procedure consists of two phases: first requesting a control script containing among other information a link to the content, and second, requesting this content. In the present document, YouTube™ serves as the default example but the described QoS parameters can easily be applied to other TCP-based video services.

Furthermore, the present document also offers practical guidance for measurement execution and evaluation of HTTP streaming QoS measurement.

The present document covers the video request and playout of the video. Other services offered by content providers such as e.g. uploading video or managing the private account are not covered.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

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The following referenced documents are necessary for the application of the present document.

Not applicable.

2.2 Informative references

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NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI TS 102 250-2: "Speech and multimedia Transmission Quality (STQ); QoS aspects for popular services in mobile networks; Part 2: Definition of Quality of Service parameters and their computation".

[i.2] ETSI TS 102 250-5: "Speech and multimedia Transmission Quality (STQ); QoS aspects for popular services in mobile networks; Part 5: Definition of typical measurement profiles".

3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

CPU Central Processing Unit
DASH Dynamic Adaptive Streaming over HTTP

DNS	Domain Name System
FLV	Flash® Video
FTP	File Transfer Protocol
GPU	Graphics Processing Unit
HDD	Hard Disk Drive
HTML	HyperText Markup Language
HTTP	HyperText Transfer Protocol
HTTPS	Secure HTTP
IP	Internet Protocol
LAN	Local Area Network
NDIS	Network Driver Interface Specification
OS	Operating System
PC	Personal Computer
PEC	Performance Enhancement Client
QoS	Quality of Service
RTP	Real-time Transport Protocol
RTSP	Real Time Streaming Protocol
SYN	TCP synchronize flag
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
URL	Uniform Resource Locator
WLAN	Wireless Local Area Network

4 Quality of Service measurements for TCP-based video services like YouTube™

4.0 General

Many TCP-based video services, like e.g. the YouTube™ video service, provide videos in several resolutions and qualities. For some video services the client can choose the resolution and quality of the video playback manually. On the other hand, several mobile clients often allow only lower resolutions (delivered in lower bandwidth). Usually, videos are streamed in proprietary Flash® format (FLV) over TCP. In addition, for very large videos or client devices not supporting Flash® other formats are supported as well, e.g. 3GP video down-stream via RTP/UDP for RealPlayer® on Symbian OS™.

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NOTE: Symbian OS™ is the trade name of a product supplied by Symbian Ltd. This information is given for the convenience of users of the present document and does not constitute an endorsement by ETSI of the product named. Equivalent products may be used if they can be shown to lead to the same results.

4.1 Phases of TCP-based video services

Most TCP-based video services, like the YouTube™ video service, are comprised of several phases which are mainly the set-up of a HTML context including downloading the control script for the multimedia playout entity (in the following: "player") and the down-stream of the video itself.

Figure 1 shows typical phases of TCP-based video services, like YouTube™.

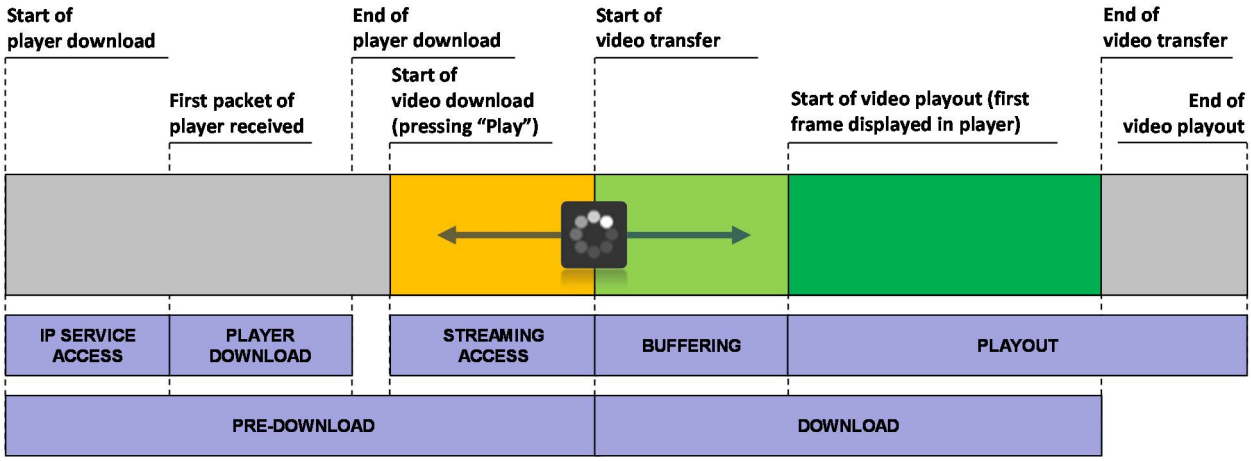

Figure 1: Typical phases of TCP-based video services

In principle the video service can be divided into the setup of the context until the player is ready to play and the download and playout of the video.

The setup of the context until the player is ready to play can be divided into two phases, the "IP service access" phase and the "player download" phase.

The "IP service access" phase starts when the HTML context and the player configuration download are requested. It ends upon receipt of the first data byte containing HTML content, starting the player download phase.

NOTE: The initial DNS request sent when e. g. the YouTube™ URL is opened is not considered to be part of the "IP service access" phase. Thus, the quality of service for the initial DNS resolution for the HTML context and the player configuration download is not covered by the QoS parameters defined in the present document for the "IP service access" phase.

The "IP service access" phase is followed by downloading the HTML context information and the player configuration script (in case of Flash® Player). It contains potential surrounding HTML based information (YouTube™ site), which can be the original YouTube™ site with an embedded player (YouTube™ in a browser window), or the player application without any visible HTML context (YouTube™ App or Flash® Player in an empty HTML context). The last step of the context setup is the download of the player configuration script. The entire download phase is called simplified "player download". At the point the context and the configuration is downloaded completely, the player is "ready to play".

The "streaming access" phase is started by pressing the "Play" button (or in case of "AutoPlay" with the event "Ready To Play" that is then equivalent to requesting the video) and ends with receiving the first video packet over TCP or RTP. This phase could be very interesting if there are proxies between the user and the content server, thus making DNS resolution and other events an influential factor.

In a simple case, during "streaming access" phase there will be only one GET (in case of a requested TCP stream) or a RTSP DESCRIBE (in case of a requested RTP stream) request for the video, followed immediately by the 200 OK message and the payload packets for FLV (TCP) or 3GP (RTP) video. In a more complex case, there may either be several ranged GET requests or it may happen that after the first GET request there will be several redirects (because of proxies) and several more resolving of DNS, etc. so this phase can be much longer. Basically, QoS parameters related to this phase allow concluding how close the network is to the content server for the measured video. Even if a preferred server (URL) is given and firstly requested, the actual approached location of the clip may differ and lead to a redirection to a closer or more appropriate server and DNS has to be contacted again.

In case of RTSP, an RTSP link is embedded in the HTML context. After receiving the final URL or the video, the video can be streamed/downloaded (Ready to Play).

Upon receiving the first video packet, the "buffering" phase commences. While the "download" phase will end with the last received video packet, the "buffering" phase ends in the moment the video playout actually starts. QoS parameters related to this phase allow estimating the initial buffer size for the measured video and current Internet connection type (e.g. DialUp, NDIS, WLAN, LAN).

The "IP service access", the "player download" and the "streaming access" phases jointly constitute the "pre-download" phase. The "buffering" and the remaining video content transfer constitute the "download" phase.

As soon as playout starts, the "playout" phase commences. This phase overlaps with the "download" phase and represents the full playout time for the video. Depending on the configuration the full video can be displayed or video playout can be cut short when video download is complete.

During the "playout" phase the "freezes" of the video display and "video skips" are detected.

4.2 QoS aspects of TCP-based video services

4.2.0 Scope of aspects

When looking at impairments of the video playout, this clause focuses on objectively measurable impairments, such as:

- failures to start;
- video freezes;
- video skips; or
- failures to download completely.

It may be that further subjective impairments exist, which limit comparability of QoS parameters obtained in different setups. Such subjective impairments can e.g. be downscaling of video image quality or frame-rate.

4.2.1 Video freezes and - skips

Freezing events are when the video playout stops (freezes), it is mainly caused by a buffer under-run. The video pauses until the re-buffering is complete. After that, the video continues. There is no video information lost. This is the common case for YouTube™ using Flash® Player.

Skip events are when playout is not continuous, which means that parts of the video content are not displayed or re-displayed, i.e. the playout jumps to a future or past point in time. A possible reason for this can be player misbehaviour or network outage in combination with live streams. When a skip occurs, there is usually no visible re-buffering information on the screen.

4.2.2 Downloading with DASH

The purpose of the employment of DASH is to avoid freezing during the reproduction of the video by adapting the quality level to the available bandwidth. To avoid a buffer under-run during the download the player can request the video content with different quality level than originally chosen. The content with lower video quality needs less download bandwidth and allows to display the video continuously without freezing even in situations with limited bandwidth. Therefore the employment of DASH can lead to varying resolution and quality levels during the reproduction. By using DASH it can happen that the same content is downloaded in different quality levels in parallel.

4.3 QoS parameters for TCP-based video services

4.3.0 Paramater and trigger points

In this clause, a set of QoS parameters based and expanding on the streaming QoS parameters as defined in ETSI TS 102 250-2 [i.1] is proposed for measuring TCP-based video services.

Table 1 gives an overview of the proposed QoS parameters and provides a mapping of these parameters to the phases introduced in clause 4.1. Furthermore, a parameter type is assigned for each QoS parameter in order to determine the calculation method to be used for the respective parameter.

Table 1: Overview of QoS parameters and mapping to typical phases of TCP-based video services

Related Phase(s)	QoS parameter name	QoS parameter type
IP service access	Player IP Service Access Failure Ratio	Failure Ratio
IP service access	Player IP Service Access Time	Duration
Player download	Player Download Cut-off Ratio	Cut-off Ratio
Player download	Player Download Time	Duration
IP service access, Player download	Player Session Failure Ratio	Failure Ratio
IP service access, Player download	Player Session Time	Duration
Streaming access	Video IP Service Access Failure Ratio	Failure Ratio
Streaming access	Video IP Service Access Time	Duration
Buffering	Video Reproduction Start Failure Ratio	Failure Ratio
Buffering	Video Reproduction Start Delay	Duration
Streaming access, Buffering	Video Play Start Failure Ratio	Failure Ratio
Streaming access, Buffering	Video Play Start Time	Duration
Pre-download	IP Service Access Failure Ratio	Failure Ratio
Pre-download	IP Service Access Time	Duration
Streaming access, Buffering, Playout	Video Session Cut-off Ratio	Cut-off Ratio
Streaming access, Buffering, Playout	Video Session Time	Duration
Streaming access, Buffering, Playout	Impairment Free Video Session Ratio	Calculation
Download	Video Expected Size	Size
Download	Video Downloaded Size	Size
Download	Video Compression Ratio	Calculation
Download	Video Transfer Cut-off Ratio	Cut-off Ratio
Download	Video Transfer Time	Duration
Download	Video Mean User Data Rate	Calculation
Playout	Video Playout Cut-off Ratio	Cut-off Ratio
Playout	Video Playout Cut-off Time	Duration
Playout	Video Expected Duration	Duration
Playout	Video Playout Duration	Duration
Playout	Video Freeze Occurrences	Count
Playout	Accumulated Video Freezing Duration	Calculation
Playout	Video Skip Occurrences	Count
Playout	Accumulated Video Skips Duration	Calculation
Playout	Video Maximum Freezing Duration	Calculation
Playout	Video Freezing Impairment Ratio	Failure Ratio
Playout	Video Freezing Time Proportion	Calculation
Whole session	End-to-End Session Failure Ratio	Failure Ratio

Within table 1, the following QoS parameter types are defined:

- Calculation;
- Count;
- Duration;
- Size;
- Cut-off Ratio; and
- Failure Ratio.

The type "Calculation" is assigned to QoS parameters getting calculated based on other QoS parameters or other measurable qualities within the same single measurement, e.g. durations of single freezes or single skips.

The type "Count" is assigned to QoS parameters where the QoS parameter is calculated by counting occurrences of a certain event during a time period between a start trigger point and a stop trigger point, both observed during a single measurement. The following equations define the abstract equation to be used to calculate such a parameter:

$$\text{Count} = \sum_{\text{i=start trigger}}^{\text{stop trigger}} occurence(t_i, event)$$

$$\text{occurrence}(t, \text{event}) = \begin{cases} 1, \text{if event occurs at time } t \\ 0, \text{else} \end{cases}$$

The type "Duration" is assigned to QoS parameters where the QoS parameter represents an expected or an actual time period between a start trigger point and a stop trigger point, both observed during a single measurement. The following equation defines the abstract equation to be used to calculate such a parameter:

$$\text{Duration}[s] = \left(t_{\text{stop trigger}} - t_{\text{start trigger}}\right)[s]$$

The type "Size" is assigned to QoS parameters where the QoS parameter is determined by the size of a quantity, e.g. the expected or the actual size of a video.

The type "{Failure | Cut-off} Ratio" is assigned to QoS parameters representing a failure or Cut-off ratio. The following equation defines the abstract equation to be used to calculate such a QoS parameter. Here, the term "unsuccessful attempt" should be understood in the way that, during a single measurement, the stop trigger point of the QoS parameter has not been observed within a given time after having observed the respective start trigger point.

$$\{\text{Failure} \mid \text{Cut-off}\}\ \text{Ratio}[\%] = \frac{\text{unsuccessful attempts}}{\text{all attempts}} \times 100$$

For the computation of the QoS parameter with type "Calculation", "Count" or "Size", further information is given for each QoS parameter within the following clauses, if applicable.

Table 2 gives an overview of the trigger points used for the QoS parameter definition. For each trigger point, an ID is introduced. This ID will later be used as a reference within the QoS parameter definitions.

Table 2: Overview of the trigger points used for the QoS parameter definition

Trigger ID	Abstract description	Technical description/protocol part
tr-1	Start of player download	TCP SYN towards streaming platform Alternative: First HTTP GET request for the player sent (see note 1) If the respective HTTP header is not accessible due to encryption of TCP segment data then the corresponding player event can be used.
tr-2	First packet of player received	HTTP 200 OK for the player request received (in TCP segment data, if it is accessible there). If the respective HTTP header is not accessible due to encryption of TCP segment data then the corresponding player event can be used.
tr-3	End of player download	Last packet of the player received If the respective HTTP packet is not accessible due to encryption of TCP segment data then the corresponding player event can be used.
tr-4	Start of video download (pressing "Play")	TCP SYN towards streaming platform Alternative: First HTTP GET request for video payload sent (see note 2) If the respective HTTP packet is not accessible due to encryption of TCP segment data then the corresponding player event can be used.
tr-5	Start of video transfer	Reception of the HTTP 200 OK for the video payload in TCP segment data If the respective HTTP header is not accessible due to encryption of TCP segment data then the corresponding player event can be used.
tr-6	Start of video playout (first frame displayed in player)	n. a.
tr-7	End of video transfer	Reception of the last packet of the video payload If the respective HTTP packet is not accessible due to encryption of TCP segment data then the corresponding player event can be used.
tr-8	Intended end of video playout reached	n. a.

NOTE 1: The HTTP GET can be used instead of TCP SYN sent to the streaming platform. This is reasonable for the following reason: During a measurement, several sockets might be opened and when the HTTP GET for the player payload is sent out, it might not be said for certain, which socket will be used for the player download. Here, it is up to the reader to choose the trigger point suiting best the actual needs and/or situation.

NOTE 2: In comparison to e.g. the respective trigger point defined in ETSI TS 102 250-2 [i.1] for the Streaming Service Non-Accessibility, the HTTP GET can be used instead of TCP SYN sent to the streaming platform. This is reasonable for the following reason: During e.g. a YouTube™ measurement, many sockets might be opened and when the HTTP GET for the video payload is sent out, it might not be said for certain, which socket will be used for the video content download. Other content like video information, etc. might also be downloaded over the same socket prior to the HTTP GET being sent out in order to receive the video payload. Especially in this case, the usage of TCP SYN would be misleading. Here, it is up to the reader to choose the trigger point suiting best the actual needs and/or situation.

4.3.1 Player IP Service Access Failure Ratio [%]

QoS parameter description	Start trigger ID	Stop trigger ID
The overall failure ratio for the player access.	tr-1	tr-2

4.3.2 Player IP Service Access Time [s]

QoS parameter description	Start trigger ID	Stop trigger ID
The time it took for the player download to start.	tr-1	tr-2

4.3.3 Player Download Cut-off Ratio [%]

QoS parameter description	Start trigger ID	Stop trigger ID
The overall cut-off ratio for the player download.	tr-2	tr-3

4.3.4 Player Download Time [s]

QoS parameter description	Start trigger ID	Stop trigger ID
The time it took to download the player.	tr-2	tr-3

4.3.5 Player Session Failure Ratio [%]

QoS parameter description	Start trigger ID	Stop trigger ID
The overall failure ratio for the player access and download.	tr-1	tr-3
NOTE: This parameter combines the player IP service access and player data download.		

4.3.6 Player Session Time [s]

QoS parameter description	Start trigger ID	Stop trigger ID
The time it took to access and download the player.	tr-1	tr-3
NOTE: This parameter combines the player IP service access and player data download.		

4.3.7 Video IP Service Access Failure Ratio [%]

QoS parameter description	Start trigger ID	Stop trigger ID
The overall failure ratio for the video access.	tr-4	tr-5
NOTE: Which of the alternatives of the start trigger point definition tr-4 was chosen should be clearly stated as part of the measurement report. For further details, please also refer to the note in table 2 "Overview of the trigger points used for the QoS parameter definition".		

4.3.8 Video IP Service Access Time [s]

QoS parameter description	Start trigger ID	Stop trigger ID
The time it took for the video transfer to start.	tr-4	tr-5
NOTE: Which of the alternatives of the start trigger point definition tr-4 was chosen should be clearly stated as part of the measurement report. For further details, please also refer to the note in table 2 "Overview of the trigger points used for the QoS parameter definition".		

4.3.9 Video Reproduction Start Failure Ratio [%]

QoS parameter description	Start trigger ID	Stop trigger ID
The overall failure ratio to display the first frame in the player.	tr-5	tr-6

4.3.10 Video Reproduction Start Delay [s]

QoS parameter description	Start trigger ID	Stop trigger ID
The time it took to display the first frame in the player.	tr-5	tr-6

4.3.11 Video Play Start Failure Ratio [%]

QoS parameter description	Start trigger ID	Stop trigger ID
The overall failure ratio for the video playout to start.	tr-4	tr-6
NOTE 1: This parameter combines the video IP service access and the video start reproduction delay. NOTE 2: Which of the alternatives of the start trigger point definition tr-4 was chosen should be clearly stated as part of the measurement report. For further details, please also refer to the note in table 2 "Overview of the trigger points used for the QoS parameter definition".		

4.3.12 Video Play Start Time [s]

QoS parameter description	Start trigger ID	Stop trigger ID
The time it took for the video playout to start.	tr-4	tr-6
NOTE 1: This parameter combines the video IP service access and the video start reproduction delay. NOTE 2: Which of the alternatives of the start trigger point definition tr-4 was chosen should be clearly stated as part of the measurement report. For further details, please also refer to the note in table 2 "Overview of the trigger points used for the QoS parameter definition".		

4.3.13 IP Service Access Failure Ratio [%]

QoS parameter description	Start trigger ID	Stop trigger ID
The overall failure ratio for player access, download and video content access.	tr-1	tr-5
NOTE: This parameter combines the player IP service access, the player data download and the video IP service access (including the possible gap between the later ones).		

4.3.14 IP Service Access Time [s]

QoS parameter description	Start trigger ID	Stop trigger ID
The time it took to access and download the player and to access the video content.	tr-1	tr-5
NOTE: This parameter combines the player IP service access, the player data download and the video IP service access (including the possible gap between the later ones).		

4.3.15 Video Session Cut-off Ratio [%]

QoS parameter description	Start trigger ID	Stop trigger ID
The overall cut-off ratio for the video session including the streaming access, buffering and playout phase.	tr-4	tr-8
NOTE: Which of the alternatives of the start trigger point definition tr-4 was chosen should be clearly stated as part of the measurement report. For further details, please also refer to the note in table 2 "Overview of the trigger points used for the QoS parameter definition".		

4.3.16 Video Session Time [s]

QoS parameter description	Start trigger ID	Stop trigger ID
The total duration of the video session including the streaming access, buffering and playout phase.	tr-4	tr-8
NOTE: Which of the alternatives of the start trigger point definition tr-4 was chosen should be clearly stated as part of the measurement report. For further details, please also refer to the note in table 2 "Overview of the trigger points used for the QoS parameter definition".		

4.3.17 Impairment Free Video Session Ratio [%]

QoS parameter description	Start trigger ID	Stop trigger ID
The overall ratio of all videos that have been played without any impairment to the user in relation to the overall number of video playout attempts.	tr-4	tr-8
NOTE 1: Impairments in this context are (i) failures to start (ii) video freezes (iii) video skips (iv) failures to download completely. Please also refer to clause 4.2. NOTE 2: Which of the alternatives of the start trigger point definition tr-4 was chosen should be clearly stated as part of the measurement report. For further details, please also refer to the note in table 2 "Overview of the trigger points used for the QoS parameter definition".		

The following equation defines the abstract equation to be used to calculate this parameter:

$$\text{Impairment Free Video Session Ratio}[\%] = \frac{\text{number of video playouts w/o impairments}}{\text{number of all video playout attempts}} \times 100$$

4.3.18 Video Expected Size [kbit]

QoS parameter description	Start trigger ID	Stop trigger ID
The expected size of the video (see notes).	n. a.	n. a.
NOTE 1: It is important to know the actual size and to use a corresponding value since some optimizers do not change e.g. the FLV-header, but perform a compression on the content. The actual size is the one expected by the chosen video quality level. NOTE 2: This is not a parameter to get calculated.		

4.3.19 Video Downloaded Size [kbit]

QoS parameter description	Start trigger ID	Stop trigger ID
The size of the downloaded video.	tr-5	tr-7
NOTE: In case of DASH this measure is only applicable if the video is completely downloaded with the initially chosen video quality level (from one URL) and no chunks of other quality level have been downloaded additionally.		

4.3.20 Video Compression Ratio [%]

QoS parameter description	Start trigger ID	Stop trigger ID
The ratio of how much the video was compressed during the video download.	n. a.	n. a.
NOTE: This parameter needs to be carefully interpreted in case of DASH. Only if the Video Downloaded Size is actually applicable (see note in clause 4.3.19) then this measure indicates the compression of the video.		

The following equation defines the abstract equation to be used to calculate this parameter:

$$\text{Video Compression Ratio}[\%] = \frac{\text{Video Downloaded Size}[\text{kbit}]}{\text{Video Expected Size}[\text{kbit}]} \times 100$$

NOTE 1: It is assumed that the Video Expected Size matches the size of the original video.

NOTE 2: The Video Compression Ratio can be a very interesting indicator of the subjective video quality. PEC optimization will always reduce the bit rate of the video, which will result in a smaller FLV file size than expected. This is why in networks with this kind of YouTube™ optimization even the YouTube™ player will be confused and sometimes not display the end of the full video download, because it expects a bigger video.

4.3.21 Video Transfer Cut-off Ratio [%]

QoS parameter description	Start trigger ID	Stop trigger ID
The overall cut-off ratio for the video download.	tr-5	tr-7

4.3.22 Video Transfer Time [s]

QoS parameter description	Start trigger ID	Stop trigger ID
The time it took to for the video to download.	tr-5	tr-7

4.3.23 Video Mean User Data Rate [kbit/s]

QoS parameter description	Start trigger ID	Stop trigger ID
The mean user data rate during the video download.	tr-5	tr-7
NOTE: This parameter needs to be carefully interpreted in case of DASH. Only if the Video Downloaded Size is actually applicable (see note in clause 4.3.19) then this measure indicates mean user data rate.		

The following equation defines the abstract equation to be used to calculate this parameter:

$$\text{Video Mean User Data Rate}\,[\text{kbit/s}] = \frac{\text{Video Downloaded Size}\,[\text{kbit}]}{\text{Video Transfer Time}\,[\text{s}]}$$

NOTE: For video measurements the highest throughput does not necessarily mean the most "economic" throughput. In fact, it can be the opposite. Video streaming requires just enough throughput so that video replay goes without freezes. Everything above that causes unnecessary load on the network side. Also, users will often only watch the first half of the video, not the full video. In this case, it is not even necessary to download the complete video.

4.3.24 Video Playout Cut-off Ratio [%]

QoS parameter description	Start trigger ID	Stop trigger ID
The overall cut-off ratio for the video playout.	tr-6	tr-8

4.3.25 Video Playout Cut-off Time [s]

To calculate this QoS parameter, the point in time where the video playout cut-off occurred should be used as the stop trigger point $t_{\text{stop trigger}}$ in the respective abstract equation.

QoS parameter description	Start trigger ID	Stop trigger ID
The duration of the video playout in case there was a cut-off (and the video playout ended unintentionally) after the start of the video playout.	tr-6	n. a.

4.3.26 Video Expected Duration [s]

QoS parameter description	Start trigger ID	Stop trigger ID
The expected duration of the video playout (see note).	n. a.	n. a.
NOTE: This is not a parameter to get calculated.		

4.3.27 Video Playout Duration [s]

QoS parameter description	Start trigger ID	Stop trigger ID
The time it took for the video to playout.	tr-6	tr-8

NOTE: Depending on the measurement software a video measurement may either stop when the complete video is downloaded or when it is displayed. E.g. when measuring with MP4 YouTube™ videos (i.e. not FLV) and PEC optimization (i.e. video quality is dynamically reduced), the exact moment when the complete video is downloaded cannot be detected exactly and in this case a measurement should run until the complete video is displayed.

4.3.28 Video Freeze Occurrences

QoS parameter description	Start trigger ID	Stop trigger ID
The number of video freezes for successful playouts.	tr-6	tr-8
NOTE: Freezes occur e.g. when video playout has started and needs to pause for re-buffering, but they can also occur in case of slow hardware, as the CPU and GPU load can be high during playout of highly compressed video.		

4.3.29 Accumulated Video Freezing Duration [s]

QoS parameter description	Start trigger ID	Stop trigger ID
The accumulated duration for all video freezes for successful playouts.	tr-6	tr-8
NOTE: Freezes occur e.g. when video playout has started and needs to pause for re-buffering, but they can also occur in case of slow hardware, as the CPU and GPU load can be high during playout of highly compressed video.		

The following equation defines the abstract equation to be used to calculate this parameter:

$$\text{Accumulated Video Freezing Duration}[s] = \sum_{i=VideoFreezeOccurances} Duration(Videofreeze_i)[s]$$

4.3.30 Video Skip Occurrences

QoS parameter description	Start trigger ID	Stop trigger ID
The number of video skips during successful playouts.	tr-6	tr-8
NOTE: Video skips may happen in concurrence with video freezes, e.g. when video catches up.		

4.3.31 Accumulated Video Skips Duration [s]

QoS parameter description	Start trigger ID	Stop trigger ID
The accumulated duration for all video skips during successful playouts.	tr-6	tr-8
NOTE: Video skips may happen in concurrence with video freezes, e.g. when video catches up.		

The following equation defines the abstract equation to be used to calculate this parameter:

$$\text{Accumulated Video Skips Duration [s]} = \sum_{i=VideoSkipsOccurances} Duration(Videoskip_i)[s]$$

4.3.32 Video Maximum Freezing Duration [s]

QoS parameter description	Start trigger ID	Stop trigger ID
The duration of the longest video freeze.	tr-6	tr-8

The following equation defines the abstract equation to be used to calculate this parameter:

$$\text{Video Maximum Freezing Duration [s]} = Maximum\left(\bigcup_{i=VideoFreezeOccurances} Duration(Videofreeze_i)\right)[s]$$

4.3.33 Video Freezing Impairment Ratio [%]

QoS parameter description	Start trigger ID	Stop trigger ID
The ratio of playouts where freezes have been observed in relation to all successful playouts.	tr-6	tr-8

The following equation defines the abstract equation to be used to calculate this parameter:

$$\text{Video Freezing Impairment Ratio [\%]} = \frac{\text{Number of successful playouts impaired by freezes}}{\text{Number of all successful playouts}} \times 100$$

In the equation above, the term "successful playouts impaired by freezes" refers to all video playouts where the following holds true:

- The playout was successful, e.g. no cut-off occurred and
- at least one freeze occurred during the playout.

4.3.34 Video Freezing Time Proportion

QoS parameter description	Start trigger ID	Stop trigger ID
The proportion of the accumulated video freezing duration in relation to the expected video duration for successful playouts.	tr-6	tr-8

The following equation defines the abstract equation to be used to calculate this parameter:

$$\text{Video Freezing Time Proportion}\,[\%] = \frac{\text{Accumulated Video Freezing Duration}\,[s]}{\text{Video Expected Duration}\,[s]} \times 100$$

4.3.35 End-to-End Session Failure Ratio [%]

QoS parameter description	Start trigger ID	Stop trigger ID
The overall session failure ratio.	tr-1	tr-8

4.4 Recommended supplementary information for TCP-based video service measurements

In particular with regards to trouble shooting purposes, certain observable quantities are recommended to include into the measurement results when performing measurements for TCP-based video services like the YouTube™ video service.

Table 3 provides a list of these quantities together with the information from where these can usually be derived and provides a mapping of these quantities to the phases introduced in clause 4.1.

Table 3: Observable quantities recommended getting included into the measurement results

Related Phase(s)	Description of the information	Indication, where the information can usually be derived from
Download	Information on the video codec used in the downloaded video payload.	Data recorded on TCP layer during the respective measurement phase.
IP service access	URL of the actual video server.	Data recorded on TCP layer during the respective measurement phase.
Streaming access	Information on the actual received image resolution.	Data recorded on TCP layer during the respective measurement phase.
Player download	The total size of the downloaded player.	Data recorded on TCP layer during the respective measurement phase.

4.5 Configuration aspects including timeout recommendations for TCP-based video service measurements

4.5.0 Purpose

This clause gives examples for configuration options that can be used to shape a YouTube™ measurement so it represents end-user experience more accurately.

4.5.1 URL

During YouTube™ measurements, any traffic beyond the player and video download should be minimized as much as possible, which is why it is recommended to display videos using the YouTube™ full screen option.

To avoid having to load the YouTube™ frontend with logos, thumbnail links to other videos, comments etc. the direct link to the video has to be entered. It is formed from the URL in the browser by replacing "/watch?v=<video ID>" and any additional parameters appended e.g. "&feature=related" with "/v/<video ID>" – with the video ID usually being an 11 character string, e.g. "eOjzLggAKis".

EXAMPLE 1: For a regular video link: http://www.youtube.com/watch?v=u1zgFlCw8Aw&feature=feedwll.

EXAMPLE 2: For corresponding full screen link: http://www.youtube.com/v/u1zgFlCw8Aw.

4.5.2 Timeouts

4.5.2.0 Application of timeouts

A range of timeouts and other thresholds can be used to:

a) derive QoS based on assumptions about the maximum tolerable degradations that a model user is willing to experience before aborting the service session; and

b) make automated YouTube™ measurements more effective.

Some of these parameters can be derived from their counterparts for streaming services in the ETSI timeouts from ETSI TS 102 250-5 [i.2], which includes the following timeouts and recommendations:

- Streaming Service Access Timeout 30 seconds.
- Stream Reproduction Start Timeout (initial buffering) 60 seconds.
- Rebuffering Timeout (Single) 30 seconds.
- Rebuffering Timeout (Total) 75 % of session time.
- Max Allowed Rebuffering Frequency 20 rebuf/min.
- Teardown Timeout 30 seconds.

In the following, different YouTube™ measurement timeouts and suggestions regarding their length are explained.

4.5.2.1 Player IP Service Access timeout

The Player IP Service Access timeout determines how long the measurement engine will try to access the player until the attempt is considered failed.

4.5.2.2 Player Download Time timeout

The Player Download Time timeout determines the maximum time it can take for the Flash® Player files to be downloaded.

In a stationary measurement at a certain hotspot where high throughputs can be expected, a smaller timeout can be applied, but for mobile measurements it should not go under 30 s.

4.5.2.3 Video IP Service Access timeout

The Video IP Service Access timeout determines how long the measurement engine will wait for the video to be accessed until the procedure is considered a failure. This parameter is very similar to the player access timeout and should be set to the same value for the same reasons. In addition, lots of redirections can occur during YouTube™ measurements while the proxy or YouTube™ are looking for the best server from which the requested video will be downloaded.

4.5.2.4 Video Reproduction Start Delay timeout

The Video Reproduction Start Delay timeout determines how long the measurement engine should wait for starting reproduction of the video after the download has started until the procedure is considered as failed. The time required here is the time for the initial buffering of the player. It is hard to say which parameters are taken into account by the player to determine buffer size.

For example, for most LAN connections the buffer will be huge and the player will download more than half of the video before video replay actually starts. On the other hand, for mobile networks the initial buffer is usually very small. With new operator-specific connection manager software (dashboards) and new NDIS devices and connections there may be variations as well.

4.5.3 Video Playout Duration

The Video Playout Duration of the video tells the measurement engine the exact duration of the video in seconds, which is required for the calculation of related QoS parameters. It should be taken from the value that is displayed when the

YouTube™ video is played manually. Measurements with videos of 90 s length are recommended which should be enough to show any problems that might occur. Savings in time and HDD space are significant with a shorter video duration and CPU load is greatly affected by video length as well.

4.5.4 Handling of video freezes

4.5.4.0 Use of freezes

Freezes in video playback can represent an important part of end-user experience and should be considered when creating a framework for YouTube™ measurements. The following parameters are suitable to control measurement execution and derive QoS based on assumptions about the maximum tolerable degradations that a model user is willing to experience before aborting the service session.

4.5.4.1 Minimum freeze duration

The minimum freeze duration is the minimum duration in milliseconds for a video to stall until it is recognized and evaluated as a freeze.

For example, if video is hidden during playout, hardware-related freezes in the worst case will be around 120 ms (with slow Hardware). In case video is displayed during playout hardware-related freezes in the worst case are around 280 ms. In comparison, actual network-related freezes are mostly bigger than 500 ms.

4.5.4.2 Maximum duration of single freeze

If a single freeze exceeds the maximum duration of single freeze value, the video download is evaluated as cut-off since a normal user would stop the video because the video got stuck. A typical user will be prepared to wait during one long rebuffering event. If one single interruption is longer than the timeout value, the playout phase is evaluated as cut-off.

4.5.4.3 Maximum duration of all freezes

If the sum of all freeze durations exceeds the maximum duration of all freezes value, the video download is evaluated as a cut-off. This reflects a regular user stopping the video because it got stuck too often in total.

4.5.4.4 Maximum number of freezes

A total number of maximum allowed freezes can be considered for use case configuration as well. This parameter is entirely subjective. The user may not be bothered with many short freezes when they are unnoticeably short and the video proceeds to play. On the other hand, someone who tries to listen to a song will be bothered even by short audio interruptions.

4.5.5 Timeout and Threshold Frameworks

The different types of timeouts and thresholds presented in the previous clauses constitute a framework of rules that models a user with specific properties, such as e.g.:

- Level of expectation/Comparable past experience.
- Level of patience/time pressure.

It needs to be understood that the setting of those parameters has immediate effect on the measured QoS parameter and hence any reporting of QoS parameter results needs to be always accompanied by the respective timeout and threshold settings applied during the related measurements.

Further, it may be wise not to change individual parameters without good reason but take into account how the different timeout mechanisms interact and always see a set of parameters as a "model" for a particular user type.

In table 4, we present examples settings and their rationales that do model a standard user and take into account technical boundary conditions.

Table 4: Example settings that do model a standard user

Timeout/Threshold	Value [Unit]	Comment/Rationale
Player IP Service Access timeout	30 [s]	The value for this parameter should be the same as the value for the IP service access timeout for a regular HTTP task, e.g. 30 seconds.
Player Download Time Timeout	30 [s]	The YouTube™ player size is usually around 300 kByte (rough estimate), which is slightly bigger than the Copernicus web page (209 kByte) for HTTP use cases. According to ETSI TS 102 250-5 [i.2] the default timeout for Copernicus web page is 34 seconds. With this in mind, the timeout for the player download should not be below 30 seconds.
Video IP Service Access timeout	30 [s]	See above.
Video reproduction start delay timeout	20 [s]	For most mobile networks this time should be around 20 seconds, but for LAN at least 30 seconds are needed. Before drawing any conclusions about the default value, statistics should be gathered on how much time this phase usually takes for the networks in question.
Minimum freeze duration	120 [ms]	A threshold of 120 milliseconds is recommended if minimized playout can be guaranteed.
Maximum duration of single freeze	8 [s]	A value of 8 seconds is an acceptable best-practice value.
Maximum duration of all freezes	15 [s]	For a video length of 90 seconds, 20 seconds would be a fitting value with the user not willing to wait longer to see the full video. If the video replay is interrupted for more than 20 seconds in summary, the YouTube™ playout phase is evaluated as cut-off.
Maximum number of freezes	10 [-]	A value of 10 seems acceptable here.

4.5.6 Hide video during playout

Hiding video playback during the playout phase will significantly reduce GPU and CPU load. This is especially recommended when connecting to a measurement system via remote desktop and the video would otherwise play back on the remote desktop machine.

4.5.7 Play until the end

The video can be played back until the end even when the video download has already been completed. Omitting this step is recommended to save time during measurements, as video skips and interruptions only happen during download.

4.5.8 Cache and cookies

The cache should be cleared after measurement, which will delete the downloaded player and video files and prevent inadequate download times.

4.6 Impacts of measurement hardware for TCP-based video service measurements

TCP-based video services are, compared to e.g. a file download via FTP, much more demanding with respect to the CPU/GPU hardware requirements of the measurement system. Thus, special care should be taken when configuring a measurement system for such measurements.

Practical hints for performing measurements are:

- Adequate hardware should always be used to avoid effects of freezing and skipping to occur due to CPU/GPU overload.
- Hiding the video playout might help to decrease CPU/GPU load on systems with less powerful CPUs/GPUs.
- Operating the measurement system via a remote desktop connection is not advisable since this, even under optimal network conditions, can cause a lot of freezing because the video should appear on the remote desktop machine, causing also a very high CPU and GPU load and the related problems.

Annex A:
Measuring YouTube™ QoS with the Smartphone App

A.0. Introduction

As indicated in the introduction YouTube™ clips can be watched in different fashions. Besides using a browser (embedded) player they can for example watched with the a dedicated App on the Smartphone. The characterization of the QoS of the clip reproduction using a Smartphone App is the subject of this appendix.

The Smartphone App is a proprietary App that can be downloaded actively from a respective store or is a preinstalled application on many Smartphones. These Apps are frequently updated and these updates are often downloaded in the background to the Smartphone unnoticed by the user. As a consequence the appearance and methods of the clip reproduction with these Apps changes over time without active interference of the user.

The App changes not only in appearance but there are also changes in methods e.g. DASH, protocol (HTTPS, SPDY™).

NOTE 1: SPDY™ is an open networking protocol and not an acronym) and collateral content delivery from version to version even though the delivery is TCP based.

NOTE 2: SPDY™ is the trade name of a product supplied by Google. This information is given for the convenience of users of the present document and does not constitute an endorsement by ETSI of the product named. Equivalent products may be used if they can be shown to lead to the same results.

This changes of the App makes it appealing to characterize the service only via the events observable by the user in any case and those that are independent of the actual way the content is delivered. For this the delivery of the clip in the case of using a Smartphone App is divided into phases. However the phases as described in clause 4.1 cannot be identified in such a detail from the perspective of the user, therefore the quality of experience of two main phases is characterized.

A.1. User observable phases of the clip reproduction

The delivery of the YouTube™ video service over Smartphone App, is comprised of two user observable phases.

Figure A.1 shows typical phases of TCP-based video services like YouTube™ as experienced by the user.

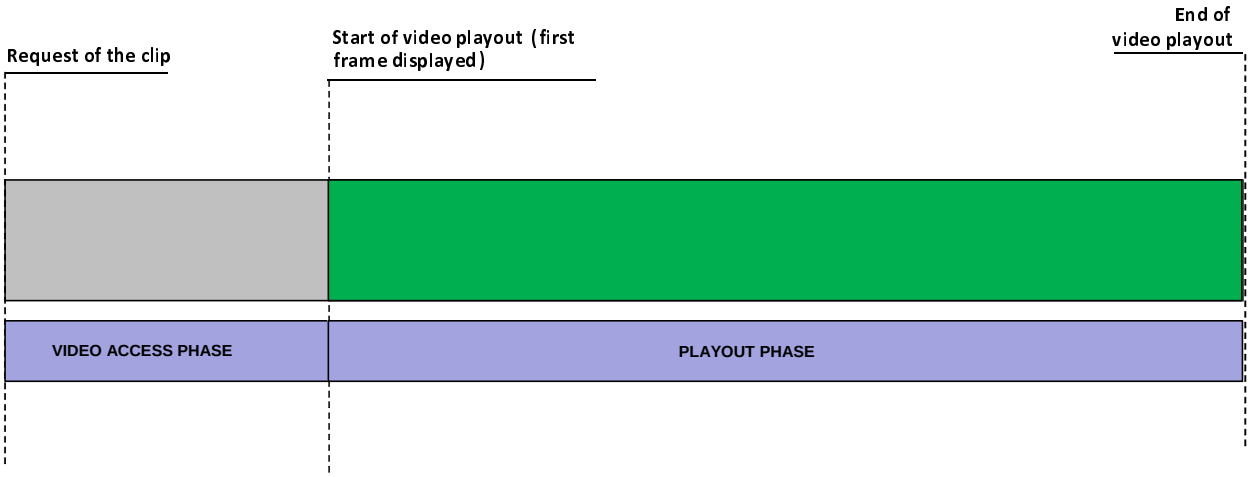

Figure A.1: Typical observable phases of Smartphone App video service

The first phase is from requesting the clip by e.g. pushing on the picture or the link and lasts until the first picture is displayed. This phase is a general property of the video clip reproduction and is not likely to be altered by changes of the underlying App. The characterization of this phase is the duration of that phase and its failure ratio meaning the failure to receive the first picture.

The second phase starts with the display of the first picture and lasts until the end of the playout of the clip. This phase is also a general property of clip reproduction and can be identified by user observable events. The characterization of this phase is the duration (certainly depending on the clip length) and the failure or cut-off ratio of the playout. Additional observable impairments like freezing are also possible.

A.2. QoS Parameter for You Tube with the Smartphone App

A.2.0 Parameter and trigger points

From these two phases parameter can be extracted that describe the service as experienced by the user.

Table A.1: Overview of QoS parameters and mapping to typical phases of the video services as experienced by the user

Related Phase(s)	QoS parameter name	QoS parameter type
Video Access	App Video Access Failure Ratio	Failure Ratio
Video Access	App Video Access Time	Duration
Playout	App Video Playout Cut-off Ratio	Failure Ratio
Playout	App Video Playout Duration	Duration
Playout	App Impairment Free Video Session Ratio	Calculation
Playout	App Video Freezing Time Ratio	Calculation

The actual trigger points a similar to or the same as those that are defined in clause 4.3 of the present document.

Table A.2: Overview of the trigger points used for the QoS parameter definition

Trigger ID	Abstract description	Technical description
tr-1A	Request of the clip	The corresponding player event
tr-2A	Start of video playout (first frame displayed in player)	n. a.
tr-3A	End of video playout reached	n. a.

From these observable events in connection with the observable phases the following five KPIs can be identified.

A.2.1 App Video Access Failure Ratio [%]

QoS parameter description	Start trigger ID	Stop trigger ID
The overall failure ratio for the video access of the App.	tr-1A	tr-2A

A.2.2 App Video Access Time [s]

QoS parameter description	Start trigger ID	Stop trigger ID
The overall duration of the video access of the App.	tr-1A	tr-2A

A.2.3 App Video Playout Cut-off Ratio [%]

QoS parameter description	Start trigger ID	Stop trigger ID
The overall cut-off ratio for the video playout.	tr-2A	tr-3A

A.2.4 App Video Playout Duration [s]

QoS parameter description	Start trigger ID	Stop trigger ID
The time it took for the video to playout.	tr-2A	tr-3A

There are a couple of impairments of the reproduction that can occur during the playout phase e.g. freezing or even cut-off of the entire clip. These impairments are the same as those that are described in clause 4.2 of the present document. This definition can be used for the characterization of the video reproduction with the App since all concerned events and phenomena are observable by the user. The following KPI represents all those in a concise manner.

A.2.5 App Impairment Free Video Session Ratio [%]

QoS parameter description	Start trigger ID	Stop trigger ID
The overall ratio of all videos that have been played without any freezings to the user in relation to the overall number of video playout attempts.	tr-2A	tr-3A
NOTE: Impairments in this context are (i) failures to start (ii) video freezes (iii) failures to download completely. Please also refer to clause 4.2.		

Certainly the various impairments can be quantified as well and therefore the metrics from clause 4.3 are applicable and can be calculated for the App approach. And in addition to that even a quality measure may be used to characterize the observed video quality that is subject to resolution and video coding.

A.2.6 App Video Freezing Time Ratio [%]

The Video Freezing Time Ratio describes the ratio between the entire playout length versus the time of the accumulated freezing during the playout.

QoS parameter description	Start trigger ID	Stop trigger ID
The proportion of the accumulated video freezing duration in relation to the actual video playout duration (including freezings) for successful playouts.	tr-2A	tr-3A

The following equation defines the abstract equation to be used to calculate this parameter:

$$\text{App Video Freezing Time Ratio}[\%] = \frac{\text{Accumulated Video Freezing Duration}[s]}{\text{Actual Video Playout Duration}[s]} \times 100$$

A.3. Configuration aspects

Besides those aspects described in the clause 4.5 of the present document there are important aspects that are only applicable for the Smartphone App scenario. To maintain comparability of results the actual App version and phone model used needs to be reported. The orientation of the phone is also a special property of the clip reproduction on the Smartphone. This can either be upright when the phone is held vertically (often with additional content on the lower part of the display) or when it is held horizontally in landscape mode. This aspect has a consequence on the reproduction of the quality and is therefore an information element which is important to be reported.

History

Document history		
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