ATSC Technology Group Report: ATSC 3.0 Launch – DASH Timeline and IMSC1

Doc. T/300
9 October 2020

Advanced Television Systems Committee
1776 K Street, N.W.
Washington, D.C. 20006
202-872-9160

The Advanced Television Systems Committee, Inc., is an international, non-profit organization developing voluntary standards and recommended practices for digital television. ATSC member organizations represent the broadcast, broadcast equipment, motion picture, consumer electronics, computer, cable, satellite, and semiconductor industries. ATSC also develops digital television implementation strategies and supports educational activities on ATSC standards. ATSC was formed in 1983 by the member organizations of the Joint Committee on Inter-society Coordination (JCIC): the Electronic Industries Association (EIA), the Institute of Electrical and Electronic Engineers (IEEE), the National Association of Broadcasters (NAB), the National Cable Telecommunications Association (NCTA), and the Society of Motion Picture and Television Engineers (SMPTE). For more information visit www.atsc.org.

Note: The user's attention is called to the possibility that compliance with this document may require use of an invention covered by patent rights. By publication of this document, no position is taken with respect to the validity of this claim or of any patent rights in connection therewith. One or more patent holders have, however, filed a statement regarding the terms on which such patent holder(s) may be willing to grant a license under these rights to individuals or entities desiring to obtain such a license. Details may be obtained from the ATSC Secretary and the patent holder.

Implementers with feedback, comments, or potential bug reports relating to this document may contact ATSC at https://www.atsc.org/feedback/.

Revision History

Version	Date
Technology Group Report approved	9 October 2020

Table of Contents

ATSC Technology Group Report: ATSC 3.0 Launch – DASH Timeline and IMSC1

1. SCOPE

1.1 Introduction and Background

This document provides a tutorial on the MPD and IMSC1 timelines, as well as recommendations on an initial "launch" constraint set. The purpose of the recommendations in this document is to provide interoperability of the ATSC 3.0 IMSC1 Component [3].

Broadcasters and others have noticed inconsistencies with early IMSC1 encoding and decoding implementations. This is a proposed solution to this issue. The goal is to provide conformant and consistent encoding and decoding, including a conformance test plan.

The target audience is engineers. It is assumed that the reader is knowledgeable about MPEG DASH [11], ISO BMFF[10], and IMSC1 [12] in general.

1.2 Organization

This document is organized as follows:

- Section 1 – Outlines the scope of this document and provides a general introduction.
- Section 2 – Lists informative references and applicable documents.
- Section 3 – Provides definitions of terms, acronyms, and abbreviations for this document.
- Section 4 – Overview.
- Section 5 – Describes the assumed Station Model.
- Section 6 – Provides recommendations for IMSC1 Segment encoding.
- Section 7 – Provides a few words on MPD updates.
- Section 8 – Describes the MPD timeline and provides recommendations.
- Section 9 – Describes the decoder timing calculations.
- Section 10 – Recommends near term priority features to implement.
- Section 11 – Provides examples of MPDs and IMSC1 Segments.
- Section 12 – Lists resources that may be helpful.

2. REFERENCES

All referenced documents are subject to revision. Users of this document are cautioned that newer editions might or might not be compatible.

2.1 Informative References

The following documents contain information that may be helpful in applying this Technology Group Report.

[1] ATSC: "Physical Layer Protocol," Doc. A/322:2020, Advanced Television Systems Committee, Washington, D.C., 23 January 2020, https://www.atsc.org/atsc-documents/type/3-0-standards/.

[2] ATSC: "Signaling, Delivery, Synchronization, and Error Protection," Doc. A/331:2020, Advanced Television Systems Committee, Washington, D.C., 16 January 2020, https://www.atsc.org/atsc-documents/type/3-0-standards/.

[3] ATSC: "Captions and Subtitles," Doc. A/343:2018, Advanced Television Systems Committee, Washington, D.C., 10 October 2018, https://www.atsc.org/atsc-documents/type/3-0-standards/.
[4] ATSC: "Techniques for Signaling, Delivery, and Synchronization," Doc. A/351:2019, Advanced Television Systems Committee, Washington, D.C., 28 August 2019, https://www.atsc.org/atsc-documents/type/3-0-recommended-practices/.
[5] DASH-IF ATSC IOP v1.1, https://dashif.org/guidelines/.
[6] DASH-IF IOP v4.2, https://dashif.org/guidelines/.
[7] DASH-IF IOP v4.3, https://dashif.org/guidelines/.
[8] DASH-IF IOP v5, "Restricted Timing Model" (work in process), https://dashif-documents.azurewebsites.net/Guidelines-TimingModel/master/Guidelines-TimingModel.pdf. (Note: ignore Section 15.)
[9] EBU Tech 3381, "CARRIAGE OF EBU-TT-D IN ISOBMFF," https://tech.ebu.ch/docs/tech/tech3381.pdf.
[10] ISO/IEC 14496-30:2018, "Timed Text and Other Visual Overlays in ISO Base Media File Format," https://www.iso.org/standard/75394.html.
[11] ISO/IEC 23009-1:2019, "DASH 4th Ed (equivalent to 3rd Ed + DASH-IF IOP Annex A)," https://www.iso.org/standard/75485.html.
[12] W3C, "TTML Profiles for Internet Media Subtitles and Captions 1.0.1 (IMSC1)," https://www.w3.org/TR/ttml-imsc1.0.1/.
[13] W3C, "Timed Text Markup Language 1 (TTML1) (Third Edition)," https://www.w3.org/TR/2018/REC-ttml1-20181108/.

3. DEFINITION OF TERMS

3.1 Acronyms and Abbreviations

Although there are numerous acronyms and abbreviations in this document, there are no new ones defined and the reader is referred to the relevant documents in Section 2.

3.2 Terms

Although there are numerous technical terms in this document, there are no new ones defined and the reader is referred to the relevant documents in Section 2.

4. OVERVIEW

This document is mostly focused on a single DASH MPD Period.

This document accommodates segmentation and MPD creation downstream of the encoders without any knowledge about a "program". These guidelines generally follow the recommendations of DASH-IF IOP v4.2 Section 4.4.

> *Note*: The details for multi-Period MPD content are still an area of ongoing development in MPEG and DASH-IF. This includes xlink resolution and general support for client-side ad replacement. Low Latency DASH is also still under refinement. Guidelines for multi-Period, xlink and Low Latency are for future study.

This document assumes a traditional SDI-based station workflow; i.e. not an IP-based workflow. As such, this imposes various constraints on the use and distribution of IMSC1 in the station and results in fewer options on the IMSC1 encoding.

Note: The details for IP-based station workflow is an area for future study.

Existing encoder practice is observed to be either "all UNIX time to date" or "time between encoder resets". The former has some issues in that the observed AST values are the TAI/UNIX epoch (1/1/1970).

This document contains a mix of provisions required by the underlying DASH specifications and new recommendations. The latter are identified with the preface "**Recommendation**:".

5. STATION MODEL

Today's station model is SDI-based (see Figure 5.1). Ultimately all content is converted to SDI formats (uncompressed video, compressed/uncompressed audio, and digital closed captions (DTVCC 708 + 608). This SDI content is routed to the media encoders and then a ROUTE/DASH or MMT packager and scheduler. The output is then sent via STL to the transmitter. Today's station model does not easily support new formats at the encoder, e.g. IMSC1 documents. The scope of this discussion is the output of the encoders – the MPD and IMSC1.

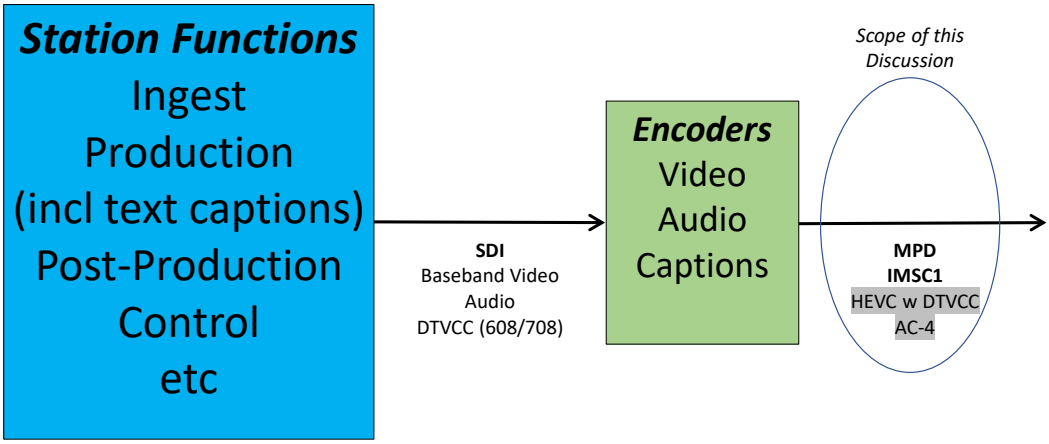

Figure 5.1 SDI-based station model.

6. IMSC1 SEGMENT ENCODING

The Segment encoding details here are intended for both ROUTE/DASH and MMT.

There are two basic Segment encoding strategies:

- Post-production single instance Segment for an entire program
- Live with many short-duration Segments (same as video and audio)

The former is not practical in the SDI-based station since program information and IMSC1 carriage is not defined over SDI today. However, the single instance Segment is viable for testing and for (future) remote ad replacement and testing, hence its inclusion here and now.

The "live", short duration Segments are what is practical today in the SDI-based Station.

Recommendation: Encode IMSC1 Segments with a single ISO BMFF Sample containing a single IMSC1 document.

Each IMSC1 document stands alone. So, for all but the first Segment, IMSC1 encoding must first reproduce the state of the presentation at the end of the last Segment, including its timing.

IMSC1 (captions in general) can be "sparse". That is, they may not be present in the presentation for an extended period of time. For DTVCC (608/708), there are simply no captions put into the video SEI. Since DTVCC is not in its own track, there is no disruption to the decoder. In ATSC 3.0, IMSC1 is in its own track. So, the question then is what to do when there are no captions. The choices are to either "fill" in Segments so the track is not sparse; or allow Segments to be missing when there are no captions to be displayed ("sparse track"). There are OTT IMSC1 decoders today that do not handle sparse tracks.

Recommendation: For times when there is no IMSC1 content to be presented, ensure that the Segments contain a minimally conforming document as defined in Section 11.3.

Note: Fragments (ISO BMFF subsegments) are not supported.

6.1 'tfdt' baseMediaDecodeTime

This is the Segment presentation time coded in the ISO BMFF layer. It is expected that this increments for each Segment by the Segment duration.

6.2 'trun' compositionTimeOffset

This allows samples to be re-ordered on the timeline. This is used for, e.g. video to re-arrange I, P and B frame samples. It is not expected to be present in IMSC1 Segments.

6.3 'elst' (Edit List)

This allows modifications to the timeline, some of which can be complex. It is not expected to be present in IMSC1 Segments.

7. MPD UPDATES

In theory a broadcast MPD could be set up for 24 hours and not change. However, there are certain events that make that impractical. The requirements for when the broadcast MPD must be updated are found in DASH Section 8.11.4 [11]. These may be the result of service configuration changes due to program transitions, ad insertions and network/government breaks that result in:

1) Video format and frame rate changes
2) Audio format, tracks added/removed
3) Caption tracks added/removed

In general, all MPDs including updates must, of course, be valid against the MPEG DASH XML schema. See Resources Section 12 for tools for assisting with this.

Updates to an MPD are restricted as to what elements and attributes can be modified. See MPEG DASH [11] and the DASH-IF IOPs [6] and [5] for details.

8. MPD TIMING AND VERSIONING

8.1 Overview

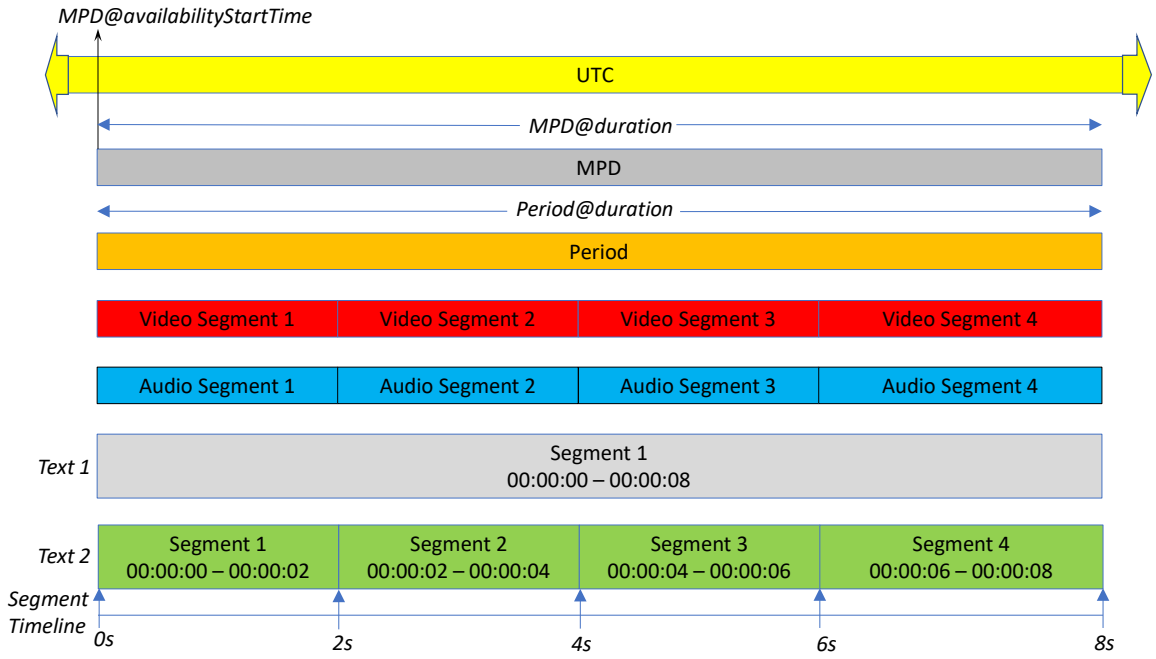

Figure 8.1 Simple MPD, Single-Period with Two Text Tracks, Period-Relative IMSC1 Timing.

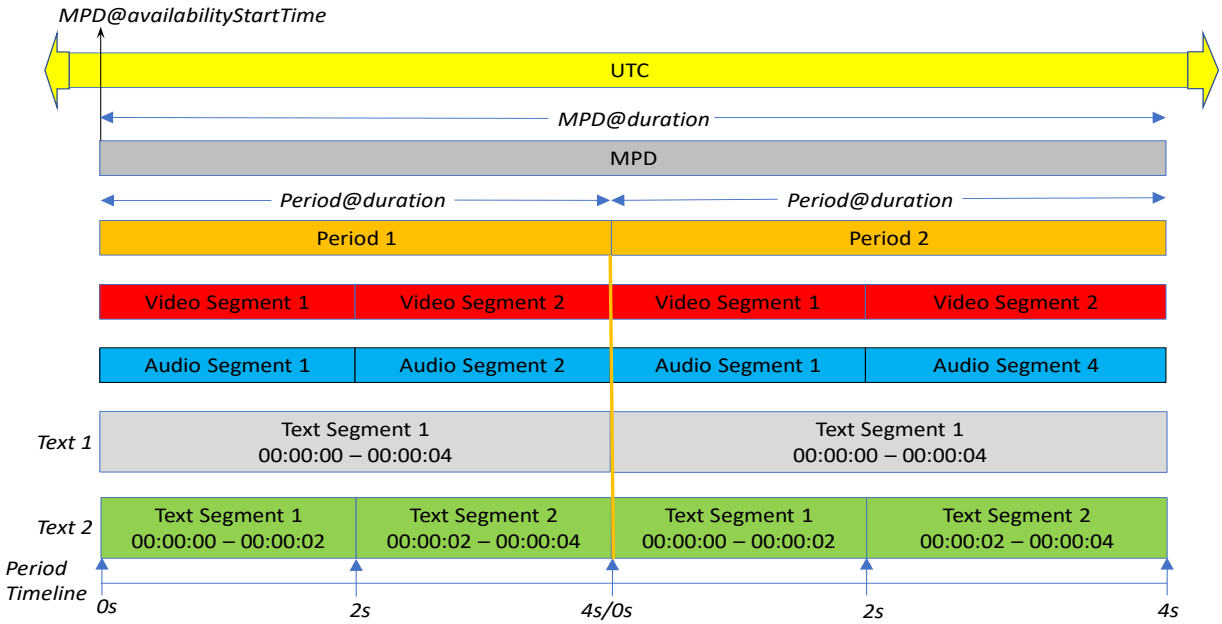

Figure 8.2 Multi-Period MPD with Two Text Tracks, Period-Relative IMSC1 Timing.

The MPD enables a relative timeline from 0 through its duration. In the simple case, the timeline is a single Period (see Figure 8.1), which is used today for lots of content, but in general, there can be multiple Periods (see Figure 8.2). The Period duration is the sum of its Segment durations. Broadcast MPDs also establish a relationship to UTC.

Figure 8.1 shows the relationship between these timelines for a simple, single-Period MPD with 2-second duration Segments ("Text 2") using Period-Relative IMSC1 timing. In this case of a single Period, the IMSC1 document/sample/Segment timing is relative to both the Period and MPD@availabilityStartTime for each document/sample. That is, the time for each Segment increases across the Period. DASH.js expects this timing, as do current ATSC 3.0 decoder deployments. This also aligns with the content used in the NEXTGEN TV logo program.

In contrast, Figure 8.2 shows the relationship between these timelines for a multi-Period MPD with 2-second duration Segments ("Text 2"). In both cases the IMSC1 document/sample/Segment timing starts at zero for each Period. That is, IMSC1 timing for each Period starts at zero.

> *Note*: There is a 14496-30 [10] provision that says:
> "*…the begin and end attributes of the <body> element…are relative to the start of the track, not relative to the start of the sample*."

The above was written in the context of an ISO BMFF "track" in a file where there are multiple samples per file. That is, it is for self-contained "movie" files. This is not a constraint on a DASH "track" or CMAF "track". This is expected to be clarified in 14496-30 in the newer context of DASH and CMAF and the overloading of "track".

There is an additional text track, "Text 1", that represents a single Segment across the entire Period. There are some test scenarios that make this convenient, even though it probably will not be used in an SDI-based station emission until ad replacement is addressed.

> *Note*: Multi-Period decoding is not explicitly required by ATSC 3.0 standards or the DASH ATSC IOP, and multi-Period decoding is not addressed by the CTA-CEB32 suite of standards nor are there such test streams in the NEXTGEN TV logo test program. Before deploying multi-Period emissions, backward compatibility considerations would be important to ensure interoperability.

8.2 MPD@id

Recommendation: Set to SLT.Service@globalServiceId per A/351 Section 5.3 [4] using EIDR video service identifier, plus an xs:dateTime value using a '#' separator; e.g., "https://doi.org/10.5239/8A23-2B0B#2020-06-10T04:00:00Z". This will uniquely identify the MPD within all ATSC 3.0 services. The EIDR URL is constant per service. A change in the time value identifies a new MPD (not an update).

8.3 MPD@publishTime

This is required for dynamic MPDs and is used to identify a "newer" **updated MPD** with the same MPD@id.

8.4 MPD@profiles

The MPD and all media Segments are required to conform to the "ISO Base media file format broadcast TV profile" as defined in DASH, Section 8.11 [11]. MPD@profiles therefore must contain the profile URI, urn:mpeg:dash:profile:isoff-broadcast:2015. In addition, DASH-IF ATSC

IOP suggests (http://dashif.org/guidelines/dash-atsc-main) and the DASH-IF IOP requires: urn:mpeg:dash:profile:isoff-live:2011.

8.5 MPD@mediaPresentationDuration

The end (and thus duration) of an MPD does not have to be aligned with anything in particular like it is for OTT On-Demand content. Thus, an explicit end (@mediaPresentationDuration) is not usually signaled.

8.6 MPD@availabilityStartTime

As required by the DASH broadcast profile, MPD@availabilityStartTime must be present. This time provides the "anchor" of the entire relative MPD timeline onto UTC. **The value of MPD@availabilityStartTime must be added to the effective relative presentation times for all Representations (not just IMSC1).**

The AST applies to all AdaptationSets (e.g. video and audio), not just IMSC1. IMSC1 has to be aligned with the video and audio presentation times.

Note that large offsets in AST complicate multi-Period, including client-side ad replacement using xlink since the replacement Period is nominally zero-based timing and unaware of the AST.

8.7 MPD@minimumUpdatePeriod

This is required for dynamic MPDs and is required to be set to zero per DASH-IF ATSC IOP [5]. It is used in broadband content to throttle the polling of the MPD to check for updates, but it serves no purpose in broadcast.

8.8 MPD@suggestedPresentationDelay

This is set to allow the decoder to accumulate Segments. DASH-IF IOP Section 4.3.3.2.2 [7] suggests greater than 2-4 Segment durations.

8.9 Period@start

This is the start time offset and is required for the first Period in a dynamic MPD. It is optional on subsequent Periods. It must not change across MPD updates.

8.10 AdaptationSet@codecs

For IMSC1 text profile, this must be set to 'stpp.ttml.im1t'.

> *Note*: There is an error in DASH-IF IOP v4.2 [6] and ATSC IOP v1.1 that was corrected in v4.3 [7] and is logged here: https://github.com/Dash-Industry-Forum/ATSC/issues/67.

8.11 AdaptationSet Descriptors

Based on the processing model defined in DASH-IF IOP Section 3.9.5 [6] the following Accessibility element is required verbatim:

```
<Accessibility schemeIdUri="urn:mpeg:dash:role:2011" value="caption"/>
```

DASH-IF IOP Table 4 [6] suggests that the following Role element is also required:

```
<Role schemeIdUri="urn:mpeg:dash:role:2011" value="subtitle"/>
```

Recommendation: When caption service metadata (see A/343 Section 7.1 [3]) is present in the SDI VANC, include the following "descriptor" (shown here with only aspect ratio set to 16:9):

```
<SupplementalProperty schemeIdUri="http://dashif.org/guidelines/dash-atsc-closedcaption"
        value="ar:16-9"/>
```

8.12 SegmentBase@presentationTimeOffset

This optional Segment timeline offset is used to "index" into the first Segment of a Period. This is normally not needed, except when the first sample of content "begins" before the Period start. For IMSC1 content made to the recommendations in this document (Period-relative), it is not needed. When used, it then offsets all Segments in the Period.

8.13 SegmentBase@timescale

Recommendation: Set to a value large enough to ensure video frame accurate offsets for the entire Period duration; e.g., 90000.

8.14 SegmentTemplate

Recommendation: For live encoding ensure that SegmentTemplate is present and is used with `$Number$`. For future client-side ad replacement and seamless switching, `$Time$` will be required. See Section 10.2.

8.15 SegmentTimeline

SegmentTimeline can be used in the MPD. Segments with the same duration can be grouped by the @r attribute (repeat count). The following example has 433 segments of the same duration (2.002s) (r="432"), 2 segments of a different duration and 120 segments of the same original duration (2.002s) (r="119"). In addition to $Time$, SegmentTimeline will be required to support client-side ad insertion. See Section 10.2.

> *Note*: SegmentTimeline decoding is not explicitly required by ATSC 3.0 standards or the DASH ATSC IOP, and SegmentTimeline decoding is not addressed by the CTA-CEB32 suite of standards nor are there such test streams in the NEXTGEN TV logo test program. Before deploying SegmentTimeline emissions, backward compatibility considerations would be important to ensure interoperability.

```
<SegmentTemplate timescale="90000" initialization="$Bandwidth%/init.mp4v"
       media="$Bandwidth%/$Time$.mp4v">
     <SegmentTimeline>
          <S t="0" d="180180" r="432"/>
          <S d="180000" />
          <S d="180360" />
          <S d="180180" r="119"/>
     </SegmentTimeline>
</SegmentTemplate>
```

8.16 IMSC1 Time Syntax

IMSC1 requires that ttp:frameRate be an integer digit and is only relevant if the frame time syntax is used. When using frame time syntax with fractional frame rates as IMSC1 timing, then frameRateMultiplier is required; e.g., frameRateMultiplier="1000 1001".

Recommendation: Use real number seconds, i.e. not seconds+frames, and therefore ttp:frameRate and ttp:frameRateMultiplier will not be present.

9. DECODER TIMING RECOMMENDATIONS

9.1 UTC Time Recovery

In ATSC, all DASH MPD timing is foundationally in UTC, but the ATSC 3.0 PHY delivers the lower 32 bits of the PTP time scale (TAI with an epoch at 1 Jan 1970 00:00:00) (A/322 Section 9.3 [1]) plus the information necessary to convert the delivered values to UTC values (which includes the upper 16 bits of the PTP time scale) (A/331 Section 6.4 [2]).

The TAI time at the precise moment at which the first sample of the first symbol of the most recently received bootstrap was transmitted is

$$TAI = \begin{vmatrix} \texttt{SystemTime@ptpPrepend} \times 2^{32} \\ +\texttt{L1D\_time\_sec} \\ +\texttt{L1D\_time\_msec} \times 10^{-3} \\ +\texttt{L1D\_time\_usec} \times 10^{-6} \\ +\texttt{L1D\_time\_nsec} \times 10^{-9} \end{vmatrix}$$

Thus, the UTC time at that precise moment is

$$UTC = TAI - \texttt{SystemTime@currentUtcOffset}$$

9.2 MPD Time Signaling

The DASH MPD is a zero-based presentation time. When the MPD@type is “dynamic” (all of ATSC 3.0) then the time is in UTC, and MPD@availabilityStartTime is the “anchor” UTC time of the start of the presentation.

9.3 IMSC1 Time Signaling

IMSC1 requires that ttp:timeBase =“media”, and thus a time expression is a coordinate in a media object’s time line (see TTML1 6.2.11 [13]). The media object’s timeline is the timescale of UTC seconds with an epoch of the presentation time of the beginning of the Segment. For a single instance document in post-produced content, this translates to starting at zero and running the duration of the program. For short Segments such as is required for live content, IMSC1 timecodes remain Period-relative starting at zero continuing across Segments through the entire Period.

The overall DASH Segment timeline is computed external to IMSC1.

9.4 General DASH Timeline Math

DASH clients must follow the presentation timeline computations using the time-related fields as defined in DASH-IF IOP Section 4 [6]. A simplified computation to find the presentation time of text in the current IMSC1 Segment is

$$\text{UTC Presentation Time} = \texttt{MPD@availabilityStartTime} + \texttt{MPD@suggestedPresentationDelay} + \texttt{Period@start} - \left(\frac{\texttt{SegmentBase@peresentationTimeOffset}}{\texttt{@timescale}} \right) + \sum \text{all prior segment durations}$$

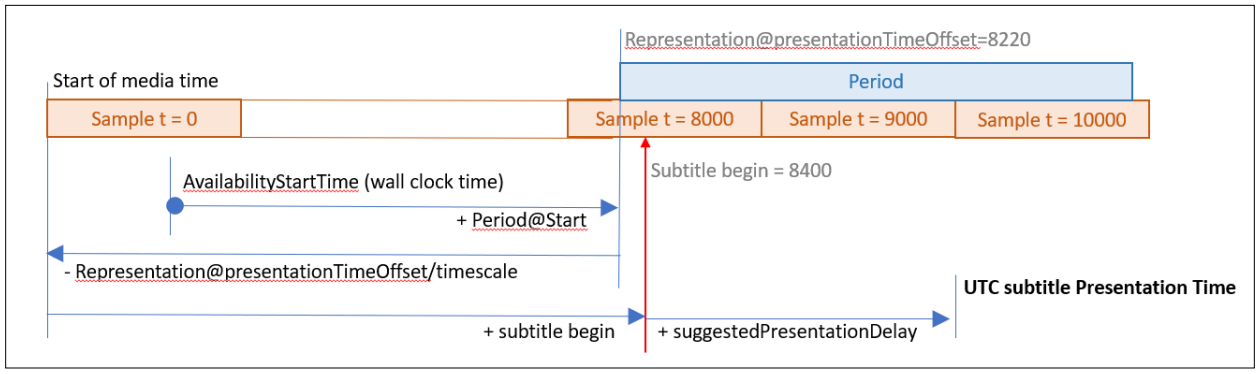

Figure 9.1 Segment presentation time since period start.

Figure 9.1 is an example of the calculation of UTC Subtitle Presentation Time based on the example (Figure 7) of DASH IOPI v5 Restricted Timing Model [8].

- Period@start: the start time of the Period relative to the MPD@availabilityStartTime.
- Representation@presentationTimeOffset: the presentation time offset of the Representation in the Period, i.e. it provides the media time of the Representation that is supposed to be rendered at the start of the Period.
- Subtitle begin: begin time of subtitles in IMSC1 subtitle segment.

10. URGENT ITEMS TO ADDRESS NEAR TERM

Two features covered in the Sections above are believed to be urgent to address and become "Recommended" as soon as possible. These are support for multi-Period and $Time$.

10.1 Multiple Periods

As covered in Section 8.1, support for more than one Period element is needed to support client-side ad replacement and other purposes. Decoder vendors need to develop a transition plan to implement support for multiple Period elements.

10.2 $Time$

As covered in Sections 8.14 and 8.15, support for time-based ($Time$) versus number-based ($Number$) is needed to support precise splicing in support of client-side ad replacement and other purposes. Decoder vendors need to develop a transition plan to implement support for $Time$ as well as $Number$.

11. MPD AND IMSC1 EXAMPLES

11.1 Single Segment

11.1.1 MPD

```
<?xml version="1.0" encoding="UTF-8"?>
<MPD xmlns="urn:mpeg:dash:schema:mpd:2011" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="urn:mpeg:dash:schema:mpd:2011 DASH-MPD.xsd"
    id=https://doi.org/10.5239/8A23-2B0B#2020-06-10T04:00:00Z
    availabilityStartTime="2020-06-10T05:00:00Z"
    publishTime="2020-06-10T04:03:03.775Z" type="dynamic"
    profiles="urn:mpeg:dash:profile:isoff-broadcast:2015,http://dashif.org/guidelines/dash-atsc-
main,urn:mpeg:dash:profile:isoff-live:2011"
    minimumUpdatePeriod="PT0S" minBufferTime="PT14S" suggestedPresentationDelay="PT24S">
    <Period id="1">
        <AdaptationSet id="1" codecs="stpp.ttml.im1t" contentType="text" lang="eng"
            mimeType="application/mp4" segmentAlignment="true" startWithSAP="1">
            <SupplementalProperty schemeIdUri="http://dashif.org/guidelines/dash-atsc-closedcaption"
                value="ar:16-9"/>
            <Accessibility schemeIdUri="urn:mpeg:dash:role:2011" value="caption"/>
            <Role schemeIdUri="urn:mpeg:dash:role:2011" value="subtitle"/>
            <Representation id="1" bandwidth="500">
                <SegmentList timescale="90000" duration="720000">
                    <SegmentURL media="example_single.mp4"/>
                </SegmentList>
            </Representation>
        </AdaptationSet>
    </Period>
</MPD>
```

11.1.2 IMSC1

```
<?xml version="1.0" encoding="UTF-8"?>
<tt xml:lang="en" ttp:profile="http://www.w3.org/ns/ttml/profile/imsc1/text"
    xmlns="http://www.w3.org/ns/ttml" xmlns:tts="http://www.w3.org/ns/ttml#styling"
    xmlns:ttp="http://www.w3.org/ns/ttml#parameter" xmlns:ebutts="urn:ebu:tt:style"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://www.w3.org/ns/ttml ttml1.xsd"
    ttp:timeBase="media" ttp:frameRate="30" tts:extent="1920px 1080px">
    <head>
        <styling>
            <style xml:id="basic" tts:color="white" tts:backgroundColor="black"
                tts:fontFamily="monospace" tts:fontSize="72%" tts:lineHeight="100%"/>
        </styling>
        <layout>
            <region xml:id="row2" tts:origin="24% 81%" tts:extent="70% 11%"
                tts:backgroundColor="transparent" tts:showBackground="whenActive"
                tts:displayAlign="after" ebutts:linePadding="0.5c"/>
        </layout>
    </head>
    <body>
        <div region="row2">
            <p begin="0s" dur="4s">
                <span style="basic" xml:space="preserve">Line 1</span>
            </p>
            <p begin="2s" dur="4s">
                <span style="basic" xml:space="preserve">Line 2</span>
            </p>
            <p begin="4s" dur="4s">
                <span style="basic" xml:space="preserve">Line 3</span>
            </p>
            <p begin="6s" dur="2s">
                <span style="basic" xml:space="preserve">Line 4</span>
            </p>
        </div>
    </body>
</tt>
```

11.2 Segmented

11.2.1 MPD

```
<?xml version="1.0" encoding="UTF-8"?>
<MPD xmlns="urn:mpeg:dash:schema:mpd:2011" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="urn:mpeg:dash:schema:mpd:2011 DASH-MPD.xsd"
  id="https://doi.org/10.5239/8A23-2B0B#2020-06-10T04:00:00Z" publishTime="2020-06-10T04:03:03.775Z"
type="dynamic"
  profiles="urn:mpeg:dash:profile:isoff-broadcast:2015,http://dashif.org/guidelines/dash-atsc-
main,urn:mpeg:dash:profile:isoff-live:2011"
  availabilityStartTime="2020-06-10T05:00:00Z" minimumUpdatePeriod="PT0S" minBufferTime="PT14S"
  suggestedPresentationDelay="PT6S">
  <Period id="1">
    <AdaptationSet id="1" codecs="stpp.ttml.im1t" contentType="text" lang="eng"
      mimeType="application/mp4" segmentAlignment="true" startWithSAP="1">
      <Accessibility schemeIdUri="urn:mpeg:dash:role:2011" value="caption"/>
      <Role schemeIdUri="urn:mpeg:dash:role:2011" value="subtitle"/>
      <SegmentTemplate media="captions-$Time$.mp4" timescale="90000">
        <SegmentTimeline>
          <S t="0" d="180000" r="1"/>
        </SegmentTimeline>
      </SegmentTemplate>
      <Representation id="1" bandwidth="500"/>
    </AdaptationSet>
  </Period>
</MPD>
```

11.2.2 IMSC1 Segment 1

```
<?xml version="1.0" encoding="UTF-8"?>
<tt xml:lang="en" ttp:profile="http://www.w3.org/ns/ttml/profile/imsc1/text"
    xmlns="http://www.w3.org/ns/ttml" xmlns:tts="http://www.w3.org/ns/ttml#styling"
    xmlns:ttp="http://www.w3.org/ns/ttml#parameter" xmlns:ebutts="urn:ebu:tt:style"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://www.w3.org/ns/ttml ttml1.xsd"
    ttp:timeBase="media" ttp:frameRate="30" tts:extent="1920px 1080px">
    <head>
        <styling>
            <style xml:id="basic" tts:color="white" tts:backgroundColor="black"
                tts:fontFamily="monospace" tts:fontSize="72%" tts:lineHeight="100%"/>
        </styling>
        <layout>
            <region xml:id="row2" tts:origin="24% 81%" tts:extent="70% 11%"
                tts:backgroundColor="transparent" tts:showBackground="whenActive"
                tts:displayAlign="after" ebutts:linePadding="0.5c"/>
        </layout>
    </head>
    <body>
        <div region="row2">
            <p begin="0s" dur="4s">
                <span style="basic" xml:space="preserve">Line 1</span>
            </p>
        </div>
    </body>
</tt>
```

11.2.3 IMSC1 Segment 2

```
<?xml version="1.0" encoding="UTF-8"?>
<tt xml:lang="en" ttp:profile="http://www.w3.org/ns/ttml/profile/imsc1/text"
    xmlns="http://www.w3.org/ns/ttml" xmlns:tts="http://www.w3.org/ns/ttml#styling"
    xmlns:ttp="http://www.w3.org/ns/ttml#parameter" xmlns:ebutts="urn:ebu:tt:style"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://www.w3.org/ns/ttml ttml1.xsd"
    ttp:timeBase="media" ttp:frameRate="30" tts:extent="1920px 1080px">
    <head>
        <styling>
            <style xml:id="basic" tts:color="white" tts:backgroundColor="black"
                tts:fontFamily="monospace" tts:fontSize="72%" tts:lineHeight="100%"/>
        </styling>
        <layout>
            <region xml:id="row2" tts:origin="24% 81%" tts:extent="70% 11%"
                tts:backgroundColor="transparent" tts:showBackground="whenActive"
                tts:displayAlign="after" ebutts:linePadding="0.5c"/>
        </layout>
    </head>
    <body>
        <div region="row2">
            <p begin="0s" dur="2s">
                <span style="basic" xml:space="preserve">Line 1</span>
            </p>
            <p begin="2s" dur="4s">
                <span style="basic" xml:space="preserve">Line 2</span>
            </p>
        </div>
    </body>
</tt>
```

11.3 Empty Segment

Recommendation: Follow this example of an "empty" IMSC1 document – one that is valid IMSC1, yet contains no presentation. FYI, this is compatible with EBU TT-D Tech 3381 [9].

```
<tt xml:lang="" xmlns="http://www.w3.org/ns/ttml"/>
```

12. RESOURCES

DASH-IF IMSC1 "IT1" test (sidecar only)
https://reference.dashif.org/dash.js/nightly/samples/dash-if-reference-player/index.html?mpd=https://dash.akamaized.net/dash264/CTA/imsc1/IT1-20171027_dash.mpd

DASH-IF MPD & Segment verifier
https://conformance.dashif.org/

DASH-IF reference decoder
https://github.com/Dash-Industry-Forum/dash.js

FFMPEG
https://ffmpeg.org/

MPEG MPD 4th Edition XML schema
https://standards.iso.org/iso-iec/23009/-1/ed-4/en/

MPEG MPD latest work in process schema (please report any issues on github)
https://github.com/MPEGGroup/DASHSchema

Sandflow IMSC1 Renderer
http://sandflow.com/imsc1_1/index.html

Sandflow IMSC1 Verifier
https://apps.sandflow.com/imscV/

W3C IMSC1 XML schema
https://www.w3.org/TR/ttml-imsc1.0.1/xml-schemas/

W3C TTML Media Type Definition and Profile Registry
https://www.w3.org/TR/ttml-profile-registry/

– End of Document–