MISB MOTION IMAGERY STANDARDS BOARD	**MISB ST 0604.6**
STANDARD	
Timestamps for Class 1/Class 2 Motion Imagery	**5 October 2017**

1 Scope

The MISP mandates that a timestamp based on Absolute Time be inserted into Class 0/1/2 Motion Imagery. This standard provides guidance and specifies requirements for inserting a Precision Time Stamp into H.262/MPEG-2, H.264/AVC and H.265/HEVC Class 1 and Class 2 Motion Imagery (compressed imagery). This standard also provides guidance and specific requirements for inserting a Nano Precision Time Stamp into H.265/HEVC Class 1 and Class 2 Motion Imagery.

These compression standards, approved by the MISP for use in Class1/Class 2 Motion Imagery, allocate user-defined data fields. This standard specifies the format, encoding and mapping of timestamp information into these user-defined data fields.

Finally, this standard provides guidance for inserting an optional Commercial Time Stamp in reserved fields as identified in the respective compression standard.

This standard does not address timestamp information within Class 2 Motion Imagery JPEG2000.

2 References

[1] MISB ST 0603.5 MISP Time System and Timestamps, Oct 2017.

[2] ITU-Rec H.262 Information technology - Generic coding of moving pictures and associated audio information: Video, 2012 Feb.

[3] ISO/IEC 13818-2:2013 Information Technology - Generic coding of moving pictures and associated audio information: Video.

[4] ITU-T Rec. H.264 Advanced video coding for generic audiovisual, Oct 2016.

[5] ISO/IEC 14496-10:2014 Information Technology - Coding of audio-visual objects - Part 10: Advanced Video Coding.

[6] ITU-T H.265 SERIES H: AUDIOVISUAL AND MULTIMEDIA SYSTEMS - High efficiency video coding.

[7] ISO/IEC 23008-2:2015 Information Technology - High efficiency coding and media delivery in heterogenous envirnoments - Part 2: High efficiency video coding.

[8] SMPTE EG 40:2016 Conversion of Time Values between SMPTE 12-1 Time Code, MPEG-2 PCR Time Base and Absolute Time, 2016.

[9] MISB ST 0605.8 Class 0 Motion Imagery, Metadata and Audio over SDI, Oct 2017.

3   Revision History

Revision	Date	Summary of Changes
0604.6	10/05/2017	• Revised to include the Nano Precision Time Stamp for H.265; defines a second UUID for H.265 to signal the Nano Precision Time Stamp
		• Nomenclature change: Precision Time Stamp Status to Time Status to agree with ST 0603 revisions
		• Reordered for clarity
		• Deprecated REQ -03; Replaced with REQ -21
		• Deprecated REQ's -13 and -14; Replaced with REQ's -22 and -23
		• Deprecated REQ -07
		• Add new REQ's -20, -24, -25
		• References updated; added ITU versions of MPEG-2, H.264, H.265

4   Acronyms

AVC	Advanced Video Coding
GOP	Group of Pictures
HEVC	High Efficiency Video Coding
MISB	Motion Imagery Standards Board
MISP	Motion Imagery Standards Profile
SDI	Serial Digital Interface
SEI	Supplemental Enhancement Information
ST	Standard
UUID	Universally Unique Identifier
VANC	Vertical Ancillary Data Space

5   Timestamp Types

Timestamps, when applied to both Motion Imagery and metadata provide a means for correlating the events of both data types in time. MISB ST 0603 [1] defines two timestamps based on Absolute Time: The Precision Time Stamp, which is specified with a resolution of microseconds, and the Nano Precision Time Stamp, which is specified with a resolution of nanoseconds. Both represent a sampling of the MISP Time System since the Epoch of 1970-01-01T00:00:00.0Z – not including leap seconds – based on the International System (SI) second. MISB ST 0603 provides guidance on converting one timestamp type to another.

The Precision Time Stamp is used in H.262/MPEG-2 [2] [3], H.264/AVC [4] [5]. For H.265/HEVC [6] [7], there is a choice between either timestamp depending on application requirements.

MISB ST 0603 also defines a Commercial Time Stamp, which is essentially time code widely used in the commercial broadcast industry for content processing/editing. Although a non-persistent, relative time indicator within a sequence of Motion Imagery, the Commercial Time Stamp can be derived from an absolute time reference; such conversions are found in SMPTE EG 40 [8].

6 Timestamp Sources

A timestamp can originate from several possible sources as shown in Figure 1; these include: 1) a non-image data space, such as the Defined Data Space of the Vertical Ancillary Data Space (VANC) in SMPTE SDI, within a Class 0 Motion Imagery frame, the Chunk Data Space within GigE Vision, or other such container; or 2) generated by a local time reference. The commercial Motion Imagery compression standards for Class 1 and Class 2 Motion Imagery allocate fields for user-defined data. Timestamp information obtained from a time source is mapped into these user-defined data fields, typically during the compression process by an encoder.
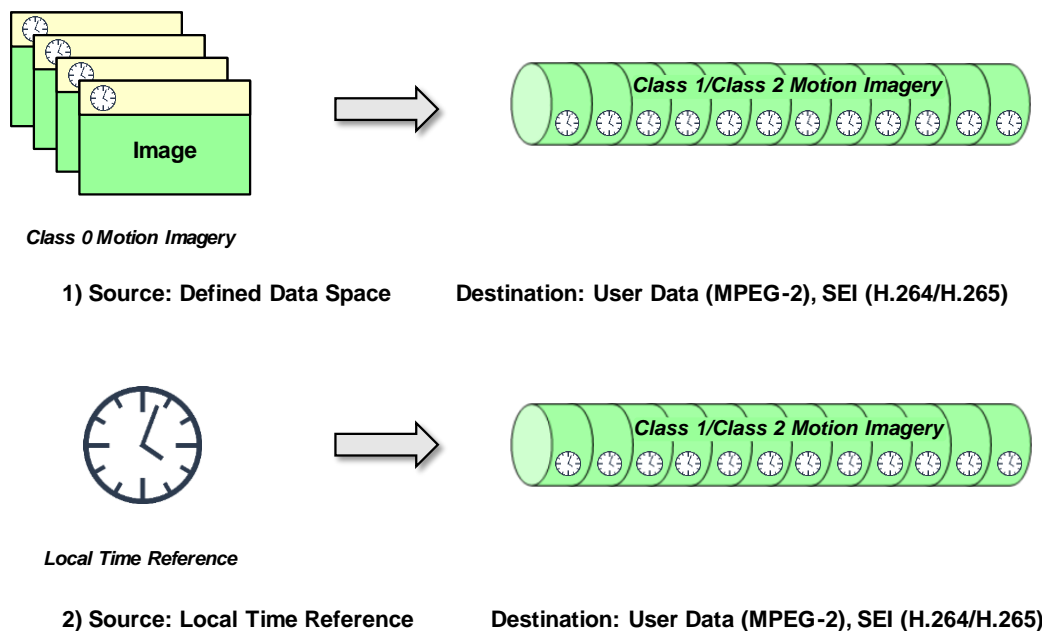

Figure 1: Sources of timestamps

The following requirements apply to the reference source for a timestamp:

Requirement(s)	
ST 0604.5-16	When Class 0 Motion Imagery contains a Precision Time Stamp Pack, the Precision Time Stamp shall be extracted and used as the timestamp in the corresponding compressed Class 1/Class 2 Motion Imagery.
ST 0604.6-20	When Class 0 Motion Imagery contains the Nano Precision Time Stamp Pack, the Nano Precision Time Stamp shall be extracted and used as the timestamp in the corresponding compressed Class 1/Class 2 Motion Imagery.

ST 0604.6-21	If Class 0 Motion Imagery does not contain a timestamp based on Absolute Time and one is available, then that time reference shall be used to generate either a Precision Time Stamp or a Nano Precision Time Stamp for compressed Class 1/ Class 2 Motion Imagery.

Because a compression standard precisely defines the syntax and semantics of coded bits, measures are taken to prevent user-defined data to be mistakenly interpreted by a decoder – which is termed Start Code Emulation Prevention. Thus, added user data is formatted specifically to prevent erroneous decoder interpretation. The MISP timestamps are therefore formatted as indicated below for this purpose.

7 Precision Time Stamp Information

Information needed to support the Precision Time Stamp consists of the following three elements as shown in Figure 2:

1. A Precision Time Stamp Identifier (16 bytes),
2. A Time Status (1 byte), and
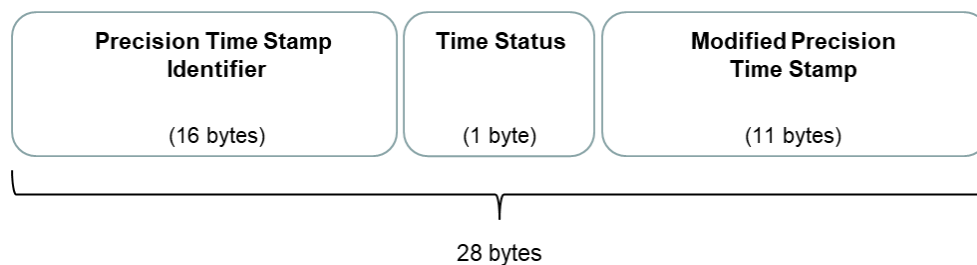3. A Modified Precision Time Stamp (11 bytes).

Figure 2: Precision Time Stamp Information

7.1 Precision Time Stamp Identifier (H.262/MPEG-2 & H.264/AVC)

The Precision Time Stamp Identifier signals the presence of the Precision Time Stamp when parsing the user-defined data field in the compressed data. The Precision Time Stamp Identifier for H.262/MPEG-2 and H.264/AVC is the ASCII string "MISPmicrosectime". The mapping of this ASCII string to its byte equivalent is given in Table 1.

Table 1: Byte Equivalent for ASCII String "MISPmicrosectime"

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
M	I	S	P	m	i	c	r
0x4D	0x49	0x53	0x50	0x6D	0x69	0x63	0x72
Byte 9	Byte 10	Byte 11	Byte 12	Byte 13	Byte 14	Byte 15	Byte 16
o	s	e	c	t	i	m	e
0x6F	0x73	0x65	0x63	0x74	0x69	0x6D	0x65

7.2   Precision Time Stamp Identifier (H.265/HEVC)

The Precision Time Stamp Identifier for H.265/HEVC is the following UUID[1]:

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a8687dd4-d759-3758-a5ce-f0338b6545f1
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This Precision Time Stamp Identifier signals the presence of the Precision Time Stamp when parsing the user-defined data field in H.265 compressed data.

7.3   Time Status

The Time Status is a one-byte value which precedes a Modified Precision Time Stamp (discussed below). It provides information regarding the reference source for the Precision Time Stamp. The status byte is used for all compression types described here. Refer to MISB ST 0603 for the details on the Time Status.

7.4   Modified Precision Time Stamp

The Precision Time Stamp is an 8-byte, unsigned integer value, as defined in MISB ST 0603. For encoding within Class 1/Class 2 Motion Imagery, this 8-byte value is formatted to prevent false interpretation of the data by a decoder; the practice is known as Start Code Emulation Prevention. The modified 8-byte Precision Time Stamp contains successive two-byte values spaced by a 0xFF value, thus forming an 11-byte Modified Precision Time Stamp value.

Table 2 provides the byte assignment for the one-byte Time Status (Byte 17), and the 11-byte (Bytes 18-28) Modified Precision Time Stamp, where Byte 18 is the most significant byte of the Precision Time Stamp. The Time Status plus the Modified Precision Time Stamp collectively form twelve bytes of data. Along with the 16-byte Precision Time Stamp Identifier, 28 bytes of data are then inserted into the compressed Motion Imagery.

Table 2: Byte Assignment for the Time Status and the Modified Precision Time Stamp

Byte 17	Time Status (see MISB ST 0603 [1])	
Bytes 18, 19	Byte 1 and 2 (Most significant bytes) of Precision Time Stamp	
Byte 20	*Start Code Emulation Prevention Byte (0xFF)*	
Bytes 21,22	Byte 3 and 4 of Precision Time Stamp	Modified Precision Time Stamp
Byte 23	*Start Code Emulation Prevention Byte (0xFF)*	
Byte 24, 25	Byte 5 and 6 of Precision Time Stamp	
Byte 26	*Start Code Emulation Prevention Byte (0xFF)*	
Byte 27, 28	Byte 7 and 8 (Least significant bytes) of Precision Time Stamp	

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[1] UUID generated from the string "MISPmicrosectime-v2" as a version 3 UUID

8   Nano Precision Time Stamp Information

The Nano Precision Time Stamp information consists of the following three elements, shown in Figure 3:

1. A Nano Precision Time Stamp Identifier (16 bytes),
2. A Time Status (1 byte), and
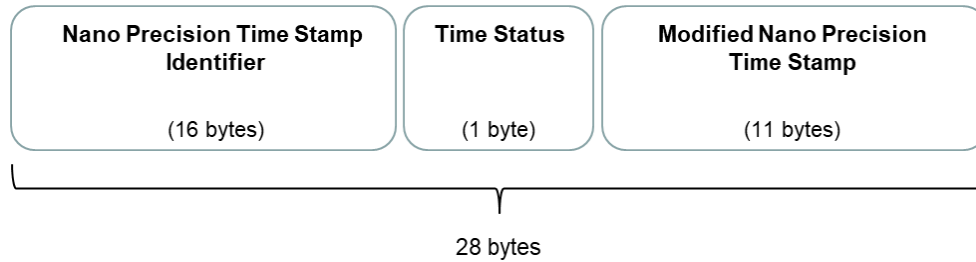3. A Modified Nano Precision Time Stamp (11 bytes).

Figure 3: Nano Precision Time Stamp Information

8.1   Nano Precision Time Stamp Identifier (H.265)

The Nano Precision Time Stamp Identifier for H.265/HEVC is the following UUID[2]:

$$\texttt{cf848278-ee23-306c-9265-e8fef22fb8b8}$$

This Nano Precision Time Stamp Identifier signals the presence of the 64-bit unsigned Nano Precision Time Stamp when parsing the user-defined data field in H.265.

8.2   Time Status

The Time Status as already discussed (see Section 7.3) is likewise used to provide timestamp status for the Nano Precision Time Stamp. This one-byte value precedes the Modified Nano Precision Time Stamp as discussed next.

8.3   Modified Nano Precision Time Stamp

The Nano Precision Time Stamp is an 8-byte, unsigned integer value as defined in MISB ST 0603. For encoding within Class 1/Class 2 Motion Imagery, this 8-byte value is modified to prevent false interpretation of the data by a decoder; the practice is known as Start Code Emulation Prevention. The modified 8-byte Nano Precision Time Stamp contains successive two-byte values spaced by a 0xFF value, thus forming an 11-byte Modified Nano Precision Time Stamp value.

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[2] UUID generated from the string "MISPnanosectime-v1" as a version 3 UUID

Table 3 shows the byte assignment for the one-byte Time Status (Byte 17), and the 11-byte (Bytes 18-28) Modified Nano Precision Time Stamp, where Byte 18 is the most significant byte of the Nano Precision Time Stamp. The Time Status plus the Modified Nano Precision Time Stamp collectively form twelve bytes of data. Along with the 16-byte Nano Precision Time Stamp Indicator, 28 bytes of data are then inserted into the compressed H.265 Motion Imagery.

Table 3: Byte Assignment for the Time Status and the Modified Nano Precision Time Stamp

Byte 17	Time Status (see MISB ST 0603 [1])	
Bytes 18, 19	Byte 1 and 2 (Most significant bytes) of Nano Precision Time Stamp	
Byte 20	*Start Code Emulation Prevention Byte (0xFF)*	Modified Nano Precision Time Stamp
Bytes 21,22	Byte 3 and 4 of Nano Precision Time Stamp	
Byte 23	*Start Code Emulation Prevention Byte (0xFF)*	
Byte 24, 25	Byte 5 and 6 of Nano Precision Time Stamp	
Byte 26	*Start Code Emulation Prevention Byte (0xFF)*	
Byte 27, 28	Byte 7 and 8 (Least significant bytes) of Nano Precision Time Stamp	

9 Commercial Time Stamp

The Commercial Time Stamp can originate from several sources: 1) the Vertical Ancillary Data Space (VANC) in SMPTE SDI, the Chunk Data space in GigE Vision, or other available non-image data space within Class 0 Motion Imagery [9]; 2) generated by a local clock reference; or 3) generated in a downstream process (such as a ground station). The Commercial Time Stamp is expressed as HH:MM:SS:FF (hours, minutes, seconds, frames; see MISB ST 0603).

The following requirement applies to the reference used for the Commercial Time Stamp:

Requirement	
ST 0604.5-17	Where Class 0 Motion Imagery contains a Commercial Time Stamp, the Commercial Time Stamp shall be extracted and used as the Commercial Time Stamp in the corresponding compressed Class 1/Class 2 Motion Imagery.

10 Inserting Timestamps into H.262/MPEG-2

10.1 Precision Time Stamp Information

H.262/MPEG-2 allocates a user_data field for user defined data. The 16-byte Precision Time Stamp Identifier, the one-byte Time Status and the 11-byte Modified Precision Time Stamp form 28 bytes, which are inserted into the user_data field located between the picture header and the picture data, so it relates to a specific frame of Motion Imagery.

Requirement(s)	
ST 0604.5-18	A Precision Time Stamp Identifier, equal to the ASCII string "MISPmicrosectime," shall be inserted into the H.262/MPEG-2 user_data field located between the picture header and the picture data.
ST 0604.5-19	A one-byte Time Status followed by an 11-byte Modified Precision Time Stamp shall be inserted into the H.262/MPEG-2 user_data field after the Precision Time Stamp Identifier, so that it relates to a specific Motion Imagery frame.

10.2 Commercial Time Stamp Information

H.262/MPEG-2 includes a 25-bit field time code (time_code) within the "group of pictures" (GOP) header. The Commercial Time Stamp is mapped into the time_code field as time_code_hours (5 bits, 0-23), time_code_minutes (6 bits, 0-59), time_code_seconds (6 bits, 0-59), and time_code_pictures (6 bits, 0-59). A drop_frame_flag and marker_bit complete the bit assignment.

Requirement	
ST 0604.3-09	Where a Commercial Time Stamp is available, it shall be inserted into every Group-of-Pictures (GOP) of H.262/MPEG-2 compressed data.

11 Inserting Timestamps into H.264/AVC

11.1 Precision Time Stamp Information

H.264/AVC provides a Supplemental Enhancement Information (SEI) message – designated the user_data_unregistered SEI message field. The user_data_unregistered SEI message consists of two subfields: the uuid_iso_iec_11578, which is a 16-byte UUID, and the user_data_payload_byte, which is a variable length field. The uuid_iso_iec_11578 is set to the 16-byte Precision Time Stamp Identifier. The user_data_payload_byte is set to the 12-byte combination Time Status and Modified Precision Time Stamp (Bytes 17-28 of Table 2 with Byte 17 transmitted first).

Requirement(s)	
ST 0604.4-10	A Precision Time Stamp Identifier, equal to the ASCII string "MISPmicrosectime," shall be inserted into the H.264/AVC compressed user_data_unregistered SEI message field uuid_iso_iec_11578, so that it relates to a specific Motion Imagery frame. *Note: although similar in intent there is a non-editorial change in requirement ST 0604.4-10 from ST 0604.3-10, which was deprecated.*
ST 0604.4-12	A one-byte Time Status followed by an 11-byte Modified Precision Time Stamp shall be inserted into the H.264/AVC compressed user_data_unregistered SEI message field user_data_payload_byte, so that it relates to a specific Motion Imagery frame.

11.2 Commercial Time Stamp Information

H.264/AVC provides for time code in the picture timing SEI message. The picture timing SEI message (pic_timing) specifies hours_value (5 bits, 0-23), minutes_value (6 bits, 0-59), seconds_value (6 bits, 0-59) and n_frames (9 bits) for mapping a Commercial Time Stamp. Other flags within the pic_timing field indicate the time of frame capture, drop-frame, and a discontinuity in the video time line.

Requirement
ST 0604.3-11   Where a Commercial Time Stamp is available, it shall be inserted into the H.264/AVC pic_timing SEI message in every Class 1/ Class 2 Motion Imagery frame.

12 Inserting Timestamps into H.265/HEVC

Recognizing the trend towards increased pixel density and higher temporal rate imagery supported by H.265/HEVC, users may require greater resolution in applied timestamps. For this reason, a Nano Precision Time Stamp is also supported in H.265/HEVC. The selection between the Precision Time Stamp and the Nano Precision Time Stamp is signaled by the identifier used (indicated in Sections 7.2 and 8.1).

H.265/HEVC provides a Supplemental Enhancement Information (SEI) message – designated the user_data_unregistered SEI message field. The user_data_unregistered message consists of two subfields: the uuid_iso_iec_11578, which is a 16-byte field UUID, and the user_data_payload_byte, which is a variable length field.

12.1 Precision Time Stamp Information

The uuid_iso_iec_11578 is set to the 16-byte UUID given in Section 7.2 for the Precision Time Stamp.

The user_data_payload_byte is set to the 12-byte combination Time Status and Modified Precision Time Stamp (Bytes 17-28 of Table 2 with Byte 17 transmitted first).

Requirement(s)
ST 0604.6-22   Where a Precision Time Stamp is used, a Precision Time Stamp Identifier equal to the UUID a8687dd4-d759-3758-a5ce-f0338b6545f1 shall be inserted into the H.265/HEVC compressed user_data_unregistered SEI message field uuid_iso_iec_11578, so that it relates to a specific Motion Imagery frame.
ST 0604.6-23   Where a Precision Time Stamp is used, a one-byte Time Status followed by an 11-byte Modified Precision Time Stamp shall be inserted into the H.265/HEVC compressed user_data_unregistered SEI message field user_data_payload_byte, so that it relates to a specific Motion Imagery frame.

12.2 Nano Precision Time Stamp Information

The uuid_iso_iec_11578 is set to the 16-byte UUID given in Section 8.1 for the Nano Precision Time Stamp.

The user_data_payload_byte is set to the 12-byte combination Time Status and Modified Nano Precision Time Stamp (Bytes 17-28 of Table 3 with Byte 17 transmitted first).

Requirement(s)	
ST 0604.6-24	Where a Nano Precision Time Stamp is used, a Nano Precision Time Stamp Identifier equal to the UUID cf848278-ee23-306c-9265-e8fef22fb8b8 shall be inserted into the H.265/HEVC compressed user_data_unregistered SEI message field uuid_iso_iec_11578, so that it relates to a specific Motion Imagery frame.
ST 0604.6-25	Where a Nano Precision Time Stamp is used, a one-byte Times Status followed by an 11-byte Modified Nano Precision Time Stamp shall be inserted into the H.265/HEVC compressed user_data_unregistered SEI message field user_data_payload_byte, so that it relates to a specific Motion Imagery frame.

12.3 Commercial Time Stamp Information

H.265/HEVC provides for time code in the time code SEI message. The time code SEI message (time_code) specifies hours_value (5 bits, 0-23), minutes_value (6 bits, 0-59), seconds_value (6 bits, 0-59) and n_frames (9 bits) for mapping a Commercial Time Stamp. Other flags within the time_code field indicate the time of frame capture, drop-frame, and a discontinuity in the video time line.

Requirement	
ST 0604.4-15	Where a Commercial Time Stamp is available, it shall be inserted into the H.265/HEVC time_code SEI message in every Class 1/Class 2 Motion Imagery frame.

13 Deprecated Requirements

Requirement(s)	
ST 0604.3-02 (Deprecated)	If an uncompressed motion imagery signal does not contain a Precision Time Stamp but contains a Commercial Time Stamp in the VANC (Vertical Ancillary Data Space) (MISB ST 0605), the Commercial shall be extracted from the VANC and used to calculate the Precision Time Stamp in the compressed Motion Imagery.
ST 0604.3-04 (Deprecated)	When Class 0 Motion Imagery contains a Precision Time Stamp in the VANC (Vertical Ancillary Data Space) (MISB ST 0605), the Precision Time Stamp shall be extracted from the VANC and used to calculate the Commercial Time Stamp in the corresponding compressed Class 1/Class 2 Motion Imagery.
ST 0604.3-06 (Deprecated)	If Class 0 Motion Imagery does not contain either a Precision Time Stamp or a Commercial Time Stamp and a UTC time reference is available, then that time reference shall be used to generate a Commercial Time Stamp.

ST 0604.3-10 (Deprecated)	A Precision Time Stamp consisting of Time Stamp Identifier, a Time Stamp Status and a start-code emulation-modified Precision Time Stamp shall be inserted into the H.264 elementary stream user data unregistered SEI Message field uuid_iso_iec_11578, so that it relates to a specific frame.
ST 0604.3-01 (Deprecated)	When Class 0 Motion Imagery contains a Precision Time Stamp in the VANC (Vertical Ancillary Data Space) (MISB ST 0605), the Precision Time Stamp shall be extracted from the VANC and used as the Precision Time Stamp in the corresponding compressed Class 1/Class 2 Motion Imagery.
ST 0604.3-05 (Deprecated)	If Class 0 Motion Imagery contains a Commercial Time Stamp in the VANC (Vertical Ancillary Data Space) (MISB ST 0605), the Commercial Time Stamp shall be extracted from the VANC and used as the Commercial Time Stamp in the corresponding compressed Class 1/Class 2 Motion Imagery.
ST 0604.3-08 (Deprecated)	A Precision Time Stamp Identifier, equal to the ASCII string "MISPmicrosectime", a Precision Time Stamp Status and a Modified Precision Time Stamp shall be inserted into the MPEG-2 user_data field located between the picture header and the picture data – in order.
ST 0604.3-03 (Deprecated)	If Class 0 Motion Imagery does not contain a Precision Time Stamp and an absolute time reference is available, then that time reference shall be used to generate the Precision Time Stamp for the compressed Class 1/ Class 2 Motion Imagery.
ST 0604.3-07 (Deprecated)	A Precision Time Stamp as defined in MISB ST 0603 shall be inserted in every Motion Imagery frame.
ST 0604.4-13 (Deprecated)	A Precision Time Stamp Identifier, equal to the UUID a8687dd4-d759-3758-a5ce-f0338b6545f1, shall be inserted into the H.265/HEVC compressed user_data_unregistered SEI message field uuid_iso_iec_11578, so that it relates to a specific Motion Imagery frame.
ST 0604.4-14 (Deprecated)	A one-byte Precision Time Stamp Status followed by an 11-byte Modified Precision Time Stamp shall be inserted into the H.265/HEVC compressed user_data_unregistered SEI message field user_data_payload_byte, so that it relates to a specific Motion Imagery frame.