MISB MOTION IMAGERY STANDARDS BOARD **STANDARD** **Class 0 Motion Imagery Metadata and Audio over SDI**	**MISB ST 0605.10** **29 October 2020**

1 Scope

This standard provides guidance for carrying Class 0 Motion Imagery metadata and audio over a Serial Digital Interface (SDI) using the ancillary (ANC) data space.

This standard provides for inclusion of Absolute Time as either a microsecond-resolution Precision Time Stamp, or a nanosecond-resolution Nano Precision Time Stamp as defined in MISB ST 0603 [1].

This standard defines a Precision Time Stamp Pack, which is a KLV construct consisting of a Time Status byte and a Precision Time Stamp. To support the Nano Precision Time Stamp, this standard defines a Nano Precision Time Stamp Pack, which is a KLV construct consisting of a Time Status byte and a Nano Precision Time Stamp. Also specified is the location for these timestamp KLV packs along with other KLV metadata within the ANC data space allocated in SMPTE-defined image formats.

2 References

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

[2] MISB ST 1603.2 Time Transfer Pack, Oct 2017.

[3] MISB MISP-2021.1 Motion Imagery Standards Profile, Oct 2020.

[4] MISB ST 0807.25 MISB KLV Metadata Registry, Jun 2020.

[5] SMPTE RP 168:2009 Definition of Vertical Interval Switching Point for Synchronous Video Switching.

[6] SMPTE RP 214:2002 Packing KLV Encoded Metadata and Data Essence into SMPTE 291M Ancillary Data Packets.

[7] SMPTE ST 425-5:2015 Image Format and Ancillary Data Mapping for the Quad Link 3 Gb/s Serial Interface.

[8] SMPTE ST 291-1:2011 Television - Ancillary Data Packet and Space Formatting.

[9] SMPTE ST 12-2:2014 Television - Transmission of Tme Code in the Ancillary Space.

[10] SMPTE ST 352:2013 Television - Video Payload Identification for Digital Interfaces.

[11] SMPTE ST 299-1:2009 Television - 24-Bit Digital Audio Format for SMPTE 292 Bit-Serial Interface.

[12] SMPTE ST 299-2:2010 Television - Extension of the 24-Bit Digital Audio Format to 32 Channels for 3 Gb/s Bit-Serial Interfaces.

[13] SMPTE ST 355:2001 Television - Format for Non-PCM Audio and Data in AES3 - KLV Data Type.

[14] SMPTE ST 337:2015 Television - Format for Non-PCM Audio and Data in an AES3 Serial Digital Audio Interface.

[15] SMPTE ST 339:2015 Television - Format for Non-PCM Audio and Data in AES3 - Generic Data Types.

[16] SMPTE ST 267:1995 Television - Bit-Parallel Digital Interface - Component Video Signal 4:2:2 16x9 Aspect Ratio.

[17] SMPTE ST 294:2001 Television - 720x483 Active Line at 59.94-Hz Progressive Scan Production –Bit-Serial Interfaces.

[18] SMPTE ST 259:2008 Television - SDTV Digital Signal/Data - Serial Digital Interface.

[19] SMPTE ST 293:2003 Television - 720x483 Active Line at 59.94-Hz Progressive Scan Production – Digital Representation.

[20] SMPTE ST 349:2001 Television - Transport of Alternate Source Image Formats though SMPTE 292M.

[21] SMPTE ST 292-1:2018 1.5 Gb/s Signal/Data Serial Interface.

[22] ITU-R BT.1358-1 (09/2007) Studio Parameters of 625 and 525 Line Progressive Television.

[23] SMPTE ST 296:2012 1280x720 Progressive Image 4:2:2 and 4:4:4 Sample Structure - Analog and Digital Representation and Analog Interface.

[24] SMPTE ST 274:2008 Television - 1920x1080 Image Sample Structure, Digital Representation and Digital Timing Reference Sequence for Multiple Picture Rates.

[25] SMPTE ST 425-1:2017 Source Image Format and Ancillary Data Mapping for the 3 Gb/s Serial Interface.

[26] SMPTE ST 424:2012 3 Gb/s Signal/Data Serial Interface.

[27] SMPTE 425-3:2015 Image Format and Ancillary Data Mapping for the Dual Link 3 Gb/s Serial Interface.

[28] SMPTE ST 2081-10:2018 2160-Line and 1080-Line Source Image and Ancillary Data Mapping for Single-Link 6G-SDI.

[29] SMPTE ST 2081-1:2015 6 Gb/s Signal/Data Serial Interface - Electrical.

[30] SMPTE ST 2081-11:2016 2160-Line Source Image and Ancillary Data Mapping for Dual-Link 6G-SDI.

[31] SMPTE ST 2081-12:2016 4320-Line and 2160-Line Source Image and Ancillary Data Mapping for Quad-Link 6G-SDI.

[32] SMPTE ST 2082-10:2018 2160-Line Source Image and Ancillary Data Mapping for 12G-SDI.

[33] SMPTE ST 2082-1:2015 12 Gb/s Signal/Data Serial Interface – Electrical.

[34] SMPTE ST 2082-12:2016 4320-Line and 2160-Line Source Image and Ancillary Data Mapping for Quad-Link 12G-SDI.

[35] SMPTE ST 2082-11:2016 4320-Line and 2160-Line Source Image and Ancillary Data Mapping for Dual-Link 12G-SDI.

[36] SMPTE ST 435-1:2012 10 Gb/s Serial/Data Interface - Part 1: Basic Stream Distribution.

[37] SMPTE ST 435-2:2012 10 Gb/s Serial Signal/Data Interface - Part 2: 10.692 Gb/s Stream - Basic Stream Data Mapping.

[38] MISB ST 0403.3 Digital Representation and Source Interface Formats for Infrared Motion Imagery Mapped into 1280x720 format Bit-Serial Digital Interface, Jun 2015.

[39] Ancillary Data Space Use - 4:2:2 SDTV and HDTV Component Systems and 4:2:2 2048x1080 Production Image Formats.SMPTE.

3 Revision History

Revision	Date	Summary of Changes
ST 0605.10	10/29/2020	• Added information for ANC data for 2160p & 4320p systems • Added Req -28 for KLV in UHD systems • Added reference to modified Payload Identifier section 10.3 • Title changed for accuracy • Revised for clarity • Updated references

4 Acronyms and Definitions

ADF Ancillary Data Flag
ANC Ancillary Data Space
DC Data Count
DID Data ID
ED Enhanced Definition
HANC Horizontal Ancillary Data Space
HD High Definition
KLV Key Length Value
MID Message ID
MISB Motion Imagery Standards Board
MISP Motion Imagery Standards Profile
PCM Pulse Code Modulation
PSC Packet Sequence Count
SD Standard Definition
SDI Serial Digital Interface
SDID Secondary Data ID
SMPTE Society of Motion Picture and Television Engineers
UDW User Data Word
UHD Ultra-High Definition
VANC Vertical Ancillary Data Space

3G-SDI 2.97 gigabits per second serial digital interface

6G-SDI	5.94 gigabits per second serial digital interface
12G-SDI	11.88 gigabits per second serial digital interface
480p	Line-progressive Enhanced Definition (ED) format of the 525-line Standard Definition (SD) system
576p	Line-progressive Enhanced Definition (ED) format of the 625-line Standard Definition (SD) system
720p	High Definition (HD) 1280 x 720 format, progressive scan
1080p	High Definition (HD) 1920 x 1080 format, progressive scan
2160p	Ultra-High Definition (UHD-1) 3840 x 2160 format, progressive scan
4320p	Ultra-High Definition (UHD-2) 7680 x 4320 format, progressive scan

5 Introduction

Serial Digital Interface (SDI) – developed by SMPTE – is a standardized family of digital video interfaces which accommodate various non-compressed image formats. The SMPTE suite of SDI standards provide the physical interface, timing, encoding, payload, and image format for digital video transport. In addition, SDI allocates an ancillary data space (ANC) for non-image data transport defined as the horizontal ANC (HANC) data space, corresponding to the horizontal blanking interval, and the vertical ANC (VANC) data space, corresponding to the vertical blanking interval. Available per frame, both the HANC and VANC enable synchronizing non-image data to a specific frame of imagery thus facilitating frame-accurate metadata and audio with non-compressed Class 0 Motion Imagery.

This document assumes image sampling formats prescribed by SMPTE for the commercial broadcast industry specified with an active image area surrounded by vertical and horizontal non-image blanking areas. For non-image data each specific image sampling format defines the location and quantity of space available. Data is encapsulated in an ANC data packet, which is a generic wrapper for various types of non-image data.

This document provides guidance on encoding KLV metadata into an ANC data packet for carriage within the VANC of Class 0 Motion Imagery (non-compressed) to include a Precision Time Stamp or a Nano Precision Time Stamp, a Commercial Time Stamp, and other Key Length Value (KLV) encoded metadata. Introduced in MISB ST 1603 [2] is a Time Quality Local Set to qualify the relationship between a receptor clock and its reference clock with status information. The Time Transfer Local Set provides far greater information than the Time Status as defined in MISB ST 0603 and is recommended for inclusion if needed in applications.

The HANC, generally reserved for carrying audio, can optionally carry additional metadata once the VANC is exhausted.

6 Timestamps based on Absolute Time

The MISP [3] mandates all Motion Imagery contain a timestamp based on Absolute Time governed by the MISP Time System as defined in MISB ST 0603. Two KLV pack constructs provide for either a microsecond resolution (Precision Time Stamp) or a nanosecond resolution (Nano Precision Time Stamp) count of Absolute Time. The choice in timestamp depends on application requirements for time resolution.

The MISP allows only one type of timestamp within an instantiation of Motion Imagery. This prevents confusion as to which timestamp is valid.

7 Precision Time Stamp Pack

The Precision Time Stamp Pack (shown in Figure 1) includes a Pack Key, its Length and its Value where the timestamp is encoded.

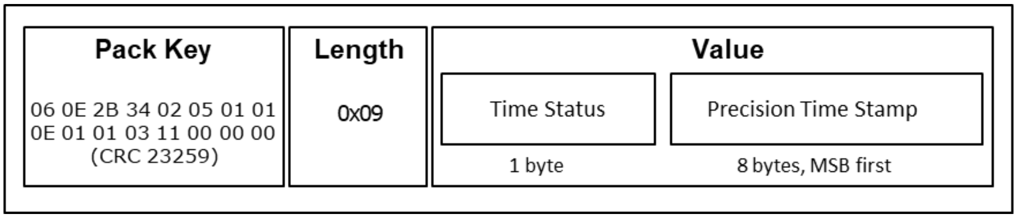

Figure 1: Precision Time Stamp Pack

The Precision Time Stamp Pack Key registered in MISB ST 0807 [4] is:

06.0E.2B.34.02.05.01.01.0E.01.01.03.11.00.00.00 (CRC 23259)

The Length of the pack is 0x09 (9 bytes).

The Value in the pack contains two subfields:

1) A one-byte Time Status, which indicates the state of the source time reference
2) A uint64 (8-byte) Precision Time Stamp

7.1 Time Status

The Time Status provides information about the timing source reference. See MISB ST 0603 for the definition of this value.

7.2 Precision Time Stamp

The Precision Time Stamp is a microsecond-resolution, 8-byte value as specified in MISB ST 0603. The Precision Time Stamp follows the Time Status byte in the pack. Table 1 shows the byte ordering of the Precision Time Stamp, where Byte 1 is the most significant byte.

Table 1: Byte Assignment for 64-bit Precision Time Stamp

Bytes 1, 2	Byte 1 and 2 (Most significant bytes) of Precision Time Stamp
Bytes 3, 4	Byte 3 and 4 of Precision Time Stamp
Bytes 5, 6	Byte 5 and 6 of Precision Time Stamp
Bytes 7, 8	Byte 7 and 8 (Least significant bytes) of Precision Time Stamp

Requirement(s)	
ST 0605.4-07	The Precision Time Stamp Pack shall contain the Length (in hex) 0x09.
ST 0605.4-08	The Precision Time Stamp Pack shall contain the Time Status value.
ST 0605.4-09	The Precision Time Stamp Pack shall contain the Precision Time Stamp.

8 Nano Precision Time Stamp Pack

The Nano Precision Time Stamp Pack (shown in Figure 2) includes a Pack Key, its Length and its Value, where the timestamp information is encoded.

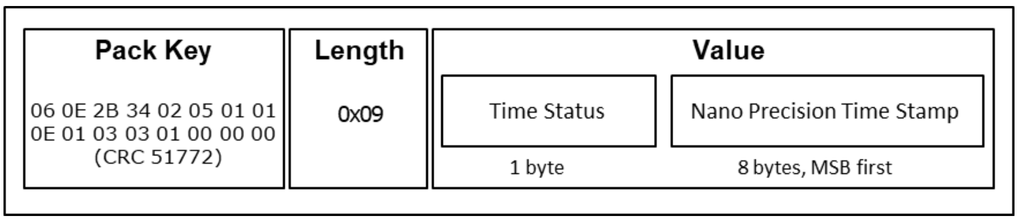

Figure 2: Nano Precision Time Stamp Pack

The Pack Key for the Nano Precision Time Stamp registered in MISB ST 0807 is:

06.0E.2B.34.02.05.01.01.0E.01.03.03.01.00.00.00 (CRC 51772)

The Length of the pack is 0x09 (9 bytes).

The Value in the pack contains two subfields:

1) A one-byte Time Status, which indicates the state of the source time reference
2) A uint64 (8-byte) Nano Precision Time Stamp

8.1 Time Status

The Time Status provides information about the timing source reference. See MISB ST 0603 for the definition of this value.

8.2 Nano Precision Time Stamp

The Nano Precision Time Stamp is a nanosecond-resolution, 8-byte value as specified in MISB ST 0603. The Nano Precision Time Stamp follows the Time Status byte in the pack. Table 2 shows the byte ordering of the Nano Precision Time Stamp, where Byte 1 is the most significant byte.

Table 2: Byte Assignment for 64-bit Nano Precision Time Stamp

Bytes 1, 2	Byte 1 and 2 (Most significant bytes) of Nano Precision Time Stamp
Bytes 3, 4	Byte 3 and 4 of Nano Precision Time Stamp
Bytes 5, 6	Byte 5 and 6 of Nano Precision Time Stamp

Bytes 7, 8	Byte 7 and 8 (Least significant bytes) of Nano Precision Time Stamp

Requirement(s)	
ST 0605.8-20	The Nano Precision Time Stamp Pack shall contain the Length (in hex) 0x09.
ST 0605.8-21	The Nano Precision Time Stamp Pack shall contain the Time Status value.
ST 0605.8-22	The Nano Precision Time Stamp Pack shall contain the Nano Precision Time Stamp.

9 Class 0 Motion Imagery

The guidance in this document specifically applies to Class 0 Motion Imagery formats defined by SMPTE standards for enhanced (ED), high (HD), and ultra-high definition (UHD) image formats. See the MISP for specific image characteristics for these image formats.

9.1 Image Format

SMPTE image formats share a common structure as shown in Figure 3.

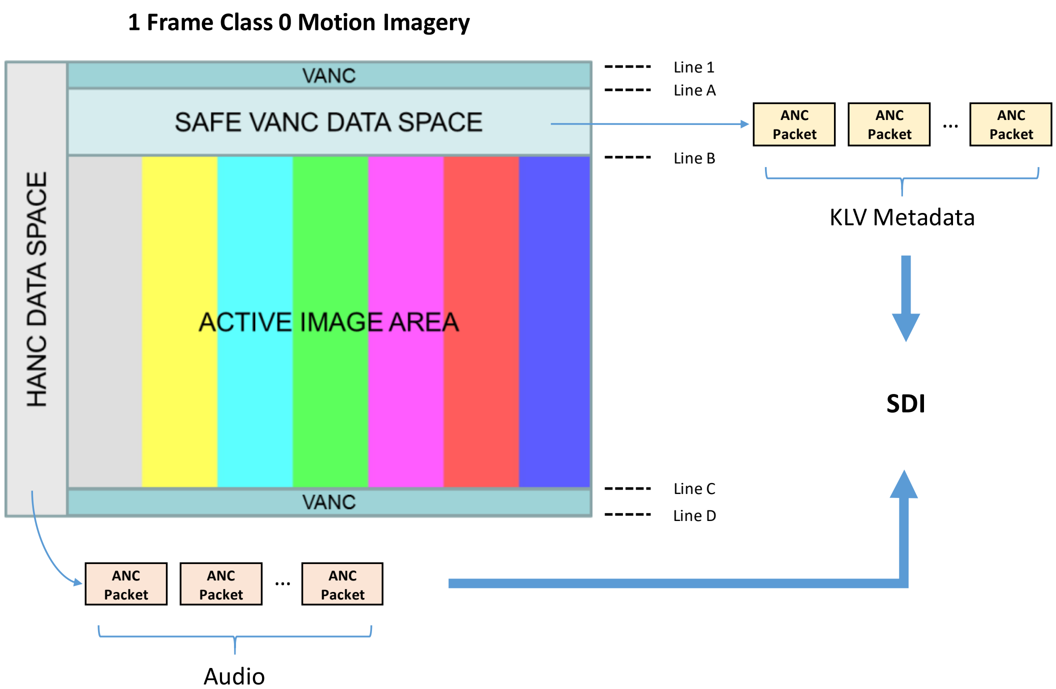

Figure 3: General SMPTE Image Format

The structure has three "data areas": 1) the VANC including a SAFE VANC DATA SPACE, 2) the HANC DATA SPACE, and 3) the ACTIVE IMAGE AREA. The ACTIVE IMAGE AREA, extending from the line following Line B through Line C inclusively contains the imagery content, while the VANC and HANC are data areas for non-image data.

The SAFE VANC DATA SPACE, as defined by the specific format standard is an area considered "safe" for inserting non-image data indicated by Lines A through Line B inclusive.

SMPTE RP 168 [5] defines a switching point area within the format considered unreliable to insert data. The line designated for the switching point is after the vertical synchronization information (to minimize the possibility of disturbances to this information), but early in the vertical interval space. This ensures that data (time information, audio, etc.) transmitted during the VANC remains with the image frame with which it is associated. SMPTE RP 168 recommends excluding vital ancillary data or payload data from the line following the switching line.

Table 3 indicates the values for Line A and Line B which bound the SAFE VANC DATA SPACE for image formats. The available safe lines per frame for metadata and other data is Line B – Line A + 1 plus Line C – Line D + 1.

Table 3: Available Scan Lines for ANC Data Packets

Image Format	Total Lines per Image	Active Image Lines (inclusive)	SAFE VANC DATA SPACE				Available Safe Lines per Frame
			Line A	Line B	Line C	Line D	
480p	525	44- 523	11	41[1]	-	-	31
576p	625	45 - 620	7	44	-	-	38
720p	750	26 - 745	8	25	746	750	23
1080p	1125	42 - 1121	8	41	1122	1125	38

[1]SMPTE RP 214 [6] recommends a limit of 3 lines earlier than the start of the active lines

For UHD formats, SDI mappings divide a 3840x2160p or 7680x4320p source image into four or sixteen 1920x1080p sub-images, respectively. As an example, Figure 4 shows the intermediate mapping of a 2160p format to a quad-link 3G-SDI transport (courtesy of SMPTE ST 425-5 [7]).

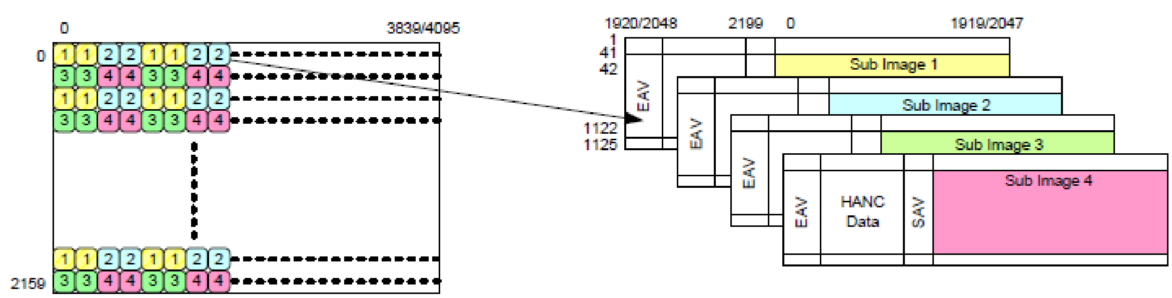

Figure 4: 2-sample interleave division to Sub Image's 1-4

Note that each pair of samples map to a different sub-image. For example, samples labeled 1 shown in yellow map to Sub Image 1; samples labeled 2 shown in blue map to Sub Image 2; samples labeled 3 shown in green map to Sub Image 3; samples labeled 4 shown in pink map to Sub Image 4. Other image formats may have different mappings. Note however that each sub-image has an accompanying HANC/VANC data area.

Specification for the SAFE VANC DATA SPACE and Available Safe Lines per Frame for these UHD formats follows that of the 1080p format. Each successive sub-image in order has an equivalent ANC data space. Continuing the example, in Figure 5 the four sub-images map into respective data streams according to their color space, bit depth, etc. In a Luma/Chroma color model Luma values map to Data Stream One while Chroma values map to Data Stream Two. Finally, pairs of data streams multiplex to form one SDI link e.g., SDI Link 1.

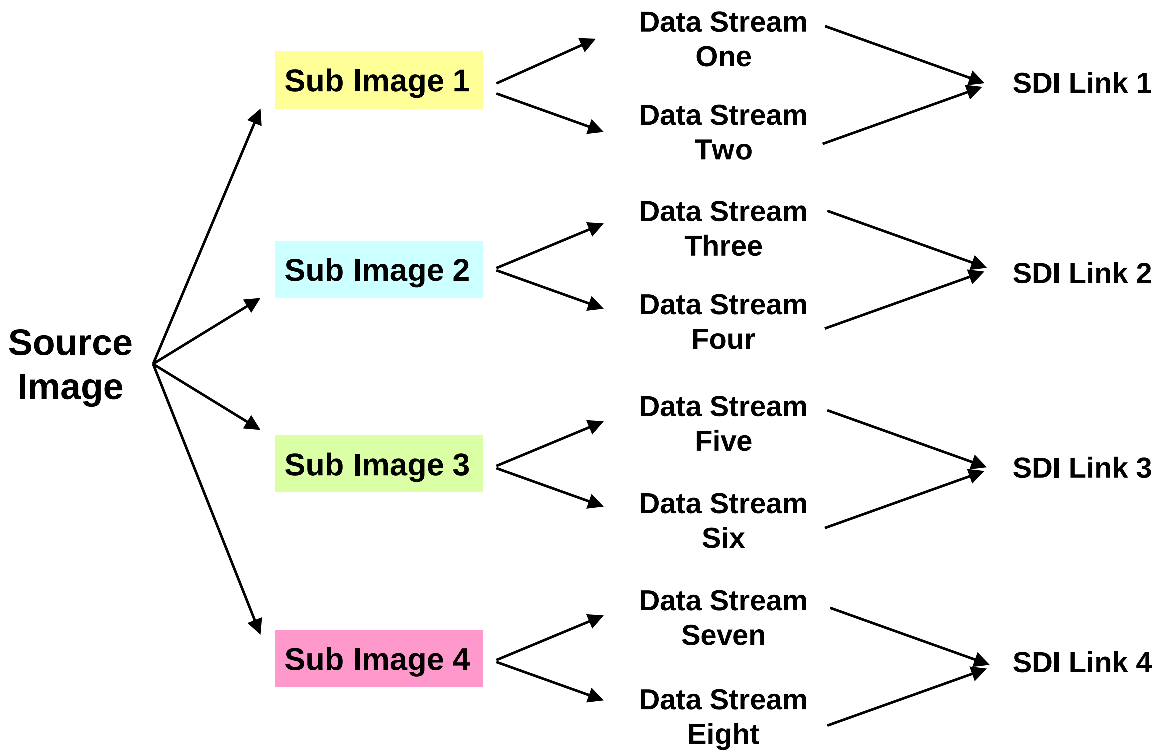

Figure 5: Mapping for Quad link 3G-SDI 2160p Source Image Example

SMPTE ST 425-5 *requires* ANC data to first map into the ancillary data space of Sub Image 1 forming the data stream pair consisting of Data Streams One and Two. The different SDI standards define where to map ANC data; typically, all mappings begin with Sub Image 1 to Data Stream One, however. Consult the appropriate standard for guidance on specific mappings.

9.2 KLV Metadata

KLV metadata encapsulated in an ANC data packet primarily maps into the VANC (see Figure 3), and secondarily the HANC. SMPTE ST 291-1 [8] specifies the format for ANC data packets inserted into either the VANC or the HANC. An ANC data packet begins with a preamble called the Ancillary Data Flag (ADF), which is a three-value 10-bit word sequence of 0x000 (ADF-1), 0x3FF (ADF-2), and 0x3FF (ADF-3) as shown in Figure 6.

Each ANC data packet carries a Type 1 or Type 2 Data Identification (DID) word registered with SMPTE; the DID signals the type and format of the data contained in the packet. ST 0605 uses SMPTE ST 291-1 Type 2 packets. SMPTE RP 214 defines DID = 0x44 for KLV encoded data, while the Secondary DID word (SDID) signals the use of the VANC (SDID = 0x04) or HANC (SDID = 0x14). The Data Count (DC) represents the number of User Data Words (UDW) in an ANC data packet, which has a maximum value of 255.

The DID, SDID, DC, and the UDWs within an ANC data packet are 10-bit values. Bit 8 (b8) indicates even parity, while bit 9 (b9) = NOT b8 indicates its inverse.

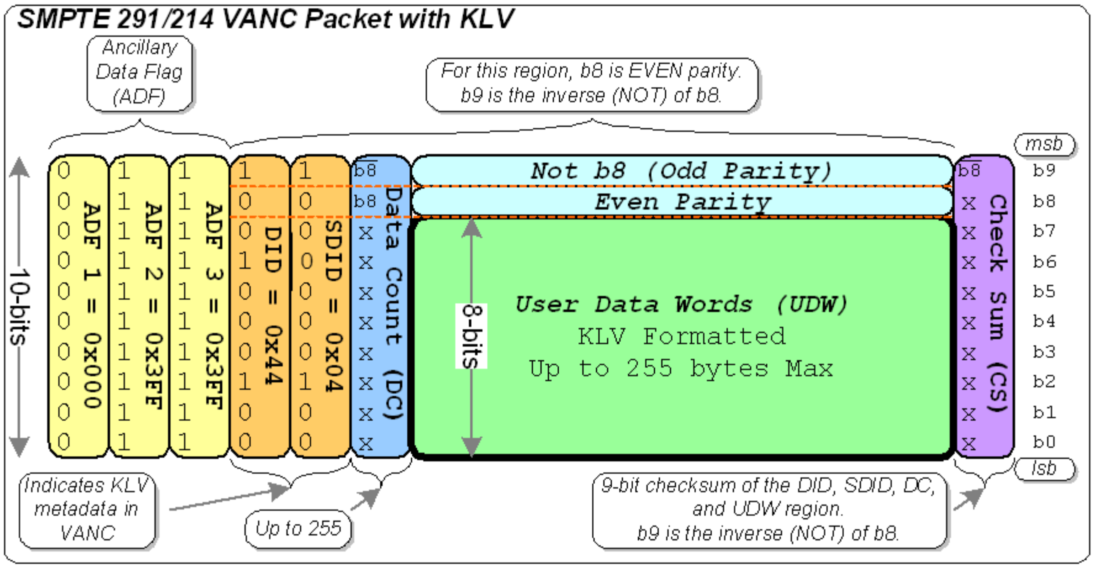

Figure 6: ANC Data Packet with KLV

9.2.1 User Data Words (UDW) formatting for KLV data

The UDW space of an ANC data packet formatted to carry KLV data is shown in Figure 7. SMPTE RP 214 specifies a method for inserting KLV-formatted data into ANC data packets. It describes the packaging of 8-bit data within the 10-bit UDW space of an ANC data packet, a Message ID (MID) field, and a Packet Sequence Count (PSC).

The first three words of the UDW space are mandatory per SMPTE RP 214:

- The first word of the UDW space is a Message ID (MID) field, which identifies ANC packets as belonging to the same KLV message
- The next two words of the UDW space represent a Packet Sequence Counter (PSC), which links long KLV messages to one another

This leaves 255-3=252 bytes available for KLV data payload within each ANC packet

- The balance of the UDW space is for KLV data (up to 252 bytes). Over a digital interface, bit 8 of a KLV UDW is the even parity of bits 0 through 7, and bit 9 is the logical NOT of bit 8.

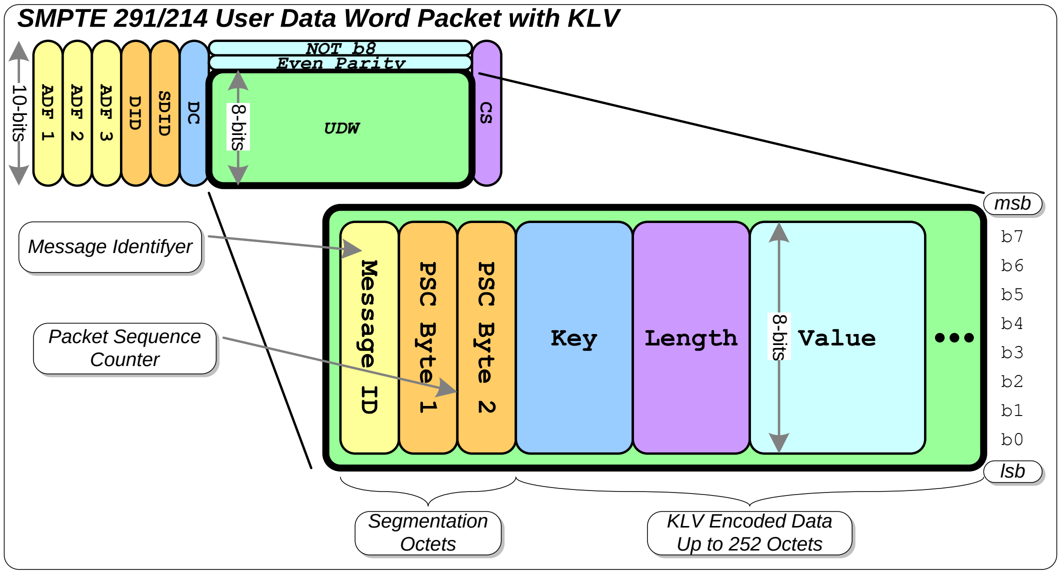

Figure 7: User Data Word space carrying KLV data

Requirement	
ST 0605.4-02	KLV Metadata shall be formatted in accordance with SMPTE RP 214.

9.2.1.1 Message ID (MID) Information

In SMPTE RP 214, the MID value identifies ANC data packets carrying information belonging to the same KLV encoded message. The MID increments with each different message from one (1) to 255 with each KLV message sent within the ANC data space.

Note: The initial release of this document (MISB RP 0605 Aug 2006) recommended using the MID field to convey additional information about the type of KLV data contained in the ANC packet. This older method allowed the same MID to be for multiple different KLV packets each falling into a common group (i.e. "Geospatial / Security Data" had a MID of 0x01). The PSC repeats for a second KLV packet with the same MID value as a previous packet. Downstream systems then ignore the second set of KLV packets as they have identical MID and PSC values as previous packets. This practice is deprecated (RP 0605.2 May 2008).

Requirement	
ST 0605.4-04	The practices for identifying Message ID (MID) values shall be in accordance with SMPTE RP 214.

9.2.1.2 Packet Sequence Count (PSC) Information

KLV encoded messages may span multiple ANC data packets. The two UDWs following the MID field represent a packet sequence count (PSC). The PSC – a 16-bit number – indicates the ANC data packet for the KLV encoded message. The first data word of the PSC represents the upper 8 bits and the second data word represents the lower 8 bits of the 16-bit number (bit 7 of the first word represents the MSB, while bit 0 of the second word represents the LSB of the PSC value).

The first ANC data packet for each different MID has a PSC value starting at one (1) and increments by one (1) for each successive VANC ANC packet carrying a KLV packet. KLV data is removed beginning with the ANC data packet with PSC = 1.

9.2.2 Inserting the Precision Time Stamp Pack into the VANC

Requirement(s)	
ST 0605.8-23	Where a Precision Time Stamp Pack is used, the Precision Time Stamp Pack shall be present in a SMPTE RP 214 packet in the VANC data space of every Motion Imagery frame.
ST 0605.8-24	Where a Precision Time Stamp Pack is used, the Precision Time Stamp Pack shall be the first ANC data packet on Line 9 of the Motion Imagery frame.

As some systems may benefit from additional quality information about the timestamp, a Time Transfer Local Set as defined in MISB ST 1603 may be inserted following the Precision Time Stamp Pack.

Additional ANC data packets may follow the Precision Time Stamp Pack.

Note: versions prior to ST 0605.5 did not account for 480p where Line 9 is outside the Safe VANC Data Space. To maintain interoperability and considering 480p a legacy format the guidance for timestamp location continues to use Line 9 regardless.

9.2.3 Inserting the Nano Precision Time Stamp Pack into the VANC

Requirement(s)	
ST 0605.8-25	Where a Nano Precision Time Stamp Pack is used, the Nano Precision Time Stamp Pack shall be present in a SMPTE RP 214 packet in the VANC data space of every Motion Imagery frame.
ST 0605.8-26	Where a Nano Precision Time Stamp Pack is used, the Nano Precision Time Stamp Pack shall be the first ANC data packet on Line 9 of the Motion Imagery frame.

As some systems may benefit from additional quality information about the timestamp, a Time Transfer Local Set as defined in MISB ST 1603 may be inserted following the Nano Precision Time Stamp Pack.

Additional ANC data packets may follow the Nano Precision Time Stamp Pack.

9.2.4 Commercial Time Stamp

To improve interoperability with commercial equipment, a Commercial Time Stamp as defined in MISB ST 0603 may be inserted into each Motion Imagery frame. The Commercial Time Stamp is formatted into a SMPTE ST 291-1 ANC data packet (called Ancillary Time Code or ATC) per SMPTE ST 12-2 [9].

Requirement(s)	
ST 0605.4-11	When available, a Commercial Time Stamp shall be inserted in the VANC of every Motion Imagery frame.
ST 0605.5-16	When present, the Commercial Time Stamp shall be the only ANC data packet on Line 14 of the Motion Imagery frame.

It is recommended that no other data be placed onto Line 14 other than the Commercial Time Stamp.

9.3 Payload Identifier

A 4-byte payload identifier describes aspects of an image carried such as picture rate, sampling structure, aspect ratio, bit depth, colorimetry, and link assignment. The payload identifier is mandatory in some standards and optional in others, so consult the specific interface standard. SMPTE ST 352 [10] defines codes for payload identification as well as the data space area for the code.

9.4 Guidelines for Data Placement

Image formats allow various color models; for example, a color model based on R'G'B' tristimulus values, or a color model based on Luma and Chroma values (e.g., $Y'C'_bC'_r$). When using a Luma/Chroma color model, insert metadata into the Luma area first followed by the Chroma area. For example, Line 9 Luma data, Line 10 Luma data … Line B Luma data, followed by Line 9 Chroma data, Line 10 Chroma data … etc.

As indicated in Section 9.1 for 2160p and 4320p systems, ancillary data is initially mapped into Sub Image 1 of the appropriate link type. Insert KLV metadata into the Luma area of Sub Image 1 followed by the Chroma area for Sub Image 1.

Requirement(s)	
ST 0605.4-03	The Luma data space within the VANC shall be used for KLV data prior to using the Chroma data space.
ST 0605.4-15	When inserting ANC packets containing non-KLV data into the VANC, those packets shall follow all ANC data packets containing KLV data.
ST 0605.5-17	KLV data shall be inserted into the VANC only in the SAFE VANC DATA SPACE as specified in MISB ST 0605 Table 3.
ST 0605.10-28	KLV data for 2160p and 4320p systems shall be inserted into the SAFE VANC DATA SPACE of Sub Image 1 as specified in MISB ST 0605 Table 3.

9.5 Audio Encoding in AES3

The HANC principally carries digital audio. SMPTE ST 299-1 [11] (16 audio channels) and SMPTE ST 229-2 [12] (32 audio channels) defines the mapping of 24-bit AES3 (Digital Audio Interface Format) digital audio data into the ancillary data space as ANC data packets. The formatting of non-PCM audio and other data, such as metadata, to AES3 is defined by SMPTE ST 355 [13], SMPTE ST 337 [14], and SMPTE ST 339 [15].

Note: Although some legacy systems used the HANC to carry metadata, it is recommended that no metadata be inserted into the HANC.

See specific SDI standards for more on carrying audio.

Requirement	
ST 0605.5-18	KLV data encapsulated in an AES3 serial digital audio stream shall comply with SMPTE ST 299-1 and SMPTE ST 299-2 with data formatted according to SMPTE ST 355, SMPTE ST 337 and SMPTE ST 339.

10 SDI Standards: Formats/Interfaces

The ANC data space is a reserved data space within the SDI interface defined by the specific SDI standard for a specific image format. These standards define mapping for 1080p, 2160p, and 4320p to 3G, 6G, and 12G SDI single, dual, and quad links. All share a common framework for data carried within the ANC data space which divides an image into numerous 1080p sub-images. These sub-images then map into respective data streams with one or two data streams multiplexed into one or more SDI links.

Table 4 lists a subset of SMPTE standards for various Image Formats and the supporting SDI standard(s). Also, shown is the number of Active Pixels per Line, Active Lines per Frame, and the common supported Frame Rate(s). Please consult the relevant standard for a complete list of supported frame rates. The designations in the Format Standard column following the reference for 3G/6G/12G indicate the following: "S" = Single-Link, "D" = Dual-Link, "Q" = Quad-Link SDI. Appendix C provides additional information on the decomposition of an image source into multiple links.

Table 4: Image Format Standards and Companion SDI Standards

Image Format	Format Standard	SDI Standard	Active Pixels per Line	Active Lines per Frame	Frame Rate	Aspect Ratio
Enhanced Definition (progressive line Standard Definition)						
480p	SMPTE ST 267 [16] SMPTE ST 294 [17]	SMPTE ST 259 [18] (Level D 4:2:0)	720	483	60M[1]	4:3, 16:9
480p	SMPTE ST 293 [19]	SMPTE ST 349 [20] SMPTE ST 292-1 [21]	720	483	60M[1]/30M[1]	
576p	ITU-R BT.1358 [22]	SMPTE ST 349 [20] SMPTE ST 292-1 [21]	720	576	50/25	
High Definition (HD-SDI)						
720p	SMPTE ST 296 [23]	SMPTE ST 292-1 [21]	1280	720	60/50/30/25	16:9
1080p	SMPTE ST 274 [24]		1920	1080	30/25	
HD/UHD-1 10-bit 4:2:0 (3G-SDI)						
1080p	SMPTE ST 425-1 [25] S	SMPTE ST 424 [26]	1920	1080	60	16:9

2160p	SMPTE ST 425-5 [7] Q	SMPTE ST 424 [26]	3840	2160	60	16:9
	SMPTE ST 425-3 [27] D	SMPTE ST 424 [26]			30/25	16:9
HD/UHD-1/UHD-2 10-bit 4:2:0 (6G-SDI)						
1080p	SMPTE ST 2081-10 [28] S	SMPTE ST 2081-1 [29]	1920	1080	120	16:9
2160p	SMPTE ST 2081-11 [30] D	SMPTE ST 2081-1 [29]	3840	2160	60	16:9
	SMPTE ST 2081-10 [28] S	SMPTE ST 2081-1 [29]			30/25	
4320p	SMPTE ST 2081-12 [31] Q	SMPTE ST 2081-1 [29]	3840	2160	30/25	16:9
UHD-1/UHD-2 10-bit 4:2:0 (12G-SDI)						
2160p	SMPTE ST 2082-10 [32] S	SMPTE ST 2082-1 [33]	3840	2160	60	16:9
4320p	SMPTE ST 2082-12 [34] Q	SMPTE ST 2082-1 [33]	7680	4320	60	16:9
	SMPTE ST 2082-11 [35] D	SMPTE ST 2082-1 [33]			30/25	
UHD-1 (10G-SDI optical)						
2160p	SMPTE ST 435-1 [36]	SMPTE ST 435-2 [37]	3840	2160	30/25	16:9
[1] M = 1000/1001						

Guidance for mapping ANC data into 2160p/4320p image formats thus follows that indicated for 1080p. Pixel densities for these two image formats afford proportionally greater ANC capacity (i.e., 4x and 16x respectively); however, per SMPTE guidance ANC data maps first into Data Stream One (which contains Sub Image One) followed by a subsequent ordering defined by the standard. Data Stream One ultimately maps into Link One of a dual or quad SDI carrier, as an example.

Figure 8 pictorially shows a subset from the family of SDI containers along with corresponding supporting standards which define the formats for Motion Imagery, Audio and Metadata.

The SDI standards are hierarchical, where higher capacity transports support increased pixel density and frame rate while also supporting lower capacity formats. This allows one transport to support a multitude of capacities.

Standards SMPTE ST 355, SMPTE ST 337 and SMPTE ST 339 support the formatting of digital audio and data into the AES3 [30] format, while SMPTE ST 299-1 and SMPTE ST 299-2 define the mapping from AES3 into HD-SDI and 3G-SDI formats, respectively.

MISB ST 0403 [38] provides guidance for mapping infrared Motion Imagery into SDI.

Requirement	
ST 0605.9-27	The mapping of digital infrared Class 0 Motion Imagery into a SMPTE ST 292-1 interface shall be defined by MISB ST 0403.

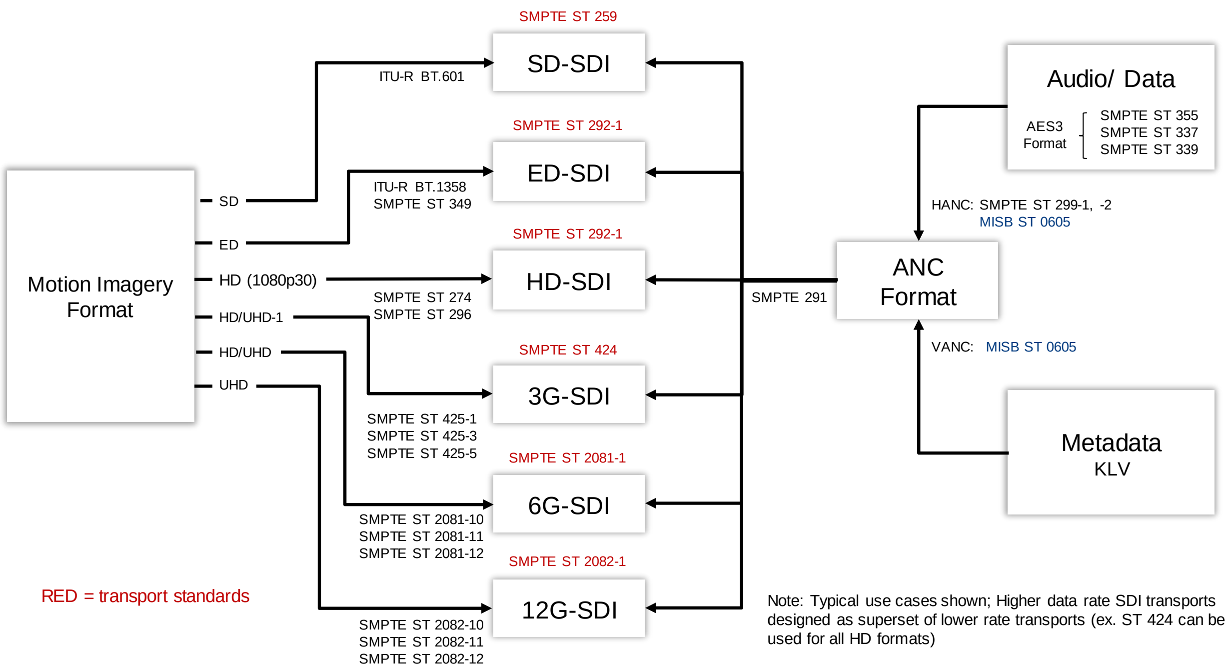

Figure 8: Subset of SDI Containers and Format Standards

11 Deprecated Requirements

Requirement(s)	
ST 0605.4-01 (Deprecated)	The Precision Time Stamp, Commercial Time Stamp and KLV Metadata shall be inserted into the Vertical Ancillary Data Space (VANC). [Redundant: covered by REQ's 5 &11]
ST 0605.4-05 (Deprecated)	A Precision Time Stamp Pack representing Coordinated Universal Time (UTC) for the start of a Motion Imagery frame shall be present in a SMPTE RP 214 packet in the VANC data space of every Motion Imagery frame. [Precision Time Stamp based on count since Epoch, not UTC]
ST 0605.4-06 (Deprecated)	The Precision Time Stamp Pack shall contain the Key (in hex) 06.0E.2B.34.02.05.01.01.0E.01.01.03.11.00.00.00 (CRC 23259). [defined in ST 0807, so no requirement necessary]
ST 0605.4-12 (Deprecated)	When present, the Commercial Time Stamp shall be the first SMPTE ST 291-1 packet on Line 14 of the Motion Imagery frame. [changed “first” to “only” as recommended by SMPTE]
ST 0605.4-13 (Deprecated)	KLV data shall be allowed to be inserted into the VANC on Line 15 and above. Non-KLV data is allowed on line 14 after the Commercial Time Stamp. [VANC is not limited to KLV; non-image data allowed in safe VANC data space]
ST 0605.4-14 (Deprecated)	The insertion of KLV data in a frame shall discontinue once the end of the VANC is reached [states an obvious fact and should not be a requirement]
ST 0605.7-19 (Deprecated)	A Precision Time Stamp Pack shall be present in a SMPTE RP 214 packet in the VANC data space of every Motion Imagery frame.
ST 0605.4-10 (Deprecated)	The Precision Time Stamp Pack shall be the first SMPTE ST 291-1 ANC packet on Line 9 of the Motion Imagery frame.

12 Appendix A: Example VANC Capacities – *Informative*

SMPTE ST 291-1 specifies the format of an ANC data packet. A packet contains 10-bytes of overhead (3-bytes ADF, 1-byte DID, 1-byte SDID, 1-byte DC, 1-byte MID, 2-byte PSC, 1-byte CS) with a maximum of 252 bytes available for data. Thus, each ANC data packet has a maximum of 262 bytes. Table 5 shows the metadata capacity calculated for ED 480p, 576p, HD 720p/1080p, and UHD 2160p/4320p systems. For each format, the number of ANC Data Packets (full) per VANC Line along with the VANC Safe Lines provides the number of KLV Bytes per Frame, which corresponds to a computed Data Rate (of KLV) for 60 FPS (Frames per Second).

Table 5: VANC Capacity for Full ANC Packets

Image Format	Samples per Line	ANC Data Packets (full) per VANC Line	VANC Safe Lines[1] (Table 3)	KLV Bytes per Frame	KLV Data Rate (60 FPS) (Mbps)
480p	720	2	58	29,232	14.03
576p	720	2	76	38,304	18.38
720p	1280	4	46	46,368	22.25
1080p	1920	7	76	134,064	64.35
2160p	3840	7	76	134,064[2]	64.35[2]
4320p	7680	7	76	134,064[3]	64.35[3]

[1]Assuming an equal number of lines for Luma and Chroma the number of VANC Safe Lines is twice that specified in Table 3
[2]Assumes Sub Image 1 only; 4x this quantity for all four sub-images
[3]Assumes Sub Image 1 only; 16x this quantity for all 16 sub-images

The computed capacity for a format is as follows:

- A full ANC data packet is 262 bytes (10 bytes overhead, 252 bytes data)
- The ANC Data Packets (full) per VANC Line = Samples per Line / 262 bytes
- From Table 3, and assuming a color model of 4:2:2:
    - KLV Bytes per Frame = (ANC Data Packets per VANC Line) x (VANC Safe Lines) x (262 bytes per ANC data packet)
    - KLV Data Rate, expressed in megabits per second, for 60 FPS (frames per second) = (KLV Bytes per Frame) x (8 bits per byte) x 60 FPS

These calculations ignore partial packets, which could increase the data rate, and do not account for the requirements for data on Lines 9 and 14 indicated in this document.

SMPTE RP 291-2 Annex E [39] provides details on computing the potential ANC data space capacity for various image formats.

13 Appendix B: Ultra-High Definition Mapping – *Informative*

For UHD the mapping of ANC data into 3G-SDI, 6G-SDI and 12G-SDI follow the guidelines for 1080p after a decomposition of UHD into sub-images equivalent to 1080p. UHD-1 is characterized as "4K" imagery, while UHD-2 is characterized as "8K" imagery. The current roadmap for UHD, which includes UHD-1 and UHD-2, divides a UHD image into multiple HD (1080p) sub-images – 4 for UHD-1 and 16 for UHD-2. Each sub-image has timing, audio, and data space equivalent to that of 1080p HD. The sub-images combine into sub-data streams which are then multiplexed into links as indicated by its governing standard.

Like other formats, UHD comes in a variety of image formats supporting numerous image rates, pixel bit depths, and color sampling models. The type of SDI transport is based on the election of these format choices. For example, a UHD-1 format of 3840x2160p30 4:2:2 10-bits produces approximately 5 Gbps, which necessitates either a dual-link 3G-SDI or a single-link 6G-SDI link. Stepping up the image rate to 60 Images per second produces approximately 10 Gbps, thus necessitating a quad-link 3G-SDI, a dual-link 6G-SDI, or a single-link 12G-SDI.

For UHD-1, the sub-images ultimately combine into a single-link 12G-SDI (SMPTE ST 2082-10), dual-link 6G-SDI (SMPTE ST 2081-11), or quad-link 3G-SDI (SMPTE ST 425-5) as shown in Figure 9. Payload identifiers indicate the specific 1080p sub-image. 1080p sub-images map into sub-data streams, where one or more sub-data streams are multiplexed into an SDI link. SMPTE requires mapping ANC data into Data Stream One (which carries Sub Image 1) first followed then by higher-order data streams. ANC data inserted into the VANC follows the same rules as the 1080p format.

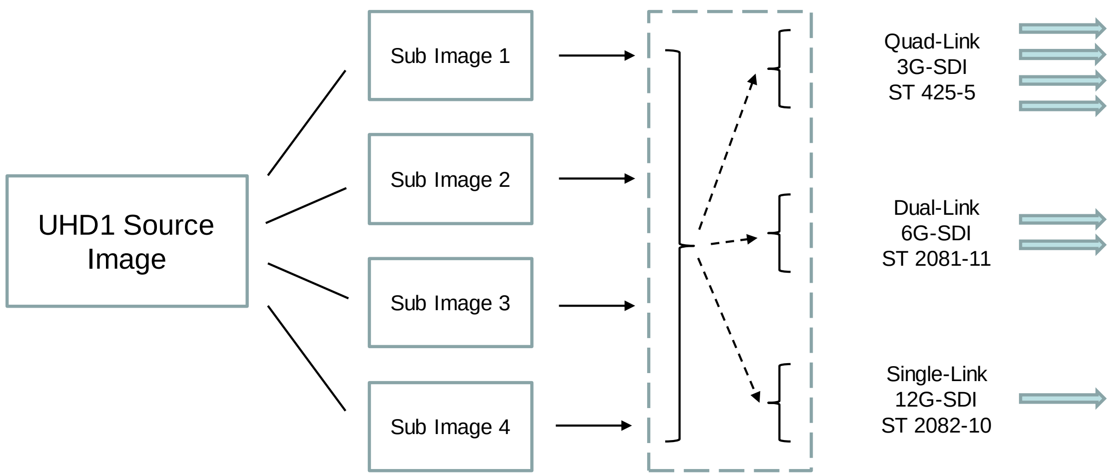

Figure 9: UHD 1 Transport over 3G/6G/12G SDI

For 8K UHD-2 a dual-link 12G-SDI interface supports 7680x4320p30 4:2:2 10-bits, while a quad-link 12G-SDI supports 60 Images per second.

Consult the appropriate SDI documentation for further guidance on SDI standards for a given application.