SMPTE STANDARD

Definition and Representation of Haptic-Tactile Essence for Broadcast Production Applications

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Approved
June 27, 2017

Foreword

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SMPTE Engineering Documents are drafted in accordance with the rules given in its Standards Operations Manual.

SMPTE ST 2021-1 was prepared by Technology Committee 10E.

Intellectual Property

SMPTE draws attention to the fact that it is claimed that compliance with this Standard may involve the use of one or more patents or other intellectual property rights (collectively, "IPR"). The Society takes no position concerning the evidence, validity, or scope of this IPR.

Each holder of claimed IPR has assured the Society that it is willing to License all IPR it owns, and any third party IPR it has the right to sublicense, that is essential to the implementation of this Standard to those (Members and non-Members alike) desiring to implement this Standard under reasonable terms and conditions, demonstrably free of discrimination. Each holder of claimed IPR has filed a statement to such effect with SMPTE. Information may be obtained from the Director, Standards & Engineering at SMPTE Headquarters.

Attention is also drawn to the possibility that elements of this Standard may be subject to IPR other than those identified above. The Society shall not be responsible for identifying any or all such IPR.

Introduction

This section is entirely informative and does not form an integral part of this Engineering Document.

Haptic-tactile enabled broadcasts and transmissions can be described as follows:

- They are the end to end use of technology to capture, encode, broadcast and deliver haptic-tactile information conveying the "feeling" or "impact" of an originating event. This enables the end user to receive and experience the haptic-tactile experience at a remote location.

- The "capture" part of the system is accomplished by means of sensors (single or multi-axis accelerometers and / or other means of sensing or capturing the haptic-tactile vibration or movement) on a remote object or person (such as a hockey player, a race car, etc.). The haptic-tactile essence can be incorporated into the media production that is sent from the remote production location to the broadcast plant, and then to the end user's device for extraction and decoding.

- The haptic-tactile essence is decoded or extracted at the end user's location and converted into a digital or analog signal that is used by the appropriate electro-mechanical hardware so that the end user can experience substantially the same haptic-tactile effects of the captured event.

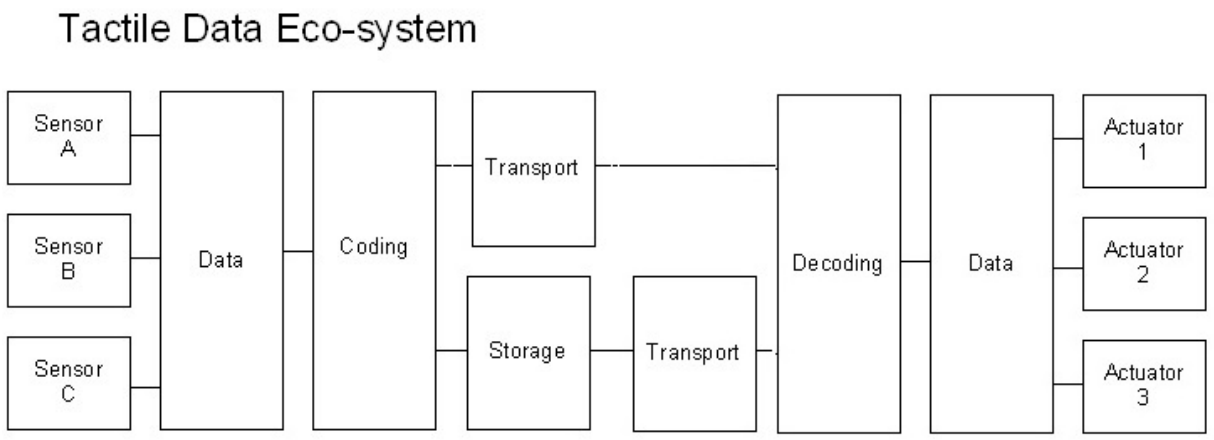
The Flow Chart below illustrates a simplified view of a haptic-tactile broadcast system, showing the haptic-tactile information captured by one or more sensors, the coding of the haptic-tactile essence, the communication, and the decoding for use of the haptic-tactile essence by end user hardware.

While sensors can create either analog or digital signals of different magnitudes and resolutions, the inputs to the haptic-tactile broadcast system are expected to be presented in a digital format as half-precision floating point numbers at a rate not exceeding 800 samples per second, per sensor.

Data from multiple sensors can be used to represent different locations or aspects of one physical object and multiple sensors can convey information for different motion axis and for linear or rotational movement.

Electro-mechanical end user hardware is commonly referred to as a “tactile transducer”, “actuator”, “motion” system or “simulator”.

This document is part of a suite of documents that address the definition and representation of haptic-tactile essence, as well as its transport. The acquisition of the haptic-tactile essence is out of scope for this suite of documents.



Haptic-Tactile Data Flow Chart

This document addresses only sensors that measure motion or direction. Other types of haptic-tactile essence, such as texture, temperature, etc. are not addressed by this document.

Haptic-Tactile essence is synchronized with visual and aural elements of the program stream. If it is not, the experience for the viewer can be unpleasant, and not an accurate representation of the content being presented. For this reason, latency is also considered.

1 Scope

This standard defines the haptic-tactile essence associated with a live event that is used together with audiovisual content in the broadcast production environment. This standard excludes any specification of the type of “capture” or sensor device(s) used to generate the haptic-tactile essence.

This standard defines the format and identity of the sensor data received. The responsibility for selecting the sensor data that is transmitted is outside the scope of this standard and is left to other processes.

Finally, this document also excludes the specification of the end user hardware necessary for the use of the haptic-tactile essence.

The transport of haptic-tactile essence is out of the scope of this document but will be addressed in other SMPTE documents.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:”

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords, "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword “reserved” indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword “forbidden” indicates “reserved” and in addition indicates that the provision will never be defined in the future.

A conformant implementation according to this document is one that includes all mandatory provisions ("shall") and, if implemented, all recommended provisions ("should") as described. A conformant implementation need not implement optional provisions ("may") and need not implement them as described.

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows: Normative prose shall be the authoritative definition; Tables shall be next; then formal languages; then figures; and then any other language forms.

3 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this engineering document. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this engineering document are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

SMPTE ST 330:2011, Unique Material Identifier (UMID)

IEEE 754-2008, Standard for Floating-Point Arithmetic

4 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

4.1 aggregation

collection of discrete sensors whose outputs are aggregated to be represented as a single value (e.g., by summing, averaging, or vector summing)

4.2 electro-mechanical

combined electrical and mechanical

4.3 half-precision floating point number

16-bit floating-point representation of a number, as defined as “binary16” in IEEE Std. 754

4.4 sensor

device that detects events or changes in quantities and provides a corresponding output

4.5 haptic-tactile sensor

device used to sense or detect haptic/tactile effects of an object and output dynamical information (such as position, heading, velocity, and acceleration)

4.6 sensor data

data received from a haptic-tactile sensor or aggregation

4.7 linear acceleration

linear vector quantity given by the derivative of the linear velocity with respect to time, in units of meters per second (m/s^2)

Note 1: Additional description is available in IEC 60050-113-01-38.

Note 2: The gravitational field intensity at the surface of the Earth is 1 g, approximately 9.8 m/s^2.

4.8 angular acceleration

axial vector quantity given by the derivative of the angular velocity with respect to time, in units of degrees per second squared ($^{o}/s^{2}$)

Note 1: The coherent SI unit of angular acceleration is radian per second.

Note 2: Additional description is available in IEC 60050-113-01-46.

4.9 linear velocity

linear vector quantity given by the derivative of the position along an axis with respect to time, in units of meters per second

Note : Additional description is available in IEC 60050-113-01-32.

4.10 angular velocity

axial vector quantity describing the rotation around an axis, given by the derivative of the angular orientation about an axis with respect to time, in units of degrees per second ($^{o}/s$)

Note 1: The coherent SI unit of angular velocity is radian per second.

Note 2: Additional description is available in IEC 60050-113-01-41.

5 Haptic-Tactile Essence

5.1 General

Each sensor, or aggregation, provides elements of sensor data, each one corresponding to a point in time. Likewise, a sensor data element may be created by aggregating other sensor data elements. Each sensor data element may be identified using the Haptic Tactile Essence Type codes defined in Section 5.2.

A sensor data element and a corresponding identification shall be mapped to a binary representation as shown in the Table 1, Table 2, and Table 3 below, with sensor data, either from a single sensor or an aggregation, at a sample rate not exceeding 800 samples per second, per sensor (or aggregation).

5.2 Haptic-Tactile Essence Type

A Haptic-Tactile Essence Type enumeration as defined in Table 1 shall be used to describe each individual element of haptic-tactile essence.

Table 1 – Enumerated Types of Haptic-Tactile Data and Axis

Code	Type	Units	Axis	Positive value
00h	Linear Acceleration	m/s^2	Not Specified	Not Specified
01h			Longitudinal (Z)	Forward
02h			Transverse (X)	Right
03h			Vertical (Y)	Down
04h	Rotational Acceleration	$^o/s^2$	Not Specified	Not Specified
05h			Roll (Z)	Left wing Up
06h			Pitch (X)	Nose Up
07h			Yaw (Y)	Nose Right
08h	Linear Velocity	m/s	Not Specified	Not Specified
09h			Longitudinal (Z)	Forward
0Ah			Transverse (X)	Right
0Bh			Vertical (Y)	Down
0Ch	Rotational Velocity	$^o/s$	Not Specified	Not Specified
0Dh			Roll (Z)	Left wing Up
0Eh			Pitch (X)	Nose Up
0Fh			Yaw (Y)	Nose Right
10h	Linear Position	meters	Not Specified	Not Specified
11h			Longitudinal (Z)	Forward
12h			Transverse (X)	Right
13h			Vertical (Y)	Down
14h	Rotational Orientation	degrees	Not Specified	Not Specified
15h			Roll (Z)	Left wing Up
16h			Pitch (X)	Nose Up
17h			Yaw (Y)	Nose Right
18h-FFh	Reserved	Reserved	Reserved	Reserved

Note 1: This standard addresses common types of haptic-tactile essence. The reserved enumerations for haptic-tactile essence types shown in Table 1 are intended for future haptic-tactile essence types.

Note 2: Coordinate systems are application-specific, and are out of scope for this standard.

Note 3: Entries having an axis and direction indicated as 'Not Specified' are appropriate to use when the orientation of the sensor or aggregation is unknown; is known but not aligned with one of the X, Y, Z, roll, pitch, and yaw axes indicated by other entries; or is not provided by the implementer for any reason of their choosing. “Not Specified” is used in the ‘Positive value’ column to indicate unknown, known but not aligned, or no direction provided.

The Yaw, Pitch, and Roll items shall be applied in this order: Yaw, Pitch, Roll.

Axis rotations shall follow the “Right-hand” rule for rotation about their respective axes, as shown in Figure 1.

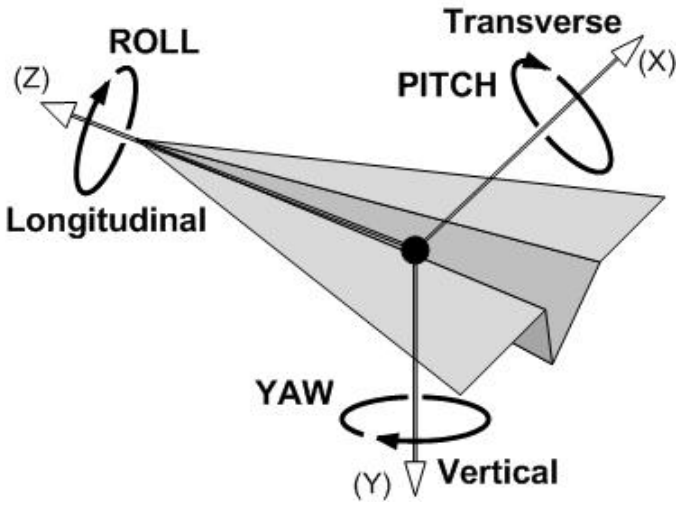


Figure 1 – Axis Illustrations

5.3 Haptic-Tactile Essence Update Rate

The rate at which haptic-tactile essence is repeated or updated shall be an update rate of zero (indicating a static value of the element) or a fixed rate between one and 800 samples per second.

5.4 Haptic-Tactile Essence Value

The value representing the output of each sensor (or aggregation) shall be converted into the appropriate units as defined in Table 1. The conversion process is out of scope of this document and is the responsibility of the implementer. The value shall be represented as a half-precision floating-point number.

5.5 Haptic-Tactile Essence Data Components

The components describing each element of haptic-tactile essence are shown in Table 2. The haptic-tactile essence type, update rate and sensor ID shall be identifiable for each element of the essence.

The type of each element shall be identified by an enumeration selected from Table 2 – Haptic-Tactile Data Components.

The byte order is specific for each transport mechanism. Sensor ID shall be treated as a sequence of (Sensor ID Length) bytes.

Table 2 – Haptic-Tactile Data Components

Data Size	Name	Description	Remarks
1 byte	Haptic-Tactile Essence Type	Enumerated Code	See Table 1
2 bytes	Essence Value	16-bit half-precision float – binary16	See Section 5.4
2 bytes	Update Rate	Unsigned Integer Samples/ second	See Section 5.3
1 byte	Sensor ID Type	Enumerated Code	See Table 3
1 byte	Sensor ID Length	Identifier Length as defined in Table 3	See Table 3
Varies	Sensor ID	Identifier of Type as defined in Table 3	See Table 3

5.6 Sensor Identification

5.6.1 Sensor IDs

A Sensor ID as defined in Table 3 shall identify one or more individual sensors and/or aggregation.

Table 3 – Enumerated Codes for Source Identification Types of Sensor IDs

Code	Identifier Type	Identifier Length
20h	Unknown or Not available	0 bytes
21h	IEEE EUI-64	8 bytes
22h	IEEE EUI-48 (MAC-48)	6 bytes
23h	UMID SMPTE ST 330	32 bytes
24h	User defined	Maximum 16 bytes
All Others	Reserved	Reserved

5.6.2 IEEE EUI Identifiers (Informative)

The IEEE defined 48-bit extended unique identifier (EUI-48) is a concatenation of either a 24-bit Organizationally Unique Identifier (OUI) value administered by the IEEE Registration Authority (https://standards.ieee.org/develop/regauth/) and a 24-bit extension identifier assigned by the organization with that OUI assignment, or the concatenation of a 36-bit Individual Address Block (IAB) identifier (or 36-bit Organizationally Unique Identifier (OUI-36)) and a 12-bit extension identifier assigned by the organization with that IAB assignment.

The IEEE-defined 64-bit extended unique identifier (EUI-64) is a concatenation of the Organizationally Unique Identifier (OUI) value assigned by the IEEE Registration Authority (IEEE RA) and the extension identifier assigned by the organization with that OUI assignment resulting in a 64-bit unique identifier.

This is described in more detail on the IEEE Registration Authority's website section on OUI (also known as Mac Address Block – Large (MA-L) found here; https://standards.ieee.org/develop/regauth/oui/index.html.

5.6.3 Unique Material Identifier (UMID) (Informative)

The SMPTE ST 330 Unique Material Identifier (UMID) is a standard for providing a stand-alone method for generating a unique label designed to be used to attach to media files and streams.

The Basic UMID contains the minimal components necessary for the unique identification (the essential metadata). The length of the basic UMID is 32 bytes.

Bibliography (Informative)

EUI-48, Guidelines for 48-Bit Global Identifier (EUI-48), Institute of Electrical and Electronics Engineers *https://standards.ieee.org/develop/regauth/tut/eui48.pdf*

EUI-64, Guidelines for 64-Bit Global Identifier (EUI-64), Institute of Electrical and Electronics Engineers *https://standards.ieee.org/develop/regauth/tut/eui64.pdf*