AIRLINE PASSENGER EXPERIENCE ASSOCIATION

APEX SPECIFICATION 0403

MPEG* CONTENT SPECIFICATION & CONTENT SECURITY REQUIREMENTS FOR AIRLINE IN-FLIGHT ENTERTAINMENT AND CONNECTIVITY SYSTEMS

*** MPEG-4 Part 10, MPEG-H Part 2**

VERSION 3.0

Release Candidate 2

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FOREWORD

The Digital Content Management Working Group (DCMWG) is a working group established by the Airline Passenger Experience Association (APEX), formerly the World Airline Entertainment Association (WAEA), Technology Committee to develop and publish technical specifications for supplying digital content to in-flight entertainment and connectivity (IFEC) systems. The DCMWG membership includes representatives of in-flight entertainment and connectivity equipment manufacturers, content providers, post-production laboratories, service providers, airlines and experts in the fields of digital video and audio compression, closed captioning, metadata, connectivity, Internet and security technologies.

The work of the DCMWG was expanded to the development of this specification in 2003, following nearly three years during which the DCMWG functioned as an educational entity for APEX. A call for contributions from technology companies was widely distributed in January and February 2004. There were regular DCMWG meetings and discussions on the resulting contributions, leading to the development of this specification.

In response to changing requirements, APEX in 2009 began a review of the standards adopted May 1, 2009 as Version 1.1 of this document. Member surveys and teleconferences were conducted, and input regarding potential changes to the document was discussed at the APEX Technology Committee Meeting in March 2010, and regular conversations and teleconferences were held in June and July 2010 leading to version 1.2.

Following a mandate to embrace HD content that was proposed and adopted at the February 2011 APEX-TC meeting, the High Definition Working Group (HDWG) was formed. Weekly Internet based meetings and several in person meetings were held. Much education and discussion led to the consensus that is expressed in this document. The results were presented at the November 2011 APEX-TC meeting.

Content providers requested the retagging of the Security Section from “Informative” to “Normative” as well as an update of this section to security countermeasures known as of 2014 for availability of HD content and/or premium content in In-Flight Entertainment and Connectivity (IFEC) systems. The HDWG was asked to take on this task and deliver it for adoption by APEX TC of November 2014. Weekly webinars were held to analyze comments from APEX members for the update of the whole APEX 0403 specification. This 3.0 version is the result of the consensus between all APEX volunteers that attended the webinars.

The key concerns, purposes and objectives of the DCMWG in establishing this specification are:

- The development and publication of an open, voluntary technical specification that encourages a common digital content delivery methodology for IFEC systems
- The interoperability of content across multiple IFEC implementations
- The utilization of efficient encoding methods for high quality image and sound, helping to ensure a quality airline passenger experience
- Non-proprietary and interoperable system components
- A secure IFEC system infrastructure with secure content preparation and delivery
- Low complexity, high efficiency and effectiveness
- The establishment of an encoding parameter set that a) achieves the highest visual quality on IFEC screens, b) eases the positioning of the Trick Modes, and c) decreases the load on the seat decoding CPUs.

The scope of work for this specification includes the interfaces, delivery processes, security and key management between content point of origin and delivery to the onboard IFEC systems. Content storage archives and onboard playback systems that were outside the scope of this specification previously are now being addressed for Premium content. Premium content is defined by each content provider and could be listed as Early Window or Late Window content in SD or HD format.

1 INTRODUCTION

The DCMWG recognizes that the commercial and consumer industries have created broad standards for creating, formatting and delivering digital content. This specification draws from those standards and applies them to IFEC content. Other specifications generally allow a wide range of options to be utilized. However, there are certain requirements that are unique to IFEC systems, e.g., IFEC systems are generally constrained with respect to processing, bandwidth and screen resolution as a result of requirements for very low power, size and weight. By agreeing in this specification to constrain the use of digital content to a subset of these broader standards, greater interoperability will be achieved for digital content destined for IFEC systems.

As a result of wide-ranging emerging compression technologies for the commercial and consumer industries that require decoding compatibility with MPEG-2 and MPEG-4, integrated circuit (IC) manufacturers are designing decoders that support at least these formats. Many decoders are implemented with a digital signal processor where code can be downloaded for support of additional types of audio/video (A/V) codecs.

The DCMWG acknowledges that the short-term future includes MPEG-1 and MPEG-2, already in use in IFEC systems, but that the adoption of the MPEG-4 part 10 codec has now begun and will have primacy in the long term. Consequently the DCMWG, in recognition of these trends, sets forth parameters in the following areas in this specification:

- Implementations of MPEG-4 Part 10.
- A security system for these new codecs that encourages the provisioning of early-window release content to aircraft IFEC systems.
- Simplification of the process of content distribution, including enhanced automation of the supply chain between content providers, postproduction laboratories, service providers, security entities, IFEC content integrators, IFEC providers and airlines.

The DCMWG intends, as a separate initiative, to examine the evolving high-speed Internet access technologies. This includes automated content delivery through the entire supply chain. The passage from manual delivery to automated delivery will facilitate migration from monthly delivery to on demand delivery of content and data. Also, when aircraft have high-speed Internet access on the ground, it is contemplated that content, keys, metadata and other required elements can be delivered directly to the aircraft, potentially bypassing the need for physical media delivery.

2 SYSTEM REFERENCE MODEL

This specification is primarily intended for third and future generations of cabin networks that are compliant with ARINC Specifications 808, 809 and 820. Present IFEC systems compliant with ARINC Specification 628 may not be able to accommodate this specification.

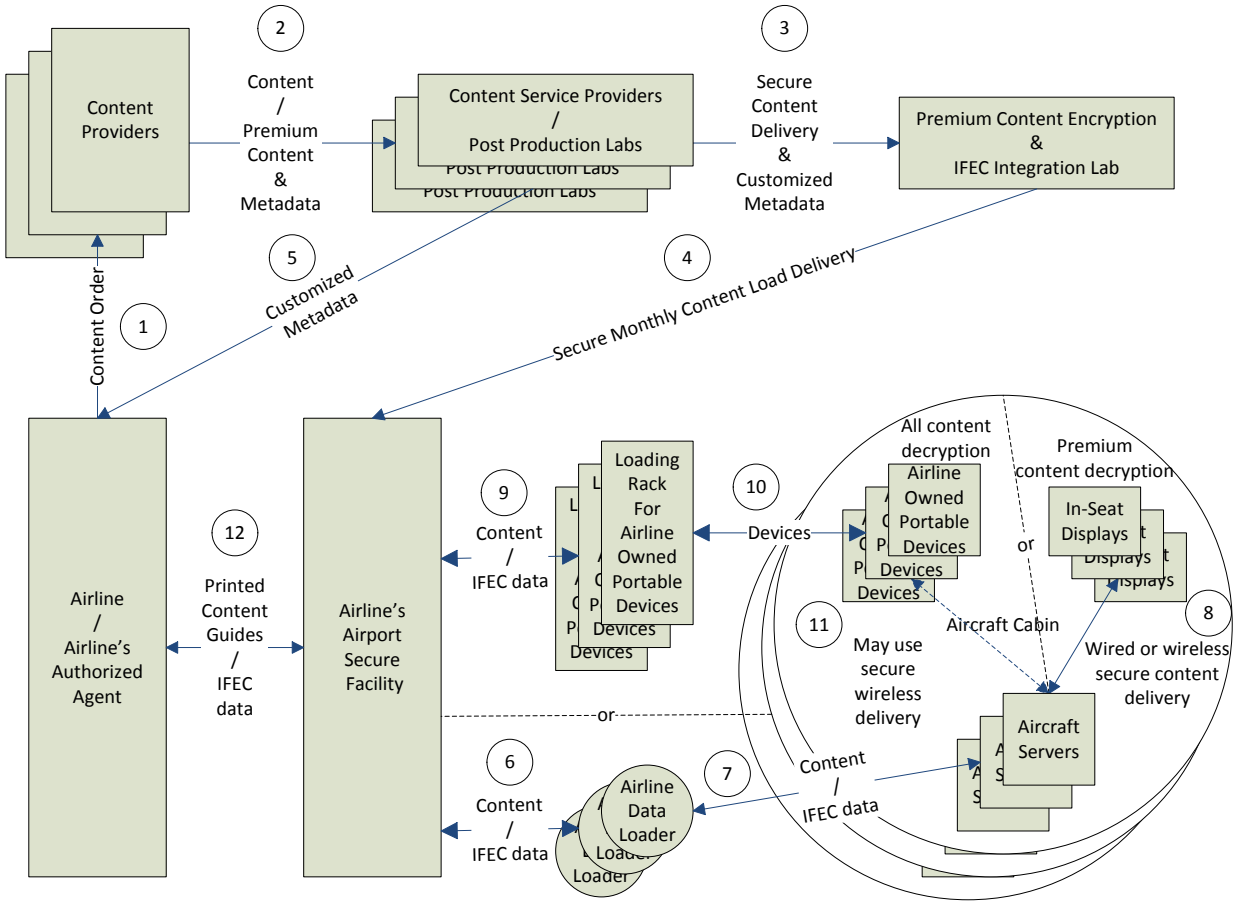

Figure 1: System Reference Model with Manual Content Loading to Aircraft

The system reference model addressed by this specification is illustrated in Figure 1. With respect to Figure 1, the following workflow descriptions and key components apply, with the numbers in the figure corresponding to the numbered items below:

1. A content provider accepts an order from an airline or from an airline's authorized agent.
2. Content and metadata are delivered to a content service provider (CSP) or a post-production laboratory (PPL). The content provider elects content to be categorized as Premium or not.
3. The CSP/PPL securely delivers to the Airline's IFEC Integration Lab all content and metadata customized to airline requirements.
4. After premium content encryption and integration, the IFEC Integration Lab delivers securely the monthly content load to the Airline's airport secure facility.
5. All content customized metadata required by the Airline's monthly magazine (containing the content guide) are delivered by CSP/PPL.
6. Airline's maintenance personnel or authorized agents transfer monthly content to portable data loaders that are carried to each aircraft for loading content to onboard servers. Other types of aircraft content loading exist such as duplicating an encrypted content disk for each aircraft embedded content loader or loading multiple servers on a bench loader or using wireless communications. These loading methods are not described here as they require separate security approvals from content owners.
7. After content is loaded into aircraft servers, IFEC data may be downloaded such as BITE, passenger usage information, passenger purchase orders, etc…

8. The onboard servers play out the content either over wired connections to in-seat displays or secure wireless connections to in-seat displays for use by passengers. Premium video content shall be maintained encrypted while on board except during playback and rendering in the seatback display.
9. Alternatively, airline's maintenance personnel or authorized agents transfer monthly content to airline owned portable devices through loading racks.
10. The airline owned portable devices are then carried to the aircraft.
11. Airline owned portable devices play out the content for use by passengers with or without the use of secure wireless connections.
12. Printed airline's magazine containing content guides are sent to the Airline's airport maintenance facility to be carried to the aircraft. IFEC data and portable device data, consisting of passenger usage and maintenance information, are downloaded to the airline facility for further processing. As agreed between the necessary parties, passenger content usage data may be shared to enable better content customization.

Passenger-owned notebook computers, personal digital assistants and personal electronic devices are outside the scope of this specification.

3 REFERENCES

3.1 Normative References

The following international and industry standards contain provisions that, through reference in this specification's text, constitute provisions of this specification. At the time of publication, the editions indicated were valid. All of these referenced standards are subject to revision, and parties to agreements based on this specification are encouraged to investigate the possibility of applying the most recent editions of the referenced standards indicated below.

Cable Television Laboratories, Inc., (CableLabs) Asset Distribution Interface Specification, Version 1.1, 2006. Available from <www.cablelabs.com>.

Cable Television Laboratories, Inc., (CableLabs) Video-On-Demand Content Specification, Version 1.1, 2006. Available from <www.cablelabs.com>.

ISO/IEC 11172-3:1993, "Information Technology – Coding of Moving Pictures and Associated Audio for Digital Storage Media at Up to About 1,5 Mbit/s – Part 3: Audio", 1993. Available from <www.iso.ch>.

ISO/IEC 13818-1:2000, "Information technology – Generic Coding of Moving Pictures and Associated Audio Information: Systems", 2000. Available from <www.iso.ch>.

ISO/IEC 14496-1:2004, "Information Technology – Coding of Audio-Visual Objects – Part 1: Systems", 2004. Available from <www.iso.ch>.

ISO/IEC 14496-3:2009, "Information Technology – Coding of Audio-Visual Objects – Part 3: Audio", 2006. Available from <www.iso.ch>.

ISO/IEC 14496-8:2004, "Information Technology – Coding of Audio-Visual Objects – Part 8: Carriage of ISO/IEC 14496 Contents Over IP Networks", 2004. Available from <www.iso.ch>.

ISO/IEC 14496-10:2005, "Information Technology – Coding of Audio-Visual Objects – Part 10: Advanced Video Coding", 2005. Available from <www.iso.ch>.

ISO/IEC 14496-14:2003, "Information Technology – Coding of Audio-Visual Objects – Part 14: MP4 File Format", 2003. Available from <www.iso.ch>.

ISO/IEC 15938, Parts 1-11, "Information Technology – Multimedia Content Description Interface", 2002-2005. Available from <www.iso.ch>.

ISO/IEC 21000, Parts 1-17, "Information Technology – Multimedia Framework (MPEG-21)", 2003-2006. Available from <www.iso.ch>.

ISO/IEC 23008-2:2015, “Information Technology – High Efficiency Coding and Media Delivery in Heterogeneous Environments – Part 2: High Efficiency Video Coding”, 2013-2015. Available from <www.iso.ch>.

ITU-R Recommendation BT.601-5, “Studio Encoding Parameters of Digital Television for Standard 4:3 and Wide-screen 16:9 Aspect Ratios”, October 1995. Available from <www.itu.int>.

ITU-R Recommendation BT.709-5, “Parameter values for the HDTV standards for production and international programme exchange”, April 2002. Available from <www.itu.int>.

WAEA Specification 0395, Version 2.0, “Content Delivery for In-Flight Entertainment”, 6 November 2001. Available from <www.apex.aero>.

WAEA Specification 0598, v1.0, “DVD Delivery for In-Flight Entertainment”, 24 January 2001. Available from <www.apex.aero>.

WAEA Specification 1289-2, Revision 3, “Specification for Mastertape Recording, Tape Duplication, Compact Disc Replication, and Digital Encoding for Airborne Audio Entertainment Systems”, 20 January 2005. Available from <www.apex.aero>.

Worldwide Web Consortium Recommendation: Extensible Markup Language (XML) 1.0, Fourth Edition, 16 August 2006. Available from <www.w3c.org>.

FIPS Publication 197, “Specification for the Advanced Encryption Standard (AES)”, 26 November 2001. Available from <www.csrc.nist.gov>.

R.L. Rivest, A. Shamir, and L. Adleman. “A method for obtaining digital signatures and public-key cryptosystems.” Communications of the ACM, 21(2):120-126, February 1978.

FIPS PUB 140-2 Annex C, Approved Random Number Generators for FIPS PUB 140-2, “Security Requirements for Cryptographic Modules”, February 16, 2012, Draft. Available from <www.csrc.nist.gov>.

3.2 Informative References

The following references contain information that relates to this specification, but are not provisions of this specification. At the time of publication, the editions indicated were valid.

ARINC Specification 809, “3rd Generation Cabin Network, Seat Distribution System”, November 2006. Available from <www.arinc.com>.

ARINC Specification 820, “3rd Generation Cabin Network, Wireless In-Flight Entertainment System”, November 2006. Available from <www.arinc.com>.

ARINC Specification 628, “Cabin Equipment Interfaces”, Parts 0-9, 1999-2006. Available from <www.arinc.com>.

ARINC Specification 808, “3rd Generation Cabin Network, Cabin Distribution System”, November 2006. Available from <www.arinc.com>.

Consumer Electronics Association (CEA) Standard 608-D, “Line 21 Data Services”, 2006. Available from <www.global.ihs.com>.

CEA Standard 708-C, “Digital Television Closed Captioning”, 2006. Available from <www.global.ihs.com>.

MovieLabs Specification for Enhanced Content Protection v1.0, 2013

EIDR – Registrations from Other Systems v0.8.4, 7-June-2012. Available from <www.eidr.org/documents/EIDR_Registrations_from_Other_Systems-v084.pdf>

4 VIDEO COMPRESSION

To ensure visual quality on a wide array of screen sizes and the interoperability of content, the following video codecs meet the requirements of this specification.

4.1 MPEG-4 Part 10 (ISO/IEC 14496-10:2005) aka AVC, H.264

Image data parameters shall be as specified in Table 1.

Coded Picture Format	Video Encoding Resolution
Full-frame (4:3) SDTV	720 x 480 (NTSC, non-square pixels) ITU-R Recommendation BT.601-5
Widescreen (16:9) SDTV	720 x 480 (NTSC widescreen, non-square pixels) ITU-R Recommendation BT.601-5
Widescreen (16:9) HD 720P	1280 x 720 (square pixels) ITU-R Recommendation BT.709-5
Widescreen (16:9) HD 1080P	1920 x 1080 (square pixels) ITU-R Recommendation BT.709-5

Table 1: Coded Picture Format and Video Encoding Resolution

Support for 4:3 content to be displayed in 16:9 screens without distortion and support for 16:9 content to be displayed in 4:3 screens without distortion are required. While systems may be technologically capable of automatically converting 4:3 content into 16:9 displays, or 16:9 content into 4:3 displays, the execution of this capability may be bound by private agreements. Implementers are cautioned to read and understand all applicable agreements. IFEC manufacturer and content provider migration to 16:9 content and 16:9 displays is encouraged.

These specifications are for displays on the IFEC system. This specification is not a definition for source files that can be transcoded into different bitrates and resolutions (e.g. use the 1080 file as a source for a 720 encode). This is a specification for "Play-out files" (intended to define a format to be rendered on the playback device) as opposed to "Master Files".

Video editing may be performed prior to encoding; these processes are outside the scope of this specification.

The parameters for MPEG-4 settings shall be as specified in Table 2.

FEATURES	CONFIGURATION FOR STANDARD DEFINITION	CONFIGURATION FOR HD 720P	CONFIGURATION FOR HD 1080P

FEATURES	CONFIGURATION FOR STANDARD DEFINITION	CONFIGURATION FOR HD 720P	CONFIGURATION FOR HD 1080P
Objective of encoding parameters	The objectives of the encoding Parameter Set shall be: a) To achieve the highest visual quality on IFEC screens; b) to ease the positioning of the Trick Modes; and c) to decrease the load on the seat decoding CPUs.	The objectives of the encoding Parameter Set shall be: a) To achieve the highest visual quality on IFEC screens; b) to ease the positioning of the Trick Modes; and c) to decrease the load on the seat decoding CPUs.	The objectives of the encoding Parameter Set shall be: a) To achieve the highest visual quality on IFEC screens; b) to ease the positioning of the Trick Modes; and c) to decrease the load on the seat decoding CPUs.
Video Input	Progressive	Progressive	Progressive
Resolution	720 x 480	1280 x 720	1920 x 1080
Differentiate by screen size	No size Limitation	For displays up to and including 50 inches measured diagonally	No Size Limitation
Frame Rate	The reference to Frame Rate and the reference to Progressive video input shall mean that when the source content to be encoded originates in 24fps film, the appropriate frame rate is 23.976fps (24P), and when the content to be encoded originates in 30fps NTSC video, the appropriate frame rate is 29.97fps (30P). If the content to be encoded originates in 24fps film, but has been converted to 30fps NTSC, the Best Practice is to reverse telecine the 30fps NTSC video back to the original 24fps and encode as 24P.	The following Frame Rates are acceptable for video encoded to this specification, 23.976 fps, 25 fps, and 29.97 fps. Content originated at film rates should be available as 23.976 HD masters, and shall be encoded at that rate. Content mastered at 25fps shall be encoded as 25P or converted to 23.976P. Higher frame rates, such as 50P, 50i, 60P and 60i shall be reduced to a frame rate available in the standard. When the content to be encoded is presented as 29.97 fps or 59.94 fps video, best practice is to, if possible, reverse telecine down to a film frame rate and encode as 23.976. In any event the source shall be de-interlaced before encoding.	The following Frame Rates are acceptable for video encoded to this specification, 23.976 fps, 25 fps, and 29.97 fps. Content originated at film rates should be available as 23.976 HD masters, and shall be encoded at that rate. Content mastered at 25fps shall be encoded as 25P or converted to 23.976P. Higher frame rates, such as 50P, 50i, 60P and 60i shall be reduced to a frame rate available in the standard. When the content to be encoded is presented as 29.97 fps or 59.94 fps video, best practice is to, if possible, reverse telecine down to a film frame rate and encode as 23.976. In any event the source shall be de-interlaced before encoding.
Reverse Telecine	Yes	To be used before encoding in the case where telecine pull-down is present in the source	To be used before encoding in the case where telecine pull-down is present in the source
Codec(s)	MPEG-4 Part 10 (H.264)	MPEG-4 Part 10 (H.264)	MPEG-4 Part 10 (H.264)
Profile	Main Profile	High Profile	High Profile
Level	3.1	3.1	4.1

FEATURES	CONFIGURATION FOR STANDARD DEFINITION	CONFIGURATION FOR HD 720P	CONFIGURATION FOR HD 1080P
Aspect Ratios Supported	4:3, 16:9	16:9 only HD content shall be encoded as 16:9 display aspect ratio. HD content with an Original Aspect Ratio (OAR) other than 16:9 shall be framed in a 16:9 presentation. HD content that is in 4:3 shall be pillar-box matted. HD content with an aspect ratio wider than 16:9 shall be letterbox matted.	16:9 only HD content shall be encoded as 16:9 display aspect ratio. HD content with an Original Aspect Ratio (OAR) other than 16:9 shall be framed in a 16:9 presentation. HD content that is in 4:3 shall be pillar-box matted. HD content with an aspect ratio wider than 16:9 shall be letterbox matted.
Bit Rate Mode	CBR	CBR or VBR	CBR or VBR
Bit Rate**	Standard definition (SD) video shall be encoded in a range from 1.5Mb/s to 2.0Mb/s with a default value of 1.5Mb/s. When visual quality requires it, encoding may deviate from the default value with the consent of the stakeholders, who may include the compressionist, the content provider, the system provider and/or the airline. This bit rate refers to the video elementary stream only without audio.	High definition (HD) in 720P format shall be encoded within a range from 4.0 Mb/s to 8.0 Mb/s, depending on the application and rate control method. Constant bit rate (CBR) default will be 4.0 Mb/s with a maximum of 8.0 Mb/s. When supported by the IFEC system, a variable bit rate (VBR) may be used with peak bit rates that shall be in the same range with 6.0 Mb/s as the default value. When visual quality requires it, encoding may deviate from the default value with the consent of the stakeholders, who may include the compressionist, the content provider, the system provider and/or the airline. This bit rate refers to the video elementary stream only without audio.	High definition (HD) in 1080P format at constant bit rate (CBR) shall be encoded within a range from 6.0 Mb/s (default) to 8.0 Mb/s (max.), depending on the application. Variable Bit Rate (VBR) is not specified here. When visual quality requires it, encoding may deviate from the default value with the consent of the stakeholders, who may include the compressionist, the content provider, the system provider and/or the airline. This bit rate refers to the video elementary stream only without audio.
Slice	1, 2 or 4	4	4
Pixel Accuracy	1/4	1/4	1/4
Reference B-frames	No	No	No
Number of Reference Frames	2	3	3

FEATURES	CONFIGURATION FOR STANDARD DEFINITION	CONFIGURATION FOR HD 720P	CONFIGURATION FOR HD 1080P
Min/Max GOP Size	GOP size shall be set at: - 15 frames for 30fps media - 12 frames for 24 or 25fps media but may be shortened if an I-Frame is triggered by a scene change	GOP size shall be set at: - 15 frames for 30fps media - 12 frames for 24 or 25fps media but may be shortened if an I-Frame is triggered by a scene change	GOP size shall be set at: - 15 frames for 30fps media - 12 frames for 24 or 25fps media but may be shortened if an I-Frame is triggered by a scene change
Number of B-frames	2	3	3
IDR Frequency	1 on every key frame	1 on every key frame	1 on every key frame
Access Unit Delimiters	The Parameter Set shall include Access Unit Delimiters	The Parameter Set shall include Access Unit Delimiters	The Parameter Set shall include Access Unit Delimiters
Sequence End Code	No	No	No
Timestamp	No	No	No
Timestamp Offset	No	No	No
Deblocking Filter	The Parameter Set shall include a Deblocking Filter	The Parameter Set shall include a Deblocking Filter	The Parameter Set shall include a Deblocking Filter
Entropy	CABAC	CABAC	CABAC
Weighted Prediction	No	Yes	Yes
Key Frame Insertion on Scene Cut	Yes	Yes	Yes

Table 2: Parameters for MPEG-4 Part 10 Settings

These suggested bit rate values are known to produce exemplary results. Unfortunately, no fixed compression profile can guarantee perceptually lossless quality. It is the intention of this specification to preclude any possibility of the introduction of even slightly annoying compression impairments. In view of ongoing improvements in codec technology and the diversity of facilities that serve the global IFE marketplace, an optional alternative to the above Bit Rate parameters is allowed.

There is no such thing as an acceptable impairment. Files employing this optional methodology shall be completely free of normally perceivable[1] impairments.

The informative annex "INFORMATIVE ANNEX: Video Quality Measurement Tools" outlines specific tools, parameters, and internationally standardized recommended methodologies as well as practical reference files that may be employed to ensure against the introduction of any impairments.

[1]Visual inspections shall be performed at play speed.

4.2 MPEG-H Part 2 (ISO/IEC 23008-2) aka HEVC, H.265

The parameters for MPEG-H settings shall be as specified in Tables 3 & 4.

Features	480P	720P	1080P
Resolution	720x480	1280x720	1920x1080
Max Frame Rate (use native)	30	30	30
Profile	Main	Main10	Main10
Level	3	3.1	4
Tier	Main	Main	Main
Aspect Ratio	4:3, 16:9	16:9	16:9
Bit Rate Mode	Constrained VBR	Constrained VBR	Constrained VBR
Bit Rate (nominal & max)[‡]	750 Kb/s 1 Mb/s	2.0 Mb/s 2.5 Mb/s	3.5 Mb/s 4.5 Mb/s
GOP Size (nominal)[†]	0.5 sec	0.5 sec	0.5 sec
IDR Frequency	1 on every key frame	1 on every key frame	1 on every key frame

Table 3: Parameters for MPEG-H Part 2 Settings (1 of 2)

Features	1080P60	4K	4K 60
Resolution	1920x1080	3840x2160	3840x2160
Max Frame Rate (use native)	60	30	60
Profile	Main10	Main10	Main10
Level	4.1	5	5.1
Tier	Main	Main	Main
Aspect Ratio	16:9	16:9	16:9
Bit Rate Mode	Constrained VBR	Constrained VBR	Constrained VBR
Bit Rate	Evaluation ongoing	Evaluation ongoing	Evaluation ongoing
GOP Size (nominal)[†]	0.5 sec	Evaluation ongoing	Evaluation ongoing
IDR Frequency	1 on every key frame	1 on every key frame	1 on every key frame

Table 4: Parameters for MPEG-H Part 2 Settings (2 of 2)

Items marked “evaluation ongoing” reflect resolution and frame rate where APEX has yet to establish experience-based consensus.

Frame rate shall be the native frame rate of the program material. For most feature films this would 23.976 fps or 25 fps. The intent is to avoid using material that has been frame rate converted, such as 23.976 to 29.97.

Frame based encoding only, progressive mode. No fields

† Nominal GOP value reflects a general system use case. Some implementations may select other GOP values for their use cases.

‡ Bit rate can be lower if quality criteria are met per applicable quality checks

5 AUDIO COMPRESSION

To ensure aural quality and interoperability of content, the following audio codecs meet the requirements of this specification:

- MPEG-4, Part 3 – High Efficiency Advanced Audio Coding (HE-AAC) (ISO/IEC 14496-3:2009)
- MPEG-4, Part 3 – Low Complexity Advanced Audio Coding (LC-AAC) (ISO/IEC 14496-3:2009)
- MPEG-1 Audio, Layer 2 (MP2) (ISO/IEC 11172-3:1993)

Audio content shall be encoded at the data rates specified in Table 5.

Audio Formats	**HE-AAC CBR in Kb/s**	**LC-AAC & MP2 CBR in Kb/s**
Joint Stereo	64	128
Dual Channel or Independent Stereo	128	256
Single Channel Monaural	64	128

Table 5: Audio Formats and Data Rates

Audio quality shall comply with APEX Specification 1289-2, Revision 3, “Specification for Mastertape Recording, Tape Duplication, Compact Disc Replication, and Digital Encoding for Airborne Audio Entertainment Systems”.

Frequency response shall be 20 Hz to 20 kHz at ± 3 dB (“Hi-Fi”). Sampling frequency shall be 44.1 kHz for all audio content.

Audio editing may be performed prior to encoding; these processes are outside the scope of this specification.

6 MPEG SYSTEM

MPEG system multiplexing is required for the delivery of elementary encoded video and audio, data and metadata. PPLs provide the required encrypted elementary streams and each IFEC manufacturer or their agent multiplexes them pursuant to their unique IFEC MPEG systems requirements. This allows for cross-utilization of the same encoded content with different IFEC architectures.

The following systems multiplexing meet the requirements of this specification:

- MPEG-4, Part 14 (ISO/IEC 14496-14:2004)
- MPEG-4 over MPEG-2 as specified in MPEG-2 Systems (ISO/IEC 13818-1:2000)
- MPEG-4 over IP networks (ISO/IEC 14496-8:2004)
- MPEG-4 over http as specified in MPEG-4 Systems (ISO/IEC 14496-1:2004)

Precise synchronization of multiplexed elementary video and audio streams is required to prevent noticeable and objectionable lip-sync problems. It is a synchronization requirement of this specification that video shall lag audio no more than 20 ms and video shall lead audio no more than 40 ms.

7 SECURITY

7.1 Security Introduction

IFEC systems must be capable of protecting intellectual property from unauthorized access. It is desirable that security systems have minimum impact on the operations of airlines for handling protected content. Both plain text and secure content shall be accommodated throughout the content delivery process and in the IFEC systems. Not all content need to be made secure. Premium content is defined by each content provider and could be listed as Early Window or Late Window content in SD or HD format. Premium content shall be protected in the IFEC systems. The content provider shall determine if a particular security implementation offered by an IFEC vendor is acceptable. Passenger Electronic Devices are out of scope of this specification.

The security scope is described in the following table:

	Fixed installation	**Airline-owned portable device**	**Passenger-owned device**
Stored on device	"seat-centric" IFE where all content stored in fixed-installed, passenger-accessible devices (7.4.1)	standalone hand-out IFE (ex. DigEplayer) (7.4.3)	N/A
Wired streaming	traditional server-based IFE (7.4.1)	N/A	N/A
Wireless streaming	"wireless" IFE (7.4.2)	server-based hand-out IFE (7.4.3)	out of scope

Table 6: Security Scope

7.1.1 Note on Security of Content Beyond HD

This specification has been updated to introduce the H.265 video codec, and content formats beyond HD. Specifically, UHD (4K resolution) content settings are referred to in Section 4, Video Compression. A corresponding update to security will be required but is considered outside the scope at this time.

7.2 Content Transfer between Secure Facilities

The handling of copyrighted content inside a Secure Facility and between Secure Facilities is described below. Copyrighted content includes all entertainment content including Premium content (Video, audio, text, etc…):

A Secure Environment is where access to copyrighted content and security keys are closely controlled in Secure Facilities. Secure Facilities have the following highly desirable characteristics:

1. A clear, structurally-delineated restricted perimeter,
2. Physical access to secured areas is monitored and limited to authorized personnel,
3. Security processes and procedures are codified and enforced,
4. Inventory and movement of individual copyrighted content and security keys are tracked and traceable.

For the purpose of this specification, Secure Facilities have all the above characteristics and include at least one of the following:

1. Facilities that have adopted the recommendations resulting from an MPAA security review,
2. Facilities that are JAR 145 and/or FAR 145 approved (Repair Stations),
3. Facilities that are JAR 21 and/or FAR 21 approved (Certification Procedures for Products and Parts),
4. Those portions of airport premises which are within the airport security perimeter (commonly referred to as "airside"),
5. IFEC equipment installed on a commercial passenger aircraft.

Transport of copyrighted content with security keys between non-contiguous Secure Environments shall be traceable pursuant to JAR 145 and/or FAR 145 and shall comply with the following security requirements:

1. Transport of copyrighted content between non-contiguous Secure Environments shall occur only in encrypted form,
2. Copyrighted content shall be individually file-level encrypted or transported on disks or drives that are volume-level encrypted or sent through encrypted virtual private networks (VPN),
3. Premium content shall stay encrypted as described in section 7.4 below,
4. The encryption algorithm shall be at least as strong as the Advanced Encryption Standard (AES) with a 128-bit content key in Cipher Block Chaining (CBC) mode,
5. Each unique content key and each unique initial vector (IV) shall be randomly generated as recommended in Security Requirements for Cryptographic Modules, Annex C: Approved Random Number Generators for FIPS PUB 140-2 or later,
6. Each content key and, optionally, the IV shall be encrypted using a public key encryption algorithm at least as strong as RSA with a 2048-bit key pair,
7. The encrypted content key and the optionally encrypted IV shall be maintained encrypted during transit between non-contiguous Secure Environments,
8. The airline or their agent shall be responsible for maintaining the secrecy and security of their airline private keys,
9. If the airline private key needs to be sent to the airline, it shall be sent using a different transport mechanism than the one used to send the encrypted content,
10. Private keys shall be encrypted, obfuscated, or otherwise secured when outside the boundaries of a Hardware Security Module,
11. All selected encryption/decryption algorithms shall be exportable from the U.S. by complying with currently applicable U.S. export regulations (e.g., ITAR, EAR),
12. The airline or their agent shall be responsible for providing a key revocation or update process acceptable to the content provider, e.g. in the event of a security breach,
13. The content provider shall determine if a particular key management system (KMS) implementation offered by the airline or their agent is acceptable.

7.3 Non-Premium Content Security in IFEC systems

Security of non-Premium content is specified in WAEA Specifications 0395, "Content Delivery for In-Flight Entertainment", version 2.0, As Amended and Approved by the World Airline Entertainment Association Technology Committee, November 6, 2001. (Original Version 1.1, Approved June 7, 1996.)

7.4 Premium Content Security in IFEC systems

The following requirements are in addition to the above already required non-premium content security and apply to premium content. Airline owned devices whether in-seat or portable need to be designed or modified to prevent unauthorized access or copying of premium content.

7.4.1 IFEC systems with in-seat displays over wired connections

This type of IFEC systems consists of head end servers and in-seat displays connected by cables (fiber and/or copper) and require maintenance personnel to install or remove any LRU, seat display or access any cable. This type of IFEC systems is in a trusted environment while on ground due to physical security, FAA regulations, airport regulations and airlines operational regulations that keep this type of IFEC systems inherently secure from threats from hackers, terrorists or criminal organizations. The likelihood of an attack by maintenance personnel is extremely improbable.

This type of IFEC systems is more vulnerable in the air due to potential hackers among passengers and connectivity that can bring an attack from a ground hacker. The likelihood of an attack by a cabin crew member is extremely improbable. The likelihood of an IFEC system side channel attack by a passenger has been evaluated as extremely improbable. The likelihood of an IFEC system physical attack by a passenger getting access to a cable has been evaluated as extremely remote. An extensive Security Risk Analysis is required to cover an IFEC system remote attack through connectivity and any IFEC manufacturer may share its results during its security presentation to content providers. Through Security Risk Analysis (SRA), IFEC manufacturers come up with a list of security countermeasures to decrease the likelihood of threats.

This type of IFEC systems shall provide the following content security:

1. Premium video content shall be maintained encrypted while on board except during playback and rendering in the seatback display,
2. The encryption algorithm for premium video shall be at least as strong as the Advanced Encryption Standard (AES) with a 128-bit content key in Cipher Block Chaining (CBC) mode,
3. Audio, CC & Subtitle are protected per at least the same security required in APEX 0395,
4. Premium video content shall be uniquely encrypted for each airline with a different randomly generated content key and randomly generated initial vector (IV) used for each video, such random generation shall follow the recommended Security Requirements for Cryptographic Modules, Annex C: Approved Random Number Generators for FIPS PUB 140-2 or later,
5. Each content key and, optionally, the IV used to encrypt each premium content shall be encrypted using a public key encryption algorithm at least as strong as RSA with a 2048-bit key pair,
6. The encrypted content key and the optionally encrypted IV shall be maintained encrypted while on board except during playback and rendering in the seatback display,
7. The airline or their agent shall be responsible for maintaining the secrecy and security of their airline private keys in the IFEC systems,
8. All selected encryption/decryption algorithms shall be exportable from the U.S. by complying with currently applicable U.S. export regulations (e.g., ITAR, EAR),
9. The airline or their agent shall be responsible for providing a key revocation or update process acceptable to the content provider, e.g. in the event of a security breach,
10. The content provider shall determine if a particular key management system (KMS) implementation offered by the airline or their agent is acceptable.

7.4.2 IFEC systems with in-seat displays over wireless connections

This type of IFEC systems consists of head end servers and in-seat displays communicating over a cabin wireless network and requiring maintenance personnel to install or remove any LRU, seat display or access any cable.

This type of IFEC system is secure while on ground and is more vulnerable in the air due to potential hackers among passengers and connectivity that can bring an attack from a passenger or a ground hacker. An extensive Security Risk Analysis is required to cover an IFEC system's vulnerability to local or remote attack through connectivity (wireless on-board only or wireless / SATCOM inbound/outbound) and any IFEC manufacturer may share its results during its security presentation to content providers.

Premium content may be streamed from an on-board aircraft server to in-seat displays that meet the security requirements of section 7.4.1 above and comply with the following network conditions:

1. Each playback device must be authenticated to the server before authorizing delivery of content or content keys,
2. Delivery of premium content or content keys to a device shall only be over encrypted and private network connections,
3. Bandwidth allocation necessary to deliver content must be guaranteed to the device,
4. Content key(s) shall only be delivered to the device after device authentication and playback of content has been requested,
5. Content shall be encrypted during any transmission,
6. The network shall be monitored to detect any network attack and take appropriate action to protect premium content.

7.4.3 IFEC systems with airline owned portable electronic devices

This type of IFEC systems consists of head end servers and airline owned portable devices including devices that are removable from the seatback by passengers. These portable devices may get stolen by hackers who can then use sophisticated hacking equipment in a lab environment to get keys and content, when present, after opening the stolen device.

The minimum requirements for these devices are:

1. No device video outputs,
2. No device audio outputs except for a personal listening port, i.e. headphone output,
3. Requirements for wireless network security are the same as section 7.4.2 above,
4. No data output if content is resident on the device, except as noted in 4.1 & 4.2 below, at any time while premium content is available or playing,
    4.1. As required by law or regulation, portable devices that only support preloaded premium content shall allow for secured Wi-Fi connectivity to accommodate incoming communications and related return messaging,
    4.2. In the event that a portable device supports both preloaded premium content and streaming premium content then Wi-Fi connectivity shall only be available for either (i) as described in 4.1 above when playing preloaded content; or (ii) as described in 3 & 4.1 above when playing streaming content,
5. No device data output, e.g. USB, during passenger use. Such outputs are acceptable for content loading and maintenance under secure administrative authorization,
6. Any content stored on a device shall remain encrypted while at rest and any content keys shall be stored physically separate from the encrypted content,
7. All content rendering shall occur in a Trusted Execution Environment which includes all of the following:

7.1. The device must implement a set of security features to enable protection of media content rendering path on the device, such that content decryption to decode, decompression and rendering/output to external links, is protected from unauthorized software and hardware components,

7.2. The device must implement a set of security features to enable robust DRM implementations to protect assets such as usage policy, account info, DRM application secrets and keys which allow media access,

7.3. Device Security features and assets must be protected against tampering and modification by other unauthorized software and hardware components controlled by unauthorized software on the device,

8. Other than the operating system or other required low level system applications, only airline authorized applications shall be accessible on the device,

9. Streaming of premium content to a device via Wi-Fi, if available, shall only be allowed over a secure and private local network connection to the on-board aircraft server. Note, there is no Wi-Fi restriction if premium content is not selected for playback,

10. Any airline supplied portable device shall be housed in a tamper resistant case that allows for unique identification from similar publically available versions of the device.

8 OTHER CONSIDERATIONS

8.1 Metadata

To allow automated generation of passenger GUIs, A/V content attribute metadata should be provided for, at a minimum, title, credits, synopsis, ratings, promotional material, and key art. Audio only content attribute metadata should be provided for, at a minimum, title, credits, lyrics, ratings and key art.

The following metadata formats are applicable to content meet the requirements of this specification:

- MPEG-7 (ISO/IEC 15938, Parts 1-11), including XML (Worldwide Web Consortium Recommendation: XML 1.0, Fourth Edition)
- MPEG-21 (ISO/IEC 21000, Parts 1-17)
- Cable Television Laboratories, Inc., (CableLabs) Video-On-Demand Metadata Specifications, Version 1.1 (CableLabs Asset Distribution Interface Specification, Version 1.1, and CableLabs Video-On-Demand Content Specification, Version 1.1)

All files and metadata associated with particular content should include a corresponding UUID content identifier. There is a dedicated field in MPEG-4 for carrying a content ID.

The Entertainment ID Registry (EIDR) and the International Standard Audiovisual Number International Agency (ISAN-IA) support seamless registration of content IDs in either of their namespace systems. The workflows used for most Hollywood productions currently support the EIDR system. The EIDR system is accessible via a web UI, as well as through available SDKs that access the EIDR web services APIs.

8.2 Content Source Media

Recommended source media for the A/V content encoding process include:

- One content release, HD 1920 x 1080 resolution, language tracks with digital audio,
- One content release, HD 1280 x 720 resolution, language tracks with digital audio,
- One content release, Full D-1 resolution, widescreen (16:9, 4:3) SDTV format, language tracks with digital audio,
- Promotional material, Full D-1 resolution, widescreen (16:9, 4:3) SDTV format, language tracks with digital audio,

- Key art files, JPEG format,
- A metadata file containing content description information (e.g., title, credits, synopsis, ratings and other metadata).

Recommended source media for the audio only content encoding process include:

- Audio programs with Hi-Fi audio,
- Key art files, JPEG format,
- A metadata file containing content description information (e.g., title, credits, lyrics, ratings and other metadata).

8.3 Quality

Compliance with this specification does not guarantee acceptable quality of the encoded media, and does not replace the need for skill and judgment in the art and science of motion picture and video postproduction laboratory practices. Nothing in this specification is intended to replace normal content provider quality assurance processes.

8.4 Intellectual Property Disclaimer

The intention of this specification is to only require the use of intellectual property that meets the ISO/IEC/ITU guidelines for inclusion of intellectual property in international standards, which, paraphrased, requires licensing of intellectual property on a fair, reasonable and non-discriminatory basis. It is the responsibility of parties implementing this specification to ensure they obtain necessary licenses for use of intellectual property used in their implementation.

This specification is based on material submitted by various participants during the drafting process. APEX has not made any determination whether these materials could be subject to valid claims of patent, copyright or other proprietary rights by third parties, and no representation or warranty, expressed or implied, is made in this regard. Any use of or reliance on this document shall constitute an acceptance thereof "as is" and be subject to this disclaimer.

8.5 Subtitles and Closed Captions for Video Files

This document describes the proposed standard digital media encoding requirements for interchange of Subtitles and Closed Captions for caption-capable IFEC systems.

8.5.1 Closed Caption and Subtitle Feature Overview

Closed Captions and Subtitles for IFEC systems will be provided in the Scenarist DVD authoring format for subtitling. This format consists of a combination of TIFF images and a display schedule file with time-on/off for each CC/Subtitle image. The requirements for this delivery or interchange format are outlined in this section.

It is expected that an IFEC system will post-process this interchange format into another format usable internally. The use of this interchange format makes the delivery of Captions and Subtitles independent of the encoding format (refer to Section 4) and transport format (Section 6) of the ultimate video file or stream.

Future: Closed Captions and Subtitles may be provided in DVB compliant TS file format; where the TS file includes the final versions of video, audio tracks and textual tracks. The requirements for this delivery format may be found in a future revision of this document, but would only be specific to one of the four Systems choices listed in Section 6.

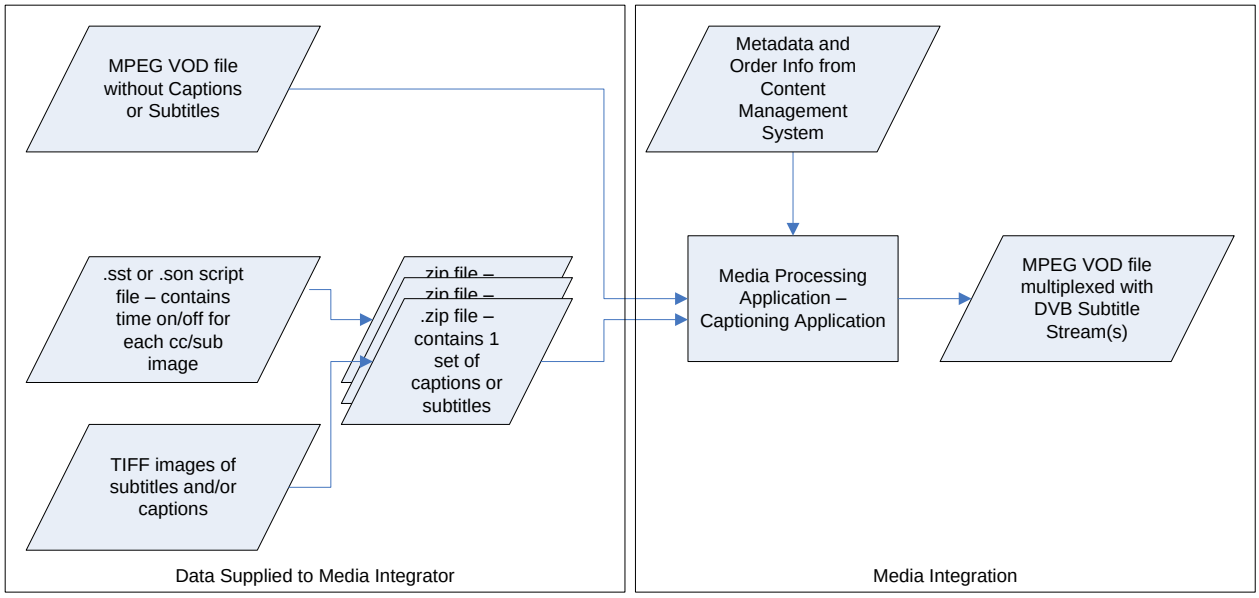

Figure 2: Captioning and Subtitling Process Flow

8.5.1.1 The supported subtitle and captioning streams may contain any language and any font. Since input requirement for captioning and subtitle streams is image-based, the IFEC system will support captioning and subtitles in any language, including Asian character sets, languages that read right-to-left as well as Western languages.

8.5.1.2 Up to 12 independent subtitle streams and closed caption streams shall be supported in a single file. For example, a single VOD file may contain 3 streams of captioning for the hard of hearing and 9 streams of subtitles for language translation purposes.

8.5.1.3 When supplying captioning and subtitles in the DVD subtitle authoring format, they shall be provided as a separate archive containing the timing and associated subtitle/closed caption images. The Media Integrator must provide the ability to integrate the DVD formatted captioning and subtitles stored in a Scenarist DVD authoring format into the multiplexed VOD file. The following sections describe the accepted Scenarist DVD authoring format.

8.5.1.4 Closed Captions and Subtitles File Format Specifications

8.5.1.4.1 The basic requirement for delivery of Closed Captions and Subtitles is the Scenarist DVD authoring format. It is a combination of TIFF images and a display schedule file with time-on/off for each CC/Subtitle image.

8.5.1.4.2 A separate zip file shall be required for each CC/Subtitle stream. The display schedule file and all corresponding images shall be compressed into a single zip file. In other words, if 3 languages are required, there shall be 3 separate zip files each with the complete set of files for one language.

8.5.1.4.3 The zip file shall be named as follows: <VOD_File_Name>_<CC/Sub_Language> <Caption_Type>.zip; where:

<VOD_File_Name> = the base name of the corresponding mpeg video file.

<CC/Sub_Language> = the ISO 639 3-letter code for this language

<Caption_Type> = CAP for captions for hard of hearing persons, SUB for subtitles for language translation

Example: AA0123M2_ENG_CAP.ZIP

8.5.2 Display Schedule File Format

The display schedule file shall be provided in a Scenarist compliant script file format, also known as ".sst" or ".son" files; a st_format 2 file type. Section 8.6 includes a sample of a display schedule file. Although other Scenarist fields/parameters may be included in the display schedule file, only the Base_Time and Tape_Type parameters are processed by the integration tools at this time.

8.5.2.1 Base_Time

Base_Time is a required parameter in the display schedule file. It represents the PTS of the start of the mpeg file and can be used to offset the display of the captions from the time codes shown in the schedule file. This value is specified as follows:

hh:mm:ss:ff

Where:

hh = 2-digit hours value of the PTS at the start of the video stream

mm = 2-digit minutes value of the PTS at the start of the video stream

ss = 2-digit seconds value of the PTS at the start of the video stream

ff = 2-digit frame number value after the start of the above specified second within the video stream (non-drop frame count)

Note: Typically, it is expected the Base_Time and PTS in the mpeg file will be 01:00:00:00 at the start of the mpeg file. In this case, the Time-On and Time-Off values, in the display schedule file, shall include this offset.

8.5.2.2 Tape_Type

Tape_Type is a required parameter in the display schedule file. It represents the type of timing used in the display schedule. Possible values are DROP for Drop Frame Time Code and NON_DROP for Non Drop Frame Time Code. Proper timing of the subtitles will depend on this parameter being defined properly; it must correspond with the type of time code used in the control file. An error in the value of this parameter will lead to a drift in the subtitle timing of 3.58 seconds per hour of video!

8.5.3 Image File Format

Both TIFF and BMP file formats are accepted. The following are specific image file parameter requirements:

- Width = 720 pixels, Height = 480 pixels. Note that the bitmaps will be stretched beyond the 3:2 aspect ratio to fit a given display. The fonts may be rendered with that in mind; however, in most cases one rendering should view fine both when display aspect ratio is 4x3 and when it is 16x9.
- Color Depth (bit depth) = 4bit (recommended) or 8bit
- Number of unique colors: 4 colors or less For example, 8 bit TIFF images can be accepted, as long as the color pallet includes 4, or less, colors.
- Color Representation = Palletized and RGB are both acceptable
- Compression = RLE and other similar TIFF compression types are supported
- The background color must be different from the other colors used for the fonts; all pixels equal to the background color will be made transparent when the image is displayed on the IFEC system.

Font sizes shall be based on a 32pixel height for a full size character, e.g. "[".

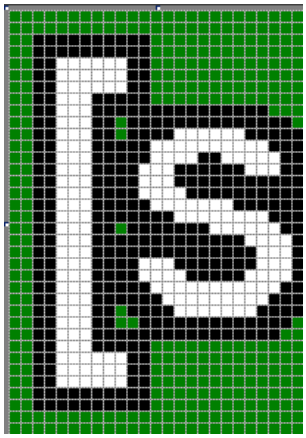

Figure 3: Pixel View of Captioning and Subtitle Characters

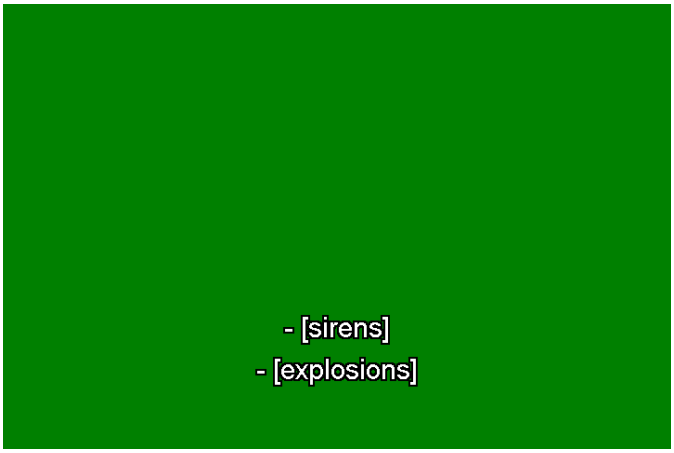

Figure 4: Example of Full Screen Caption Image

8.5.4 Timing Validation

It is expected that incoming media shall be validated for proper video-captioning synchronization prior to receipt by the Media Integrator.

8.5.4.1 For each image identified in the display schedule file, the Time On must be less than the Time Off.

8.5.4.2 For each image identified in the display schedule file, the preceding Time Off value must be less than the Time On value of the next image.

8.5.4.3 For each image identified in the display schedule file, the Time Off value must be at least 20 frames greater than the Time On value. That is, a minimum duration for a single subtitle is 20 frames. Durations less than 20 frames may not be displayed.

8.5.4.4 If the caption display schedule file was produced for DVD production, care is required to provide an adjusted Base_Time to align the timing to a new MPEG encoded movie file. Two common elements that introduce an offset are described in the following subsections, but others may be considered.

8.5.4.4.1 The file produced for a DVD may have the first subtitle cued in at 01:00:43:11, whereas the cue time in the new MPEG file will be 00:00:43:11. For example, where the DVD file lists the first subtitle in hour=1, instead of hour=0, a Base_Time of 01:00:00:00 will correct the misalignment.

8.5.4.4.2 The new MPEG encoded file might have 5 seconds of Black appended at its head or a content warning for example. For example, if the newly encoded file has 12 seconds of added footage then the Base_Time becomes 00:59:48:00 (1 hour minus 12 seconds)

8.5.4.5 In the absence of the ability to play the MPEG file and display or overlay the subtitles and verify synchronization, the following steps shall be followed to verify video-caption synchronization:

- Look at the first caption image file (.tif file) with a viewer.
- From the display schedule take the start time for that image and subtract the Base_Time (to arrive at the actual display time).
- Using a software media player, check the video and audio at the same point in the media file.
- Verify the initial caption is correctly aligned with the video.

8.6 Sample Subtitle and Captioning Display Schedule File

```
st_format 2
##############################################
#      Title :
#
#      English Subtitle File
#
#      Edited by :
#      Date : 070403
#
##############################################
# BG = Background color
# PA = Text foreground color (letter body)
# E1 = Antialiasing color
# E2 = Text border color
##############################################
Subtitle        ERCH
Tape_Type DROP
Display_Start   non_forced
Pixel_Area (2 479)
Display_Area (0 2 719 479)
Color (3 3 7 4)
Contrast (15 2 15 0)
BG   (0 255 0   = = = )
PA   (255 255 255   = = = )
E1   (0 0 0   = = = )
E2   (0 0 255   = = = )
directory C:\media\movie1
Base_Time       00:59:58:00
##############################################
SP_NUMBER     START        END       FILE_NAME
0001 01:00:30:12 01:00:35:08 eng0001.tif
```

```
0002 01:00:35:13 01:00:40:07 eng0002.tif
0003 01:00:41:17 01:00:44:08 eng0003.tif
0004 01:00:44:13 01:00:48:02 eng0004.tif
```

9 INFORMATIVE ANNEX: MEDIA ACCESSIBILITY OVERVIEW

9.1 Introduction

9.1.1 Captioning

There are millions of people worldwide that have a hearing loss so acute that they cannot fully understand the audio portion of A/V content. This is especially true of the elderly, the fastest growing category of individuals who are deaf and hard of hearing. Text captions enable viewers who are deaf and hard of hearing to understand the audio portion of A/V content. Captions can also benefit adults and children learning to read, as well as people learning second languages.

Like subtitles, captions display spoken dialogue as printed words on the screen. Unlike subtitles, captions are specifically designed for viewers who are deaf and hard of hearing. Captions are carefully placed to identify speakers, on-screen and off-screen sound effects, music, and laughter. Closed-captions are hidden as data within the A/V content's data package, and they must be decoded in order to be displayed. Open captions are imprinted as part of the A/V content's visual display and cannot be turned on or off.

9.1.2 Descriptive Narration

Descriptive narration is a service that makes A/V content accessible to people who are blind or who have low vision. Descriptive narration consists of a script written to highlight key visual elements that a viewer who is blind or who has low vision would ordinarily miss in the content (e.g., action, settings, costumes, gestures, and scene changes). The script is then voiced by a professional narrator, interspersing the descriptions between dialog so as not to interfere with the audio or dialog of the content. The descriptive narration track is then mixed with the original content audio track to create a new audio track that includes the descriptions. Such descriptive narration audio is delivered to users via a variety of technologies, depending on the platform: stereo television's secondary audio program for broadcast and cable distribution, selectable audio tracks for DVD distribution, and via infrared or frequency modulation systems in motion picture theaters.

9.1.3 Accessible Navigation

People who are blind or who have low vision have difficulty navigating on-screen menus, particularly those which employ touch screens. Solutions to overcome these difficulties are proposed in this annex that may help create a better passenger experience for those with visual impairments.

9.2 Captioning in IFEC systems

There are several techniques that can be employed to provide captioning in IFEC systems:

9.2.1 Parallel Content

For A/V content that is provided to IFEC passengers, it is possible to provide a parallel content library with open captions imprinted in the A/V content, allowing the deaf and hard of hearing to select from the library of captioned material.

If open captions are offered, they should be readable at a distance of 4.25 times the diagonal size of the display. Given the limitations of most IFEC screens (i.e., their limited size and close distance to the viewer), open captions should use the same process as subtitling, which provides readable characters while keeping most of the picture visible. This implementation also interferes less with the appearance of the A/V content.

9.2.2 Closed-Captioned Content

Alternatively, A/V content may be made available with closed-caption data. This data can take the form of line-21 data for analog content (CEA 608-D, "Line 21 Data Services") or digital television closed-caption data for digital content (CEA 708-C, "Digital Television Closed Captioning"). Line 21 closed-caption decoder technology is widely available as integrated circuits or software. Decoding could happen at the seatback, or could be centralized at an onboard server and accomplished in software for each passenger.

9.2.3 Subpicture Stream Technology

Captions are commonly provided for DVD titles as subpicture streams specifically authored for the needs of deaf and hard-of-hearing viewers. Similarly, an IFEC system could utilize such captions as subpicture streams and provide a passenger interface to allow for the selection of a given subpicture stream. The MPEG-4 format also supports text data in the stream file.

9.3 Descriptive Narration in IFEC systems

Care should be taken to provide descriptive narration audio that can contend with a noisy airborne environment by utilizing WAEA Specification 1289-2, Revision 3. Like captioning, several techniques can be employed to provide descriptive narration in IFEC systems:

9.3.1 Parallel Content

For A/V content that is provided to IFEC systems, it is possible to provide a parallel content library with descriptive narration, allowing the blind or low vision passenger to select from the library of described material.

9.3.2 Multiple Audio Tracks

A/V content may be made available for IFEC systems with multiple audio tracks, such as alternate languages or a descriptive narration audio track. The IFEC system provides a user interface allowing for the selection of a given alternate audio track, including the descriptive narration.

9.4 Accessible Navigation in IFEC systems

Most IFEC systems rely on graphical user interfaces, which typically include hierarchies of onscreen menus not readily usable by people who are blind or who have low vision. Accommodation of these users can be accomplished in a number of ways, or more often, using a combination of the following methods:

9.4.1 Tactile Controls

User handsets have tactile indicators ("nibs") on essential keys and differentiated key shapes (square, triangle, round) so that different functions are readily discernable.

9.4.2 Audible Feedback

The IFEC user interface can be programmed to provide audible feedback. Key elements include descriptions of positioning within the menu structure, available choices, navigation instructions, audible prompts, and audible versions of other key information on the screen that is otherwise only available to sighted users. When this feature is enabled as an option by user choice, audio files that enunciate the name or function of a menu, button or key press are automatically triggered as the user navigates the GUI. Such techniques are commonly referred to as "talking menus".

9.4.3 Speech Control

Where there are no tactile controls for IFEC navigation, speech-to-text solutions, if practicable and available, may allow the passenger to speak commands to the system to accomplish such tasks as moving the cursor and selecting menu items.

10 INFORMATIVE ANNEX: VIDEO QUALITY MEASUREMENT TOOLS

10.1 Introduction

Digital videos are subject to a wide variety of impairments during acquisition, processing, compression, storage, transmission, reproduction, and display, any of which may result in degradation of visual quality. The interaction between video content properties and display device capabilities along with viewing conditions play a pivotal role in the visibility of the impairments. For applications in which videos are ultimately to be viewed by human beings, the only "correct" method of quantifying visual image quality is through subjective evaluation. In practice, however, subjective evaluation may be too inconvenient, time-consuming or expensive. Objective video quality assessment tools automatically predict the quality assessment behaviors of humans viewing the video signals. Video quality assessment (VQA) methods have broad applications 1) in the evaluations and comparisons of the quality of videos and the performance of different video acquisition, processing, compression, storage, transmission, reproduction, and display methods and systems; 2) in the control, maintenance, streaming, and resource allocation of visual communication systems; and 3) in the design and optimization of video acquisition, processing, compression, storage, transmission, reproduction, and display methods and systems.

The bit rate parameters shown in Table 2 of Section 4 (Video Compression) are not necessarily prescriptive. Lower bit rates are permitted when considered methodologies are employed to ensure against any form of bit rate starvation. These methods shall specifically preclude delivery of files containing any normally, e.g., when viewed at played speed, perceivable impairment.

A variety of acceptable post-compression workflows exists which may include visual inspection, automated VQA, or a combination of tools and practices that enforce an automation-assisted quality control regimen. A diversity of VQA methodologies and their specific assessment thresholds are detailed below. It is expected that any "minor" (i.e., for SSIMplus 41 to 70) impairments in excess of 1/2 second shall be detected and addressed. Please note that this additive restriction applies even when the overall quality of the video is good and appears to be free of minor impairments.

ITU-R Recommendation BT.500-13 defines five-grade impairment and quality scales for the adjectival categorical judgment of perceptual video quality of television pictures. Considering the digital content delivery methodology for IFE systems, a two-grade impairment scale is used to differentiate between normally perceivable and non-perceivable impairments. For the purpose of establishing the impairment threshold that separates the grades, a set of 12 reference video files are created that span the good perceptual quality grade. Table 8 provides the details of the practical reference video files.

The unencumbered files can be downloaded from here <http://alturl.com/xa88c>.

10.2 SSIMWave Inc. - SSIMplus

http://ssimwave·com

SSIMplus, a state-of-the-art full-reference objective video quality-of-experience measurement algorithm developed by Professor Zhou Wang, et al. (https://ece.uwaterloo.ca/~z70wang/research/ssimplus/), has the unique capability to automate the control and management of video quality by accurately modeling the behaviors of human visual system in real time, considering the display device and viewing conditions. The algorithm provides straightforward predictions on what an average consumer would say about the quality of video content on a scale of 0 - 100 and categorizes the quality as either bad [0 - 20], poor [21 - 40], fair [41 - 60], good [61 - 80], or excellent [81 - 100]. Table 8 shows the reference video SSIMplus scores for the display and viewing condition profiles given in Table 7. The reference video files in the tables are meant to provide examples of acceptable perceptual video quality. Therefore, the perceptual quality threshold is chosen to be the video quality score of the file that has the lowest perceptual quality, considering the video properties, display device, and viewing conditions, as given.

Profile Name	Viewing	Display Resolution	Display Size	Display Brightness	Display Area

	Distance	(Width x Height)	(Diagonal)	[cd/m2]	
Economy	14	1920x1080	12	300	100%
Business	20	1920x1080	24	300	100%
First Class	30	1920x1080	32	300	100%
SSIMplus Core	Quantifies the perceptual quality of video content for normalized viewing conditions				

Table 7: Display Device and Viewing Condition Profiles

Video File Name	Resolution	Bitrate	SSIMplus QoE score [Economy]	SSIMplus QoE score [Business]	SSIMplus QoE score [First Class]	SSIMplus Core
APEX-TOS_01_480_60	720x480	0.9 Mbps	74	70	71	87
APEX-TOS_01_480_80	720x480	1.2 Mbps	77	73	74	89
APEX-TOS_01_480_100	720x480	1.5 Mbps	79	75	76	90
APEX-TOS_01_480_120	720x480	1.8 Mbps	80	77	78	91
APEX-TOS_01_720_60	1280x720	2.4 Mbps	87	84	85	92
APEX-TOS_01_720_80	1280x720	3.2 Mbps	89	86	87	93
APEX-TOS_01_720_100	1280x720	4.0 Mbps	91	88	89	94
APEX-TOS_01_720_120	1280x720	4.8 Mbps	92	89	90	95
APEX-TOS_01_1080_60	1920x1080	3.6 Mbps	90	87	88	90
APEX-TOS_01_1080_80	1920x1080	4.8 Mbps	92	89	90	92
APEX-TOS_01_1080_100	1920x1080	6.0 Mbps	94	91	92	93
APEX-TOS_01_1080_120	1920x1080	7.2 Mbps	94	92	93	95

Table 8: Reference Video Files SSIMPlus Scores

Video Quality Measure	Min Score	Max Score	Impairment Threshold	Overall Perceptual QoE desired value
SSIMplus	0	100	70	85

Table 9: Impairment Thresholds

10.3 Tektronix - Aurora

http://www·tek·com/file-based-validation-suite

Tektronix Aurora is an enterprise-grade distributed processing VQA tool commonly employed as a component of a larger workflow management solution. The following settings generally reflect this specification's intent, which is to preclude the possibility of allowing normally perceivable impairments. More specifically, the thresholds for delineation of non-perceivable impairments shown in Table 11 reflect approximations of three specific EBU QC Tests: visible macroblocking of 0.05 percent for three or more consecutive frames (test item 0023B), video blurriness equal to a QP > 40 in any frames that are non-frozen (test item 0050B), and any missing/non-coded information exceeding ten percent of the overall frame. More than 150 frames that have no change with no audio at the same time is likely a frozen frame. Frames that are black for more than 30 frames with no audio is normally an issue. Content exhibiting any of these characteristics should be flagged for further inspection.

Video Quality Measure	Test Number	Duration	Detection Threshold
Level 2 macroblocking artifacts	4001.002	3 frames	0.05% of frame
Quantization-based blurring	4007	3 frames	Quantization: 40
Macroblock missing information	1204	3 frames	10%
Freeze frames	4002.003	150 frames	Silence, ignore black
Black frames	4002.001	30 frames	Audio silence

Table 11: Aurora Thresholds

The DMOS-Tek (differential mean opinion score) measurement is in terms of objective picture quality scoring through a human visual model (HVM). The DMOS scoring is done with the full-reference video quality-of-experience measurement algorithm developed by Tektronix for measurement of all types of content taking into account viewing conditions, screen size and type and video resolutions through the HVM. This work references the Double Stimulus, Continuous Quality Scale (DSCQS See ITU BT.500) and the Tektronix Application Note (http://www.tek.com/document/application-note/objective-measurements-and-subjective-assessments-application-note). The PQA algorithm has the unique capability to model the ITU BT.500, providing the user the viewing and measurement conditions and tools necessary to control and manage the video quality of the finished product, considering the display device, display resolution, and viewing conditions. The ITUBT.500 scale is viewed on the PQA as a 100-point scale, where 0 is no impairment and 100 is worst case, based on the user provided worst-case model.

Video Quality Measure*	Min Score	Max Score	Impairment Threshold
SD PQA DMOS-Tek	0	100	20
HD 720 DMOS-Tek	0	100	20
HD 1080 DMOS-Tek	0	100	20

Table 10: Impairment Thresholds and Tests

* The PQA test takes into account screen size and resolution; a score of zero is best, and 100 is worst case.

10.4 Venera Technologies - Pulsar

http://www.veneratech.com

The Pulsar file-based automated QC tool from Venera Technologies, with its scalable architecture and ability to take advantage of all available server cores, either as a standalone tool or as an integrated component of systems such as Telestream's Vantage or Evertz's Mediator, provides rapid stream compliance and payload assessment information. The settings listed below provide for detection of perceivable impairments, fine-tuned for different file resolutions.

The detection of black frames is set at 150 frames, which would approximate 5 seconds of video loss that may be caused during transcode. The luma/chroma violations are included in the table to address signal legality issues, and the content must fall within the stated range (with a tolerance of a few points).

In regards to the detection of block artifacts, which is of main concern for various content resolutions and bit rates, Venera recommends the duration to be set at 3 frames. Per human visual systems (HVS), our persistence of vision is around 80-100 Milliseconds. If any degradation is below this threshold it will likely not be noticed, which results in recommending a frame count of 3.

Blockiness is a subjective check, meaning that different people can perceive the same picture differently. EBU blockiness definition (http://ebu.io/qc/items/0023B) states: "*There are many accepted methods to detect such artifacts which are optimized for detecting various specific artifacts. It should be noted that different tools will likely give different results when using this test.*"

Pulsar uses a threshold, based on its proprietary algorithm for detecting the blockiness. It is primarily based on the 'edge detection' algorithm; however, it also takes into account the other factors that could perceptually affect the blockiness, like brightness and ringing effect. An error will be reported if the measured blockiness is higher than the blockiness reporting threshold.

The sensitivity itself is a function of:

1. Blockiness reporting threshold (i.e., prominence of the block edges)
2. Number of blocks in the frame (which is covered with the blocks)

For lower sensitivity, the picture containing the higher percentage of blocks with more prominent edges will be reported as blocky. As the sensitivity setting increases, the picture containing the lesser percentage of blocks with lesser prominent edges will be reported as blocky.

In other words, as the sensitivity goes up:

1. The threshold goes down so that even less visible edges will be considered as edges.
2. The percentage block (with visible edges) threshold goes down so that the pictures with lesser affected area will be considered as blocky.

The blockiness sensitivity recommended below is based on analysis of the provided sample files to produce the optimum result.

Pulsar has a set of pre-configured ready-to-use 'templates' (APEX_480, APEX_720, APEX_1080), which incorporate the settings mentioned below (Table 13 – Pulsar Thresholds), along with compliance parameters stated in Table 2 – Parameters For MPEG-4 Settings. These templates provide the users with readymade, easy to use means of verifying file compliance and QoE. These templates will be modified and enhanced as the APEX standards evolve.

Content flagged by Pulsar templates as exceeding the detection threshold should be inspected manually, using the specific time-code and frame index provided in the Pulsar report.

File Resolution	Video Quality Measure	Bit Depth	Duration (Frame Count)	Min Level	Max Level	Tolerance
720x480						
	Black Frames	8	>150	16	n/a	n/a
	Luma Violations	8	1 Illegal Pixel:1%	16	235	2
	Chroma Violations	8	1 Illegal Pixel:1%	16	240	2
	Block Artifacts	n/a	3	n/a	n/a	Sensitivity: 2
1280x720						
	Black Frames	8	>150	16	n/a	n/a
	Luma Violations	8	1 Illegal Pixel:1%	16	235	2
	Chroma Violations	8	1 Illegal Pixel:1%	16	240	2
	Block Artifacts	n/a	3	n/a	n/a	Sensitivity: 3
1920x1080						
	Black Frames	8	>150	16	n/a	n/a
	Luma Violations	8	10 Illegal Pixel:5%	16	235	2
	Chroma Violations	8	10 Illegal Pixel:5%	16	240	2
	Block Artifacts	n/a	1	n/a	n/a	Sensitivity: 4

Table 12: Pulsar Thresholds

10.5 Interra Systems, Inc. – Baton

http://www.interrasystems.com/file-based-qc.php

Interra Systems' Baton is a leading enterprise-class, automated file-based QC solution used by global telcos, broadcasters, post production houses, IPTV and archiving companies working with file-based content. Baton has comprehensive quality checks, scalability, support for a wide range of media formats, and an intuitive web-based interface.

The threshold for checking audio and video contents are extremely flexible in Baton and provides the user the ability to set multi-severity for a single type of check. This feature is very helpful when users want to verify the same types of quality checks but for different restriction.

QC Test: Blockiness is a kind of noticeable distortion that is perceived as square pixel blocks in a video that is compressed using the lossy compression method (generally block based) with high compression rates. It mostly occurs when the video encoder cannot keep up with the allocated bandwidth for video, especially with fast motion sequences or quick scene changes. Perceived level 50 for 3 frames or defined duration for blockiness and blurriness should be checked for visual quality of the video. During digital ingest, a frame or field can be corrupted and Baton has an extensive list of checks under video dropout which can take care of them. Some of them are chroma dropouts, frame/field corruption, gray frames, boundary artifacts, unwanted frames, etc.

Video Quality	Threshold	Level	Persists	Related Settings
Blockiness	3 frames / duration	50	30% more than/ less than / between	Exclude black bars, in-depth analysis
Blurriness	3 frames / duration	50	30% more than/ less than / between	Exclude black bars, camera defocus, or compression-based.
Frame / field corruption (dropout)	0 frame / duration	Check	If persists for the defined threshold	
Freeze frames	150 frames /duration	Check	If persists for the defined threshold	Error filter: audio silence/minimum level / test tone
Black frames	3 secs / frames	Check	Lead-in / lead-out / during	Error filter: audio silence/minimum level / test tone
Video signal level	500 ms / frames	1.0 out of range	Acceptable level 8 bits	Exclude black bars

Table 13: Baton Profile Restriction

10.6 Manzanita Systems – Transport Stream Analyzer (TSA)

http://www.manzanitasystems.com/

Manzanita Systems, a DTS company, offers the Transport Stream Analyzer (TSA) product for analyzing and QC-ing transport streams. The set of APEX test files were examined by TSA and a configuration was created which provides a way to check similar files for quality issues. The APEX configuration includes video quality checks for blockiness, black frames, frozen frames, and luma or chroma level issues.

TSA uses a scale of 1-100 for setting the threshold on a picture-by-picture basis for reporting blockiness issues. A value of 40 provides a good threshold, pointing out issues in the lower rate streams. While the test streams did not contain any black or frozen pictures, a setting of 1 second was used in the APEX configuration. Finally, the check for luma and chroma levels outside of those allowed was included with a 2% error threshold.

The APEX configuration will be included with all future versions of TSA beginning with v6.1. This configuration is available from our technical support department, ManzanitaSupport@DTS.com. This configuration may be copied and modified for customization. Additional checks may be added to check other aspects of the transport stream.

11 INFORMATIVE ANNEX: ACRONYMS AND ABBREVIATIONS

A/V	Audio/Video
AES	Advanced Encryption Standard
APEX	Airline Passenger Experience Association *formerly* World Airline Entertainment Association [WAEA]
ARINC	Aeronautical Radio, Inc.
AVOD	Audio/Video On-Demand
CBC	Cipher-Block Chaining
CBR	Constant bit rate
CEA	Consumer Electronics Association
CP	Content Provider
CSP	Content Service Provider
dB	Decibels
DCMWG	Digital Content Management Working Group
DES	Data Encryption Standard
DR	Download Request
DVD	Digital Versatile Disc
FIPS	Federal Information Processing Standards
GUI	Graphical User Interface
HE-AAC	High Efficiency Advanced Audio Coding, now version 2
Hi-Fi	High-Fidelity audio with a frequency response of 20 Hz to 20 kHz at ± 3 dB
http	Hypertext Transfer Protocol
Hz	Hertz (cycles per second)
IC	Integrated Circuit
ID	Identifier

IEC	International Electrotechnical Commission
IETF	Internet Engineering Task Force
IFE	In-Flight Entertainment
IFEC	In-Flight Entertainment & Connectivity
IFES	In-Flight Entertainment Systems
IP	Internet Protocol
ISO	International Organization for Standardization
ITU	International Telecommunication Union
ITU-R	International Telecommunication Union - Radiocommunication
JPEG	Joint Photographic Experts Group
Kb	Kilobit
kHz	Kilohertz (one thousand cycles per second)
KMA	Key Management Authority
KMS	Key Management System
LC-AAC	Low Complexity Advanced Audio Coding
Mb/s	Megabit per second
MP2	MPEG-1 Audio, Layer 2
MPEG	Moving Picture Experts Group
OAR	Original aspect ratio
PPL	Postproduction Laboratory
RSA	A cryptographic algorithm invented by R. Rivest, A. Shamir and L. Adleman
RTC	Real-Time Clock
SAMI	Synchronized Accessible Media Interchange
SDTV	Standard Definition Television
SMPTE	Society of Motion Picture and Television Engineers
VC	Video Codec
WAEA	World Airline Entertainment Association (now the Airline Passenger Experience Association [APEX])
XML	Extensible Mark-Up Language

12 INFORMATIVE ANNEX: LIST OF PARTICIPANTS

This specification could not have been produced without the dedicated involvement of many individuals and companies. The following persons participated in the creation of this document by attendance at one or more meetings of the APEX EETWG and its predecessors in this work. Their company affiliation at the time of their participation is also given.

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