AIRLINE PASSENGER EXPERIENCE ASSOCIATION

APEX SPECIFICATION 0415

MEDIA & DEVICE IFE ECOSYSTEM SPECIFICATION

VERSION 1.0

Approved by Technical Committee 2017-06-14

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1 Foreword

The Encoding and Encryption Technologies Working Group (EETWG) is a working group established by the Airline Passenger Experience Association (APEX) and its standing committee, the Digital Content Management Working Group (DCMWG), with the objective of integrating the inflight entertainment industry's content delivery supply chain into the broader content delivery ecosystem(s) of the entertainment and media industries from which IFE deliverables are sourced.

The EETWG was launched on April 2015 and has conducted weekly web conference meetings during most weeks through May 2017. An in-person meeting was held on 24-25 May 2017 at Panasonic Hollywood Labs, Los Angeles, California. Membership was open to members of APEX as well as qualified subject matter experts (SMEs). This document is the result of consensus between participants.

This Specification and the EETWG build on previous standards produced by working groups and committees dating from the introduction of digital media to IFE uses in 1994. The preceding core standards are "APEX 0395: Content Delivery for Inflight Entertainment" and "APEX 0403: MPEG-4 Content Specification & Content Security Requirements for Airline Inflight Entertainment and Connectivity Systems". These standards were based on codecs and/or file formats that have been broadly superseded by the formats incorporated here.

An important factor in the evolution and integration of these specifications has been APEX's outreach to entities such as the Digital Entertainment Content Ecosystem (DECE), the Society of Motion Picture and Television Engineers (SMPTE), MovieLabs, and others, to establish relationships ranging from collaborative to formal liaisons.

The vision behind this effort is seen in the principles of digital asset management that maintain that deliverables for such content as theatrical motion pictures and television are created once, at the top of the supply chain, and are repurposed market-by-market from the original assets. The concept of an interoperable file format has been around for some time, but the concept of truly interoperable files gained the most traction when the Digital Entertainment Content Ecosystem (DECE) launched the Common File Format (CFF), now known as Common Format.

The cooperation, input, and collaboration of DECE in the activities of EETWG and development of this Specification have been invaluable.

MPEG-CMAF (ISO/IEC 23000-19) has further codified Common Format, and is now the single deliverable media format for all IFEC uses.

The related MPEG Common Encryption (ISO/IEC 23001-7 CENC) scheme established a DRM independent common set of encryptions. This APEX 0415 Security specification is built on top of APEX 0403 Security to support Enhanced content (UHD, HDR), PED content, and wireless upload of content to onboard IFEC systems.

Additionally, the work by the Society of Motion Picture and Television Engineers (SMPTE) on an international standard for the file-based interchange of multi-version finished audio-visual works, mezzanine files, known as the Interoperable Master Format (IMF) continues to gain adoption by studios. SMPTE's IMF Working Group has worked collaboratively and supportively with APEX for several years.

MovieLabs, the research and development organization of the major studios, codified Media Manifest which has become an essential element of delivering files from studios to retailers in the home entertainment market.

For automation of digital workflows and supply chain efficiency, MovieLabs recommends adoption of a suite of compatible standards and specifications. They cover core aspects of online distribution, including identification,

metadata, avails, asset delivery, and reporting. Developed and delivered through industry collaboration, these standards and technologies enable automation, cost reduction, and improved consumer experiences across the industry. Collectively, these are called the MovieLabs Digital Distribution Framework.

Major airlines are looking ahead to greater utilization of passenger devices (PEDs) in IFE. An important enabler of streaming to PEDs will be the Web Application Video Ecosystem (WAVE). Various initiatives will be involved in WAVE implementation, including CTA's Content Specification Task Force—that will identify requirements in content streams centered around the MPEG CMAF proposal—and the HTML5 API Task Force that will identify requirements for the HTML5 app environment on the device side.

This Specification includes an informative reference to trackable media identification and Ad-ID for the purpose of making advertising sales in IFE compatible with an emerging global initiative to enable cross-platform marketing of advertising.

The next steps beyond this Specification involve further outreach, including establishing IFE profiles in CMAF and IMF, and the establishment of cooperative workflows that support the utilization of interoperable assets and monetizable impressions throughout the supply chain.

Specific objectives include:

- Enabling content providers to deliver to IFE using established profiles, for example, in IMF and CMAF.
- Streamlining IFE workflows and reducing post-production activity by enabling the use of such tools as late-binding.
- Providing for the secure delivery of higher quality materials for use in IFE such as UHD and HDR.
- Providing for potential increased use of PEDs in IFEC.
- Enabling IFE providers a wide range of compliant parameters while supporting the concept of content providers delivering a single set of deliverables into the IFE space.
- Harmonizing IFEC media delivery with the current and emerging standards used to serve consumers. This will enable broader media use and availability.
- The development and publication of an open, voluntary technical specification that highlights 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.

While this specification includes profiles of security and quality level requirements, the ultimate decision to approve a profile/level falls on the content owner. Additionally, enhanced or premium or non-premium content is defined by each content provider as well as whether designated as Early Window or Late Window, in SD, HD, UHD with or without HDR format.

2 Scope

This specification describes an ecosystem for delivery and distribution of next generation IFEC content to passengers. As with the previous 0403 specification, 0415 describes minimum security requirements, format constraints, workflow recommendations and a single unifying file format. The specification utilizes the Common Media Application Format for Segmented Media (CMAF), as defined in ISO/IEC 23000 Part 19 (MPEG-A), as the single deliverable media format for all IFEC uses. CMAF utilizes standardized encoding and packaging of segmented media objects that is well documented and allows a wide range of delivery implementations without specifying any single one. This format supports IFEC embedded systems as well as airline-owned and passenger-owned (PAX) Portable Electronic Devices (PED) and is an appropriate foundation for new designs of dedicated IFE hardware.

3 Reference model

This specification is primarily intended for future generations of cabin networks.

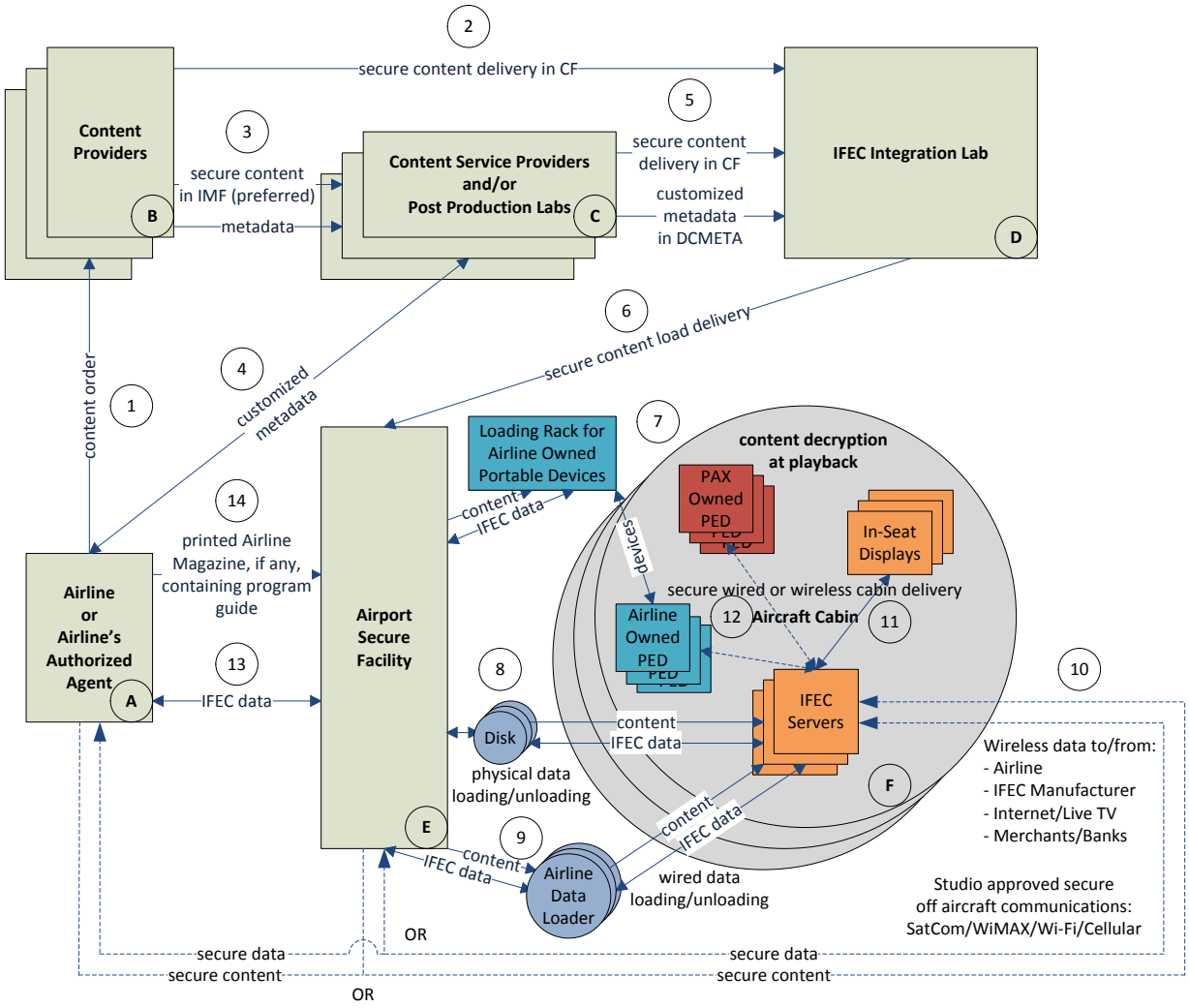

Figure 1: System Reference Model

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

A. Airline or Airline's Authorized Agent: Periodically, it selects appropriate content targeted to its passengers for each route.

B. Content Providers (CP): Movie, documentary, news, TV and radio programs, music, interviews, educational courses, games, map, etc. owners and licensors.

C. Content Service Providers and/or Post Production Labs (CSP/PPL): Encoding and transcoding houses, close captions and subtitles productions, metadata providers, encryption and multiplexing facilities.

D. IFEC Integration Lab: Storage management of IFEC servers, seats or airline-owned PEDs, passenger experience integration with available content.

E. Airport Secure Facility: Airline / service facility situated inside airport, as needed.

F. Aircraft Cabin: Equipped with IFE seat displays, passenger control units and IFE networks (wired or wireless) to consume available content. Airlines may instead provide airline-owned PEDs that may or may not require a Wi-Fi connection. Passenger may bring on board their own devices such as smartphones, tablets and notebooks and may expect similar services as available on the ground. Aircraft may use air to ground communication for data loading/unloading.

1. A Content Provider accepts an order from an Airline or from an Airline's authorized agent. The Content Provider elects content to be categorized as enhanced, premium or non-premium.

2. Content may be delivered directly to the IFEC Integration Lab in APEX 0415 Compliant CMAF from a Content Provider.

3. Or content and metadata may be delivered to a Content Service Provider (CSP) and/or Post Production Laboratory (PPL) with content preferably in an IMF format.

4. All content customized metadata required by the Airline's applications including the monthly magazine (containing the program guide) are delivered by the CP or by the CSP/PPL.

5. The CSP/PPL securely delivers to the Airline's IFEC Integration Lab all content (in APEX 0415 Compliant CMAF) and metadata (in DCMETA format), customized to airline requirements.

6. After any required content encryption and integration, the IFEC Integration Lab securely delivers content to an airline/airport secure facility.

7. Airline's maintenance personnel or authorized agents transfer content to airline-owned PEDs through loading racks. The airline-owned PEDs are then carried to the aircraft. Airline-owned PEDs play out the content for use by passengers with or without the use of secure wireless connections.

8. 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 and delivering them to the cabin.

9. Alternatively, airline's maintenance personnel or authorized agents transfer content updates to portable data loaders (PDL) that are carried to each aircraft for loading content to onboard IFEC servers.

10. If equipped, using studio approved secure wireless communications such as SATCOM, WiMAX, Wi-Fi or cellular standards. Other types of content and transactions are then facilitated such as bi-directional data exchange with Airline or IFEC Manufacturer, internet/live TV and Merchants/Banks.

12. The onboard IFEC servers deliver the content in APEX 0415 Compliant CMAF either over secure wired or secure wireless connections to in-seat displays for use by passengers.

13. PAX-owned PEDs may play out content if equipped with an airline approved application or player on their personal devices.

14. IFEC data, such as Built-In Test Equipment data (BITE), passenger usage information, passenger purchase orders, etc. may be uploaded 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.

15. Printed airline's magazines, if any, containing the periodic program guide are sent to the Airline's airport maintenance facility to be carried into the aircraft.

4 References

4.1 Normative references

- ISO/IEC 23000-19 Information technology - Coding of audio-visual objects - Part 19: Common Media Application Format for Segmented Media
  - http://www.iso.org
- TR-META-MPD Media Manifest Product Definition, v1.0
  - http://www.movielabs.com/md/manifest/product/
  - BP-META-MMMD Using Media Manifest, File Manifest and Avails for File Delivery (Best Practices), v1.2
- TR-META-MMIMF Using Common Media Manifest with Interoperable Media Format (IMF), v0.5a
- TR-META-CM
  - www.movielabs.com/md/md/v2.3/Common_Metadata_v2.3c.pdf
- ITU-R BS.1770-4 Algorithms to Measure Audio Programme loudness and true-peak audio level
- EBU R 128 Loudness Normalisation And Permitted Maximum Level Of Audio Signals
- EBU TECH 3342 Loudness Range: A Measure To Supplement EBU R 128 Loudness Normalization
- APEX Specification 0403 v3.0 "MPEG Content Specification & Content Security Requirements for Airline In-Flight Entertainment and Connectivity Systems"
  - http://apex.aero
- APEX Specification 0814 v1.0 Captions and Subtitles for Inflight Entertainment Systems
  - http://apex.aero
- EIDR- Entertainment Identifier Registry Association
  - http://eidr.org/technology/
- Ad-ID, LLC
  - www.ad-id.org
  - http://www.ad-id.org/how-it-works/ad-id-structure

4.2 Informative references

- ATSC A/85:2013 Establishing and Maintaining Audio Loudness
- UltraViolet Specifications and Schemas, System Release 2.4
  - http://www.uvcentral.com/specs\
  - http://uvcentral.com/page/ultraviolet-online-guide-homepage
- Technical Note on EIDR and UltraViolet
  - http://eidr.org/documents/Technical_Note_on_EIDR_and_UV.pdf
- How to use EIDR in UltraViolet
  - http://eidr.org/documents/FAQ_How_to_Use_EIDR_in_UltraViolet_2013-11-07.pdf
- EIDR Documentation Guide
  - http://eidr.org/documents/EIDR_Documentation_Guide.pdf
- EIDR Data Fields Reference Guide
  - http://eidr.org/documents

5 Media Objects

The format and specification of Common Media Application Format (CMAF) as described in ISO/IEC 23000-19 is hereby referenced and incorporated into this document. Media objects shall comply with the specification, and the further constraints defined by the IFE specific media profiles defined in Section 5.2.

CMAF defines the encoding and packaging of segmented media objects for delivery and decoding on end user devices in adaptive multimedia presentations. Delivery and presentation are abstracted by a hypothetical application model for segmented Media Objects described by a manifest that allows a wide range of implementations without specifying any. CMAF constrains media encoding and packaging to allow interoperable adaptive delivery to different devices, over different networks. CMAF does not specify a manifest, player, or delivery protocol, with the intent that any that meet the functional requirements can be used.

5.1 Media Packaging

CMAF Presentations contain sets of tracks comprising addressable video, audio, and subtitle objects.

5.2 Media Profiles

This section contains specific media profiles based on the requirements of IFE hardware.

5.2.1 IFE-SD Video Profile

The IFE-SD Media Profile defines a visual content profile for devices supporting standard definition (up to 576P) video encoded as AVC. This profile is based on the CMAF SD media profile as specified in ISO/IEC 23000-19 Annex A, and all requirements apply except as modified here.

5.2.1.1 Overview

The IFE-SD Media Profile is identified by the ‘ifsd’ four character code registered with [MP4RA]. The profile includes and is based on the constraints of Annex A, SD Media profile as detailed in CMAF.

5.2.1.2 Constraints on IFE-SD [AVC] Elementary Streams

5.2.1.2.1 Profile and Level

No additional constraints.

5.2.1.2.2 Bitrate

[AVC] elementary streams conforming to the IFE-SD Media Profile SHALL comply with APEX0403 video bit rate guidance.

5.2.1.2.3 Encoding Parameters

[AVC] elementary streams conforming to the IFE-SD Media Profile

SHALL be encoded as Constrained VBR. This is meant to effectively be a constant bit rate.

SHALL have an IDR frequency set to one on every key frame.

5.2.2 IFE-HSD Video Profile

The IFE-HSD Media Profile defines a visual content profile for devices supporting standard definition (up to 576P) video encoded as HEVC. This profile is based on the CMAF SD media profile as specified in ISO/IEC 23000-19 Annex A, with a change of codec to HEVC

5.2.2.1 Overview

The IFE-HSD Media Profile is identified by the ‘ifhs” four character code registered with [MP4RA].

5.2.2.2 Constraints on IFE-HSD [HEVC] Elementary Streams

5.2.2.2.1 Tier and Level

[HEVC] elementary streams conforming to the IFE-HHD10 Media Profile SHALL comply with the following [HEVC] Profile and Level constraints:

- Main Profile, Main Tier as defined in [HEVC]
- Up to Level 3 as defined in [HEVC].

5.2.2.2.2 Bitrate

[HEVC] elementary streams conforming to the IFE-HSD Media Profile SHALL be compatible to APEX0403 video bit rate guidance.

5.2.2.2.3 Encoding Parameters

[HEVC] elementary streams conforming to the IFE-HSD Media Profile

SHALL be encoded as Constrained VBR

SHALL have an IDR frequency set to one on every key frame.

5.2.3 IFE-HD Video Profile

The IFE-HD Media Profile defines an audio-visual content profile for devices supporting high definition (up to 1080p) video encoded as AVC. This profile is based on the CMAF HD media profile as specified in ISO/IEC 23000-19 Annex A, and all requirements apply except as modified here.

5.2.3.1 Overview

The IFE-HD Media Profile is identified by the ‘ifhd’ four character code registered with [MP4RA].

5.2.3.2 Constraints on IFE-HD [AVC] Elementary Streams

5.2.3.2.1 Profile and Level

No additional constraints.

5.2.3.2.2 Bitrate

[AVC] elementary streams conforming to the IFE-HD Media Profile SHALL comply with APEX0403 video bit rate guidance.

5.2.3.2.3 Encoding Parameters

[AVC] elementary streams conforming to the IFE-HD Media Profile

SHALL be encoded as Constrained VBR

SHALL have an IDR frequency set to one on every key frame.

5.2.4 IFE-HHD10 Video Profile

The IFE-HHD10 Media Profile defines an audio-visual content profile for devices supporting high definition (up to 1080) video encoded at 8 to 10 bits. This profile is based on the CMAF HHD10 media profile as specified in ISO/IEC 23000-19 Annex B, and all requirements apply except as modified here.

5.2.4.1 Overview

The IFE-HHD10 Media Profile is identified by the "ifhx" four character code registered with [MP4RA].

5.2.4.2 Constraints on IFE-HHD10 [HEVC] Elementary Streams

5.2.4.2.1 Profile and Level

[HEVC] elementary streams conforming to the IFE-HHD10 Media Profile SHALL comply with the following [HEVC] Profile and Level constraints:

- Main10 Profile, Main Tier as defined in [HEVC]
- Up to Level 4 as defined in [HEVC].

5.2.4.2.2 Bitrate

[HEVC] elementary streams conforming to the IFE-HHD10 Media Profile SHOULD comply with APEX0403 video bit rate guidance.

5.2.4.2.3 Encoding Parameters

[HEVC] elementary streams conforming to the IFE-HHD10 Media Profile:

SHALL be encoded as Constrained VBR

SHALL have an IDR frequency set to one on every key frame

5.2.5 IFE-UHD10 Video Profile

The IFE-UHD10 Media Profile defines an audio-visual content profile for devices supporting high definition (up to 2160) video encoded at 8 or10 bits. This profile is based on the CMAF UHD10 media profile as specified in ISO/IEC 23000-19 Annex B, and all requirements apply except as modified here.

5.2.5.1 Overview

The IFE-UHD10 Media Profile is identified by the "ifhu" four character code registered with [MP4RA].

5.2.5.2 Constraints on IFE-UHD10 [HEVC] Elementary Streams

5.2.5.2.1 Profile and Level

[HEVC] elementary streams conforming to the IFE-UHD10 Media Profile SHALL comply with the following [HEVC] Profile and Level constraints:

- Main 10 Profile, Main Tier as defined in [HEVC]
- Up to Level 5 as defined in [HEVC].

5.2.5.2.2 Bitrate

[HEVC] elementary streams conforming to the IFE-UHD10 Media Profile SHALL NOT exceed 20 Mb/s, with a default of 15 Mb/s.

5.2.5.2.3 Encoding Parameters

[HEVC] elementary streams conforming to the IFE-UHD10 Media Profile

SHALL be encoded as Constrained VBR

SHALL have an IDR frequency set to one on every key frame

5.2.6 IFE-HDR10 Video Profile

This IFE-HDR10 is based on SMPTE 2084.

The IFE-HDR10 Media Profile defines an audio-visual content profile for devices supporting high definition (up to 2160) 10 bit video with high dynamic range (HDR). This profile is based on the CMAF HDR10 media profile as specified in ISO/IEC 23000-19 Annex B, and all requirements apply except as modified here.

Note: UHD HDR content to be defined in a subsequent revision of this specification.

5.2.6.1 Overview

The IFE-HDR10 Media Profile is identified by the “ifhr” four character code registered with [MP4RA.

5.2.6.2 Constraints on IFE-HDR10 [HEVC] Elementary Streams

5.2.6.2.1 Profile and Level

[HEVC] elementary streams conforming to the IFE-HDR10 Media Profile SHALL comply with the following [HEVC] Profile and Level constraints:

- Main 10 Profile, Main Tier as defined in [HEVC]
- Up to Level 5.0 as defined in [HEVC].

5.2.6.2.2 Bitrate

[HEVC] elementary streams conforming to the IFE-HDR10 Media Profile SHALL NOT exceed 25.0 Mb/s, with a default of 20.0 Mb/s.

5.2.6.2.3 Encoding Parameters

[HEVC] elementary streams conforming to the IFE-HDR10 Media Profile

SHALL be encoded as Constrained VBR

SHALL have an IDR frequency set to one on every key frame

5.2.7 IFE-AAC Core Media Profile

The IFE-AAC Core Media Profile defines an audio content profile. The profile includes and is based on the constraints of Annex A, AAC Core Media profile as detailed in CMAF

5.2.7.1 Overview

The IFE-AAC Core Media Profile is identified by the "ifaa" four character code registered with [MP4RA].

5.2.7.2 Constraints on [AAC] Elementary Streams

5.2.7.2.1 Codec and Profile

[AAC] elementary streams conforming to the IFE-AAC Core Media Profile SHALL comply with the following [AAC] Codec and Profile constraints:

- AAC-LC or HE-AAC as specified in APEX0403, for mono or stereo programs.

5.2.8 IFE-IMSC1 Text Subtitle Media Profile

The IFE-IMSC1 Text Media Profile includes and is based on the constraints of Annex A, IMSC1 Text Subtitle Media profile as detailed in CMAF. Subtitles and captions shall otherwise be compatible with specification APEX 0814 "Captions and Subtitles for Inflight Entertainment Systems". Media files should minimally include closed caption files matching language tracks as required by law or regulation.

6 Audio Program Loudness and True-Peak

6.1 Overview

The audio parameters of IFE programs require constraint from a typical theatrical or quiet room listening mix. This may be achieved either in the mix room equipped to emulate the aircraft listening environment, or in source files provided for encoding or by audio processing during encoding.

The technical requirements indicated in this section are meant to allow the most engaging and pleasant listening experience to passengers, provided that full range, full dynamic, noise cancelling headphones are used. This is achieved by controlling several loudness parameters such as "Maximum Dialog/Program Difference" and "Maximum Loudness Range" as specified in the paragraphs below. In case frequency/dynamic range limited, non-noise cancelling earphones or in-earbuds are used, it is advised to apply further loudness adaptation to conform with the narrower comfort zone allowed by the lower quality electroacoustic transducer. This additional adaptation process can be performed either offline on a duplicated copy of the audio asset, thus appearing as an additional audio option in the device, or online, as a real-time audio process occurring in the seatback device or in the PED.

Dialog Level, as described in ATSC A/85, shall be used as the Anchor Element to measure and normalize overall audio average levels to Target Level, and to produce consistent average loudness across all content. When dialog is not present, Program Loudness should be used instead.

Furthermore, in order to supply the airline with quality audio content, the source program should be produced in accordance with the following requirements:

- Sampling rate 44.1kHz or 48kHz (or higher)
- Bit depth 16bit or 24bit (or higher)
- Frequency range 20Hz to 20kHz

When producing audio content, all requirements indicated in the parameters below should be entirely fulfilled. However, some tolerances are anticipated and accepted in order to allow minor measurement inconsistencies due to differences in dialog meters' detection and audio meters' resolution, and to facilitate QC operations.

6.2 Dialog Level

Dialog Level shall be normalized to a Target Level of -18 LUFS with a tolerance of ±1 LU, as measured per recommendation ATSC A/85. When dialog is not present, Program Loudness should be used instead to normalize the content to the Target Level of -18LUFS.

6.3 Maximum Program Loudness

All content shall have a Program Loudness level not greater than -15 LUFS as measured per recommendation ITU-R BS.1770-4. Note that this is a maximum allowed integrated Program Loudness level, not a target level, for content that is being normalized as per 6.2 using a Target Level at -18LUFS.

6.4 Maximum Dialog/Program difference

As a result of applying the requirements specified in 6.2 and 6.3, the allowed Maximum Dialog to Program difference is 3 LU, as measured per recommendations ATSC A/85 and ITU-R BS.1770-4, and with a tolerance of +1 LU.

6.5 Maximum Loudness Range

The allowed Maximum Loudness Range is 15 LU as measured per EBU TECH 3342-2016, and with a tolerance of +1 LU.

6.6 Maximum True-Peak

The Maximum True-Peak shall be constrained to -1 dBTP as measured per Recommendation ITU-R BS.1770-4

Note: “Program Loudness” is labeled “Programme Loudness” in ITU-R.BS1770-4 and in EBU R128.

7 Content identification

7.1 Content

Content Identifiers (CIDs) and Asset Logical IDs (ALIDs) shall be structured according to [DSYSTEM] v2.4, Section 5.

Content conforming to APEX 0415 SHALL NOT use the concept of "DECE Bundles" to identify composite groupings of content.

Asset Physical IDs (APIDs) defined in [DSYSTEM] are not applicable to content conforming to APEX 0415.

Please see the informative section of this specification for more details on the use of EIDR IDs with content conforming to APEX 0415. http://eidr.org/documents/Technical_Note_on_EIDR_and_UV.pdf

7.2 Advertisement

As opportunities for non-broadcast video advertising expand, the pace of efforts to standardize content identification systems accelerates.

The structure of the Ad-ID (and shortly the utilization within MPEG-CMAF) can be found at www.ad-id.org/how-it-works/ad-id-structure

For an overview of the latest trends and unifications currently underway, please see the informative section on advertising.

8 Security

APEX 0403 security still governs Content Transfer between Secure Facilities (Section 7.2), Non-Premium Content Security in IFEC systems (section 7.3) and Premium Content Security in IFEC systems (section 7.4) for 3 configurations: IFEC systems with in-seat displays over wired connections (section 7.4.1), IFEC systems with in-seat displays over wireless connections (section 7.4.2) and IFEC systems with airline owned portable electronic devices (section 7.4.3).

APEX 0415 is built on top of APEX 0403 security to support Enhanced content (UHD, HDR), PED content and wireless upload of content to on-board IFEC systems.

8.1 Levels of Security: Contents vs. Devices

The following table summarizes the minimum requirements.

	Enhanced (UHD, HDR)	Premium (1080p/720p/480p)	Non-Premium (1080p/720p/480p)
Wired Seat Devices	MPEG-CENC (see CMAF) Watermarking	*(see 0403, §7.4.1)*	*(see 0403, §7.3)*
Wireless Seat Devices	MPEG-CENC (see CMAF) Watermarking	*(see 0403, §7.4.2)*	*(see 0403, §7.3)*
Airline-owned PEDs	MPEG-CENC+DRM (see CMAF) Watermarking	*(see 0403, §7.4.3)*	*(see 0403, §7.3)*
PAX-owned PEDs	TBD	TBD	MPEG-CENC+DRM (see CMAF) Watermarking

Notes

- 0403 security for premium: AES-128, customized DRM per IFE manufacturer
- Secure delivery required for off aircraft connectivity
- Enhanced content, Premium content and related security are specified through bilateral agreements with airlines, IFE suppliers and content aggregators.

8.1.1 Common Encryption (MPEG-CENC)

MPEG-CENC (CMAF Requirement): AES-CBC encryption recommended with AES-CTR encryption optional

[CMAF] specification, Section 8, Common Encryption of Tracks.

CENC-MPEG systems technologies -- Part 7: Common encryption in ISO base media file format files (ISO/IEC 23001-7:2016).

8.2 DRM

Use of commercial Digital Right Management systems, if any, shall be required and approved by each content owner through bilateral agreements with airlines, IFE suppliers and content aggregators.

8.3 Forensic Watermarking

When required by bilateral agreements, watermarking technology should minimally meet the following requirements:

1. Watermarking shall be imperceptible to the passenger.

2. No audio, closed caption, or subtitle watermarks are required for airlines licensed content.

3. The level of traceability provided by watermarking may vary from identifying:
   - Level 1: particular airlines licensed content,
   - Level 2: the instance based on flight number and date,
   - Level 3: the session to a seat and/or device that the content was played on.
4. The above level of watermarking required will be defined by each content owner.

5. Session based watermark processing shall be done in a Trusted Execution Environment (TEE) and approved by each content owner.

6. The robustness of the watermark shall resist to the following attacks:
   - Camcorder capturing (straight or with offset angle),
   - Image rotation, cropping, blurring and stretching,
   - Adding noise, quantization, temporal modifications and MPEG compression.

8.4 Visible Watermarking

Visible watermarking is defined in APEX Recommended Practice 0210, "Visible Watermarking Best Practices", Version .9, July 26, 2010.

8.5 Wireless Content Loading

Wireless loading of content to on-board IFEC systems could be performed through SATCOM, WiMAX, Wi-Fi and cellular at the gate or in the air. Wireless transfer of content and security keys between airlines and aircraft cabins shall comply with the following security requirements:

- Enhanced, premium, and PED content shall at all times remain encrypted in AES-128,
- Each unique content key shall at all times remain encrypted in RSA-2048,
- Content keys and content shall be sent through separate encrypted secure private channel,
- Each secure client on the airlines side shall use a different client computer with a different certificate.

9 Informative Annex- Technical

The information included in this annex is meant to help in understanding the relationship to industry standards and guide implementations.

9.1 Audio Bitrate Recommendations

In the past years, several independent subjective listening assessment tests have been performed by various international organizations including EBU, ITU, AES and ISO/IEC, and with the goal to determine what is the minimum bitrate required for providing transparent audio quality resulting after a lossy encoding/decoding pass (MUSHRA rating). Amongst others, AAC, HE-AAC and HE-AAC v2 codecs were tested. The table below is the result of averaging the indicated recommended minimum bitrate officially published by those organizations. Mono, Stereo and Multichannel 5.1 formats, with sampling rate at either 44.1kHz or 48kHz, are specified and for each of the supported APEX audio codec*.

CODEC	AUDIO FORMAT	SAMPLING RATE	MINIMUM BITRATE
AAC-LC	MONO	44.1 kHz	64 kb/s
AAC-LC	MONO	48 kHz	72 kb/s
AAC-LC	STEREO	44.1 kHz	128 kb/s
AAC-LC	STEREO	48 kHz	144 kb/s
AAC-LC	MULTICHANNEL 5.1	44.1 kHz	284 (426**) kb/s
AAC-LC	MULTICHANNEL 5.1	48 kHz	320 (480**) kb/s
HE-AAC V 1/2 *	MONO	44.1 kHz	58 kb/s
HE-AAC V 1/2 *	MONO	48 kHz	64 kb/s
HE-AAC V 1/2 *	STEREO	44.1 kHz	96 kb/s
HE-AAC V 1/2 *	STEREO	48 kHz	110 kb/s
HE-AAC V 1/2 *	MULTICHANNEL 5.1	44.1 kHz	148 (220**) kb/s
HE-AAC V 1/2 *	MULTICHANNEL 5.1	48 kHz	160 (240**) kb/s

** Please notice that in "ISO/IEC JTC 1/SC 29/WG 11N7137", published by ISO/IEC in 2005, as well as in "EBU Technical Review: MPEG HE-AAC v2 – audio coding for today's digital media world", published by EBU in 2006, it is reported that HE-AACv2 produces benefits only at very low bitrate, while for bitrate higher than 48 kbps it performs as good as HE-AACv1. This evidence seems to suggest applying the same minimum bitrate recommendation to both HE-AACv1 and HE-AACv2.*

*** For multichannel 5.1 encoding, some critical audio samples would require higher bitrate in order to be encoded/decoded transparently. Values indicated in parenthesis are recommended for guaranteeing transparent audio quality for all content.*

Official reference documents include:

- AES CP4740 Subjective Evaluation of State-of-the-art 2-channel Audio Codecs
- ITU-R.BS.1196-5: Audio coding for digital broadcasting
- ITU-R.BS.1548-4: User requirements for audio coding systems for digital broadcasting
- EBU tech3324: Evaluation of Multichannel Audio Codecs
- EBU Tech Review: MPEG-4 HE-AAC v2 – audio coding for today's digital media world
- ISO/IEC JTC 1/SC 29/WG 11N7137: coding of moving pictures and audio
- AES 17 Conference: mp3 and AAC explained

9.2 Delivery Targets for Specific Operations

This section lists two delivery target types for IFE use in specific operation workflows.

9.2.1 Simple

This is a package containing a single profile. Suitable for delivery to end users.

9.2.2 Complex

A collection of profiles that enable multiple device types. Ideal for re-packaging operations.

9.2.3 Re-packaging

The process of extracting a specific profile from a complex set, and creating a simple package. The new package has a manifest listing only the elements included.

9.3 Video Quality Measurement Process and Tools

9.3.1 Overview

The Quality methodology and guidelines in APEX 0403 apply here. Info on one QC tool suite is updated below.

9.3.2 Venera Technologies – Pulsar/Quasar/Nima

http://www.veneratech.com

Venera Technologies provides three different QC systems, depending on user's platforms and needs, to satisfy the QC requirements defined by APEX. These systems enhance and augment the Venera Technologies functionality stated in APEX 0403 specifications document. Please refer to the APEX 0403 – section 10.4 for details of Venera support for APEX defined specifications.

Pulsar is the 'on-premise' file-based QC system that supports the APEX specifications. It provides a series of pre-canned APEX "templates" (profiles) to QC media content and to verify compliance with APEX 0403 and 0415 specifications. With these templates, the QC process is simplified dramatically as little time is needed to define what needs to be checked and more on the results of the QC.

Quasar is the first 'native' cloud based file-based QC system, with similar QC functionality as Pulsar. And similar to Pulsar, Quasar provides support for APEX 0403 and 0415 specifications. The same pre-canned templates have been ported to Quasar. For the users who have moved their file-based workflow to the cloud, using Quasar to QC their content would allow them to continue working in the cloud and avoid dealing with on-premise tools.

Nima is a reference-based quality of experience scoring system, offering the advanced capabilities to score a media content in comparison to a source media file. It provides the user with the advantage of quickly and easily verifying that many variations of a media file (e.g. different bit rates, different resolutions), provide user experience similar to the original/reference file. The many variations may be due to creation of multiple Adaptive Bit Rate (ABR) variants, or needing other derivatives of the main source media file. Nima supports and incorporates various industry standard quality scoring technologies to provide the user with the ability and flexibility to choose the technology of their liking. Nima has the flexibility to include additional scoring technologies as they become available.

9.4 Advertisement

9.4.1 Trackable Media identification

Mainstream advertisers around the world adhere to the principles of good conduct expressed in the Minimum Standards for Media Rating Research as set forth by the Media Rating Council (MRC). The commonly accepted mechanisms that protect against measurement bias impose specific content identification delivery and tracking system requirements. The current ATSC candidate standard for content metadata recovery employs an audio watermark called VP1. This system, also known as 'Aspect', is optimized for live TV and is not designed to convey MRC compliance accreditation on its own. Forthcoming standards from SMPTE support both live and on-demand workflows and will help close that accreditation gap. Without that helpful unification, on-demand system implementers and service providers are typically obliged to build proprietary systems for measuring audience impressions. These systems are regularly submitted to the MRC for review and accreditation on a case-by-case basis.

9.4.2 Ad ID

Some well-known agreements require that professionally produced commercial messages be registered with Ad-ID, LLC. This mirrors the existing global adoption of EIDR and ISAN for identification of long-form content. Expansion of the infrastructures that support these systems is underway. In the future, all mainstream advertisements will automatically be delivered with an Ad-ID identifier in the form of a SMPTE OBID audio watermark. Until that time, a prudent content delivery automation alternative is to employ SMPTE RP-2092 to extract the Ad-ID value from the MXF Ad-ID Digital Ad Slate.

9.4.3 Ads customized for IFE vs. other media

Customized infomercials, mid-program promotional consideration announcements, billboards and product placements are typically tracked by EIDR Manifestation IDs rather than by issuing multiple Ad-ID values. In a parallel manner, short-form commercial spots are commonly exchanged using MXF and DPP packages rather than IMF packages.

9.4.4 An introduction to cross-platform marketing

In response to search engine-based advertising, Madison Avenue has established a number of new standards, specifications and spot advertising practices. Taken together, these published and pending initiatives describe an agile landscape where real-time bidding systems can dynamically determine the market value of this new cross-platform media currency.

The TAXI initiative of the Coalition for Innovative Media Measurement established the validity of coordinated advertising campaigns that combine Internet advertising with traditional broadcast ad placement. WideOrbit and ClusterTV are merely two examples of existing systems that provide coordinated cross-platform ad placement on a just-in-time basis.

9.4.5 Technology in transition

SMPTE OBID has passed the technology selection phase. While broadcasters await the firmware updates that add support for this newer content identification standard, some are already deploying cross-platform interactivity trials based on the ATSC's VP1 watermark. The following table provides a brief comparison of the VP1 and OBID feature set. A historical survey of prior North American audience measurement practices was presented at the SMPTE 2016 fall conference.

9.4.5.1 Two Types of Broadcast Watermarks

Both of these inaudible audio watermarks can convey standardized content identifiers. Please note that the ATSC ecosystem depends upon Internet connectivity; SMPTE OBID does not.

9.5 CMAF

Note that with regard to Manifests, CMAF supports two different Manifest formats that can be referenced: HLS m3u8 and DASH .mpd

9.6 IMF – APEX IMF OPL

Content prepared for use in IFE that originates in IMF SHOULD include a Media Manifest that will support conversion from IMF to CMAF using appropriate IMF OPL. CMAF files produced in this manner SHALL support late binding. Guidance for producing updated files is included in [BP-META-MMMD].

Steps for converting from IMF to CMAF:

IMF	Source format (Interoperable Master Format)
CPL	One or more playback sequences (IMF Composition Playlist, SMPTE ST 2067-3)
CMAF Profile/Target	One or more desired playback profiles (SD, HD, UHD, etc.) and targets (streaming, download, etc.)
OPL	One IMF output profile per CMAF Profile/Target (IMF Output Profile List, SMPTE ST 2067-100)
Transform/Output	**Process CPLs/OPLs to produce sets of single-track CMAF files (video, audio, subtitles) for each Profile/Target, plus ancillary files.** This step includes encryption, using CENC. See [BP-META-MMMD].
CM	Produce a Common Manifest per CMAF Profile/Target. *Note: CMAM has the ability to reference IMF CPL/OPL tracks directly, per MovieLabs TR-META-MMIMF (Using Common Media Manifest with Interoperable Media Format [IMF]), but such CMs are not directly playable by consumer-oriented applications. CAFM files referencing IMF CPL/OPL may be useful input to the Transform/Output step. The CMs indicated here should reference CMAF files, which are directly playable by consumer-oriented applications.*
CMP	Collect files from Transform/Output process into CMP
Distribution	Distribute CMPs to storage/playback environments. (Separately distribute keys through high-security channels.)

10 Informative Annex- Acronyms and Abbreviations

ACF	APEX Content Format, any format specified in this document
AVC	Advanced Video Codec, H.264, MPEG-4 Part 10
BITE	built-in test equipment
CMAF	Common Media Application Format as in ISO/IEC 23000 Part 19 (MPEG-A)
Constrained VBR	VBR mode settings that approximate a constant bit rate data flow
CP	Content Providers
CSP	Content Service Provider
DCMETA	Movie Labs metadata specification
HEVC	High Efficiency Video Codec, H.265, MPEG-H
HSD	HEVC-encoded SD
IFEC	Inflight Entertainment and Communications
IMF	Interoperable Master Format, SMPTE ST 2067-2)
MP4RA	MPEG4 Registration Authority
Pax	passenger(s)
PDL	portable Data loader
PED	Portable Electronic Device
PPL	Post Production Labs
SD	Standard definition video up to 576 vertical samples. Commonly 720 x 480 in NTSC

Content Types (see section 9)

Non-premium

Premium - requiring greater security protections

Enhanced (HD, UHD) - even more security

11 Informative Annex- List of Participants

Bill Baltra	Sky Definition Aero System
Andrew Beer	spafax hub
Sam Carswell	Zodiac Aerospace
Michael Childers	Lufthansa Systems
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Brian Evetts	American Airlines
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Geffrey Fischer	Delta Airlines
Eric Grab	Disruption Wave
Stuart Guest	Panasonic Avionics
Greg Henigman	Fotokem
Victor Hernandez	Thales InFlyt Experience
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Albert Koval	DECE
Swapan Kumar Kundu	Ittiam
Avis Landrum	American Airlines
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Dirk Ottens	Lufthansa Systems
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Andy Rosen	Sequence Key
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Bryan Rusenko	APEX Technical Director, Consultant
Sander Saares	Axinom
Rich Salter	FTS Technologies
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Randy Schwarz	Panasonic Avionics
Gordon Shelhon	American Airlines
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Gregory Taieb	Paramount Pictures
Jim Taylor	DECE
Alessandro Travaglini	The Telos Alliance
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