ATSC Recommended Practice: Delivery of ATSC 3.0 Services for Redistribution

A/371:2026-04

14 April 2026

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Revision History

Version	**Date**
Recommended Practice approved	7 November 2025
A/371:2026-04 (references to ATSC documents updated)	14 April 2026

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1. SCOPE

1.1 ATSC 3.0 Introduction

ATSC 3.0 is an Internet Protocol (IP) based over-the-air (OTA) television transmission system that can deliver multiple, high-quality Services using advanced and highly efficient video and audio codecs. HEVC [1] video encoding is specified with a wide range of scan and frame formats of up to 4K Ultra HD resolution. In addition, High Dynamic Range (HDR) and Wide Color Gamut (WCG) video are supported. AC-4 audio [36] is specified for North America, providing immersive surround sound capabilities and multiple presentations supporting audio description and various languages in immersive surround with viewer-controlled audio dialog enhancement.

ATSC 3.0 over-the-air receivers (TVs) require Metadata – or signaling, from the OTA transmission to allow them to discover the TV Service within the transmission channel and to demultiplex ATSC 3.0's Dynamic Adaptive Streaming Over HTTP (DASH) or MPEG Media Transport (MMT) [2] segments for reconstruction and display. This signaling also carries information required for content security and service protection. An ATSC 3.0 transmission is an object-based transport that provides receivers with organizational details to quickly find and display the viewer's selections.

Although all these capabilities are integral to over-the-air transmission, many are superfluous for redistribution. Downstream systems use similar but uniquely different forms of transport technology matched to their platforms. For example, each retransmission system likely supports the functions of ATSC 3.0's Service signaling, content security, transport segmentation, and captioning, utilizing different approaches.

1.2 Direct Feed Introduction and Background

This Recommended Practice describes methods for transporting ATSC 3.0 Services for Redistribution, including both Direct Feed distribution and OTA delivery, ensuring smooth distribution to service operators such as MVPDs, Virtual MVPDs and other similar service providers (e.g., Use Case 4) referenced herein as (v)MVPDs. In this framework, content feeds such as those managed by STLTP [3], DSTP [3], and Essence handlers play a critical role, facilitating the secure and seamless delivery of ATSC 3.0 content to service operators. Additionally, this practice incorporates OTA delivery as a failover mechanism, enabling (v)MVPDs to maintain access to ATSC 3.0 Services in the event of primary distribution interruptions, ensuring high signal quality for downstream distribution to end-users. While this recommended practice is intended to cover all ATSC 3.0 features and how they may be delivered to a (v)MVPD by OTA reception or by Direct Feed, not all (v)MVPDs have the ability, for technical reasons, to carry all ATSC 3.0 features described here. Such situations are often subject to commercial agreements, which are beyond the scope of this document.

Familiarity with the ATSC standards outlined in the A/300 [4] ATSC 3.0 System Standard is assumed, as it provides an overview of the entire ATSC 3.0 system and defines the normative requirements for the incorporation and use of its various subsystems within the broader broadcast framework.

This document introduces features that extend beyond what the existing A/370 [5] recommended practice offers, enabling ATSC 3.0 broadcasters to maintain the highest-quality video, audio, and captioning Essence. It also describes support for the secure and efficient delivery of additional data, such as interactive features, targeted advertisements, and metadata that enhances viewer experiences by providing program-related information like enriched content descriptions, viewing history, emergency alert information, and accessibility services, including multiple language options and audio descriptions. These enhancements ensure that the broadcast content remains rich in quality while being adaptable to the diverse needs of service providers.

1.3 Use Cases and Scope of Recommendations

This document provides recommended practices for managing ATSC 3.0 services for redistribution across various service operators. The distribution of ATSC 3.0 services is coordinated through three primary handlers — STLTP, DSTP, and Essence handlers — each tailored to meet the specific requirements of the target operator.

While these handlers prioritize Direct Feed service delivery, OTA broadcasting remains continuously available as an alternative feed. If the Direct Feed encounters any issues, the service operator can rely on OTA as a fallback, ensuring uninterrupted service and continued content availability for end users.

At the same time, OTA broadcasting may serve as the primary method for delivering services, with Direct Feed available as a backup. If the OTA signal experiences any disruptions, the service operator can switch to the Direct Feed to maintain content delivery. This dual approach ensures that OTA is the primary option, with the Direct Feed always ready to step in when needed, providing a seamless service experience for end users.

Several use cases demonstrate the role of these handlers in content delivery and the fallback to OTA when necessary:

- **Use Case 1: Direct Feed of ATSC 3.0 services to (v)MVPDs**
  A Direct Feed provides an IP data stream directly from a broadcaster to a (v)MVPD typically using a reliable Wide Area Network as the distribution system. Depending upon the needs of the (v)MVPD, different types of data streams may be used as described below.
  - **Use Case 1-1: STLTP Handler**
    The STLTP handler manages the Direct Feed delivery of ATSC 3.0 services. Optimized for low-latency, high-efficiency IP transmission, STLTP outputs the stream from the Broadcast Gateway, ensuring that video, audio, signaling, and other data are delivered intact while maintaining service quality and protection.
  - **Use Case 1-2: DSTP Handler**
    The DSTP handler operates with the Packager. The DSTP handler ensures secure delivery of video, audio, and metadata directly from the Packager, allowing the service operator to manage the stream efficiently within their system.
  - **Use Case 1-3: Essence Handler**
    When the content needs to be handled in a modular format, the Essence handlers are used to distribute separate components of video, audio, and metadata streams from the Encoder. This setup allows flexibility in how the service operator processes each part of the content, enabling more efficient content management and customization. The Essence refers to the core audio, video, and captions content within ATSC 3.0-compatible broadcast systems. The Essence Handler manages these streams — such as audio, video, and captions, typically in formats like HEVC for video, AC-4 for audio, and IMSC1 for captions — directly from the encoder, before they are encapsulated into transport protocols like ROUTE/DASH or MMTP and thus limited by constraints in

ATSC 3.0. The Essence Handler processes and readies the streams for Direct Feed to the (v)MVPD. Content flows seamlessly to the (v)MVPD, where it's prepared for final distribution to end-users, ensuring that essential elements reach audiences with precision and quality.

  - **Use Case 1-4: SCTE DVS Handler**
    The SCTE DVS Handler performs the same functions as the Essence Handler, but in compliance with the document SCTE 277 2024: "Linear Contribution Encoding," [6] enabling delivery of higher quality, mezzanine-like formats.

- **Use Case 2: Over-the-Air (OTA) Distribution as a Backup**
  OTA broadcasting operates independently and remains available as a fallback signal. While the Direct Feed is prioritized, the service operator can utilize the OTA signal if issues arise with STLTP, DSTP, or Essence handlers. OTA ensures that essential service signaling, content protection, and metadata are maintained, allowing for uninterrupted service when Direct Feed distribution is unavailable. Although Direct Feed has priority, OTA is consistently available as a reliable fallback option.
- **Use Case 3: Over-the-Air (OTA) Distribution as the Primary Delivery Method**
  OTA broadcasting may be the default method for delivering content to end users. The OTA signal ensures that essential services such as signaling, content protection, and metadata are delivered with wide coverage and reliability. If the OTA broadcast encounters any issues, the service operator can seamlessly switch to a Direct Feed like STLTP, DSTP, or Essence handlers to prevent service disruption. This ensures that OTA remains the preferred distribution channel, with the Direct Feed available as a backup, ready to take over when needed.
- **Use Case 4: In-Building Redistribution Using Direct Feed**
  For redistributing ATSC 3.0 signals within buildings (e.g., apartment complexes, large venues, or buildings equipped with a Master Antenna TV (MATV) system), signal delivery is managed by activating either the STLTP, DSTP, or Essence handler, depending on the building's specific requirements. STLTP can be used for low-latency, high-efficiency Direct Feed, while DSTP or Essences can handle alternative Direct Feed protocols or modular content distribution, providing flexibility to meet various infrastructure needs.

In all cases, Direct Feed delivery relies on the appropriate handler — STLTP, DSTP, or Essences — depending on the specific needs of the service operator. These handlers are prioritized to ensure that each type of content is delivered in the most efficient way possible. While the Direct Feed is the primary means of delivery, the service operator has the option to use OTA as a fallback, which operates independently and remains available whenever needed. This approach ensures a seamless and reliable broadcast service, with Direct Feed as the primary delivery method and OTA as a backup when required.

Table 1.1 provides a concise overview of the feature list and its alignment with specific use cases in an ATSC 3.0 broadcaster's redistribution workflow. Each feature represents a key component of the broadcast, with the table highlighting which features are managed by specific handlers and how these features align with their corresponding use cases.

The Supplemental Content Handler, described in Section 4.2 , is a Web-based system designed to deliver additional content, such as Advanced Emergency Alert information (AEA) and the Regional Service Availability Table (RSAT). Operating within the ATSC 3.0 broadcaster's infrastructure, this handler acts as the source for supplemental content, with the destination being the (v)MVPD. At the (v)MVPD, this content is integrated into headend systems for further distribution or used to enhance services provided to end-users.

Table 1.1 Use Cases and Feature List

Feature List	Use Cases					
	1-1: STLTP Handler	**1-2: DSTP Handler**	**1-3, 1.4: Essences Handlers**	**2, 3: OTA**	**4: MATV**	**Supplemental Content Handler**
Regional Service Availability	YES	YES	NO	YES	YES	YES
Presentation Metadata	YES	YES	YES	YES	YES	YES
Service Announcement	YES	YES	NO	YES	YES	YES
Service Usage	NO	NO	NO	NO	NO	YES
Audio/Video Watermark Emission	YES	YES	YES	YES	YES	NO
Content Recovery in Redistribution	YES	YES	YES	YES	YES	YES
Application Event (Stream) Delivery	YES	YES	NO	YES	YES	NO
Video	YES	YES	YES	YES	YES	NO
SL-HDR1	YES	YES	YES	YES	YES	NO
AC-4	YES	YES	YES	YES	YES	NO
(IMSC1) Captions and Subtitles	YES	YES	YES	YES	YES	NO
W3C HTML-5 Compliant Interactive Broadcaster Application	YES	YES	NO	YES	YES	YES
AEAT Emergency Messaging	YES	YES	NO	YES	YES	YES
Audio Description	YES	YES	YES	YES	YES	NO
Dialog Enhancement	YES	YES	YES	YES	YES	NO
Content Security (DRM) and Service Protection	YES	YES	NO	YES	YES	NO
RF signal with Physical Layer	NO	NO	NO	YES	YES	NO
STLTP	YES	NO	NO	YES	YES	NO
ROUTE	YES	YES	NO	YES	YES	NO
MMT	YES	YES	NO	YES	YES	NO
LLS	YES	YES	NO	YES	YES	NO
SLS	YES	YES	NO	YES	YES	NO

1.4 Organization

This document is organized as follows:

- Section 1 – Outlines the scope of this document and provides a general introduction.
- Section 2 – Lists references and applicable documents.
- Section 3 – Defines this document's terms, acronyms, and abbreviations used in this document.
- Section 4 – System Overview.
- Section 5 – Describes the components and features in ATSC 3.0 for use in the near term and at a later stage by an advanced television-capable retransmission system.

- Section 6 – Describes recommended video, audio, and closed captioning component streams and metadata, recommended formats, and definitions.
- Section 7 – Describes general redistribution recommendations.
- Annex A – Describes an example demonstration of ATSC 3.0 service delivery over Direct Feed.

2. REFERENCES

All referenced documents are subject to revision. Users of this Recommended Practice are cautioned that newer editions might or might not be compatible.

2.1 Informative References

The following documents contain information that may help apply and implement these Recommended Practices:

[1] ITU | ISO/IEC: [High Efficiency Video Coding] "Rec. ITU-T H.265 Series H: Audiovisual and multimedia systems, Infrastructure of audiovisual services – Coding of moving video, High efficiency video coding" | "ISO/IEC 23008-2 Information technology — High efficiency coding and media delivery in heterogeneous environments, MPEG-H Part 2: High efficiency video coding", International Telecommunication Union | International Organization for Standardization/International Electrotechnical Commission, Geneva, Switzerland.

[2] ISO/IEC: ISO/IEC 23008-1, "Information technology – High efficiency coding and media delivery in heterogeneous environments, MPEG-H Part 1: MPEG media transport (MMT)", International Organization for Standardization / International Electrotechnical Commission, Geneva, Switzerland.

[3] ATSC: "ATSC Standard: Scheduler / Studio to Transmitter Link," Doc. A/324:2026-04, ATSC, Washington, DC, 14 April 2026.

[4] ATSC: "ATSC Standard: ATSC 3.0 System," Doc. A/300:2026-04, ATSC, Washington, DC, 14 April 2026.

[5] ATSC: "ATSC 3.0 Recommended Practice: Conversion of ATSC 3.0 Services for Redistribution," Doc. A/370:2026-04, ATSC, Washington, DC, 14 April 2026.

[6] SCTE: "Linear Contribution Encoding," Doc. SCTE 277 2024, Society of Cable Telecommunications Engineers, Exton, PA, 2024.

[7] IEEE: "Use of the International Systems of Units (SI): The Modern Metric System," Doc. SI 10-2002, Institute of Electrical and Electronics Engineers, New York, N.Y.

[8] DASH IF: "Guidelines for Implementation: DASH-IF Interoperability Points for ATSC 3.0, Version 1.1," DASH Interoperability Forum, June 12, 2018: https://dashif.org/guidelines/.

[9] ITU | ISO/IEC: [Advanced Video Coding] "Rec. ITU-T H.264 Series H: Audiovisual and multimedia systems, Infrastructure of audiovisual services – Coding of moving video, Advanced video coding for generic audiovisual services" | "ISO/IEC 14496-10 Information Technology – Coding of audio-visual objects, MPEG-4 Part 10: Advanced video coding", International Telecommunication Union | International Organization for Standardization / International Electrotechnical Commission, Geneva, Switzerland.

[10] SMPTE: "SMPTE Standard – High Dynamic Range Electro-Optical Transfer Function of Mastering Reference Displays," Doc. SMPTE.ST 2084:2014, Society of Motion Picture and Television Engineers, White Plains, NY, 29 August 2014.
[11] ATSC: "ATSC Standard: Signaling, Delivery, Synchronization, and Error Protection," Doc. A/331:2026-04, ATSC, Washington, DC, 14 April 2026.
[12] ATSC: "ATSC Standard: Regional Service Availability," Doc. A/200:2026-04, ATSC, Washington, DC, 14 April 2026.
[13] ATSC: "ATSC Standard: Service Announcement," Doc. A/332:2026-04, ATSC, Washington, DC, 14 April 2026.
[14] ATSC: "ATSC Standard: ATSC 3.0 Interactive Content," Doc. A/344:2026-04, ATSC, Washington, DC, 14 April 2026.
[15] ATSC: "ATSC Standard: Captions and Subtitles," Doc. A/343:2026-04, ATSC, Washington, DC, 14 April 2026.
[16] ATSC: "ATSC Standard: ATSC 3.0 Security and Service Protection," Doc. A/360:2026-04, ATSC, Washington, DC, 14 April 2026.
[17] IETF: RFC 5905 Network Time Protocol Version 4: Protocol and Algorithms Specification, D. Mills, J. Martin, J. Burbank, W. Kasch, June 2010.
[18] IEEE: "IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems," Doc. 1588, Institute of Electrical and Electronics Engineers, New York, NY, approved 27 March 2008.
[19] ATSC: "ATSC Standard: Service Usage Reporting," Doc. A/333:2026-04, ATSC, Washington, DC, 14 April 2026.
[20] ATSC: "ATSC Standard: Application Signaling," Doc. A/337:2026-04, ATSC, Washington, DC, 14 April 2026.
[21] ATSC: "ATSC Standard: System Discovery and Signaling," Doc. A/321:2026-04, ATSC, Washington, DC, 14 April 2026.
[22] ATSC: "ATSC Standard: Conditional Access System for Terrestrial Broadcast (A/70 Part 1:2010)," Doc. A/70 Part 1:2010, ATSC, Washington, DC, 30 November 2010.
[23] ATSC: "ATSC Standard: A/70 Part 2: Conditional Access System for Terrestrial Broadcast Service Protection Using Simulcrypt For IP-Delivered Services," Doc. A/70 Part 2:2011, ATSC, Washington, DC, 17 October 2011.
[24] ITU: "Recommendation ITU-R BT.709-6 – Parameter values for the HDTV standards for production and international programme exchange," Rec. ITU-R BT.709-6 (06/2015), International Telecommunication Union, Geneva, Switzerland: https://www.itu.int/rec/R-REC-BT.709.
[25] ATSC: "ATSC Standard: Video – HEVC," Doc. A/341:2026-04, ATSC, Washington, DC, 14 April 2026.
[26] ATSC: "ATSC Standard: Video – VVC," Doc. A/345:2026-04, ATSC, Washington, DC, 14 April 2026.
[27] CTA: "A DTV Profile for Uncompressed High Speed Digital Interfaces" CTA-861-I (02/2023).
[28] ATSC: "ATSC Standard: Content Recovery in Redistribution Scenarios," Doc. A/336:2026-04, ATSC, Washington, DC, 14 April 2026.

[29] ATSC: "ATSC Standard: Video Watermark Emission," Doc. A/335:2026-04, ATSC, Washington, DC, 14 April 2026.
[30] ATSC: "ATSC Standard: Audio Watermark Emission," Doc. A/334:2026-04, ATSC, Washington, DC, 14 April 2026.
[31] CTA: "Digital Television (DTV) Closed Captioning (ANSI/CTA-708-E S-2023 and Errata)," Doc. CTA-708-E, Consumer Electronics Association, Arlington, VA, August 2013 (plus 2023 errata).
[32] ATSC: "ATSC 3.0 Report: Findings Regarding Emergency Alert (EAS) and Audio Emergency Information," Doc. TG3-10-001r2, ATSC, Washington, DC, 10 April 2020.
[33] ISO/IEC: "ISO/IEC 23008-3, Information technology – High efficiency coding and media delivery in heterogeneous environments, MPEG-H Part 3: 3D Audio", International Organization for Standardization / International Electrotechnical Commission, Geneva, Switzerland.
[34] ISO/IEC: "ISO/IEC 13818-1, Information technology – Generic coding of moving pictures and associated audio information, MPEG-2 Part 1: Systems", International Organization for Standardization / International Electrotechnical Commission, Geneva, Switzerland.
[35] ATSC: "ATSC Standard: Digital Audio Compression (AC-3) (E-AC-3) Standard," Doc. A/52:2018, ATSC, Washington, DC, 25 January 2018.
[36] ATSC: "ATSC Standard: AC-4 System," Doc. A/342-2:2026-04, ATSC, Washington, DC, 14 April 2026.

3. DEFINITION OF TERMS

Concerning definition of terms, abbreviations, and units, the practice of the Institute of Electrical and Electronics Engineers (IEEE) as outlined in the Institute's published standards [7] shall be used. Where an abbreviation is not covered by IEEE practice or industry practice differs from IEEE practice will be described in Section 3.3 of this document.

3.1 Compliance Notation

This section defines compliance terms for use in this document:

should – This word indicates that a particular course of action is preferred but not necessarily required.

should not – This phrase means one specific possibility or course of action is undesirable but not prohibited.

3.2 Treatment of Syntactic Elements

This document contains symbolic references to syntactic elements used in the audio, video, and transport coding subsystems. These references are typographically distinguished by the use of a different font (e.g., restricted), may contain the underscore character (e.g., sequence_end_code) and may consist of character strings that are not English words (e.g., dynrng).

3.2.1 Reserved Elements

One or more reserved bits, symbols, fields, or ranges of values (i.e., elements) may be present in this document. These are used primarily to enable adding new values to a syntactical structure without altering its syntax or causing a problem with backward compatibility, but they also can be used for other reasons.

The ATSC default value for reserved bits is '1.' There is no default value for other reserved elements. Use of reserved elements except as defined in ATSC Standards or by an industry standards-setting body is not permitted. See individual element semantics for mandatory settings and any additional use constraints. As currently-reserved elements may be assigned values and meanings in future versions of this Standard, receiving devices built to this version are expected to ignore all values appearing in currently-reserved elements to avoid possible future failure to function as intended.

3.3 Acronyms and Abbreviations

The following acronyms and abbreviations are used within this document:

3D-TV Three-dimensional television
8-VSB 8-level Vestigial Side Band modulation
AC-3 Audio Compression 3 System [ATSC A/52]
AC-4 Audio Compression 4 System [ATSC A/342 Part 2]
AD Audio Description
AEA Advanced Emergency Alert information
AEA&I Advanced Emergency Alerts & Information
AEAT Advanced Emergency Alert Table
AEI Application Event Information [MMT]
AFB Active Format Description
AL Alternate Language
ALP ATSC 3.0 Link-Layer Protocol
API Application Programming Interface
BA Broadcaster Application
CAP Common Alerting Protocol
CDM Content Decrypt Module
CDN Content Delivery Network
CDU Consumption Data Unit
CLLI Content Light Level Information
CM Complete Main
CMS Content Management System
CTA Consumer Technology Association
DASH Dynamic Adaptive Streaming over HTTP
DASH-IF Dynamic Adaptive Streaming over HTTP Industry Forum
DRM Digital Rights Management
DSTP Data Source Transport Protocol
DTV Digital Television (ATSC 1.0)
DVS Descriptive Video Service
EAS Emergency Alert System
EPG Electronic Program Guide
ESG Electronic Service Guide
HD High Definition
HDMI High-Definition Multimedia Interface

HDR High Dynamic Range (video)
HEVC High Efficiency Video Coding
HLS HTTP Live Streaming
HTML Hypertext Markup Language
HTTP Hypertext Transfer Protocol
IEC International Electrotechnical Commission
IMSC1 Internet Media Subtitles and Captions
IP Internet Protocol
IRD Integrated Receiver/Decoder
IRDTP Integrated Receiver Decoder Transcoder Packager
ISO International Standards Organization
ITU International Telecommunications Union
LCEVC Low Complexity Enhanced Video Coding
LCT Layered Coding Transport
LLS Low Level Signaling
MAC Media Access Control
MATV Master Antenna Television
MHz MegaHertz
MMT MPEG Multimedia Transport
MMTP MMT Payload
MPD Media Presentation Description
MPEG Moving Picture Experts Group
MPU Media Processing unit
MVPD Multichannel Video Programming Distributor
NRT Non-Real Time
NTP Network Time Protocol
OSI Open Systems Interconnection
OTA Over-The-Air
OTT Over-The-Top
PCM Pulse Code Modulated
PID Packet Identifier [MPEG-2 Systems]
PLP Physical Layer Pipe
PQ Perceptual Quantizer
PTP Precision Time Protocol
REST Representational State Transfer
RF Radio Frequency
ROUTE Real-time Object delivery over Unidirectional Transport
RSAT Regional Service Availability Table
SA Service Announcement
SAP Secondary Audio Program
SCTE Society of Cable Telecommunications Engineers
SDR Standard Dynamic Range (video)

SEI Supplemental Enhancement Information
SG Service Guide
SHVC Scalable HEVC
SL-HDR1 SDR-compatible Single Layer HDR System
SLS Service Layer Signaling
SLT Service List Table
SMPTE Society of Motion Picture & Television Engineers
STB Set-Top Box
STL Studio-to-Transmitter Link
STLTP Studio-to-Transmitter Link Transport Protocol
TSID Transport Stream Identifier
TV Television
UDP User Datagram Protocol
UHD Ultra High Definition
URL Uniform Resource Locator
USBD User Service Bundle Description
vMVPD virtual (Internet-delivered) Multichannel Video Programming Distributor
(v)MVPD Either MVPD or vMVPD
VOD Video on Demand
VSB Vestigial Sideband
VVC Versatile Video Coding
W3C World Wide Web Consortium
WCG Wide Color Gamut
XML Extensible Markup Language

3.4 Terms

The following terms are used within this document:

Accessibility Descriptor – A descriptor included in an audio presentation used to describe accessibility features of an audio presentation. See DASH-IF IOP for ATSC 3.0 v1.1, Sec. 5.4.4.2.1, Table 7.

Advanced Television – Television services and features that exhibit features and capabilities as found, for example in ATSC 3.0, such as 4K UHD, HDR, WCG, High Efficiency Codecs, Immersive Sound, and advanced accessibility capabilities.

Asset – Any multimedia data entity associated with a unique identifier and used to build a multimedia presentation.

Associated Service: Emergency – The AC-4 content_classifier value '110', see ETSI TS 103 190-1 v1.3.1 Sec. 4.3.3.8.1, Table 91.

ATSC 1.0 Conversion – Denotes the process specified in ATSC A/370 for reformatting ATSC 3.0 signals into ATSC 1.0-compliant streams.

Audio Emergency Information – "Emergency Information" data to be presented aurally, such as the reading of a text crawl, which is distinct from Emergency Alert System (EAS) data and audio. See 47 CFR 79.2(b)(2)(ii).

Audio Track – A signal representing one channel or object essence comprising multiple audio samples. See ETSI TS 103 190-1 v1.3.1 §3.1. Also see A342/1 (2017) at 5.1.3.

content_classifier – The AC-4 field "content_classifier ", see ETSI TS 103 190-1 v1.3.1 Sec. 4.3.3.8.1.

Broadcast Stream – The abstraction for an RF Channel which is defined in terms of a carrier frequency centered within a specified bandwidth.

Content – The sum of Essence plus signaling.

DASH Segment – Refers to a DASH Initialization Segment or Media Segment per the DASH-IF profile [8]).

Direct Feed – An IP data stream pushed directly from a broadcaster to a (v)MVPD typically using a reliable Wide Area Network as the distribution system.

Display – A device like a TV or monitor.

Emergency Information – Information that is not conveyed as EAS about a current emergency, that is intended to further the protection of life, health, safety, and property, i.e., critical details regarding the emergency and how to respond to the emergency. Examples of the types of emergencies covered include tornadoes, hurricanes, floods, tidal waves, earthquakes, icing conditions, heavy snows, widespread fires, discharge of toxic gases, widespread power failures, industrial explosions, civil disorders, school closings and changes in school bus schedules resulting from such conditions, and warnings and watches of impending changes in weather. See 47 CFR 79.2(a)(2).

Essence – The primary material constituting an expression of the substance or intent of information being processed, communicated, or stored. Metadata supplements Essence to comprise Content. Examples are audio Essence, video Essence, and captions Essence.

Gateway – A device that converts an ATSC 3.0 OTA, cable or satellite signal to IP for distribution in the home.

Headend – Equipment or virtual services which receive television broadcasts for distribution to a local region.

LLS (Low Level Signaling) – Signaling information that supports rapid channel scans and bootstrapping of Service acquisition by the receiver.

Main Program Audio – The audio presentation with the Main Role.

Main Program Video – The video presentation with the Main Role.

Main Role – The DASH Role@value of "Main", see ISO/IEC 23009-1 Sec. 5.8.5.5.

Metadata – Information about Essence that describes the Essence itself, the characteristics of expression, communication, or storage of the Essence, or any other information related to the Essence that is not itself Essence. Metadata related to particular Essence can become Essence on its own when there is other Metadata related to it; the classic example of such relationships is closed captioning, which can be considered Metadata pertaining to video and audio Essence but which also can have associated Metadata describing the formatting of the characters used to express the Essence of the captions

MMT Protocol – Application layer transport protocol for delivering MMTP payload over IP networks.

PLP (Physical Layer Pipe) – A portion of the RF channel with specific modulation and coding parameters.

PQ– Perceptual Quantizer. A high dynamic range signal encoded using the SMPTE ST 2084 transfer function [10].

Receiver – A device that converts a digital television signal from a (v)MVPD for use on a Display, thus enabling cable, satellite or IP television to be viewed.

Redistribution System – The process of secondary distribution of a primary signal, a signal which has already been distributed**.**

Service – A collection of aggregate media components presented to the user; components can be of multiple media types; a Service can be either continuous or intermittent; a Service can be Real Time or Non-Real Time; Real Time Service can consist of a sequence of TV programs.

SLS (Service Layer Signaling) – Signaling provides information for discovering and acquiring ATSC 3.0 Services and their content components.

SLT (Service List Table) – Table of signaling information that is used to build a basic service listing and provide bootstrap discovery of SLS.

Video Description Service Audio – Audio narration describing a television program's key visual elements for the visually impaired

Video Emergency Information – Emergency Information to be presented visually, such as a text crawl or other onscreen visual display of Emergency Information. See 47 CFR 79.2(b)(2)(ii).

4. SYSTEM OVERVIEW

4.1 Overview

Direct Feed delivery is a secure method for an ATSC 3.0 broadcaster to deliver services directly to a (v)MVPD using dedicated handlers. Each handler ensures efficient and reliable content delivery. The diagram in Figure 4.1 shows the relationship between ATSC 3.0 Broadcaster Handler and (v)MVPD Decoder.

A handler manages and delivers essential streams such as HEVC video, AC-4 audio, and IMSC1 captions, as well as encapsulated transport protocols like ROUTE/DASH and MMTP. It also handles supplementary content, including AEA [11], RSAT [12], service announcements [13], and broadcast applications [14].

The handler processes content from sources such as the encoder, packager, or broadcast gateway and prepares it for seamless and secure distribution to the (v)MVPD. Upon reception, the (v)MVPD may use a Decoder to demultiplex and decode the streams, ensuring compatibility with their distribution systems, including transcoding if needed for further processing or delivery.

Essences refer to the core media streams, such as HEVC video, AC-4 audio, and IMSC1 captions. These are the primary components of the content being transmitted.

Signaling includes service and metadata-related information necessary for the proper decoding and presentation of the content.

Protocols like ROUTE/DASH and MMTP handle the encapsulation, transmission, and reception of content. These protocols ensure that the content is delivered in a format that the Handler and the receiving (v)MVPD systems can process effectively.

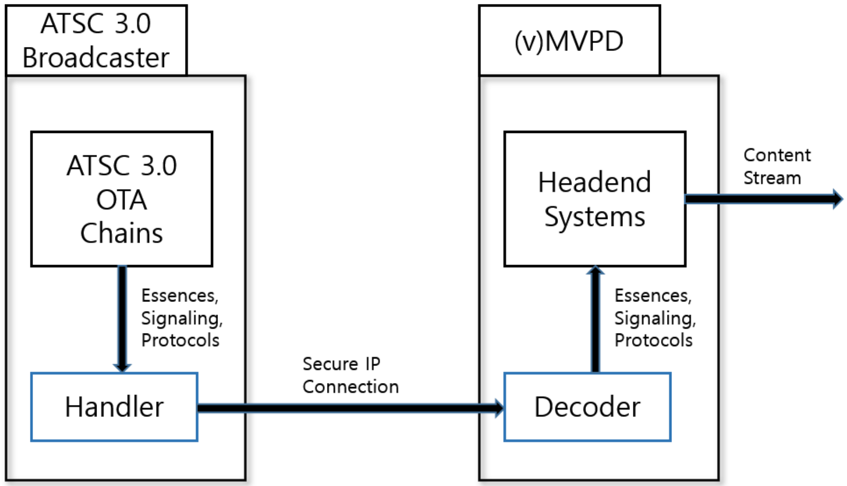

Figure 4.1 Direct Feed system block diagram.

4.2 System Architecture

Direct Feed delivery is an efficient method for delivering ATSC 3.0 services directly from the STLTP, DSTP, or Essence handlers to the (v)MVPD over a secure connection. Figure 4.2 shows the system architecture for ATSC 3.0 delivery to (v)MVPDs. Each (v)MVPD may use a dedicated handler, allowing for a customized approach to content delivery that meets specific operational needs. In this setup, each (v)MVPD is fully responsible for overseeing the operation and reliability of its assigned handler, managing any performance issues and implementing failover procedures as needed to ensure a continuous, high-quality broadcast service.

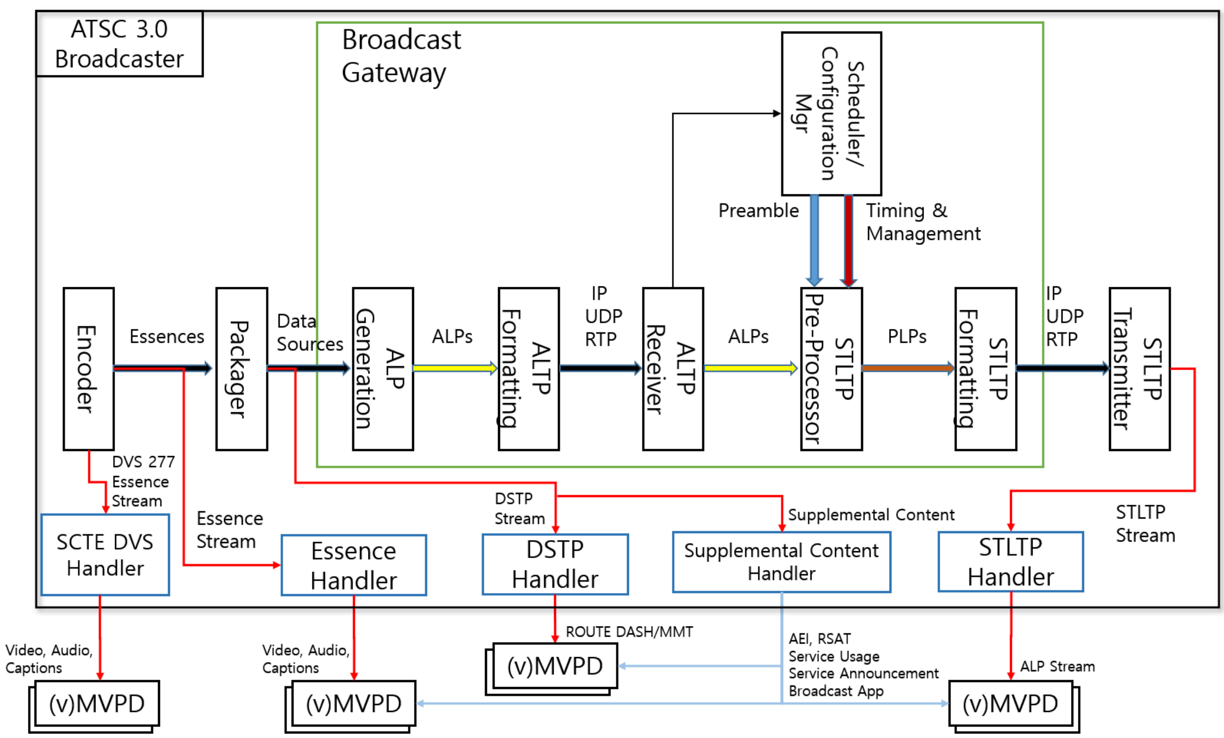

Figure 4.2 System Architecture for ATSC 3.0 Delivery

Dedicated Handler Functions in Direct Feed Delivery:

- The Essence refers to the core audio, video, and captions content within ATSC 3.0-compatible broadcast systems. The Essence Handler manages these streams - such as audio, video, and captions, typically in formats like HEVC for video, AC-4 for audio, and IMSC1 for captions - directly from the encoder, before they are encapsulated into transport protocols like ROUTE/DASH or MMTP and thus limited to the formats and bit-rates specified by ATSC 3.0. The Essence Handler processes and readies the streams for Direct Feed to the (v)MVPD. Afterward, the content flows seamlessly to the (v)MVPD, where it's prepared for final distribution to end-users, ensuring that essential elements reach audiences with precision and quality.
- DSTP Handler is a transport protocol used in ATSC 3.0 for transferring media and signaling data – such as ROUTE/DASH or MMTP signaling - between key components in the broadcast chain, such as from the packager to the broadcast gateway or other systems. The DSTP Handler processes and prepares content received from the packager for efficient delivery to the (v)MVPD. After processing, the content is promptly forwarded to the (v)MVPD, ready for decoding and further distribution to end-users. This setup ensures that real-time data arrives with minimal delay, supporting a smooth and reliable broadcast experience.
- The STLTP Handler is a protocol in ATSC 3.0 used to transport broadcast content - including media and signaling - directly from the broadcast gateway to the (v)MVPD. STLTP utilizes the ATSC Link-Layer Protocol (ALP), which operates at Layer 2 and is specifically designed for efficient transmission. ALP encapsulates data streams, such as those formatted in ROUTE/DASH or MMT protocols, for reliable delivery. The STLTP Handler processes ALP-encapsulated content from the broadcast gateway, preparing it for seamless delivery to the (v)MVPD. Once processed, the content is transmitted to the (v)MVPD, where it is decoded and distributed to end-users, supporting a smooth and uninterrupted viewing experience.
- The SCTE DVS Handler performs the same functions as the Essence Handler, but in compliance with the document SCTE 277 2024: "Linear Contribution Encoding," [6] enabling delivery of higher quality, mezzanine-like formats
- The Supplemental Content Handler is a functional and optional component within ATSC 3.0 systems that manages and delivers specific service-oriented data — including AEA (Advanced Emergency Alert information), RSAT (Regional Service Availability Table), service announcements, and broadcast applications — on an as-needed basis by the (v)MVPD. When the (v)MVPD determines a need, the Supplemental Content Handler retrieves and processes the relevant data, preparing it for efficient delivery.

Additionally, the Supplemental Content Handler may support the Essence Handler by providing supplementary data, such as AEA and RSAT, if a (v)MVPD seeks to expand the basic essence streams (audio, video, and captions) with service-related content.

After processing, the data is promptly transferred to the (v)MVPD, where it may be decoded and distributed as necessary.

Each handler provides a specialized pathway for ATSC 3.0 services, enabling a direct and dedicated connection to the (v)MVPD. By assigning each (v)MVPD to one of these four handlers, broadcasters can ensure that content is delivered securely and tailored to meet specific service requirements, while the (v)MVPD handles the ongoing operation and maintenance for continuous, high-quality broadcasting.

For (v)MVPDs, the distribution setup may include a suite of decoders — STLTP, DSTP, Essence, and Supplemental Content — each designed to handle specific ATSC 3.0 streams provided by the broadcaster. These decoders work to extract key media elements such as audio, video, subtitles, and other data, making them readily available for further processing, reformatting, or direct integration into the (v)MVPD's distribution infrastructure.

Each handler is mapped to a broadcaster, allowing the (v)MVPD to efficiently adapt and deliver broadcast content across their platforms as needed. The diagram in Figure 4.3 shows the (v)MVPD Receiver block diagram for receiving and decoding broadcaster ATSC 3.0 streams.

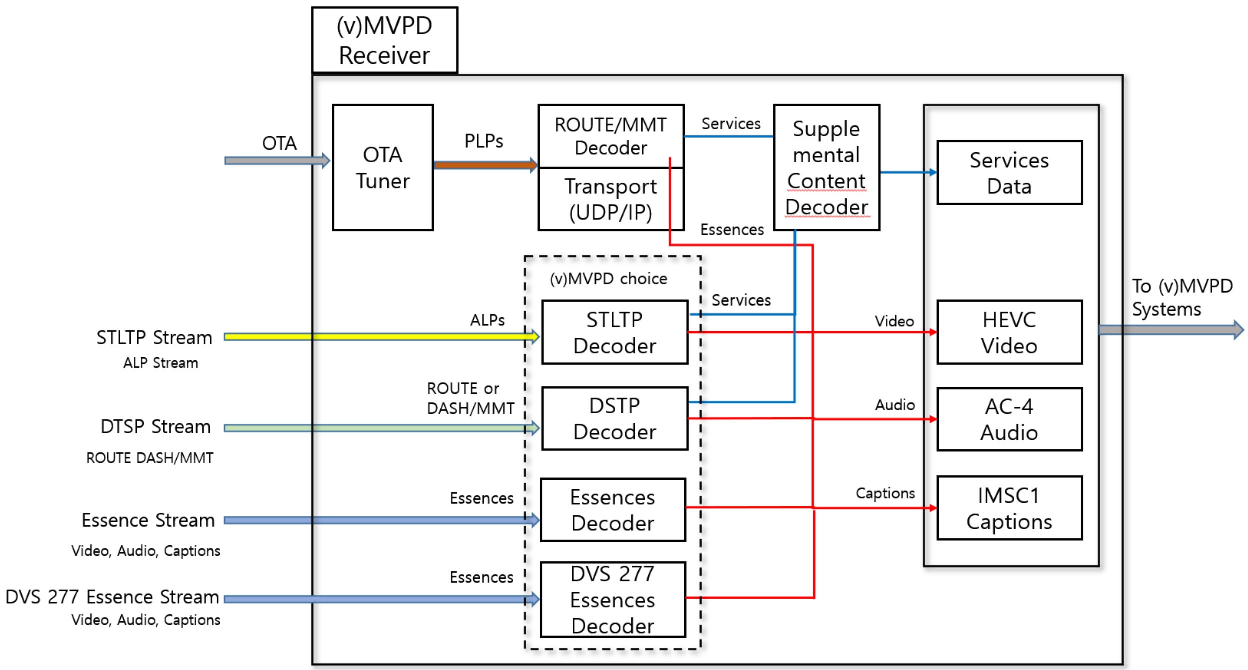

Figure 4.3 (v)MVPD Receiver block diagram.

The STLTP decoder is responsible for receiving ATSC 3.0 streams from the broadcaster, specifically handling ALP streams. It extracts high-quality audio (e.g., AC-4), video (e.g., HEVC), and captions (IMSC1) [15] content, preparing them for further processing by the (v)MVPD. This decoder ensures that all essential media components and other data are captured and made available in a format that the (v)MVPD may integrate into their distribution pipeline.

The DSTP decoder processes streams encapsulated using ROUTE/DASH or MMT protocols from the broadcaster. It manages audio, video, captions, and other content, preparing them for integration into the (v)MVPD's distribution system.

The Essence decoder is dedicated to processing core audio, video, and caption streams from the broadcaster. It makes these media components available in a format ready for further processing or reformatting as needed by the (v)MVPD's distribution system.

The SCTE DVS Essence decoder is dedicated to process content essence in compliance with the document SCTE 277 2024: "Linear Contribution Encoding."[6]

The Supplemental Content Decoder handles auxiliary data streams that accompany primary ATSC 3.0 services, such as video and audio channels. This decoder focuses on additional information like emergency alerts, regional service availability, or other metadata to enhance the viewer's experience and support various broadcasting needs.

For encrypted content, a DRM system [11] [16] is essential. This could integrate with the STLTP/DSTP decoders to ensure protected content is decrypted for further processing according to the content provider's requirements. Essence handler is primarily for DRM-free content.

An ATSC 3.0 tuner is necessary for OTA signal reception. It can demodulate and receive an ATSC 3.0 signal. By incorporating a ROUTE/MMT decoder within the OTA Reception Components, the system can effectively demultiplex the broadcast signal, enabling the separate extraction of video, audio, and caption essences. This approach ensures that each component is isolated, providing flexibility to process and utilize them independently according to specific distribution requirements.

In ATSC 3.0, time synchronization information is sent through Low-Level Signaling (LLS). The System Time Fragment within LLS provides time data that the (v)MVPD may use to synchronize with the broadcaster. If the broadcaster sends content using STLTP, the LLS packets in the STLTP stream carry this time information. The (v)MVPD may extract system time from these packets. Similarly, if the broadcaster uses DSTP including ROUTE/DASH or MMT (MPEG Media Transport) to deliver media over IP, LLS also carries data in the stream.

Another method of sending time information is through Network Time Protocol (NTP) [17] or Precision Time Protocol (PTP) [18]. NTP provides time synchronization over IP networks, allowing the (v)MVPD to match their clocks with the broadcaster. PTP offers more precise synchronization if needed, giving sub-microsecond accuracy.

Since the (v)MVPD receives the stream from the broadcaster and processes it before sending it to end-users, exact time synchronization is not critical at this stage. The (v)MVPD may modify the timing during its processing to make sure the content is aligned correctly before being distributed. Minor timing variations from the broadcaster don't impact on the (v)MVPD's capability to deliver content to the end-users.

5. ATSC 3.0 COMPONENT AND SERVICES FOR USE IN NEAR TERM AND LONGER TERM RETRANSMSSISION SERVICES

The following sections describe the recommended practices for delivering ATSC 3.0 features and services to (v)MVPDs.

5.1 Signaling Metadata

Signaling data enables accurate transport, identification, and coordination of video, audio, and related components across both broadcast and Direct Feed delivery systems. Unlike Presentation Metadata, which addresses how media is decoded and rendered [Section 5.2], signaling data supports service discovery, synchronization, emergency alerting, and reliable distribution workflows.

The following is a list of key signaling data used in ATSC 3.0, describing their roles and how they are transported across different handlers (DSTP, STLTP, and Supplemental):

- **Low-Level Signaling** (LLS, Section 6.2 in A/331 [11])
  LLS acts as the initial signaling layer that allows ATSC 3.0 receivers to acquire the Service List Table (SLT) and begin service discovery. It transports key signaling tables such as the SLT for identifying available services and the Advanced Emergency Alert Table (AEAT)

for delivering emergency messages. LLS operates over a well-known multicast IP/UDP address (224.0.23.60:4937) and is delivered via the DSTP and STLTP handler, using ALP encapsulation. By delivering the SLT, LLS enables rapid RF channel scanning and acquisition of SLS metadata necessary for accessing full-service details.

- **Service List Table** (SLT, Section 6.3 in A/331 [11])
  SLT is a key signaling component delivered through LLS that identifies all services available within an ATSC 3.0 broadcast. It provides essential information such as service names, types, channel numbers, and the IP parameters needed to locate their associated Service Layer Signaling (SLS). SLT enables ATSC 3.0 receivers (including those used by (v)MVPDs) to discover and monitor both broadcast-only and hybrid broadband-enhanced services. The SLT is delivered via both STLTP and DSTP handlers.
- **Advanced Emergency Alert Table** (AEAT, Section 6.5 in A/331 [11])
  AEAT is a key signaling component in ATSC 3.0 used to deliver emergency messages enriched with structured metadata. It supports location-targeted alerts that may include text, audio, images, video clips, and multilingual content. AEAT allows receivers to respond appropriately to urgent situations by enabling prioritized message display and alert behavior. It is delivered via both DSTP and STLTP handlers and may also be distributed through the Supplemental Handler to provide redundancy or alternate delivery paths.
- **Service Layer Signaling** (SLS, Section 7 in A/331 [11])
  SLS provides the metadata required to acquire, assemble, and present ATSC 3.0 content. It describes the media components of a service such as video, audio, captions, and data, and specifies how these are delivered using either ROUTE/DASH or MMTP protocols. SLS includes elements like the MPD for DASH delivery and Asset (ISO/IEC 23008-1) Information for MMTP. SLS is delivered via both DSTP and STLTP handlers.
- **User Service Bundle Description** (USBD, Section 7.1.3 and Section 7.2.1 in A/331 [11])
  USBD defines the structure, configuration, and delivery modes of an ATSC 3.0 service using either ROUTE or MMT. It includes metadata such as the service ID, operational status, service name with language tags, and associated delivery methods (broadcast and/or unicast). USBD enables receivers to understand how media components are grouped and accessed within a service. It is delivered via both DSTP and STLTP handlers.
- **Media Presentation Description** (MPD, Section 7.2.2 in A/331 [11])
  MPD is a central element in ATSC 3.0's DASH-based ROUTE delivery, describing the structure, timing, and segmentation of media components such as video, audio, and captions. It defines how segments are organized and aligned for synchronized presentation. Unlike adaptive OTT DASH implementations, the ATSC 3.0 MPD follows a fixed, constrained profile with pre-defined representations and no runtime bitrate switching. The MPD is delivered via the DSTP and STLTP handlers.
- **S-TSID** (Service Transport Stream Identifier, Section 7.1.4 in A/331 [11])
  S-TSID is a SLS fragment that describes how an ATSC 3.0 service is transported over ROUTE. It specifies the transport sessions, and associated LCT (Section A.3.6 in A/331) channels used to deliver individual service components such as video, audio, and captions. It is delivered via both DSTP and STLTP handlers.
- **MMT** (MPEG Media Transport) ATSC 3.0 Messages (Section 7.2 in A/331 [11])
  MMT is a transport protocol supported by ATSC 3.0 as an alternative to ROUTE/DASH. It delivers video, audio, and data streams in the form of small, individually identifiable

packets, which include both media and signaling information. This packetized structure allows for efficient multiplexing and synchronized playback without the need for external manifest files like an MPD. MMT is delivered via both DSTP and STLTP handlers.

Signaling data is a fundamental part of ATSC 3.0, enabling accurate service discovery, identification, synchronization, and emergency alert delivery. Proper handling of signaling data ensures consistent viewer experience, preserves content quality and integrity, and supports seamless integration into (v)MVPD workflows. For detailed implementation guidelines, refer to the ATSC A/331 [11] and A/332 [13] standards.

5.2 Presentation Metadata

Presentation Metadata refers to metadata used for rendering video and audio, ensuring correct decoding, display, and playback across different devices. Unlike general content metadata defined in A/332 [13] Service Announcement, which includes details such as title, description, and genre, Presentation Metadata controls how media should be processed and presented on various screens and audio systems. It is a key factor in maintaining consistent quality, compatibility, and accessibility, especially for (v)MVPDs that manage large-scale content distribution.

Presentation Metadata plays an important role in handling video coding formats, HDR settings, frame rate adjustments, scalable video formats, and audio configurations so that content is delivered and displayed as intended. Correct use of Presentation Metadata ensures that video and audio are processed reliably, preventing issues such as incorrect brightness, color distortion, playback errors, or loss of important audio details.

When converting ATSC 3.0 services for redistribution, A/370 [5] provides guidelines to ensure compatibility with (v)MVPD workflows. It covers video format conversions such as de-interlacing, frame rate adjustments, and aspect ratio changes (see A/370 Annex A). For audio, it outlines transcoding procedures, including conversion from ATSC 3.0 AC-4 [36] and MPEG-H 3D Audio [33] to ATSC 1.0 AC-3 [35], ensuring consistency across distribution systems.

To provide a high-quality and consistent experience, (v)MVPDs may correctly receive, process, and distribute Presentation Metadata without losing important details. If Presentation Metadata is not handled properly, it can lead to incorrect HDR display, aspect ratio issues, or loss of accessibility features, which may negatively affect the viewer’s experience.

5.3 Internet Media Subtitles and Captions

Internet Media Subtitles and Captions (IMSC1) is the required caption format for ATSC 3.0, as defined in ATSC A/343 [15]. It is based on the W3C Timed Text Markup Language (TTML) and supports styled text and image-based subtitles. IMSC1 provides accurate timing, styling, and multilingual metadata to meet modern accessibility needs.

Direct Feed delivery ensures seamless ingest of IMSC1 to an (v)MVPD:

- STLTP Handler: IMSC1 is transported within the STLTP stream and provided as a Direct Feed for ingest to an (v)MVPD that supports STLTP reception.
- DSTP Handler: IMSC1 is encapsulated within DSTP for Direct Feed scenarios, ensuring interoperability with (v)MVPDs capable of receiving DSTP streams.
- Essence Handler: IMSC1 is delivered as part of the caption essence alongside video and audio components, enabling (v)MVPDs with Essence Handler support to receive and synchronize caption data directly with the corresponding video/audio streams.

While IMSC1 replaces legacy caption formats used in ATSC 1.0, compatibility with CEA-608/708 [31] may be maintained through tunneling or conversion. Refer to ATSC A/370 [5] for guidance on format conversion and legacy support.

5.4 Regional Service Availability Table

The RSAT is designed to facilitate the delivery of regional services within a broadcast network. It provides information about the availability of broadcast services in different geographic regions, enabling (v)MVPDs to determine which services are accessible based on their location. Table 5.1 has descriptions of the elements within the top-level Service element and their sub-elements.

Table 5.1 Top Level Service Elements

Element Name	Description
RSAT	Includes Broadcast Availability collection elements.
@RSATInetURL	Base URL pointing to a broadband version of the RSAT XML document as defined here.
Service	Contains Service attributes and updates.
@preferred	Indicates whether the service is preferred or not for the given region.
@majorChannelNo	Major channel number associated with the Service.
@minorChannelNo	Minor channel number associated with the Service.
@frequency	Center frequency on which the Service is being broadcast in MHz.
@broadcastType	ATSC 1.0 (A/53) 8-VSB or ATSC 3.0 (A/300).
@validUntil	Expiration date or time until which the Service information is valid.
Update	Defines Updates to the Service including new Services with the same content.
@preferred	Indicates whether the service is preferred or not for the given region.
@majorChannelNo	Major channel number associated with the Service.
@minorChannelNo	Minor channel number associated with the Service.
@frequency	Center frequency on which the Service is being broadcast in MHz.
@broadcastType	ATSC 1.0 (A/53) 8-VSB or ATSC 3.0 (A/300).
@validFrom	Date and time when this update will occur.

The RSAT is essential for delivering localized content, such as regional news broadcasts, by allowing broadcasters to define which services should be available in different regions. It helps manage service distribution efficiently by providing tailored services for specific regions.

To transfer the Regional Service Availability Table (RSAT) from a broadcaster to a (v)MVPD, the following methods may be considered:

- Over-the-Air (OTA) broadcast to (v)MVPD headend: The RSAT is embedded in the service signaling data transmitted OTA via ROUTE/DASH or MMTP. The (v)MVPD headend, equipped with ATSC 3.0 receivers or demodulators, may capture the ATSC 3.0 signal and extracts the RSAT data.
- Cloud-based Delivery: The broadcaster may publish the RSAT to a cloud platform (e.g., AWS, Azure). (v)MVPDs may connect to the cloud platform via REST APIs or WebSockets to retrieve the RSAT. This setup supports both push (real-time updates) and pull (scheduled retrieval) models, depending on the (v)MVPD's requirements.
- Direct Delivery Using STLTP, DSTP, or Supplemental Handlers: The broadcaster delivers RSAT data using Direct Feed, ensuring seamless integration with (v)MVPD headends:
  - STLTP Handler: RSAT is transported within the STLTP stream and provided as a Direct Feed to (v)MVPD headends that support STLTP reception.

  - DSTP Handler: RSAT is encapsulated within DSTP for Direct Feed scenarios, ensuring interoperability with (v)MVPDs capable of receiving DSTP streams.
  - Supplemental Handler - Request-Based RSAT Retrieval:
    - RSAT is made available through a Supplemental Handler, enabling (v)MVPDs to request and retrieve RSAT data on demand instead of relying on periodic broadcasts.
    - It ensures real-time access to RSAT, improving the flexibility of service availability updates based on (v)MVPD operational needs.

The (v)MVPD may use the RSAT to determine which services are available in its current location. Upon receiving the RSAT, the (v)MVPD headend may parse the data to identify relevant services for its location and updates the service list presented to subscribers.

5.5 Service Announcement

The A/332 [13] specifies the Service Announcement layer, which defines the format and transport of service-related information, including the Service List Table (SLT) and Service Guide (SG) data, and Service Capabilities which are crucial for discovering and accessing ATSC 3.0 services.

The SLT, a key signaling table defined in A/331 [11], provides essential metadata that enables receivers to identify, discover, and initiate connections to services in a broadcast stream, acting as a discovery mechanism for listing available services and initiating tuning.

The Service Guide is a detailed service announcement mechanism that provides extensive metadata, including service descriptions, schedules, and program details, enabling user interaction with broadcast services by supplying the necessary information for creating program guides and service recommendations.

The Service Capabilities describe the technical requirements and capabilities necessary for a receiver to decode and render a service, including details about video and audio formats, codecs, accessibility features, and service-specific technical constraints; for instance, if a service requires HEVC for video decoding and the receiver supports that codec, it can play the service, otherwise, the receiver may display compatibility warnings or block incompatible content.

The broadcaster delivers Service Announcement (SA) data using a Direct Feed approach, ensuring seamless integration with a (v)MVPD headend via STLTP, DSTP, or a Supplemental Handler:

- STLTP Handler: The Service List Table (SLT) is embedded within the STLTP stream and delivered as a Direct Feed to a (v)MVPD headend that support STLTP reception. The SA is transmitted via NRT using ROUTE/DASH, which is encapsulated within the STLTP stream for retrieval by (v)MVPDs.
- DSTP Handler: The SLT is structured within the DSTP stream and distributed to a (v)MVPD headend that support DSTP-based service reception. The SA is also provided via NRT using ROUTE/DASH, which is transported within the DSTP stream for (v)MVPDs access.
- Supplemental Handler: On-Demand Service Announcement Retrieval: (v)MVPDs may request the SA from a Supplemental Handler, which functions as a retrieval service, ensuring flexible access to service announcements. This allows flexible, real-time access to the SA and availability synchronization tailored to (v)MPVDs operational requirements.

The existing A/370 [5] document provides recommendations for the signaling of services when translating from ATSC 3.0 to ATSC 1.0, but this document covers how the SA may be utilized by (v)MVPDs.

(v)MVPDs may create unified service guides or electronic program guides (EPGs) that combine ATSC 3.0 content with traditional cable/satellite content or other streaming services, while managing a Content Management System (CMS) for real-time management and updating of service offerings. The processed service announcements are used to populate the EPG on set-top boxes (STBs), smart TVs, or streaming apps, allowing users to navigate through different services, view program details, and select content for viewing, with the A/332 data potentially including rich media elements (such as images, videos) that enhance the user interface and overall experience.

5.6 Service Usage

The normative portions of A/333 [19] define a standard for reporting service usage data in ATSC 3.0, specifying methods for collecting, reporting, and managing service usage data in broadcast environments. This standard enables broadcasters and (v)MVPDs to track and analyze service usage data, including viewer behavior, service and application consumption.

The primary record for service usage data is known as a Consumption Data Unit (CDU) (see Section 4.2 of A/333 [19]). For an audio/video channel, each CDU specifies a reporting interval during which the service was accessed. The CDU contains the service identifier, the start time of service access, and the end time of service access. If a Broadcaster Application was active during this interval, the CDU also includes details about the application, such as the Application Identifier, the time the application became active, and the time it stopped being active.

To deliver service usage data from a broadcaster to a (v)MVPD headend, the following methods may be utilized:

- Supplemental Handler – Request-Based Service Usage Data Retrieval
  - Service usage data is made available through a Supplemental Handler, which (v)MVPDs can query to retrieve relevant data.
  - It supports real-time access to service usage data, enabling (v)MVPDs to request and retrieve information on demand rather than relying on periodic data pushes.
- Use of cloud-based service: The broadcaster may publish service usage data to a cloud platform (e.g., AWS, Azure), allowing (v)MVPDs to connect via REST APIs or WebSockets for data retrieval. This setup supports both push (real-time updates) and pull (scheduled retrieval) models, based on the specific requirements of the (v)MVPDs.

(v)MVPDs may aggregate service usage data from multiple sources, including various broadcast and streaming services. This aggregated data provides valuable insights into service consumption and can be leveraged for various business use cases. Key business use cases for utilizing service usage data include:

- Content optimization: Analyze service usage data to identify the most popular programs and peak viewing times, enabling (v)MVPDs to make data-driven decisions about content scheduling and programming strategies.
- Advertising and Monetization: Use detailed service usage data to enhance targeted advertising by identifying viewer demographics, preferences, and engagement patterns. This enables (v)MVPDs to implement dynamic ad insertion, tailoring ads to specific audiences based on real-time usage data.

- Personalization: Leverage service usage data to recommend personalized content based on individual viewing history and preferences. This data can also be used to develop interactive features and services that are tailored to user behavior.
- Bandwidth Allocation: Utilize service usage data to manage network bandwidth more efficiently, particularly during peak viewing times. This data can also support the implementation of CDN offload strategies, optimizing content delivery and reducing network congestion.
- Enhanced Search: Improve search functionality based on user preferences and viewing history, enabling users to find content more easily according to their interests.

5.7 Event Stream

The current A/370 [5] document does not reference `EventStream`, which is a key concept in the A/337 [20] standard. The A/337 standard specifies the delivery and synchronization of events and actions within ATSC 3.0 applications, aligning them with audio/video content. These application events can support various functions, such as synchronizing interactive content, triggering advertisements, or delivering emergency alerts.

Events are components of `EventStreams`, with each `EventStream` has the following attributes:

- `schemeIdUri`: a globally unique identifier for the type of `EventStream`
- `value`: an identifier for the sub-type of `EventStream`, scoped by `schemeIdUri`
- `timescale`: the time scale in units per second used for deriving timing information of events in the `EventStream`

Each individual event in an `EventStream` has the following additional attributes and elements:

- `presentationTime`: the start time of the event
- `duration`: the duration of the event
- `id`: a unique identifier for the event within the `EventStream`
- `data` (optional): accompanying data for the event, to be used by an application that responds to the event

These events signal the application to carry out specific actions and provide details such as when the event should occur, the type of event, and any additional data needed for the application's response.

When delivered via broadcast in a ROUTE/DASH-based system, events may be delivered as DASH Events using either of the two mechanisms:

- `EventStream` element(s) appears in a Period element of the MPD. The `EventStream` element is especially suited for "static" events, where the timing is predetermined well in advance.
- Event(s) in 'emsg' box(es) appears in the Segments of the Representation, with their presence signaled by one or more InbandEventStream elements in the AdaptationSet or Representation element of the MPD. Events delivered in 'emsg' boxes are particularly suited for "dynamic" events, where the timing is only determined at the last minute, such as triggering an action by an application when a team scores in a live sports program.

In an MMT-based broadcast system, Events may be delivered via an XML document known as the Application Event Information (AEI), which is particularly suited for static events. Additionally, dynamic events can be conveyed in 'evti' boxes [20] within MPUs [2], with an inband_event_descriptor() signaling their presence in the MPUs (refer to Section 4.1.2 of A/370).

A (v)MVPD may capture the ATSC 3.0 broadcast signal, including all embedded data, at their headend or reception point to extract events information. These extracted events are then mapped to the (v)MVPD's internal event management systems. For example, if an event signals the start of an advertisement, it is mapped to the ad management system for preparation and insertion. The (v)MVPD ensures that event timing aligns with its content distribution schedules, accounting for network delays and processing latencies.

Similar to A/370 redistribution, traditional MVPDs (Cable, Satellite, IPTV) may re-embed events within MPEG Transport Streams or equivalent formats delivered to STBs or integrated TV apps. Meanwhile, (v)MVPDs (Internet-based) may transmit events over IP networks, integrating them into applications on subscriber devices, which either periodically request updates or listen for push notifications containing event data.

The primary benefits of `EventStreams` for (v)MVPDs include enabling more interactive content experiences, such as real-time voting or access to supplementary content, and supporting precise targeting and dynamic ad insertion. By leveraging these capabilities, (v)MVPDs may make full use of A/337 Application events to enrich their service offerings, providing subscribers with more engaging and immersive viewing experience.

5.8 Emergency Alerting Support

The AEA refers to a comprehensive set of emergency alert content and metadata used to deliver detailed, context-rich emergency information. The AEAT is a data table within the ATSC 3.0 standard designed to broadcast emergency alerts and associated information to end-users.

The key elements of the AEAT are:

- Event ID and Category: Unique identifier and category of the emergency event (e.g., Advisory, Health, Weather, School, Community, Transit, Others).
- Start Time, End Time, and Duration: When the alert becomes active, when it expires, and how long it remains in effect.
- Severity, Urgency, and Certainty: Ratings that prioritize the alert and determine its impact level (e.g., Maximum/High/Moderate/Low/Minor Priority).
- Message Text and Multimedia Content: The core content of the alert includes text instructions, audio messages, videos (including live service), and URLs to additional resources.
- Geographic Targeting Information: Data specifying the areas affected by the alert.
- Language and Accessibility Options: Multiple languages and formats to accommodate diverse audiences.
- Support for Interactivity: End-users may interact with the content (e.g., clicking on a map or video) to get more detailed information.
- Dynamic Update and Cancellation: Alerts can be updated, expanded with new details, or canceled when the emergency is resolved.
- Wake-up function: Enables a receiving device in "sleep" or "stand-by" mode to recognize the presence of an emergency alert and wake up to present the emergency message to end-users using two bits in the bootstrap assigned to the wake-up function defined in A/321 [21]. The meaning of the settings of the two bits is described in A/331 [11].

To deliver AEAT, including NRT media files, from a broadcaster to a (v)MVPD headend, the following methods may be utilized:

- Over-the-Air (OTA) Broadcast to (v)MVPD Headend:
  - The AEAT is embedded in the service signaling data transmitted OTA via ROUTE/DASH or MMTP. The (v)MVPD headend may have an ATSC 3.0 receiver that extracts the AEAT data from the broadcast stream and processes it for further distribution to end-users.
  - NRT Delivery with ROUTE/DASH: Non-Real-Time (NRT) media files, such as images, maps, and video clips associated with the alert, may also be delivered using the ROUTE/DASH protocol and transmitted periodically. The (v)MVPD headend may cache these files and display them as needed.
- Cloud-Based Delivery: Broadcasters may use a cloud platform specializing in emergency alerting. This platform can receive the AEAT data, format it accordingly, and distribute it to (v)MVPD headends.
- Direct Feed Delivery Using STLTP/DSTP or Supplemental Handlers: The broadcaster delivers the AEAT using a Direct Feed method, ensuring efficient transmission to (v)MVPD headends via STLTP, DSTP, or a Supplemental Handler:
  - STLTP Handler: AEAT is embedded within the STLTP stream and transmitted as a Direct Feed to (v)MVPD headends capable of processing STLTP.
  - DSTP Handler: The AEAT is formatted and delivered using DSTP for Direct Feed scenarios, ensuring interoperability with (v)MVPDs that support DSTP reception.
  - Supplemental Handler – On-Demand AEAT Retrieval
    - (v)MVPDs may request AEAT from a supplemental handler, which acts as an AEAT request-response service. This allows (v)MVPDs to retrieve AEAT on demand rather than waiting for periodic broadcasts.
    - It ensures real-time access to AEAT, improving the flexibility in alert distribution based on (v)MVPD operational needs.

By utilizing a combination of these delivery methods, broadcasters ensure that AEAT messages and associated media are effectively delivered to (v)MVPD headends, enhancing public safety and awareness during emergencies.

Initial findings by ATSC regarding Emergency Alert and Audio Emergency Information can be found at [32].

5.9 ATSC 3.0 Content Security and Service Protection

5.9.1 DRM and Signaling Signing

Regarding Cryptographic Signing, the A/370 [5] recommended practice indicates that systems receiving signed data should verify the signature(s) for correctness, but no conversion is necessary since ATSC 1.0 does not have this capability. The same rule of verifying the signature(s) applies in this document as well.

Regarding ATSC 3.0 DRM, the A/370 recommended practice indicates that no conversion is needed since ATSC 1.0 A/70 [22] [23] has not been implemented and thus lacks this capability. However, at the ATSC 3.0 station, content is encoded using the HEVC codec for efficient video compression and then encrypted with a DRM system (such as Widevine) to prevent unauthorized access. ATSC 3.0 employs Common Encryption (CENC) standards, which allow a single encrypted content stream to be used with multiple DRM systems, thereby reducing the need for multiple encryptions.

The station broadcasts DRM-protected content over-the-air (OTA) via ATSC 3.0 signals or Direct Feed, using protocols like ROUTE/DASH or MMT for reliable delivery. In the case of OTA reception and redistribution, at the (v)MVPD, the signal may be captured, and the contents decrypted using the DRM key provided by the broadcaster, ensuring access for further distribution. In the case of Direct Feed reception and redistribution, an agreed upon encryption method between the Broadcaster and the (v)MVPD is used to secure the contents transmitted over the Direct Feed. This process is managed by the DRM License, Certificate Storage, and CDM modules as described in A/370, Section 4.2 IRDTP (Integrated Receiver Decoder Transcoder Packager, see Figure 5.1).

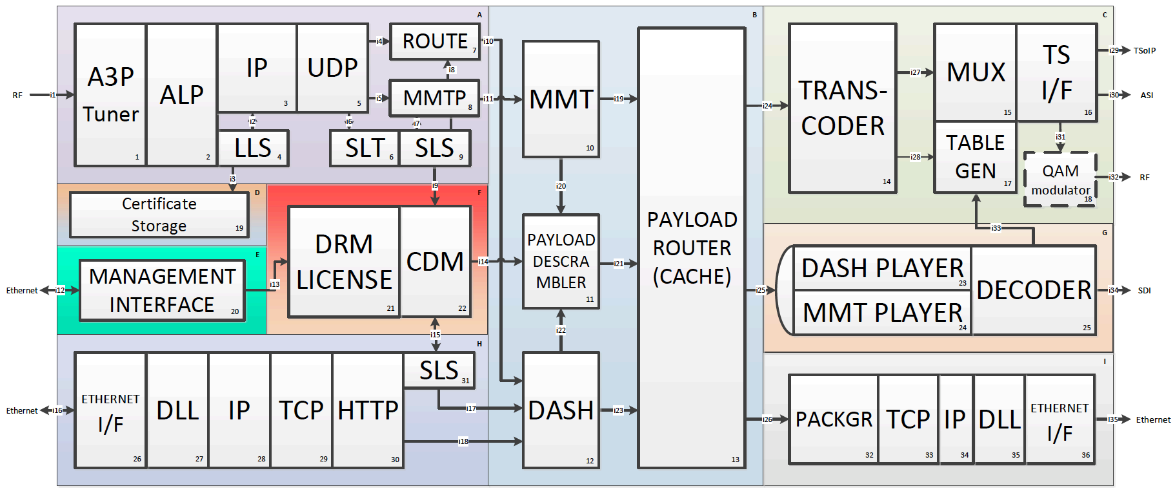

Figure 5.1 IRDTP process flow.

After decryption, the content is either stored locally or immediately re-encrypted using the MVPD's preferred DRM system or Conditional Access system to protect it during further transmission.

By following these steps, ATSC 3.0 stations and (v)MVPDs may securely deliver DRM-protected content to their subscribers while maintaining content protection throughout the delivery chain.

5.10 Broadcaster Application

A Broadcaster Application (BA) in ATSC 3.0 is coupled with the live broadcast and delivers interactive features and informational content. BAs provide for more engaged viewing experiences with contextual and personalized features including advanced emergency alerts, localized weather, Video on Demand (VOD), and other interactive services.

Key features of a BA may include the following:

- Advanced Emergency Alerts & Information (AEA&I) provide localized, multimedia-rich alerts and emergency content with interactive guidance to help users during crises. This could allow (v)MVPDs to offer timely and localized alerts without requiring additional infrastructure.
- Weather Updates deliver real-time hyper-localized weather data with the option to overlay graphics, such as live radar, on the TV screen. When sourced directly from the BA, this could help (v)MVPDs offer accurate and up-to-date weather information with minimal cost or operational effort.

- Video on Demand (VOD) offers users an extensive library of on-demand content. By utilizing the broadcaster's catalog, (v)MVPDs could expand their VOD content offerings.
- Interactive Services deepen viewer engagement through features like polls, quizzes, and dynamic overlays. These enhance the user experience and could provide (v)MVPDs with opportunities to offer additional value to their users.
- Targeted Advertising customizes advertisements based on specific regions or viewer profiles using broadcaster-supplied data. This could enable (v)MVPDs to present content that is relevant to individual users and their interests.

In summary, by utilizing BAs, (v)MVPDs could enhance their content offerings and viewer engagement, creating a benefit for the broadcaster, the (v)MVPD, and the viewer. Limitations of (v)MVPD implementations, however, also need to be considered.

In ATSC 3.0, BAs are signaled and launched through mechanisms defined in ATSC A/331 [11]. This includes use of the HTML Entry pages Location Description (HELD) and related signaling files, which are delivered using ROUTE/DASH transport protocols. These elements allow receivers to detect, download, and automatically launch BAs in sync with broadcast services.

In contrast, (v)MVPD devices, such as STBs, could lack native support for some or all ATSC 3.0 interactive features. Therefore, they might be unable to process or launch BAs and could be unable to access key features such as AEA&I, interactive services, or VOD.

Most (v)MVPD platforms support only traditional video streams and do not ingest ATSC 3.0 signaling or application data. As a result, they might not interpret the triggers or application files required to launch BAs. Supporting BAs on such platforms could require significant integration or alternate delivery paths.

These limitations could present challenges for (v)MVPD platforms aiming to offer the full interactive and personalized experience that ATSC 3.0 enables.

Alternatively, BAs can be launched using watermarks. For more information on how watermarks support BA activation in redistributed (v)MVPD environments, including device behavior, display coordination, and user interaction guidance, refer to Sections 5.12.4 and 5.12.5.

5.11 Interactivity Personalization

5.11.1 Personalization for Broadcaster Applications

Personalization in BAs refers to adapting content and interactive features to match the preferences, settings, or interests of each user or device. This adaptation is supported by the ATSC 3.0 interactive runtime environment, which enables BAs to respond to user-specific information and adjust how content is displayed.

Key personalization features within BAs may include:

- Addressable Advertising, which enables targeting based on user interests or location.
- Dynamic Content Presentation, which allows BAs to customize content such as team-specific sports statistics (e.g., favoring the home or away team), local weather updates, or event-specific overlays based on user interests or region.
- Language and Accessibility Options, which personalize the application's interface based on the viewer's preferred language, caption settings, and audio accessibility preferences.

Personalization is supported in ATSC 3.0 through mechanisms such as Filter Codes and receiver APIs:

- Filter Codes, which are broadcaster-defined values representing personalization categories, such as geographic areas, audience segments, or user interests. These codes are associated with application-related files, allowing a receiver to compare them with internally stored Filter Codes and determine which files are relevant to a particular user or device.
- Receiver Interfaces and Persistent Storage, which allow BAs to access device settings like language preference, accessibility options. Applications may dynamically modify the user experience based on these parameters, improving the user experience without requiring additional user input.

In (v)MVPD environments, there could be challenges to supporting personalization through ATSC 3.0 broadcast signaling. (v)MVPD systems might not ingest ATSC 3.0 signaling, such as Service Layer Signaling (SLS) or broadcast-delivered NRT files, into their headend infrastructures. As a result, delivering personalization files through broadcast mechanisms like Filter Codes might not be feasible for some (v)MVPD devices.

To address this, BAs can enable personalization through alternative approaches:

1) Broadband-Based Asset Retrieval:
   The BA can retrieve personalized content such as graphics overlays, targeted advertisements, or localized information via broadband using HTTP protocols. This method bypasses the need for broadcast NRT delivery.
   a) These features depend on the (v)MVPD supplying viewer device or service parameters to the ATSC 3.0 run time environment. Examples are the IP address of the device and the device ID.
2) Device-Resident Personalization:
   The BA can personalize the experience based on settings already stored in the receiver, such as language preferences, caption configurations, geographic location, or accessibility features. This ensures a customized experience even without external file retrieval.
3) Dynamic Runtime Selection:
   The BA can present users with interactive options within the application itself (such as choosing a favorite team, preferred language, or an advertisement category), storing these selections locally for future uses.

In summary, by using broadband connectivity and device-stored data, BAs can continue to offer rich, personalized experiences without requiring full ATSC 3.0 broadcast signaling. This approach maintains the value of ATSC 3.0 services across all distribution platforms, including those where signaling constraints exist.

Privacy options will be available in the BA. The details of these options are outside of the scope of this document. The Broadcaster and (v)MVPD may consider defining these options to ensure compliance with relevant regulations and company policies.

5.12 ATSC 3.0 Features and Services Delivery

In addition to delivering ATSC 3.0 content via OTA broadcast and Direct Feed distributions, broadcasters may deliver ATSC 3.0 signaling information using audio and video watermarks. ATSC 3.0 watermark-enabled receivers are capable of decoding the watermarks carried in the broadcast, and using the data in the watermark payload to retrieve ATSC 3.0 signaling data via a broadband connection and to activate ATSC 3.0 features.

5.12.1 Content Recovery of ATSC 3.0 Signaling and Other Data

ATSC A/336 [28] specifies methods for utilizing audio/video watermarking to facilitate the broadband delivery of signaling and services associated with ATSC 3.0 features to receivers, including through redistribution paths. This approach ensures that enhanced services can reach ATSC 3.0 receivers, even when content is delivered via ATSC 1.0 OTA or a third-party device (e.g., STB) connected via HDMI.

The 3.0 features that can be activated in receivers via watermarking include:

- Service Usage Reporting (A/333 [19]): This enables broadcasters to collect data on viewer engagement and usage patterns.
- Interactivity (A/344 [14]): This enables interactive features and additional information access directly through the television, enhancing viewer engagement with content.
- Advanced Emergency Alerts (A/331 [11]): This provides critical information and instructions during emergencies, with the ability to target specific regions and deliver rich media alerts beyond standard text messages.
- Hybrid Delivery (A/331): This combines over-the-air and broadband content delivery, ensuring seamless access to additional content and services.
- Broadcaster Application (A/336 [28]): Instead of relying on ATSC 3.0 signaling within the (v)MVPD, ATSC 3.0-enabled TVs can detect embedded watermarks in audio or video content delivered by the broadcaster. When a watermark is detected, the TV initiates a process to retrieve recovery data over broadband. This may involve resolving a server address and downloading signaling information, application metadata, launch instructions, or URLs related to the BA. Once the necessary information is retrieved, the TV uses it to launch the application, allowing viewers to access interactive content and additional on-screen features. This watermark-driven method works even when the content is passed through HDMI, streaming, or legacy video paths. It enables users of ATSC 3.0 receivers to access interactive services without requiring the (v)MVPD device itself to support the ATSC 3.0 stack.

5.12.2 Video Watermarks

ATSC A/335 [29] video watermarking can support a range of ATSC 3.0 features and could be utilized for applications such as content identification, audience measurement, and advanced service triggers. Video watermarks are intended to be used in conjunction with audio watermarks, providing a robust solution for enhancing service capabilities.

5.12.3 Audio Watermarks

ATSC A/334 [30] audio watermarking can support a range of ATSC 3.0 features. Broadcasters are leveraging A/334 audio watermarking to enable interactivity (A/344 [14]), enhancing viewer engagement with interactive features, and seamless access to additional content such as advanced advertisements and program-related information.

5.12.4 Redistribution of Broadcasts with Watermarks

As defined in ATSC A/370 [5], both audio and video watermarks embedded in the broadcast signal are fully compatible with ATSC 1.0 video coding and distribution systems. These watermarks carry information that can be utilized by ATSC 3.0-ready devices, even in downstream redistribution scenarios, without requiring any modification or removal of the embedded watermarks.

Audio and video watermarks are designed to pass through redistribution systems seamlessly, allowing ATSC 3.0 receivers to recover essential feature signaling. This recovered signaling enables the activation of advanced ATSC 3.0 features, such as interactivity, targeted content delivery, and enhanced viewer experiences.

In the (v)MVPD redistribution, if the television is an ATSC 3.0 receiver capable of detecting watermarks, it will handle the recovery and presentation of ATSC 3.0 features to the viewer, ensuring an enhanced and seamless user experience.

Broadcasters, (v)MVPDs, and consumer receiver device manufacturers (e.g., ATSC 3.0 receivers, STBs, gateways) should be aware that the use of watermarks for activation of interactivity in the ATSC 3.0 receiver (including the BA) creates the potential for conflict on the use of display resources (e.g., image areas, graphic overlays including captions, audio languages). This is due to the fact that the BA is executing on the ATSC 3.0 receiver and is able to use the A/344 APIs to share the TV's display resources. In contrast, it might not be possible for the (v)MVPD device (e.g., STB) to communicate with the display to share the TV's display resources. Consequently, an application running on the (v)MVPD device might be unaware of how the ATSC 3.0 receiver is using its display resources, which could result in the display of conflicting content. Care needs to be taken to make sure that an application controlling the display resources aids in communicating which device remote should be used (see Figure 5.2).

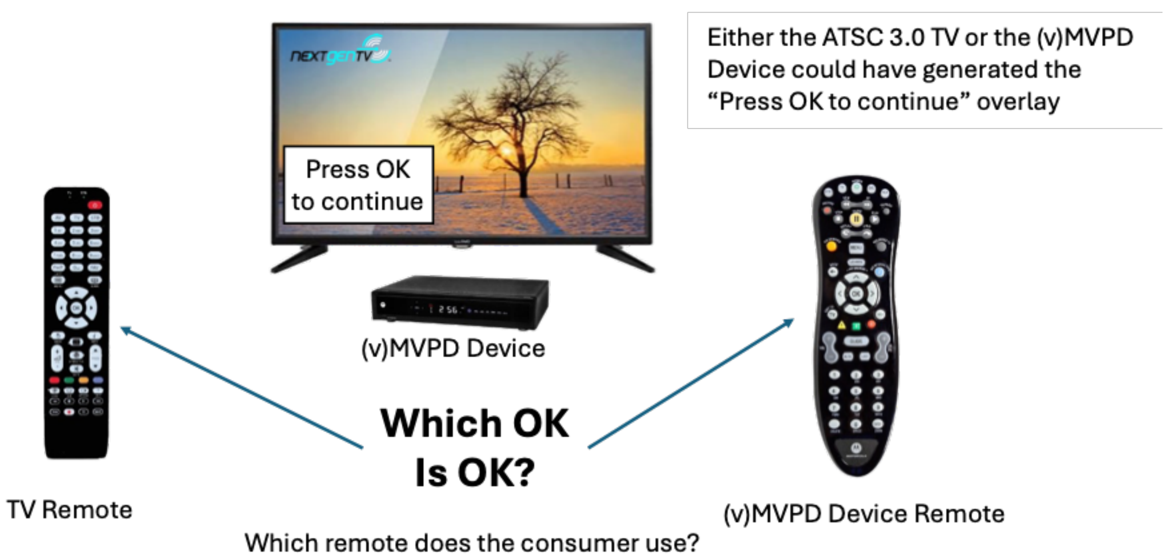

Figure 5.2 Multiple remote scenario for service selection.

Viewers watching a broadcast via a (v)MVPD device connected to an ATSC 3.0 receiver that delivers ATSC 3.0 features via watermarks are required to use the ATSC 3.0 receiver remote control to engage with the ATSC 3.0 features. To provide the best possible consumer experience, BA developers should employ clear messaging or instructions to the viewer regarding which remote control is required for the experience. Examples of possible techniques for doing this are provided in the next section.

5.12.5 Recommended Practices for ATSC 3.0 Interactive Features

As a recommended practice, developers of ATSC 3.0 interactive features based on ATSC A/344 Interactive Content [14] should consider consumer messaging with instructions regarding which remote is to be used to interact with the feature. The following list of examples provide illustration of what is possible; it is not intended to be a complete or exhaustive list of possibilities:

- A/344 Query Device Info API**.** A/344 interactive applications should make use of values returned in the A/344 Query Device Info API response, such as "*deviceMake*" to display a custom on-screen message or Call-To-Action that specifies which remote to use.
    - Example: Display a message similar to the following with explicit instructions, "Press the '*BAAppear*' key on your '*deviceMake*' remote to interact with this feature."
- QR Codes. Quick Response or "QR" codes can be used to present viewers with detailed information on how to engage and interact with the ATSC 3.0 feature.
    - Example: Display a QR code on-screen to guide viewers to a website with detailed instructions on how to interact with the ATSC 3.0 feature.
- Mobile Device as a Remote. Another consideration is the use of an alternate remote, such as a mobile phone. Pairing a mobile device to the ATSC 3.0 Receiver can provide additional flexibility and a unique user experience.
    - Example: Display a unique paring code, or QR code, to make a one-to-one connection between a mobile device and an ATSC 3.0 receiver allowing the mobile device to become the "remote" for interacting with the feature. The pairing code may require the use of a web-based or mobile application to make the pairing connection.

6. RECOMMENDED ESSENCE FORMATS FOR RETRANSMISSION SERVICES

The following sections describe the recommended practices for delivering ATSC 3.0 essence to (v)MVPDs.

6.1 Video Processing

6.1.1 HEVC Video

6.1.1.1 Description

The ATSC A/341 [25] standard details the use of HEVC for video compression. HEVC provides higher compression efficiency than AVC [9], reducing bitrate requirements while maintaining high visual quality. This efficiency enables the delivery of Ultra High Definition (UHD) video, High Dynamic Range (HDR), and Wide Color Gamut (WCG) over limited bandwidth.

ATSC A/341 specifies the use of HEVC Main 10 Profile, up to Level 5.1, supporting resolutions up to 2160p at 60 fps. When Level 5.2 is used for 2160p at 120 fps, additional constraints apply, particularly regarding temporal layering, ensuring compatibility with various playback devices.

ATSC A/345 [26] specifies the use of VVC, which offers further compression efficiency improvements over HEVC, enabling resolutions up to 4320p at 60 fps.

6.1.1.2 (v)MVPD Redistribution Recommendations

HEVC Main 10 Profile, Level 5.1 is expected to be directly ingestible by (v)MVPDs that support HEVC. However, for content encoded at Level 5.2 with temporal layering (e.g., 2160p at 120 fps), further assessment is required to determine whether (v)MVPDs can utilize the stream without modification or whether the temporal layering needs to be removed for compatibility.

For (v)MVPD redistribution, different Direct Feed methods can be applied based on network infrastructure and service requirements.

The Essence handlers deliver uncompressed or lightly processed video, audio, and captions before transport encapsulation. This gives (v)MVPDs full control over encoding and formatting but requires them to handle their own transport packaging and metadata generation.

The DSTP handler provides video, audio, and metadata in a structured format using DASH segments or MMTP streams, making it suitable for Direct Feed distribution.

The STLTP handler offers a fully structured ATSC 3.0 package with all necessary signaling and metadata. It aligns with ATSC 3.0's native transmission format, making it ideal for (v)MVPDs with existing ATSC 3.0 reception and minimal processing requirements.

6.1.2 Legacy SD Video Formats

6.1.2.1 Description

Legacy Standard Definition (SD) formats, including 720x480, 704x480, and 640x480, are supported under ATSC A/341 [25]with specific constraints on resolution, aspect ratio, and frame rate. These formats are primarily interlaced in industry use, but progressive scan variations are supported as well.

6.1.2.2 (v)MVPD Redistribution Recommendations

(v)MVPDs may support the ingestion of legacy SD formats without modification. However, adjustments such as upscaling or aspect ratio correction may be applied based on their requirements.

6.1.3 Legacy HD Video Formats

6.1.3.1 Description

Legacy High Definition (HD) 1080i format is detailed in ATSC A/341 [25], specifying the necessary parameters for resolution, aspect ratio, and frame rate, and constraining this to SDR and with no scalability support.

6.1.3.2 (v)MVPD Redistribution Recommendations

(v)MVPDs are likely to support the ingest of legacy HD interlaced formats without alteration.

6.1.4 Progressive Video Formats

6.1.4.1 Description

ATSC A/341 [25] supports progressive scan formats (e.g., 540p, 720p, 1080p, 2160p) and constrains the HEVC stream in several dimensions, e.g. 10-bit pixels, "square pixels", etc.

6.1.4.2 (v)MVPD Redistribution Recommendations

(v)MVPDs are likely to support ingest of progressive video formats with ATSC A/341[25] constraints. It is possible that some resolutions permissible by A/341 are not supported by (v)MVPDs, as A/341 has significant flexibility in this regard. Refer to A/370 [5] section regarding potential resolution conversions.

Regarding transfer characteristics: SDR and PQ video should be ingestible by (v)MVPDs without alteration. HLG video may be converted to PQ per SMPTE ST 2084 or ITU-R BT.2100. Refer to A/370 for details.

6.1.5 SHVC (Scalable HEVC)

6.1.5.1 Description

ATSC A/341 [25] defines SHVC for scalable video compression, supporting up to two quality layers, a base layer and an enhancement layer, within a single stream. SHVC enables flexible video delivery by allowing different devices to access either the base layer alone or the full-quality enhancement layer, depending on their capabilities. The standard specifies header signaling and sub-layer structures to ensure proper decoding and compatibility.

6.1.5.2 (v)MVPD Redistribution Recommendations

Direct utilization of SHVC multi-layered video will provide optimal video quality and service flexibility.

While SHVC offers optimal video quality and service flexibility, (v)MVPDs do not currently support multi-layered video coding. To enable redistribution, two options should be considered:

- Base Layer Ingestion: (v)MVPDs may ingest only the base layer, providing a compatible video stream without requiring multi-layer decoding support.
- Transcoding: The full SHVC stream can be reprocessed into a single-layer output, allowing (v)MVPDs to distribute a compatible format while retaining as much quality as possible.

The appropriate method depends on (v)MVPD capabilities and service requirements, ensuring that ATSC 3.0 content can be effectively redistributed within existing their infrastructures.

6.1.6 Static HDR Metadata

6.1.6.1 Description

Static High Dynamic Range (HDR) metadata provides fixed parameters, such as color primaries, white point, and peak luminance, essential for preserving video color fidelity.

6.1.6.2 (v)MVPD Redistribution Recommendations

ATSC optionally allows, and in some cases mandates the use of the MDCV SEI for PQ-based HDR. It is recommended that (v)MVPDs ingest and do not discard this important HDR metadata, except in the case of a transcoder/transrater that would make use of the metadata and potentially emit a modified MDCV SEI.

ATSC also allows optional use of CLLI SEI metadata. This should be preserved if present.

6.1.7 SMPTE ST 2094-10 Dynamic Metadata for Color Volume Transformation

6.1.7.1 Description

ATSC A/341 [25] and A/345 [26] detail SMPTE ST 2094-10 metadata for dynamic color volume transformation enabling adaptive rendering of color and luminance parameters.

6.1.7.2 (v)MVPD Redistribution Recommendations

ATSC recommends that (v)MVPDs preserve the associated dynamic HDR metadata SEI message for optimal video rendering at the receiving device.

ATSC enables the use of “full range” video in combination with SMPTE ST 2094-10. MVPDs may ingest this if full range is supported in their systems, or may need to convert to “legal range”. See A/370 [5] Section A3.4 for potential conversion approaches.

6.1.8 SMPTE ST 2094-40 Dynamic Metadata for HDR

6.1.8.1 Description

SMPTE ST 2094-40 metadata, as specified in ATSC A/341 [25] , conveys key HDR parameters such as maximum and minimum luminance, facilitating dynamic HDR rendering.

6.1.8.2 (v)MVPD Redistribution Recommendations

ATSC recommends that (v)MVPDs preserve the associated dynamic HDR metadata SEI message for optimal video rendering at the receiving device.

6.1.9 SL-HDR1 Dynamic Metadata for SDR Compatible Single Layer HDR

6.1.9.1 Description

SL-HDR1 dynamic metadata is defined in ATSC A/341 [25] and A/345 [26] for single-layer HDR video compatible with both HDR and SDR displays, detailing the syntax, packet structure, and interpretation guidelines. SL-HDR1 is specified in ATSC A/341 Section 6.3.2.1.1 and 6.3.2.1.2.

6.1.9.2 (v)MVPD Redistribution Recommendations

ATSC recommends that (v)MVPDs preserve the associated dynamic HDR metadata SEI message for optimal video rendering at the receiving device. In the case of SL-HDR1, if the HDR metadata is discarded, then the output video will be rendered as SDR.

6.1.10 SL-HDR1 SDR Compatible HDR System

SDR video signals (Rec. ITU-R BT.709 [24]) in ATSC 3.0 may include SL-HDR1 dynamic metadata, which guide the reconstruction of an HDR video signal from the SDR signal. The metadata are conveyed in SEI messages in the HEVC or VVC elementary streams (see Sections 6.3.2.1 and 6.3.2.2 in [25] and 5.2.5.3 in [26]). In order to preserve the content provider's HDR "look & feel", SL-HDR1 metadata SEI messages — like other SEI messages conveyed in the encoded video stream — should be carried through the (v)MVPD distribution until it reaches the device intended to render the video (which typically is either a consumer TV or a device within the (v)MVPD distribution workflow). Because the dynamic metadata are intimately tied to the SDR video signal, prior to the processing of the SL-HDR1 metadata, no picture enhancements should be performed on the SDR video (e.g., change of contrast, brightness, color primaries, black-level, sharpness, denoising), and no change in frame alignment between the video frame and its associated SL-HDR1 metadata SEI message should occur. There are no issues with changing the resolution of the SDR video. Any tables or parameters used to signal the presence or absence of SL-HDR1 should be updated to reflect correctly the presence or absence of SL-HDR1 metadata.

The following subsections describe the scenarios in which video essence with SL-HDR1 metadata is conveyed to the end user via an (v)MVPD path. To aid in this discussion, Figure 6.1 and Figure 6.2 illustrate a simplified system architecture (only the functions from the full broadcast chain that are relevant to SL-HDR1 are included).

6.1.10.1 (v)MVPD Scenarios

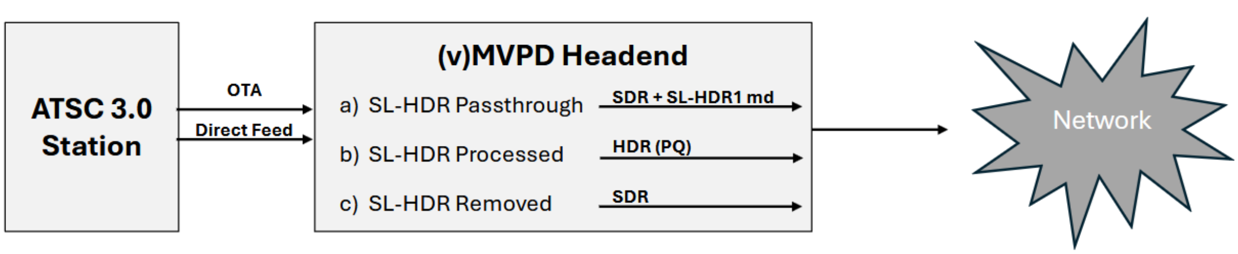

Figure 6.1 Simplified system architecture of MVPD distribution regarding SL-HDR1.

When the (v)MVPD headend receives content that contains SL-HDR1 metadata from an ATSC 3.0 station, whether via OTA or Direct Feed, there are three possible scenarios for further distribution of the video essence:

- The SL-HDR1 metadata is passed through.
  - The SEI messages that contain SL-HDR1 metadata are passed through in a manner analogous to how other video SEI messages are passed through.
  - If transcoding of the input video is performed (e.g., video is re-encoded to a different bitrate), then SEI messages — or their contents — typically are extracted then reinserted at the appropriate location in the transcoded video bitstream.
- The SL-HDR1 metadata is processed.
  - The headend has the functionality to use the SL-HDR1 metadata to reconstruct the original HDR signal (e.g., to create a 10-bit PQ HDR video signal).
- The SL-HDR1 metadata is removed.
  - Only the SDR video signal is distributed further.
  - The content provider's original HDR information is lost.

6.1.10.2 End User or Consumer Scenarios

There are two potential situations at the end user or consumer location:

- The incoming signal is received directly by the display that will render the video (e.g., consumer TV, from OTA or broadband interface).
- The incoming signal is received by an intervening receiver (e.g., (v)MVPD STB or home gateway device), which in turn sends the (processed) signal (e.g., via an HDMI interface) to the display that will render the video.

In the case where the incoming signal is received directly by the display that will render the video and the incoming video signal contains SL-HDR1 metadata, then there are two possible scenarios:

- The display device is HDR capable and has the functionality to process the SL-HDR1 metadata to reconstruct the content provider's HDR images.
  - The original HDR video essence is displayed, with appropriate display adaptation performed, based on the capabilities of the display (i.e., the shadows and brightness of the reconstructed HDR signal are adapted to match the limits of the display).
- The display device is not HDR capable (e.g., SDR only display) or it does not have the functionality to process the SL-HDR1 metadata.
  - The SDR video signal is displayed, without modification.

In the case where the incoming signal is received by an intervening receiver and the incoming video signal contains SL-HDR1 metadata, then there are three possible scenarios, with sub-scenarios based on the output transport format sent to the display that will render the video:

- The SL-HDR1 metadata is passed through.
  - If the video stream remains in the compressed domain (i.e., it remains encoded) — typically as a streaming format (e.g., HLS or DASH) or MPEG-2 Transport Stream over IP – then the SEI messages that contain SL-HDR1 metadata are passed through in a manner analogous to how other video SEI messages are passed through.
  - If the video stream is decoded to baseband for output over HDMI, then the intervening receiver communicates with the rendering display using HDMI's E-EDID protocol to determine the display's rendering capabilities (e.g., SDR, HDR, what formats of HDR,

peak white level, and a lot more). If based on the result of this query, the intervening receiver determines that the display supports SL-HDR1, then the SL-HDR1 metadata is sent over HDMI along with the video stream (see CTA-861) [27].

- The SL-HDR1 metadata is processed.
  - This occurs if the video stream is decoded to baseband for output over HDMI and the intervening device has the functionality to use the SL-HDR1 metadata to reconstruct the original HDR signal (e.g., to create a 10-bit PQ HDR video signal).
- The SL-HDR1 metadata is removed.
  - Only the SDR video signal is distributed further.
  - The content provider's original HDR information is lost.

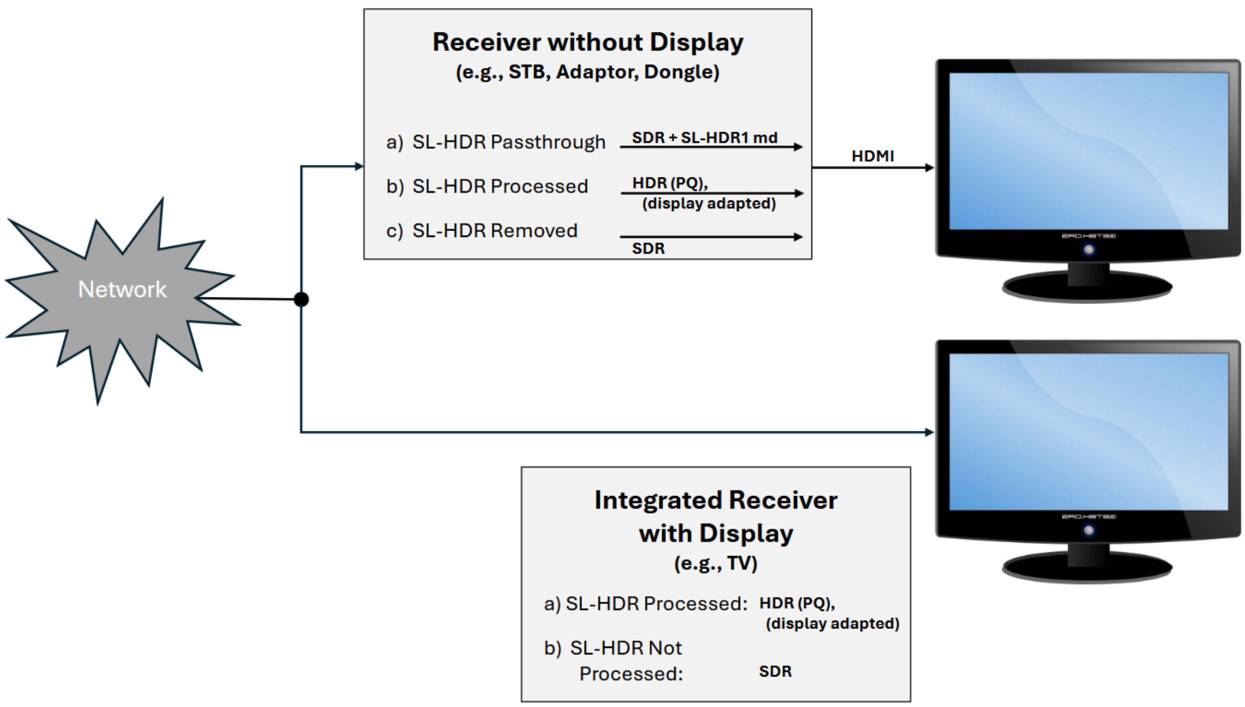

Figure 6.2 Simplified view of how SL-HDR1 metadata is processed by the consumer or end-user.

6.1.11 AFD (Active Format Description) and Bar Data

6.1.11.1 Description

ATSC A/341 [25] and A/345 [26] specify the use of AFD and bar data to denote video display formatting and aspect ratio, describing the required syntax and payload structure.

6.1.11.2 (v)MVPD Redistribution Recommendations

ATSC recommends that (v)MVPDs preserve AFD and bar data for downstream use at the receiving device.

6.1.12 Temporal Layering

6.1.12.1 Description

Temporal layering, as defined in HEVC and ATSC A/341 [25], signals video frame in an alternating fashion temporally, to enable receivers that are only capable of HEVC Level 5.1 decoding to decode a subset of a 2160p 120 fps stream that otherwise requires a Level 5.2 decoder.

6.1.12.2 (v)MVPD Redistribution Recommendations

If the (v)MVPD is not expected to use temporal layering for purposes other than ATSC use of sub-stream extraction, it is recommended to ingest temporally layered video directly. If there is planned use of temporal layering for other purposes, the video bitstream may be conditioned to remove the temporal layering syntax prior to downstream processing. See A/370 [5] Annex A.

6.2 Audio Processing

6.2.1 Audio Codecs

The ATSC 3.0 Digital Television System uses the AC-4 [36] and MPEG-H 3D Audio [33] audio codecs. AC-4 is used in North America for over-the air ATSC 3.0 broadcasting and will be described here. However, based on the needs of the (v)MVPD recipient, other audio formats may be provided for their use, with the audio sourced via AC-4 transcode or supplied as baseband PCM audio. The recipient may also choose to receive and use AC-4 directly or to convert AC-4 to a different format compatible with their systems, ideally supporting the features that AC-4 provides.

6.2.2 Content Dependent Channel Formats, Primary and Secondary Encoded Audio

6.2.2.1 Formats

Primary audio is typically acquired from the content supplier as 2-channel stereo, 5.1 surround sound, or 5.1.4 immersive surround sound for presentation to the audience. Channel encoding by the broadcaster is typically in 5.1 surround sound or 5.1.4 immersive surround sound. In addition, the ATSC 3.0 AC-4 standard supports immersive surround up to 7.1.4, however, there has been no field use of this format to date.

6.2.2.2 Primary Audio

Primary Audio is typically encoded as a “complete main” (CM). In this configuration, all elements of the soundtrack are included and presented as a composite soundtrack.

- Content may be configured as 2.0 stereo, 5.1 surround or 5.1.4 immersive surround sound.
- The channel format for complete main encoding may be 2.0 stereo, 5.1 or 5.1.4. to match typical content.
- In some cases, audio *encoded* as 5.1 or 5.1.4 may carry only 2.0 or 5.1 *content dependent* audio channels. In this case, unused channels in the stream are silent.

6.2.2.3 Upmixing

The broadcaster may choose to upmix content to the 5.1.4 channel format that provides a consistent and higher quality immersive audio experience for the listener. Using this technique, when 5.1.4 audio is acquired from the content supplier it is directly passed through to the encoder. When the audio is acquired as stereo or 5.1, it is automatically upmixed, resulting in a consistent 5.1.4 fixed channel count in all cases.

6.2.2.4 Secondary Audio

Additionally, secondary audio may be provided composed of Audio Description (AD) or Alternate Languages (AL). This audio can be acquired in various channel formats like dual channel mono, stereo, 5.1 or 5.1.4 immersive surround sound and encoded appropriately as a CM. Considering the need to simultaneously feed legacy systems with limited audio channel capacity, the secondary audio may likely be limited to 2-channel mono or stereo and be encoded as a 2.0 stereo CM.

Alternatively, when encoding supports it, secondary audio can leverage components of the primary audio CM to create an enhanced immersive AD and/or AL listening experience.

6.2.2.5 CM +AD Audio Description

This is possible when isolated describer audio is available from the content supplier and sent to the input of a compatible encoder that supports "complete main + AD" mode. In CM+AD mode, the AC-4 system will mix the isolated describer audio over the primary soundtrack (typically 5.1 or 5.1.4) and dynamically "duck" or reduce the amplitude of the primary soundtrack to increase the intelligibility of the describer.

As a result, the AD soundtrack quality is improved, benefiting from the typical 5.1 or 5.1.4 channel format of the primary audio.

6.2.2.6 Alternate Language

Additionally, substituting isolated alternate language dialog for primary language dialog and creating another alternate language CM is possible when the content supports it. This requires isolated original primary audio dialog (without effects or music) that can be replaced by isolated alternate language dialog.

As a result, the AL soundtrack quality is improved, benefiting from the typical 5.1 or 5.1.4 channel format of the primary audio.

6.2.2.7 Dialog Enhancement

Dialog intelligibility is a frequent problem for listeners. The AC-4 system supports dialog enhancement, a feature that enables listeners to reduce the amount of non-speech background sounds, therefore increasing the presence of foreground sound that is typically dialog. This maintains consistent, measurable loudness of the content while increasing the intelligibility of dialog. Dialog enhancement metadata is created during AC-4 encoding and is enabled for all content. Receivers and STBs should be provisioned to react to this information and present a switch or fader to activate the feature.

6.2.3 Contribution/Distribution

There are multiple ways audio can be delivered as a mezzanine contribution to MVPDs. Pre-encoded AC-4 could be supplied and passed through the transcoding process at the MVPD and delivered directly to consumers with compatible STBs and potentially other devices. In reality, MVPDs will likely need to transcode for widest compatibility with their distribution platforms. Linear PCM is also an option and provides more flexibility though with far less efficiency than compressed alternatives.

Table 6.1 is part of Table 15 from SCTE 277-2024 [6] showing how a fixed channel configuration could support several existing features while remaining compatible with existing workflows. For example, legacy pre-mixed Audio Description remains on channels 7/8 while higher channels for immersive audio, describer-only audio, and additional dialog channels are carried as part of a second group of eight channels.

Table 6.1 Channel Configuration Transport Example (excerpt from SCTE-277 [6])

Channel	LPCM ST302M
1 - Lf 2 - Rf 3 - C 4 - LFE 5 - Ls 6 – Rs	PID 1 Ch 1 PID 1 Ch 2 PID 1 Ch 3 PID 1 Ch 4 PID 1 Ch 5 PID 1 Ch 6
7 - SAP/AD 8 - SAP/AD	PID 1 Ch 7 PID 1 Ch 8
9 - Ltf 10 - Rtf 11 - Ltr 12 - Rtr	PID 2 Ch 1 PID 2 Ch 2 PID 2 Ch 3 PID 2 Ch 4
13 - AD Describer 14 - D1 15 - D2 16- n/a	PID 2 Ch 5 PID 2 Ch 6 PID 2 Ch 7 PID2 n/a

This same channel configuration can be preserved even when employing a compressed audio format such as AC-4 [36] or MPEG-H 3D Audio [33]. Note that in all cases, inter-channel phase alignment is essential for proper performance of audio and perhaps audience measurement systems as well.

7. GENERAL DIRECT FEED RECOMMENDATIONS

ATSC 3.0 video and audio content is fed directly to (v)MVPDs through three primary handlers such as STLTP, DSTP, and Essence handlers. These handlers ensure that video, audio, captions, and related metadata reach (v)MVPDs in the appropriate format, maintaining quality, synchronization, and service integrity. If conversion to ATSC 1.0 or another format is required, (v)MVPDs may follow A/370 specifications.

7.1 Essence Handlers

The Essence Handlers (Essence Handler or SCTE DVS Essence Handler) are responsible for delivering the core media components (HEVC video, AC-4 audio, and IMSC1 captions) directly from the encoder before any transport encapsulation takes place. This approach gives (v)MVPDs access to uncompressed or lightly processed content, allowing them to manage encoding, bitrate adjustments, and reformatting based on their specific requirements.

Since the Essence Handlers provides raw video and audio streams, it does not include service-level signaling, transport metadata, or encapsulation. (v)MVPDs that receive Essence feeds may need to apply their own transport encapsulation, such as MPEG-2 Transport Stream [34] or other proprietary formats, and generate signaling and metadata to ensure proper content distribution.

This handler is best suited for delivery of higher quality, mezzanine formats (e.g., higher resolution video or higher bit rates) in addition to the standard formats to (v)MVPDs that may require greater control over video and audio processing before redistribution.

7.2 DSTP Handler

The DSTP Handler manages the delivery of video, audio, captions, and signaling data using ROUTE/DASH or MMTP. It ensures that (v)MVPDs receive both media and essential service metadata in a structured format.

DSTP Handler carries essential signaling and metadata, including:

- Service List Table (SLT) – Provides service identification and transport parameters for (v)MVPD discovery.
- Electronic Service Guide (ESG) – Supplies program metadata for integrating ATSC 3.0 channel and schedule information.
- MPD (Media Presentation Description) for DASH – Defines segment structures, adaptation sets, and timing parameters.
- MMTP Asset Information – Includes details about media asset dependencies and stream structures.
- Emergency Alert System (EAS) Messages – Transports real-time emergency information.
- Synchronization Metadata – Aligns video and audio to prevent drift or timing mismatches.

Since DSTP Handler delivers DASH segments, (v)MVPDs may leverage them directly with minimal effort, making it an efficient choice for Direct Feed content distribution.

7.3 STLTP Handler

The STLTP Handler extends the DSTP Handler's role by carrying video, audio, captions, and all signaling and metadata described in DSTP, while repurposing ATSC Link-Layer Protocol (ALP) to structure and transport data from the broadcaster to the (v)MVPD. Although STLTP was originally designed for transmission between the broadcast gateway and the transmitter, it may be effectively reused for Direct Feed delivery to (v)MVPDs.

In addition to DSTP metadata, STLTP Handler includes:

- Physical Layer Pipe (PLP) Information – Defines how multiple services are multiplexed.
- System Time Clock (STC) Information – Ensures frame-accurate synchronization across all video and audio streams.
- ALP Packetization Details – Defines how audio, video, captions, and signaling data are encapsulated into ATSC Link-Layer Protocol (ALP) packets for structured transport between the broadcaster and (v)MVPD, ensuring compatibility with ATSC 3.0 workflows.

Since STLTP Handler is very similar to OTA reception, (v)MVPDs that already have ATSC 3.0 OTA reception modules may integrate STLTP Handler with minimal additional work.

7.4 Final Recommendations for (v)MVPD Integration

(v)MVPDs may adopt the most suitable Direct Feed method for integrating ATSC 3.0 services based on their network infrastructure, processing capabilities, and distribution model.

For situations where Broadcasters and (v)MVPDs desire the use of higher quality mezzanine formats for redistribution purposes or where (v)MVPDs require direct control over encoding and formatting, using one of the Essence Handlers (Essence Handler or SCTE DVS Essence Handler) is recommended. This provides access to raw video, audio, and captions, allowing them to apply their own compression, bitrate adjustments, and custom processing before redistribution.

For Direct Feed content delivery, DSTP Handler may be used. It provides structured content using DASH segments or MMTP streams, making it suitable for broadband or hybrid network environments. This approach simplifies service integration while maintaining metadata integrity and synchronization.

For (v)MVPDs requiring a fully encapsulated ATSC 3.0 Direct Feed, STLTP Handler is the recommended choice. It preserves video, audio, captions, and all necessary signaling metadata in a structured transport format used between the broadcast gateway and transmitter in ATSC 3.0.

Since STLTP Handler aligns with ATSC 3.0 OTA reception, (v)MVPDs with OTA reception modules may integrate STLTP feeds with minimal modifications, making it an efficient solution for seamless content redistribution.

Annex A: Demonstration of ATSC 3.0 Services Delivery via a Direct Feed

A.1 EXAMPLE SYSTEM

In support of developing this recommended practice document, techniques like those described here have been successfully demonstrated in the field. These techniques were identified as effective methods of signal carriage while preserving the essential ATSC 3.0 features identified by broadcasters and viewers during this phase of the ATSC 3.0 transition. These features included audio description over immersive surround sound, alternate language over immersive surround sound and user-selectable dialog enhancement.

The following example system diagram in Figure A.1.1 illustrates the architecture between an ATSC 3.0 broadcaster and an MVPD for delivering video, audio, and caption essences. In this configuration, the Essence Handler, implemented within the encoder, outputs mezzanine-encoded, unsegmented essences, prepares them for Direct Feed, and transmits the streams to the MVPD using SRT (Secure Reliable Transport), providing secure, low-latency delivery of high-fidelity content independent of the ATSC 3.0 OTA broadcast chain.

An OTA Integrated Receiver/Decoder (IRD) is also deployed at the MVPD site as a failover source. The IRD provides a compatible version of the broadcast service, structured as one video and multiple audio presentations, supporting basic service continuity if the Direct Feed becomes unavailable.

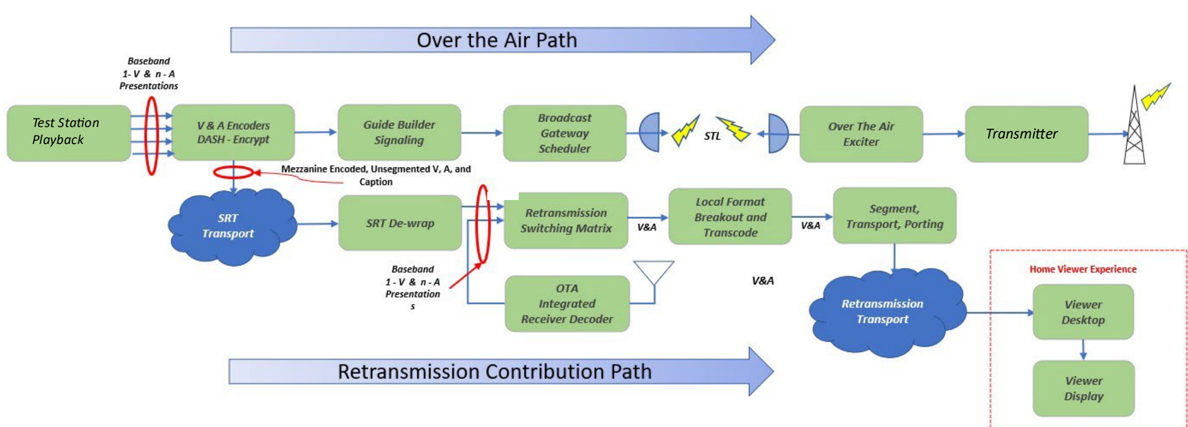

Figure A.1.1 Demonstration block diagram**.**

Upon receipt of the streams via the secure SRT connection, the MVPD system performs Local Format Breakout and Transcode as needed.

This process was designed to fulfil the MVPD's format and delivery requirements and involves converting the video, audio, and caption essences into formats compatible with downstream processing, packaging, and end-user devices. The processed essences are then multiplexed according to the MVPD's distribution specifications and integrated into their operational workflows.

– End of Document –