Doc T-26/7

Report on DISTRIBUTION TOPIC AREA

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The Distribution Topic area comprises four projects, each addressing technological aspects of digital broadcasting. These projects undertake the study and investigation of digital terrestrial television broadcasting, digital satellite broadcasting, and digital sound broadcasting. This topic area encompasses research related to Integrated Broadcast-Broadband (IBB) and Over-the-Top (OTT) services.

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Annex 1

Digital Terrestrial Television Broadcasting (D/DTTB)

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This Annex reports the current status of the next generation television broadcasting systems and the recent updates on relevant technologies and standardizations.

1.1 Second-Generation Digital Terrestrial Television Broadcasting Systems

1.1.1 Overview (Recommendation ITU-R BT.1877-4)

The evolution of digital terrestrial television broadcasting (DTTB) has reached a pivotal stage with the emergence of second-generation systems, designed to meet the growing demands for higher data capacity, improved spectral efficiency, and robust mobile reception. Recommendation ITU-R BT.1877, "Error-correction, data framing, modulation and emission methods and selection guidance for second generation digital terrestrial television broadcasting systems", was revised in June 2026 (BT.1877-4). With this revision, ISDB-T3 has been added and the Recommendation now covers four systems—DVB-T2, ATSC 3.0, DTMB-A, and ISDB-T3—which represent significant advancements over their first-generation predecessors, offering enhanced flexibility, performance, and service diversity.

DVB-T2

Developed primarily for Europe and other regions, DVB-T2 supports both fixed and mobile reception through two profiles: T2-Base and T2-Lite. It utilizes multiple Physical Layer Pipes (PLPs), allowing service-specific modulation and coding. DVB-T2 is highly configurable, supporting bandwidths from 1.7 MHz to 10 MHz, and is compatible with the GE06 spectrum planning agreement. It enables hierarchical transmission of SDTV, HDTV, and UHDTV, and is well-suited for Single Frequency Networks (SFNs) and mobile broadcasting scenarios.

ATSC 3.0

ATSC 3.0, developed by the Advanced Television Systems Committee, is a non-backward-compatible system designed for the U.S., Canada, Korea, and other regions. It integrates IP-based delivery, enabling interactive services, personalized content, and advanced emergency alerting. The system supports robust mobile reception and high-capacity fixed services, with layered architecture (Physical, Protocol, Application) that allows broadcasters to tailor configurations. ATSC 3.0 is

also positioned to complement 5G ecosystems through hybrid broadcast-broadband integration.

DTMB-A

As an evolution of China's DTMB standard, DTMB-A enhances transmission robustness and efficiency. It supports a wide range of services including UHDTV, HDTV, SDTV, and multimedia data, across both fixed and mobile environments. DTMB-A employs advanced channel coding and modulation techniques, and is optimized for high-performance delivery in complex urban and rural terrains. It is also designed to support future extensions and flexible deployment strategies.

ISDB-T3

ISDB-T3 (Integrated Services Digital Broadcasting – Terrestrial, 3rd generation), also referred to as Advanced ISDB-T, was developed in Japan as the successor to ISDB-T [1]; its system standard is ARIB STD-B80 [2]. It is designed to improve the performance, flexibility, functionality and spectral efficiency of the first- and second-generation DTTB systems. It adopts advanced modulation with non-uniform constellations (NUC), hierarchical transmission (FDM/TDM/LDM), LDPC error correction, 2 × 2 MIMO, channel bonding of two RF channels, and IP transport (MMT/TLV), and supports emergency warning. It supports multiple UHDTV/HDTV and multimedia services for fixed and mobile reception, in both multiple and single frequency networks.

The main parameters are as follows. The system supports 6, 7 and 8 MHz channels, each divided into 35 segments (a segment can be further divided into sub-segments of one third of a segment), with FFT sizes of 8k, 16k and 32k. The modulation is selectable for each layer from QPSK to 16-, 64-, 256-, 1024- and 4096-QAM, with a uniform constellation or NUC. The inner code is an LDPC code with a block length of 69120 (normal) or 17280 (short) bits and 13 code rates from 2/16 to 14/16, and the outer code is BCH. A frame consists of a frame synchronization symbol, TMCC symbols and one or more subframes; the FFT size, guard interval ratio and SISO/MIMO can be selected for each subframe, and the modulation, code rate and time-interleaving depth for each layer. Receivers can reduce power consumption by partial reception in the time or frequency domain. The net data rate for SISO ranges from 0.67 to 58.9 Mbit/s in a 6 MHz channel and from 0.91 to 78.6 Mbit/s in an 8 MHz channel, and the required C/N in an AWGN channel ranges from −6.8 to 33.4 dB. The spectrum efficiency ranges from 0.11 bit/s/Hz (QPSK 2/16) to 10.11 bit/s/Hz (4 096-QAM 14/16), the widest range among the four systems (Table 1-1).

Table 1-1: Spectrum efficiency of the second-generation DTTB systems (Recommendation ITU-R BT.1877-4, Table 7)

System	Minimum (bit/s/Hz)	Maximum (bit/s/Hz)
DVB-T2	0.25 (QPSK 1/2)	6.51 (256-QAM 5/6)
ATSC 3.0	0.16 (QPSK 2/15)	9.92 (4 096-QAM 13/15)
DTMB-A	0.66 (QPSK 1/2)	6.52 (256-APSK 5/6)
ISDB-T3	0.11 (QPSK 2/16)	10.11 (4 096-QAM 14/16)

Note: Calculated in BT.1877-4 from the minimum/maximum net data rates and the used bandwidth.

Common Features and Strategic Importance

All four systems leverage modern error correction (e.g., LDPC, BCH codes), OFDM modulation, and adaptive frame structures. They are engineered to withstand multipath interference, impulse noise, and varying reception conditions. Importantly, these systems enable broadcasters to deliver high-quality content to both fixed and mobile devices, supporting handheld services and portable reception—key for future media consumption trends.

As administrations and broadcasters consider upgrades or new deployments, the selection among these systems depends on regional spectrum policies, service goals, infrastructure readiness, and consumer needs. The Recommendation ITU-R BT.1877-4 provides detailed guidelines to help evaluate and select a specific system.

1.1.2 Recent Standardization and Deployment Activities

ISDB-T3

ISDB-T3 was standardized by the Association of Radio Industries and Businesses (ARIB) as ARIB STD-B80 version 1.0 in March 2025. The standard was revised to version 1.1 on 16 April 2026; the revision added MISO, transmitting-station identification codes and PAPR reduction as extension functions, and compiled guidelines for transmission equipment as appendices [2]. Following the drafting work at ITU-R Working Party 6A (WP 6A), ISDB-T3 has been included as Annex 4 of Recommendation ITU-R BT.1877-4, approved on 10 June 2026, with ARIB STD-B80 referenced as its system standard. The latest topics on ISDB-T3 in Japan are reported in Section 1.3.

TV 3.0 ("DTV+", Brazil)

TV 3.0 is Brazil's next-generation digital terrestrial television system, designed to merge traditional broadcasting with the flexibility of digital streaming. It builds on the legacy of ISDB-T_B (TV 2.0) and introduces ultra-high-definition (4K/8K) video, immersive MPEG-H audio, and advanced interactivity. The system integrates Over-the-Air (OTA) and Over-the-Top (OTT) delivery using IP-based protocols and ROUTE/DASH transport layers. Key technologies include VVC and MPEG-5 LCEVC video codecs for efficient bandwidth use, ATSC 3.0 for the physical layer, and support for HDR formats and VR/AR experiences [3][4].

Following extensive evaluations by the SBTVD Forum, the Brazilian government adopted the system by a presidential decree on 27 August 2025 under the name "DTV+". The system incorporates the physical and transport layers of ATSC 3.0, along with ATSC 3.0 technologies for video, audio, captioning and emergency warning [5].

Globo started experimental DTV+ transmission in Rio de Janeiro in April 2025, followed by São Paulo and Brasília [5][6]. Commercial service started on 11 June 2026, coinciding with the opening of the 2026 FIFA World Cup, in Rio de Janeiro, São Paulo and Brasilia for viewers with compatible receivers [7][8]. Globo used DTV+ to offer interactive features during its World Cup coverage.

ATSC 3.0 (United States)

ATSC 3.0 services (branded "NEXTGEN TV") reached more than 76% of U.S. households as of July 2026 [9]. Under the current FCC rules, the transition is voluntary, and a station that converts to ATSC 3.0 must continue to simulcast its primary program stream in ATSC 1.0 in the same market, with the "substantially similar" programming requirement scheduled to sunset on 17 July 2027 [10][11].

On 28 October 2025 the FCC adopted a Fifth Further Notice of Proposed Rulemaking (FNPRM) (FCC 25-72, GN Docket No. 16-142) to accelerate the transition [10][11]. The main points are:

- The FCC proposes to eliminate the ATSC 1.0 simulcast requirement, so that simulcasting becomes voluntary and each station can decide when to end ATSC 1.0 service. It does not propose a mandatory nationwide end date for ATSC 1.0 but seeks comment on whether and how a transition should be completed [10][11].
- The FCC only seeks comment on whether to require new television receivers to be capable of receiving ATSC 3.0 signals, and on its benefits and costs; it makes no tentative conclusion on such a tuner requirement [10].

- Other issues include whether recent version of the ATSC 3.0 physical layer standards should be incorporated int FCC rules, and the carriage of ATSC 3.0 signals by multichannel video programming distributors (MVPDs) [11].

Comments were due on 20 January 2026 and reply comments on 18 February 2026 [10].

The FNPRM generated extensive debate among broadcasters, equipment manufacturers, MVPDs, and consumer advocacy organizations. Broadcaster groups, led by the National Association of Broadcasters (NAB), argued that a clear transition timetable and eventual sunset of ATSC 1.0 are necessary to encourage investment and accelerate nationwide deployment of ATSC 3.0 services. By contrast, the Consumer Technology Association (CTA) opposed any mandatory ATSC 3.0 tuner requirement, arguing that television receiver standards should remain market-driven and that a mandate could increase costs for consumers. Consumer advocacy organizations, including Public Knowledge and Consumer Reports, also expressed concerns regarding the use of digital rights management (DRM), potential impacts on universal free-to-air reception, and the readiness of consumers for an eventual ATSC 1.0 shutdown. As of October 2026, the FCC had not yet issued a final decision on these issues, and the proceeding remained under consideration. No nationwide ATSC 1.0 sunset date, mandatory ATSC 3.0 tuner requirement, or new DRM regulations had been adopted. [12]-[14]

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1.2 Terrestrial Multimedia Broadcasting Systems for Mobile Reception

Mobile reception using handheld devices requires specialized technical design due to unique propagation conditions and device constraints such as small antennas, limited screen size, low power consumption, and reduced processing capabilities.

1.2.1 User Requirements (Recommendation ITU-R BT.1833-5)

To ensure effective mobile multimedia broadcasting, the following user requirements are considered:

- Delivery of high-quality multimedia content (video, audio, data)
- Flexible configuration of diverse services (AV, auxiliary data)
- Content protection via conditional access and DRM
- Seamless access across different networks
- Fast channel acquisition and service switching
- Efficient power usage and compact device compatibility
- Stable and reliable reception in various environments
- Support for interactivity and return channel capabilities
- Efficient transport mechanisms
- Interoperability between broadcast and telecom networks (e.g., IP-based services)

1.2.2 Technical Systems (Recommendation ITU-R BT.2016-4)

ITU-R BT.2016-4 defines multiple systems suitable for mobile reception via handheld devices in VHF/UHF bands. These systems include Systems A, F, H, I, T2, etc., and are characterized by the following technical components:

a. Modulation and Error Correction

- Modulation: QPSK, 16QAM, 64QAM, DQPSK, etc.
- Error correction: Convolutional codes, Turbo codes, LDPC + BCH
- Interleaving: Time and frequency interleaving for robustness

b. OFDM-Based Transmission

- Subcarrier configurations: 1k to 32k modes
- Guard intervals: Configurable from 1/128 to 1/4
- Symbol durations: Ranging from hundreds of microseconds to several milliseconds

c. Frame Structure and Synchronization

- Frame duration: Up to 250 ms, depending on system
- Synchronization: Pilot carriers, guard intervals, P1/P2 symbols

d. Data Rates

- Net data rates: Vary from hundreds of kbps to tens of Mbps depending on modulation, coding rate, and system configuration

Table 1-2: Representative systems

System	Standard / Origin	Modulation	Coding	Bandwidth	Max Data Rate	Key Features
A (T-DMB / AT-DMB)	Korea / DAB-based	DQPSK, BPSK/QPSK over DQPSK	Convolutional + Turbo	1.712 MHz	Up to 2.88 Mbps	Backward compatible with T-DMB
F (ISDB-T)	Japan	DQPSK, QPSK, 16QAM, 64QAM	Convolutional	6/7/8 MHz	Up to 2.38 Mbps per segment	Hierarchical transmission
I (DVB-SH)	Europe	QPSK, 16QAM	Turbo Code	1.7–8 MHz	Up to 17.26 Mbps	Satellite + terrestrial hybrid
H (DVB-H)	Europe	QPSK, 16QAM, 64QAM	Convolutional + MPE-FEC	5–8 MHz	Up to 23.82 Mbps	IP datacast, MPE-FEC
T2 (DVB-T2 Lite)	Europe	QPSK, 16QAM, 64QAM	LDPC + BCH	1.7–8 MHz	Up to 4 Mbps	Optimized for mobile

R (RAVIS)	Russia	QPSK, 16QAM, 64QAM	LDPC + BCH	100-250 kHz	Up to 900 kbps	Low Bitrate Channel and Reliable Data Channel apart from Main Service Channel
S (ATSC 3.0)	USA	QPSK to 4096-NUC	LDPC + BCH	6–8 MHz	Up to 77.2 Mbps	Bootstrap, LDM multiplexing, IP multicast
L (5G Broadcast)	3GPP / LTE	QPSK to 256QAM	Turbo	1.4–20 MHz	Up to 24.8 Mbps	Supports DASH, CMAF, HLS, IP-based services
N (5G NR MBS)	3GPP / NR	QPSK to 256QAM	Polar + LDPC	5–40 MHz	Up to 55.7 Mbps	Seamless unicast/broadcast switching
M (DTMB-A)	China	QSPK to 256APSK	LDPC + BCH	6–8 MHz	Up to 51.7 Mbps	Time-domain synchronous ODFM

1.2.3 Field Trials of Multimedia Mobile Broadcasting (Report ITU-R BT.2526)

Report ITU-R BT.2526, "Field trials of terrestrial multimedia mobile broadcasting systems", collects the results of field trials of the systems in Recommendation ITU-R BT.2016. The Report classifies the trials into three systems—LTE-based 5G terrestrial broadcast (TMMB System L), 5G NR multicast and broadcast services (MBS) (System N) and ATSC 3.0 (System S)—and contains 12 annexes covering trials in China, Europe and Korea.

The additions in BT.2526-2 include a 5G NR MBS trial in Wuhan, China (November 2024, 700 MHz band), which examined coverage and reception through cooperative networking of a TV tower and mobile base stations, together with network planning for 5G NR MBS, and a trial of an ATSC 3.0 diversity receiver in the Seoul metropolitan area SFN (September-October 2024, 765-771 MHz), which showed a gain in mobile reliability over single-antenna reception.

WP 6A is preparing a further revision. In September 2026 India proposed to add the results of its Direct-to-Mobile (D2M) trials, based on ATSC 3.0, in the 470-582 MHz band: laboratory verification of unwanted emissions, the priority of IMT voice calls and SMS during D2M reception, and SFN operation of a hybrid network of high-power high-tower (HPHT) and low-power low-tower (LPLT) transmitters in Delhi. These trials are reported in Section 1.4.

1.2.4 5G Broadcast (3GPP)

Overview: LTE-based 5G Broadcast (System L in BT.2016-4) is the broadcast mode of LTE developed by 3GPP as an evolution of the evolved Multimedia Broadcast Multicast Service (eMBMS) and the further evolved MBMS (FeMBMS). It

delivers TV, radio and emergency alerts over dedicated broadcast carriers, typically from high-power high-tower networks, and can be received in a receive-only mode without a SIM card, a subscription or a return channel [1]. It is profiled by ETSI in TS 103 720 [1]. It should be distinguished from 5G NR MBS (System N), introduced in 3GPP Release 17, which provides multicast and broadcast services within mobile networks, using the cells of those networks.

Table 1-3: Evolution of LTE-based 5G Broadcast in 3GPP

Release	Main features
Release 14 (2017)	FeMBMS (work item EnTV): MBMS-dedicated cell with up to about 97.5% of carrier resources for broadcast; 1.25 kHz subcarrier spacing with a cyclic prefix (CP) of about 200 µs for large SFNs; Cell Acquisition Subframe (CAS) every 40 ms; 256-QAM
Release 16 (2020)	LTE-based 5G terrestrial broadcast: receive-only mode; 2.5 kHz subcarrier spacing (CP about 100 µs) for mobile reception up to about 250 km/h; 0.37 kHz subcarrier spacing (CP about 300 µs) for SFNs with inter-site distances up to about 100 km; more robust control channels
Release 17 (2022)	6, 7 and 8 MHz channel bandwidths aligned with broadcast channel rasters; Band 107 (612–652 MHz)
Release 18 (2024)	Band 108 (470–698 MHz, the whole UHF television band); completion of RF requirements for Bands 107 and 108
Release 19 (2025)	Phase 2 enhancements (time and frequency interleaving, cyclic shift, broadcast-specific MCS tables); CAS muting; Bands 112 and 113 (UHF sub-bands); Band 246 for delivery via geostationary satellite in ITU Region 3

Release 19: The 3GPP Release 19 specifications were completed in December 2025 [2]. In Release 19, 3GPP RAN Working Group 4 approved two new frequency bands for 5G Broadcast receivers in the UHF television band: Band 112 (470-608 MHz) and Band 113 (606-698 MHz) [3][4]. These bands are specified for LTE-based 5G Broadcast (further evolved Multimedia Broadcast Multicast Service, FeMBMS), which enables receive-only reception on mobile devices without a SIM card, and is the system addressed by Report ITU-R BT.2526. 5G NR MBS, introduced by 3GPP in Release 17 and tested in Wuhan, is a separate feature that operates within mobile networks. The Release 19 specifications also include a new band of 1467–1492 MHz for 5G Broadcast delivered via a geostationary satellite in ITU Region 3, specified in separate satellite specifications [1][2]. Since it is defined for Region 3, it is of direct interest to ABU members, and could allow the same receiver technology to be used for terrestrial and satellite delivery of broadcast services to handheld devices. See Annex 3 (D/SB), Section 3.3 regarding the trial broadcast via a geostationary satellite.

Deployment plans in the United States: In the United States, a group of companies including XGN Global, X1 Mobile, Tyche Media and Milachi Media has announced plans to deploy 5G Broadcast. Two television stations in the Boston area (WCRN and WWOO), covering about 8 million people, applied for experimental 5G Broadcast licenses in early 2026 to test content delivery, use by first responders, receiver reliability and data bonding between stations [4] [5]. The partners plan 10 5G Broadcast-enabled television stations covering more than 40 million people, and commercial 5G Broadcast receivers were expected to come to market in the second quarter of 2026 [4] [5]. The FCC has not authorized 5G Broadcast for full-power television stations; the regulatory discussion so far concerns low-power television (LPTV) stations [4].

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1.3 Latest Topics on Next-Generation DTTB in Japan

1.3.1 Introduction

In April 2026, the Association of Radio Industries and Businesses (ARIB) revised the physical layer standard of Integrated Services Digital Broadcasting-Terrestrial 3rd generation (ISDB-T3) [1]. Optional features, including Multiple-Input Single-Output (MISO), Transmitter Station Identification Code (TSIC), and Peak-to-Average Power Ratio (PAPR) reduction were added to the annex, together with guidelines for simultaneous use. In addition, a practical implementation guideline for ISDB-T3 was included. This section provides an overview of these newly added items, as shown in Figure 1-1.

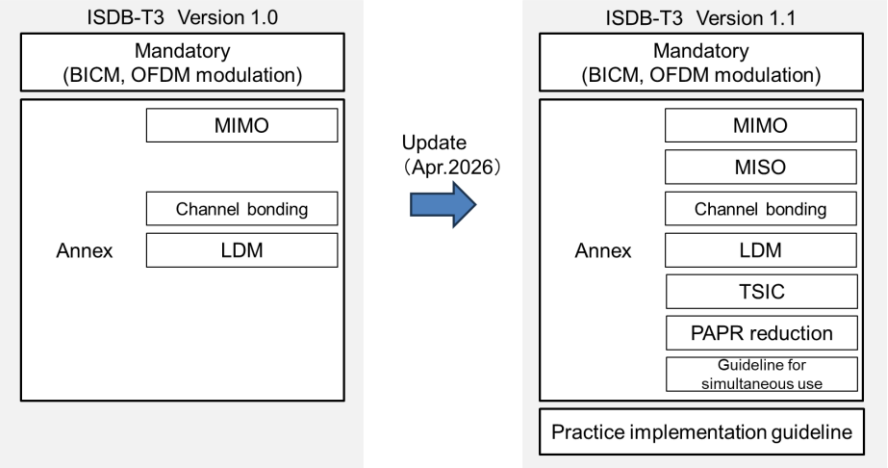


Figure 1-1: Overview of updating ISDB-T3

1.3.2 MISO

MISO is a method that utilizes multiple transmitting antennas using the same frequency. As opposed to the MIMO technique, installing multiple antennas at the receiver is not necessary. Co-located MISO uses transmitting antennas located at the same site, whereas distributed MISO uses transmitting antennas located at different sites. Both techniques can provide transmission diversity gain derived from maximal ratio combining (MRC) and increased robustness. ISDB-T3 expects that distributed MISO is used for a single frequency network (SFN) as shown in Figure 1-2.

In a MISO modulator, two consecutive carrier symbols s_0 and s_1 are coupled in either the time or frequency domain. One of the symbols remains for the output of transmitter 1 and the other is coded using the Alamouti method [2] for the output of transmitter 2. If s_0 and s_1 are coupled in the frequency domain, transmission symbol x_0 from transmitter 1 and x_1 from transmitter 2 are as follows.

$$x_0(f) = s_0 \qquad (1)$$

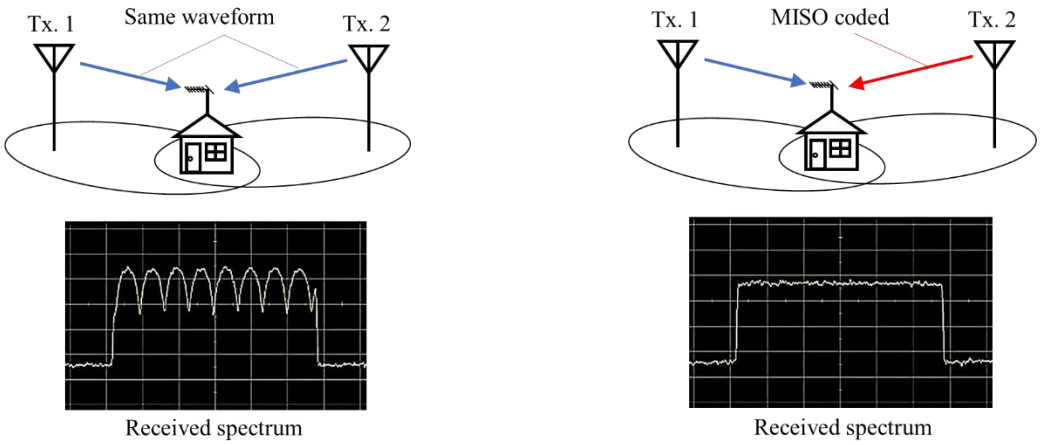
$$x_0(f+1) = s_1 \quad (2)$$

$$x_1(f) = -s_1^* \qquad (3)$$

$$x_1(f+1) = s_0^* \quad (4)$$

where s^* is the complex conjugate of s. $x(f)$ is the transmission symbol of carrier index f. In the case of coupling in the time domain, f is replaced by the time index t in equations (1) through (4). The pilot signals of both outputs are orthogonally coded, similar to the MIMO pilots. In a MISO receiver, the channel response of each transmitter signal is estimated separately using the orthogonal pilot signals. Each

data carrier is demodulated using both channel responses and the received carrier symbols coupled in time or frequency domain.



(a) Conventional SFN (b) SFN with distributed MISO

Figure 1-2: Comparison of conventional SFN and SFN with distributed MISO

1.3.3 TSIC

TSIC enables the identification of individual transmitting station by multiplexing the unique code into the broadcast signal. This feature enables the identification of the main transmitting station and interfering stations in co-channel interference environments, and facilitates channel estimation for individual transmitting stations in a single-frequency network (SFN). In addition, TSIC can be used to support regional services and provide information associated with individual transmitting stations.

A block diagram of the channel coding process of TSIC is shown in Figure 1-3. The TSIC value is represented by a 13-bit integer, which allows identification of up to 8192 different transmitting stations. The TSIC value is expressed in binary and used as the initial seed to generate a 13th-order Gold sequence, one of the pseudo-random binary sequences. The sequence is allocated to OFDM subcarriers and then processed by an inverse fast Fourier transform (IFFT) to generate the TSIC signal.

An example of a transmission frame structure containing a TSIC signal is shown in Figure 1-4. The transmission frame consists of a frame synchronization signal, a transmission and multiplexing configuration control (TMCC), one or more subframes, and the TSIC. The TSIC signal is OFDM-modulated in the same manner as other signal components of ISDB-T3 and stored at the end of the transmitting frame by time-division multiplexing. The independence of the TSIC signal from other signal components ensures robustness and ease of replacement at relay stations.

Receivers internally generate the transmitted TSIC signals, calculate the correlation between the waveforms and the received signal in the time domain, and detect the transmitted TSIC.

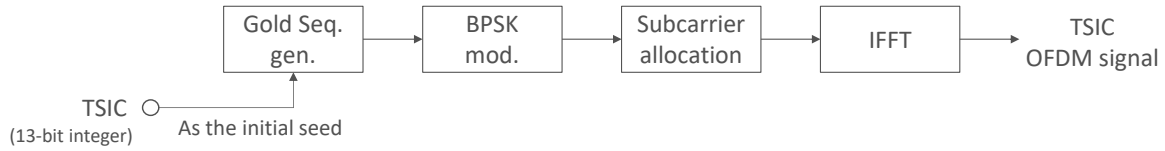


Figure 1-3: Block diagram of TSIC channel coding process

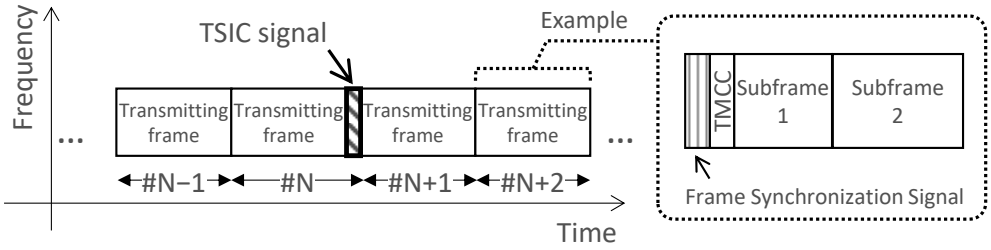


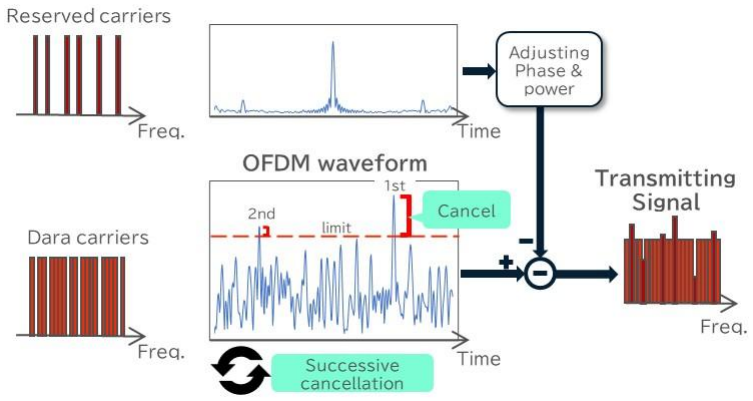
Figure 1-4: Example of transmission frame structures containing TSIC signal

1.3.4 PAPR Reduction

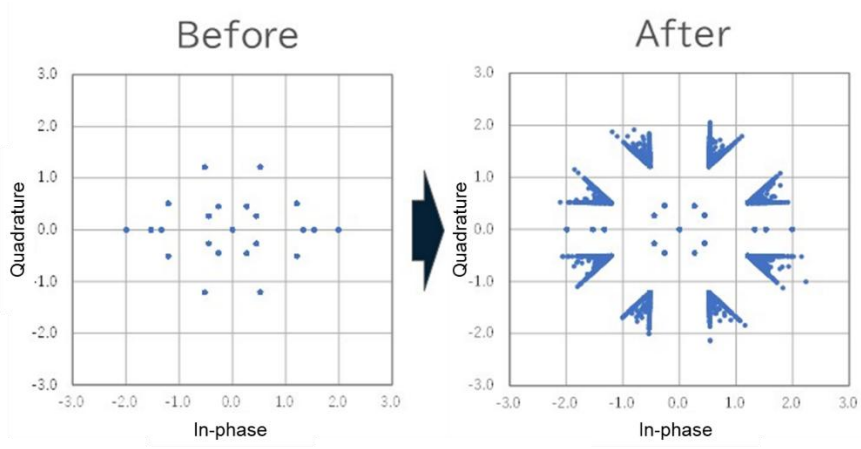
To reduce the PAPR of the transmitted signal, Tone Reservation (TR), Active Constellation Extension (ACE), or a combination of both techniques may be employed.

The TR technique reserves a few OFDM subcarriers in each segment. It utilizes reserved carriers in the frequency domain to suppress peak power in the time domain. The phase and amplitude of the reserved carriers are adjusted to cancel peaks in the OFDM waveform. As shown in Figure 1-5(a), this process is iteratively repeated using successive cancellation to reduce the PAPR of the transmitted signal.

The ACE technique modifies the transmitted constellation points. As shown in Figure 1-5(b), the outer constellation points in the I/Q plane are extended toward regions outside the original constellation boundary. The ACE may not be applied to pilot carriers or reserved carriers.



(a) Tone Reservation (TR)



(b) Active Constellation Extension (ACE)

Figure 1-5: Techniques of PAPR reduction

1.3.5 Guideline for Simultaneous Use

The guideline describes the simultaneous use of optional features, including MIMO, MISO, Channel Bonding, LDM, TSIC, TR, and ACE. Almost all combinations of these optional features are permitted, except those involving ACE. ACE may not be used in conjunction with LDM, MISO or MIMO because it modifies the I/Q constellation points.

1.3.6 Practice Implementation Guideline

The practical implementation guideline is as follows.

(a) BICM parameter selection

ISDB-T3 has 13 kinds of LDPC code rates and 6 kinds of carrier modulation schemes, e.g., QPSK, 16QAM, 64QAM, 256QAM, 1024QAM, and 4096QAM. Although there are 78 BICM combinations of LDPC code rate and carrier modulation scheme, some

combinations achieve the same transmission capacity. The guideline indicates the recommended BICM combinations. Detailed information was reported in ABU Digital Broadcasting Symposium 2026 [3].

(b) Spectrum configuration

In ISDB-T3 broadcasting network, the center frequency of transmitting OFDM signal is shifted by 1/18 MHz in each UHF channel as opposed to 1/7 MHz shift in current ISDB-T broadcasting network.

(c) Interface of ISDB-T3 modulator

An IP-based format known as Broadcast-MMT (MPEG Media Transport) is specified in the guideline to construct a single frequency network. Detailed information of Broadcast-MMT was reported in Report of Distribution Topic Area 2025 [4].

References

[1] ARIB standard: "Transmission system for advanced digital terrestrial television broadcasting based on ISDB-T3," ARIB STD-B80 ver.1.1, Apr. 2026.

[2] S. Alamouti: "A simple transmit diversity technique for wireless communications," IEEE j. Select. Areas Commun., Vol. 16, No. 8, Oct. 1998.

[3] H. Araki: "Overview and transmission performance of ISDB-T3," in Proc. ABU DBS 2026, Mar. 2026.

[4] "Report on DISTRIBUTION TOPIC AREA," Annex 1 (D/DTTB), Sep. 2025.

1.4 Latest Topics on Direct-to-Mobile (D2M) in India

1.4.1 Introduction

Direct-to-Mobile (D2M) broadcasting refers to the delivery of live television, multimedia content, and emergency information directly to handheld and mobile terminals over a terrestrial broadcast network, without a cellular data connection, a SIM card, or an Internet subscription. In India, Prasar Bharati, the public service broadcaster, has been developing and trialling such a system together with the Indian Institute of Technology (IIT) Kanpur and Tejas Networks, under the Ministry of Information and Broadcasting (MIB) [1].

The motivation is threefold. First, a large part of the Indian audience consumes video on smartphones, and linear and popular content delivered by unicast places a heavy load on mobile networks; broadcast delivery offloads this traffic. Second, D2M extends television and educational services to areas where broadband coverage or affordability is limited. Third, a broadcast layer that reaches handsets directly

provides a resilient path for emergency alerting that does not depend on the availability of mobile networks.

A Proof of Concept (PoC) was first conducted in Bengaluru, and was followed by a hybrid PoC in Delhi combining a High Power High Tower (HPHT) transmitter with several Low Power Low Tower (LPLT) transmitters. Because the 470–582 MHz range used for D2M is close to IMT bands, and because the D2M receiver is embedded in the same handset as the IMT receiver, the compatibility between D2M and mobile services has been examined in detail. The results were submitted to ITU-R Working Party 6A in September 2026 for inclusion in Report ITU-R BT.2526.

This section summarises the system configuration, the results of the field trials and of the compatibility measurements, the related ITU-R contribution, and the spectrum and regulatory status as of September 2026.

1.4.2 System Configuration

The Indian D2M system uses ATSC 3.0 as its physical layer, i.e. System S of Recommendation ITU-R BT.2016-4, with an 8 MHz channel bandwidth in the UHF frequency range 470–582 MHz. ATSC 3.0 supports IP-based transport, provides robust modes suitable for handheld and indoor reception, and offers flexibility in trading capacity against robustness.

The distinctive feature of the Indian deployment is its network architecture, which combines HPHT and LPLT transmitters operated as a Single Frequency Network (SFN). The HPHT transmitter, installed at an existing television transmitter site, provides wide-area coverage, while LPLT transmitters — implemented as compact "Broadcast Radio Head" (BRH) units that can be mounted on existing urban structures — densify the coverage in built-up areas and improve indoor reception. In the Delhi PoC, the HPHT transmitter at Pitampura was operated in SFN mode together with LPLT sites on the Shangri-La, UPSC and Kanchenjunga Tower in New Delhi.

Reception has been demonstrated both on handsets with an integrated D2M receiver, such as the Mark One D2M handset, and on off-the-shelf smartphones used with an external D2M dongle; D2M dongle, a D2M smartphone, a D2M feature phone, a D2M laptop and a D2M set-top box were all demonstrated successfully in the laboratory evaluation [1].

Table 1-4: Outline of the Indian D2M trial system

Item	Value
Physical layer	ATSC 3.0 (System S of Recommendation ITU-R BT.2016-4)
Frequency range	470–582 MHz (UHF); 538 MHz used in the Delhi SFN demonstration
Channel bandwidth	8 MHz
Network architecture	Hybrid HPHT + LPLT operated as an SFN
HPHT site (Delhi PoC)	One of the television transmitters at Pitampura, New Delhi.
LPLT sites (Delhi PoC)	Broadcast Radio Head (BRH) units on the Shangri-La, UPSC and Kanchenjunga Tower. Transmitter power of 40 W, model YOGA40W01, manufactured by Tejas Network Limited.
Terminals	Handsets with integrated D2M receiver (e.g. Mark One D2M handset) and off-the-shelf smartphones with a D2M dongle in the field tests. D2M dongle, D2M smartphone, D2M feature phone, D2M laptop and D2M set-top box, demonstrated in the laboratory evaluation.

1.4.3 Field Demonstration of SFN Operation

A small scale PoC was first carried outin Bengaluru, and was followed by the hybrid HPHT/LPLT Poc in Delhi, which is the reference deployment for the SFN reported in [1]. Trials have been extended to more than 19 cities, and the Delhi deployment was presented at BroadcastAsia 2026 in May 2026 [2][3].

In an SFN, multiple transmitters radiate the same signal on the same frequency while maintaining time and frequency synchronisation. Where the relative propagation delay between transmitters stays within the guard interval of the waveform, the signals combine constructively at the receiver, which improves signal quality and service availability in the overlap regions and near the coverage edge. For a D2M network that mixes HPHT and LPLT transmitters, SFN operation is therefore expected to close coverage gaps and improve reception robustness.

A field demonstration was carried out in the Central Vista / Kartavya Path area of New Delhi on 538 MHz, comparing receiver performance under single-transmitter and synchronised multi-transmitter operation at the same measurement locations, using both dongle-based and integrated D2M receivers. Representative results measured at Central Vista Parking 2 (28.6119° N, 77.2264° E) are given in Table 1-5.

Table 1-5: Representative results of the SFN field demonstration in New Delhi (538 MHz)

Transmitter configuration	RSSI / SNR	AV status	Observation
HPHT only	approx. −78 dBm / 4 dB	AV glitches	Weak baseline condition
LPLT only	approx. −75 dBm / 9 dB	Good	Moderate baseline
HPHT + 1 LPLT	approx. −63 dBm / 22 dB	Good	Significant improvement
HPHT + additional synchronised LPLT sites	approx. −49 to −58 dBm / 23–30 dB	Good	Strong SFN improvement

Adding a single synchronised LPLT site to a location that was marginal under HPHT-only reception raised the SNR from 4 dB to 22 dB and removed the audio-video glitches; with further synchronised LPLT sites the SNR reached 23–30 dB. The demonstration confirms that the hybrid HPHT/LPLT SFN is an effective and economical way of achieving the reception margin that handheld terminals require in a dense urban environment, which is the central practical question for any D2M deployment.

1.4.4 Compatibility with IMT Systems

Because all IMT base stations must comply with the 3GPP unwanted emission limits, and because mobile network operators raised concerns about the introduction of a broadcast transmission in the 470–582 MHz range, the compatibility of D2M with mobile services was examined jointly by Prasar Bharati, MIB, the Telecommunication Engineering Centre (TEC), the Wireless Planning and Coordination (WPC) wing of the Department of Telecommunications, the Ministry of Electronics and Information Technology (MeitY), the Department of Science and Technology (DST) and IIT Kanpur. Laboratory measurements were performed on 13 March 2026 at Aracion Technology Private Limited, Bengaluru, a laboratory recognised by TEC, and field verification was carried out on 25 March 2026 in Delhi.

1.4.4.1 Unwanted emission measurements

The laboratory tests verified the in-band transmit power, the spurious emissions, and the adjacent-channel leakage of the 40 W D2M Broadcast Radio Head. As no spurious emission limits have been defined specifically for a D2M service based on ATSC 3.0, the stringent 3GPP Category B base-station limits were applied, so that the results can be compared directly with the limits that IMT base stations must meet.

In-band power was measured at 474 MHz, 522 MHz, and 578 MHz. The measured channel power was between 45.75 dBm and 47.24 dBm, satisfying the declared limit of 46 dBm ± 1.5 dB, and remained substantially unchanged when the measurement bandwidth was widened from 8 MHz to 20 MHz, confirming that the transmitted power is contained within the nominal 8 MHz channel.

The spurious emission results are summarised in Table 1-6. All measurements met the Category B limits, the smallest margin being 2.2 dB in the 598 MHz – 1 GHz range, which is the range that contains the IMT bands immediately above the D2M band.

Table 1-6: Summary of spurious emission measurements (3GPP Category B limits)

Frequency range	RBW	Limit	Maximum spur observed	Margin
9 kHz – 150 kHz	1 kHz	−36 dBm	−42.0 dBm	6.0 dB
150 kHz – 30 MHz	10 kHz	−36 dBm	−40.0 dBm	4.0 dB
30 MHz – 460 MHz	100 kHz	−36 dBm	−42.9 dBm	6.9 dB
598 MHz – 1 GHz	100 kHz	−36 dBm	−38.2 dBm	2.2 dB
1 GHz – 2.910 GHz (5th harmonic)	1 MHz	−30 dBm	−45.0 dBm	15.0 dB

Adjacent-channel leakage was evaluated in a technology-neutral manner. Because an 8 MHz broadcast waveform does not map onto the channelisation assumptions used for 3GPP NR carriers, the adjacent-channel power was evaluated over the full 8 MHz channel bandwidth rather than over a configured transmission bandwidth, using the measurement arrangement of Annex D.1.1 of 3GPP TS 38.141-1 as a reference and limits normalised to a 220 kHz resolution bandwidth. The worst case observed over the lower, middle, and upper parts of the band is given in Table 1-7; all values met the normalised limits, with 0.7 dB of margin at the first adjacent channel.

Table 1-7: Summary of adjacent-channel leakage measurements (worst case of lower, mid, and upper band)

Adjacent channel offset	Normalised limit	Worst equivalent ACLR	Margin
1 × BWChannel (8 MHz)	30 dB	30.7 dB	0.7 dB
2 × BWChannel (16 MHz)	45 dB	48.3 dB	3.3 dB
3 × BWChannel (24 MHz)	45 dB	52.5 dB	7.5 dB

1.4.4.2 Priority of voice calls and SMS during D2M reception

A D2M service delivers continuous audio-visual content to the handset, and it is essential that this does not impair normal cellular telephony. Field verification was therefore carried out at Doordarshan Bhawan in New Delhi, while the HPHT transmitter at Pitampura and the LPLT sites at Shangri-La, UPSC and Kanchenjunga were operating in SFN mode, to confirm that incoming voice calls and SMS retain priority over an active D2M session.

Four test cases were run, covering two commercial mobile operators and 2G, 4G and 5G access. The mobile-terminating device was either a Mark One D2M handset or a

Samsung Galaxy A55 5G with a D2M dongle, receiving D2M content during the test. In each case, 10 call attempts were made, i.e. 40 attempts in total.

No call was blocked in any of the four test cases: the call block rate was 0 %, the call setup success rate 100 %, and the SMS send success rate 100 %. In every case the incoming call was notified to the user, could be answered or rejected without functional impairment, the voice session continued normally, and D2M playback resumed smoothly after the call ended. The verification confirms that cellular voice and SMS retain priority over D2M playback at the locations tested, and that the D2M service did not impair their reception or handling.

1.4.5 Spectrum and Regulatory Status

On 23 February 2026, the Committee of Secretaries approved the allocation of the 470–582 MHz band for D2M broadcasting and endorsed a public-private partnership model for its implementation, directing Prasar Bharati to execute Phase I of the rollout within six months. A Detailed Project Report covering the technical, regulatory, and commercial dimensions of a nationwide rollout was submitted to MIB in June 2026 for policy evaluation, and a Request for Proposal to select commercial implementation partners was planned for July 2026. Commercial services are targeted to begin from the end of 2026, followed by a phased national rollout.

Mobile network operators have asked for a technology-neutral evaluation that also considers cellular-based broadcast alternatives such as 5G Broadcast and 5G NR MBS, with wider participation by device manufacturers, chipset vendors and regulators, and a dedicated committee has been constituted to address stakeholder concerns in parallel with the deployment preparations.

1.4.6 Conclusion

India's D2M programme is the first large-scale trial of an ATSC 3.0-based broadcast system designed primarily for handheld reception, and its hybrid HPHT/LPLT SFN architecture is a distinctive approach to obtaining the reception margin that handheld terminals need in dense urban areas: adding one synchronised LPLT site to a marginal HPHT-only location raised the measured SNR from 4 dB to 22 dB.

Equally significant for other administrations is the compatibility evidence. Measured against the 3GPP Category B limits, the D2M transmitter met the spurious emission and adjacent-channel leakage requirements, and field verification on two commercial networks under 2G, 4G and 5G showed no degradation of voice or SMS service during active D2M reception. These results have been submitted to ITU-R WP 6A for inclusion in Report ITU-R BT.2526.

References

[1] Prasar Bharati, "Test Reports on integrated evaluation of Direct-to-Mobile (D2M) transmission impact on IMT services during the operation of D2M Technologies in frequency range 470-582 MHz," File No. DTH/IITMoU/180/2020/P-VII-(Part-1)-A, 15 May 2026. https://prasarbharati.gov.in/wp-content/uploads/2026/05/D2M_Test_ToR_BG-Note-converted.pdf

[2] "Prasar Bharati Reports Progress in India's Direct-to-Mobile Broadcasting Trials," ABU, 27 May 2026. https://www.abu.org.my/news/prasar-bharati-reports-progress-in-indias-direct-to-mobile-broadcasting-trials/

[3] "GatesAir Supports Successful ATSC 3.0 Direct-to-Mobile Trial in India," TV Technology, 20 May 2026. https://www.tvtechnology.com/platform/broadcast/gatesair-supports-successful-atsc-3-0-direct-to-mobile-trial-in-india

1.5 Other Topics

1.5.1 DTT Planning (Report ITU-R BT.2485)

Report ITU-R BT.2485, "Advanced network planning and transmission methods for enhancements of digital terrestrial television broadcasting", was revised to BT.2485-4 in March 2026. The revision completes the work on MISO reported in 2025. The new section on MISO describes a method that uses multiple transmitting antennas on the same frequency without requiring multiple receiving antennas. Two consecutive carrier symbols are coupled in the time and frequency domain, and one of them is coded with the Alamouti method for the second transmitter. Co-located MISO uses antennas at the same site, while distributed MISO uses antennas at different sites; in an SFN, distributed MISO removes the frequency-selective ripple that occurs in areas covered by two transmitters, and both forms provide transmit diversity gain from maximal ratio combining. MISO has also been added to ARIB STD-B80 version 1.1 as extension function of ISDB-T3 (see Section 1.1.2).

1.5.2 UHDTV Field Transmission Experiment (Report ITU-R BT.2343)

Report ITU-R BT.2343, "Collection of field trials of UHDTV over DTTB networks", which collects field trials from Japan, Korea, France, Spain, Sweden, the United Kingdom, Brazil, China, and Iran, was revised to BT.2343-10 in March 2025, adding an ATSC 3.0 and 1.0 integrated MATV system in Korea and the 4K terrestrial transmission experiment with Brazilian TV 3.0 Project at the 2024 Summer Olympics. It was revised again to BT.2343-11 in March 2026, adding three field trials:

- ATSC 3.0 channel bonding (Korea): two 6 MHz channels at 701 MHz and 768 MHz from the Gamak Mountain site in northern Gyeonggi Province were bonded (32k FFT, 4096-NUC, code rate 12/15) to deliver 2160p60 UHD video with MPEG-H 3D Audio at a total capacity of about 103 Mbit/s. This trial corresponds to Section 1.4.2 of the 2025 report.

- ATSC 3.0 layered MIMO Type A (Korea): dual-polarized MIMO on 768 MHz from the same site (16-NUC 7/15 and 256-NUC 9/15), delivering 2160p, 1080p and 720p services at 60 frames/s simultaneously.
- DTV+ pilot stations (Brazil, 2025): indoor and mobile reception tests of ATSC 3.0 with dual-polarized MIMO and LDM from two transmitting sites in Rio de Janeiro (Sumaré and Penna hills), carrying a 2160p service and a 1080p service and using VVC and LCEVC + VVC video coding.

Annex 2

Integrated Broadcast-Broadband and OTT (D/IBBOTT)

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This annex describes recent updates on Integrated Broadcast-Broadband (IBB) and Over-the-Top (OTT) standards and related technologies. It also covers content protection and cybersecurity in broadcasting industry.

2.1 Studies on Integrated Broadcast-Broadband Systems

Major updates in this report period (Sep. 2025 to Sep.2026) include the outcomes of the ITU-R WP 6B meetings held in September 2025 and March 2026 (subsection 2.1.1): the revision of Report ITU-R BT.2400 to add implementation examples of global platform technologies, including DVB-I and content discovery systems; the completion of a draft new Report ITU-R BT.[APPBASEDTV] on application-oriented television broadcasting; continued studies on a new Recommendation ITU-R BT.[GP] on a high-level system architecture for a global platform for broadcasting and on a new Report ITU-R BT.[PROVENANCE] on content provenance; and the start of studies on privacy mechanisms for integrated broadcast-broadband systems. In addition, a new subsection (2.1.4) has been added to summarize the deployment status of DVB-I, including the launch of Freeview NextGen in New Zealand. The descriptions of ITU-T studies (2.1.2) and the standardization of the IBB system in Japan (2.1.3) remain unchanged from the previous report.

2.1.1 Studies in ITU-R

ITU-R Working Party 6B (WP 6B) is conducting studies on IBB systems. The working party has been studying harmonization of IBB systems by comparing Hybridcast (Japan), HbbTV2.0 (Europe), TOPSmedia (South Korea) and Ginga (Brazil). It is also studying the system architecture of a global platform for broadcasting to enable interoperability between broadcast and broadband. Additionally, WP 6B addresses content provenance to ensure authenticity and traceability of media content.

At its meeting held in April 2019 in Geneva, the WP 6B developed a comparison of the application life-cycles and application transition among the IBB systems, and revised Report ITU-R BT.2267 "Integrated broadcast-broadband systems" to add a new part on the harmonization of applications among different IBB systems. Harmonizing the IBB systems and ensuring compatibility of applications and

interoperability between systems is essential for enabling the exchange and deployment of services across regions using different IBB systems.

At the same meeting, WP 6B revised Report ITU-R BT.2342 to replace information on TTML Text and Image Profiles for Internet Media Subtitles and Captions 1.0 (IMSC1.0) with the updated IMSC1.1. It also updated the list of EBU specifications pertinent to the content of the Report.

At its meeting held in July 2019 in Geneva, WP 6B revised Report ITU-R BT.2267 to add a companion application that enables the execution of IBB applications on receivers. The working party also developed new use cases of IBB systems, where object-based sound services are provided via MPEG-DASH streams.

WP 6B also developed the "global platform". The working party revised Report ITU-R BT.2400 "Usage scenarios, requirements and technical elements of a global platform for the broadcasting service" to add the specific reference to the ATSC 3.0 standard and some examples to show its Internet Protocol-based capabilities to integrate broadcast and broadband services. New digital terrestrial transmission standards such as ATSC 3.0 system can help effectuate a converged broadcast and broadband platform, which is an important aspect of a global platform for broadcasting services.

At its meeting held in October 2020, WP 6B revised Recommendation ITU-R BT.2075 "Integrated broadcast-broadband system" to update the application execution mechanism of Hybridcast, which introduced a feature that allows a companion device to send a command to a receiver to tune to a designated channel and launch a Hybridcast application.

At its meeting held in March 2021, WP 6B prepared a revised draft report of Recommendation BT.2075 by adding information regarding commonality among IBB systems and equivalency of their functions as described in Report BT.2267 Part 3. The working party also prepared a draft revision to report BT.2267 on IBB systems to align with Recommendation ITU-T J.208 on harmonization of applications between IBB systems.

At its meeting held in September 2022, WP 6B revised Recommendation ITU-R BT.2075 "Integrated broadcast-broadband system" and Report ITU-R BT.2267 "Integrated broadcast-broadband systems" to add a Broadcast-independent managed application, which is an application that can be launched when broadcast services are not selected but is still authenticated by broadcasters.

At its meeting held in May 2023, WP 6B:

- revised Recommendation ITU-R BT.2075-5 "Integrated broadcast-

broadband system" to add broadcast-independent managed applications.

At its meeting held in March 2025, WP 6B:

- prepared a preliminary draft new Report BT[GP] "High-level system architecture for content delivery and reception on a global platform for broadcasting" to describe the overall architecture and functional blocks of a global broadcasting platform.
- prepared a preliminary draft revision of Report ITU-R BT.2400-4 "Usage scenarios, requirements and technical elements of a global platform for the broadcasting service" to update usage scenarios and technical requirements.
- prepared a preliminary draft new Report ITU-R BT.[APPBASEDTV] "Application-oriented television broadcasting" to describe frameworks and requirements for application-driven TV services.
- prepared a working document towards a preliminary draft new Report ITU-R BT.[PROVENANCE] "Content provenance for programme production, international exchange and distribution of content" to address methods for ensuring authenticity and traceability of media content.

At its meeting held in September 2025, WP 6B:

- prepared a revision of Report ITU-R BT.2400 "Usage scenarios, requirements and technical elements of a global platform for the broadcasting service" to add implementation examples of global platform technologies, including DVB-I and content discovery systems.
- updated the working document towards a preliminary draft new Report ITU-R BT.[PROVENANCE] "Content provenance for programme production, international exchange and distribution of content" by adding use cases and research activities related to content provenance and by reflecting activities in other standardization organizations.

At its meeting held in March 2026, WP 6B:

- completed a draft new Report ITU-R BT.[APPBASEDTV] "Application-oriented television broadcasting" to describe a broadcasting architecture in which applications act as the primary entry point to broadcast services.
- continued studies on a new Recommendation ITU-R BT.[GP] "High-level system architecture for content delivery and reception on a global platform for broadcasting."
- continued the development of a new Report ITU-R BT.[PROVENANCE]

"Content provenance for programme production, international exchange and distribution of content" to address methods for ensuring the authenticity and traceability of media content.

- started studies on privacy mechanisms for integrated broadcast-broadband systems, including privacy management functions implemented in receiver platforms.

2.1.2 Studies in ITU-T

ITU-T Study Group 9 (SG9) is also conducting studies on IBB system applied to Cable Digital TV. At its meeting held in November 2018 in Bogota, Colombia, the Study Group started to revise IBB system Recommendation (Recommendation ITU-T J.207 "Specification for integrated broadcast and broadband digital television application control framework") to add the function of device collaboration with companion devices in Hybridcast. Recommendation ITU-T J.207 is a twin of IBB system Recommendations in ITU; Recommendation ITU-R BT.2075 is another twin on this topic. Therefore, the Study Group continues to revise the Recommendation ITU-T J.207 in line with the revision of Recommendation ITU-R BT.2075. The Study Group is studying smart TV operating systems for hybrid cable Digital TV services including IBB DTV services provided by cable television operators and third-party providers. At the Bogota meeting, the Study Group made progress the work on the architecture of smart TV operating system. The Study Group consented to the Recommendation of "The functional requirements of smart TV operating system" as Recommendation ITU-T J.1201.

At the meeting held in June 2019 in Geneve, the SG9 consented to Recommendation ITU-T J.207 to add the function of device collaboration in Hybridcast. The Study Group also made progress the work of drafting new Recommendation "Harmonization of Integrated Broadcast-Broadband DTV application control framework." As for the smart TV operating system, the Study Group consented to the Recommendation of "The architecture of smart TV operating system" as Recommendation ITU-T J.1202. In addition, the Study Group has begun developing a new Recommendation for the specification of smart TV operating systems.

At the meeting held in November 2023, SG9 reached the AAP consent for the draft new Recommendation ITU-T J.1206. It has been approved and is now part of the set of already approved Recommendations as follows:

- J.1201: Functional requirements of a smart TV operating system
- J.1202: The architecture of a smart TV operating system
- J.1203: The specification of a smart TV operating system

- J.1204: The security framework of a smart TV operating system
- J.1205: The hardware abstract layer application programming interface of a smart TV operating system
- J.1206: The application programming interface of a smart TV operating system

SG9 also consented to new Recommendation ITU-T J.208 "Harmonization of Integrated Broadcast-Broadband DTV application control framework" at its November 2020 meeting. The recommendation was created based on Report ITU-R BT.2067 which defined the methods to harmonize IBB systems by identifying commonalities across the IBB systems.

At its meeting held in October 2024, SG9 approved new Recommendation ITU-T J.1207 "Smart television operating system – Conformance test" to specify conformance testing for smart TV operating systems based on J.1201 to J.1206.

A new Study Group 21 (SG21) was established in WTSA-24 (October 2024) as a consolidation of SG9 and SG16. SG21 is responsible for studies previously covered by SG9, including integrated broadcast-broadband systems and smart television operating systems.

2.1.3 Standardization of Integrated Broadcast-Broadband System in Japan

IPTV Forum Japan standardizes the specifications of Hybridcast in Japan. The technical specification of Hybridcast is composed of two technical standards and one operational guideline, as listed below. These latest versions were published in January 2022.

- IPTVFJ STD-0010 'Integrated Broadcast-Broadband System Specification', version 2.4
- IPTVFJ STD-0011 'HTML5 Browser Specification', version 2.7
- IPTVFJ STD-0013 'Hybridcast Operational Guideline', version 2.10

In the November 2020 revision, several new features were added to the Hybridcast technical specifications. Major updates were as follows:

- Addition of the new application type named "Broadcast-independent managed application"
  An application of this type runs in the state that no broadcast channel is being tuned so that service providers can offer application services regardless of their broadcasting area.
- Enhancement to the streaming video playback function

The CMAF[*1] is added as a supported container format of streaming video, including low-latency playback features. Support for stream event delivery mechanisms such as an 'event message' (emsg) box and an 'Event' XML element of MPEG DASH[*2] are also added.

- Enhancement to the companion device function
  UHDTV broadcasting services, i.e. 4K and 8K satellite broadcasting in Japan, are added to the available channels for tuning from a companion device.
- Addition of the three-dimensional audio codec support
  The enhanced AC-3[*3] is added to the available audio codecs for video streaming.

*1 ISO/IEC 23000-19 "Multimedia application format (MPEG-A) — Part 19: Common media application format (CMAF) for segmented media".

*2 ISO/IEC 23009-1 "Dynamic adaptive streaming over HTTP (DASH) — Part 1: Media presentation description and segment formats".

*3 ETSI TS 102 366 "Digital Audio Compression (AC-3, Enhanced AC-3) Standard".

In the January 2022 revision, several features related to discontinued VOD services were removed from the Hybridcast technical specifications.

2.1.4 Deployment Status of DVB-I

DVB-I is a DVB specification (ETSI TS 103 770) for the discovery and delivery of linear television services over the Internet. Using service lists provided by broadcasters or platform operators, a DVB-I-compatible receiver can present Internet-delivered services together with broadcast services (terrestrial, satellite or cable) in a single channel list and electronic programme guide (EPG), without viewers having to launch separate apps. Media are typically delivered using DVB-DASH, and HbbTV applications can be associated with DVB-I services. DVB-I is therefore regarded as a candidate technology for maintaining the prominence and universal availability of free-to-air services as viewing shifts toward connected TVs.

The main DVB-I deployments and trials are as follows [1]:

- **New Zealand:** Freeview New Zealand announced in May 2026 "Freeview NextGen", a nationwide free-to-air television platform based on DVB-I, scheduled to launch in the third quarter of 2026 on smart TVs from Hisense and TCL. For households with both broadband and an antenna,

broadcast and Internet-delivered channels are combined into a single TV guide, with duplicate channels filtered out. It is expected to be the world's first nationwide free-to-air platform built on DVB-I [2][3].

- **Australia:** Freeview Australia announced in December 2025 that it would test DVB-I during 2026 at the Freeview Test Centre in Sydney together with TV manufacturers (TCL, Hisense, and Philips) and a technology partner. It will provide the channels of ABC, SBS, Seven, Nine and Network 10 through Freeview in the same familiar way without an antenna [4].
- **China:** Since February 2023, organizations in the AVS ecosystem, including Peng Cheng Laboratory, HiSilicon, Huawei and Peking University, have been conducting DVB-I verification combined with the AVS3 video and audio standards in cities including Shenzhen, Shanghai and Beijing, using TVs, set-top boxes, mobile phones, tablets and PCs [5].
- **Germany:** Deutsche TV-Plattform published the DVB-I Implementation Profile (Version 1.00) for German receivers in March 2026. A public launch of DVB-I services, together with the first compatible devices, is planned for around the end of 2026 [6][7].
- **Ireland:** RTÉ is conducting a closed technical trial of DVB-I for Saorview, the country's national DTT platform with approximately 100 users from June to November 2026. The results will inform a future decision on whether to proceed with a hybrid platform based on DVB-I [6].

These developments are closely related to the ITU-R studies on a global platform for broadcasting (Report ITU-R BT.2400 and the new Recommendation ITU-R BT.[GP] under study) described in 2.1.1.

References

[1] https://dvb-i.tv/deployments/

[2] https://freeviewnz.tv/news/freeview-nextgen-coming-soon/

[3] https://www.broadbandtvnews.com/2026/05/18/freeview-new-zealand-to-launch-dvb-i-nextgen-service/

[4] https://www.advanced-television.com/2025/12/18/freeview-australia-testing-dvb-i-technology/

[5] https://dvb.org/wp-content/uploads/2025/09/DVB-I-investigations-and-verification-in-China_20250913.pdf

[6] https://dvb.org/news/dvb-i-gathers-momentum-new-zealand-ireland-and-germany-announce-steps-forward/

[7] https://www.broadbandtvnews.com/2026/09/10/germany-plans-dvb-i-launch-by-end-of-2026/

2.2 Video Streaming and Content Provenance Technologies

(This section is based on the article published in NHK STRL R&D No.200 in 2025, available at https://www.nhk.or.jp/strl/publica/rd/200/3.html (in Japanese))

Major updates in this report period include the description of IETF work on securely communicating network properties to viewing devices has been updated, and the status of Managed Media Source (MMS) has been updated to reflect its formal integration into the MSE v2 specification (2.2.2). In 2.2.3, the description of C2PA has been refined to clarify what signature verification does and does not establish; the implementation examples have been updated to reflect the release of C2PA-compatible cameras supporting video (Sony), video editing software (Adobe Premiere Pro) and generative AI tools (OpenAI Sora and Google Veo); and two new NHK STRL developments have been added: a prototype web browser with built-in provenance verification, and a video management system that classifies video materials based on provenance information, which was introduced into NHK's newsroom in February 2026.

2.2.1 Introduction

When video streaming over the Internet first began around 1998, the mainstream approach was push-type delivery from dedicated servers to viewing devices using video delivery protocols such as Microsoft Media Server Protocol (MMSP), Real Time Streaming Protocol (RTSP), and Real Time Messaging Protocol (RTMP). Around 2006, a shift to HTTP streaming, a pull-type approach, began, instead of using these video delivery protocols. HTTP streaming uses the Hypertext Transfer Protocol (HTTP), the same protocol used to deliver text and images that make up web pages. This approach not only eliminates the need for dedicated video delivery servers, but also allows for the use of Content Delivery Networks (CDNs), which are used to speed up and scale websites. This approach enabled lower-cost, larger-scale delivery than traditional video streaming systems. Furthermore, around 2008, a new approach called HTTP adaptive streaming began to be used, which dynamically adjusts video quality based on network congestion, ensuring stable delivery. Today, the most popular international standards are MPEG-DASH (MPEG Dynamic Adaptive Streaming over HTTP) and HLS (HTTP Live Streaming) developed by Apple Inc. The emergence of these technologies has led to the explosive growth of today's video streaming services.

However, these methods also have their drawbacks, the most significant of which is increased latency. While UDP (User Datagram Protocol)-based delivery methods such as RTSP were capable of delivering content with a latency of approximately one second, when the transition to HTTP adaptive streaming was first made, latency of

several tens of seconds was commonplace. Even today, typical "real-time" streaming services typically experience latency of 10 seconds or more. While some argue that this is not a concern because the same video is not viewed simultaneously on different media platforms, such as television and the Internet, it is not uncommon for viewers to find out the results of a sports game online before they see it, due to cheers from a neighbor or a social media post. This could be said to lead to a loss of communication opportunities between users watching on different media platforms. Furthermore, as we strive to deliver reliable information to all audiences using a variety of transmission paths, reducing latency, in addition to ensuring video and audio quality, is an extremely important issue.

Meanwhile, on the internet, dis/misinformation such as fake news are spreading on social media, becoming a social problem. In particular, during national elections and large-scale natural disasters, a large amount of content containing false and misleading information is distributed, forcing users to discern true information from the vast amount of information available online. Furthermore, generative AI can easily be used to create fake videos impersonating broadcasters. Since the internet is open and anyone can become a source of information, it is difficult to identify the source, making it important to ensure the reliability of content broadcasters publish.

This section outlines the latest trends in technologies for stabilizing and reducing latency in video streaming and ensuring the reliability of content, as technological elements needed to realize a video streaming service that reliably delivers information as reliable as broadcasting.

2.2.2 Stabilizing and Reducing Latency in Video Streaming

This subsection discusses technological trends related to stabilizing and reducing latency in video streaming. First, an overview is provided of the currently mainstream MPEG-DASH and HLS, including explanations of the causes of latency and methods for its mitigation. Trends in adaptive bitrate control technology, which is important for stabilizing viewing, are also introduced. In addition, push-based low-latency distribution methods, which are expected to further reduce latency, are discussed, along with trends in video player technology.

2.2.2.1 Overview of MPEG-DASH and HLS

MPEG-DASH and HLS are conceptually similar. They consist of video files called "segments," which are encoded video files divided into several-second chunks, and a "manifest file," a metadata file containing information necessary for streaming playback, such as video encoding parameters (e.g., encoding method and bitrate) and segment information (e.g., segment division unit and URL). Figure 2-1 shows an

overview of adaptive streaming. Video service providers generate multiple videos of different qualities (resolution and bitrate) from a single video source, divide them into segments at time intervals, and generate a manifest containing information about all the videos. These files are provided to a web server. The viewing device first obtains the manifest from the web server and understands the segment structure (Figure 2-1(1)). It then selects and receives segments of a quality appropriate for the internet traffic and viewing environment (e.g., the device's screen resolution) (Figure 2-1(2)), and then splices and plays them back in the order in which they were split (Figure 2-1(3)). Repeating this process allows for uninterrupted viewing, even under constantly changing internet congestion conditions.

MPEG-DASH commonly uses the ISO Base Media File Format (ISO-BMFF) (also known as the MP4 format) for its segments. Initially, HLS only used the MPEG-2 Transport Stream (TS format), but in 2016, it added support for MP4. Furthermore, the Common Media Application Format (CMAF) was standardized in 2018, based on MP4, to standardize segment formats and reduce latency. Currently, CMAF can be used with both MPEG-DASH and HLS. CTA-WAVE, an industry group dedicated to improving the interoperability of video streaming services, specifies encoding and segmentation methods for CMAF to ensure interoperability between MPEG-DASH and HLS. However, in actual streaming environments, HLS still often uses the TS format to ensure compatibility with older operating systems. The manifest for MPEG-DASH is in an XML (Extensible Markup Language) format called MPD (Media Presentation Description), while for HLS it is in a text format called m3u8. Although the two formats are not compatible, they can describe similar information in many cases.

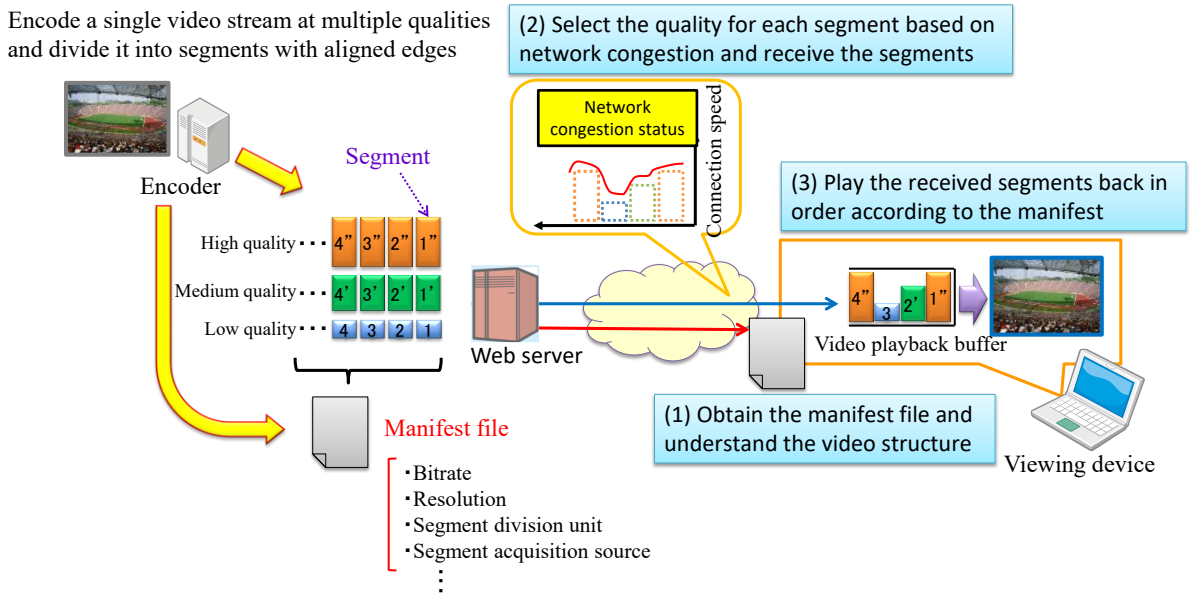


Figure 2-1: Overview of the adaptive streaming operation

2.2.2.2 Causes of Delays and How to Deal with Them - CMAF, HTTP Chunk Transmission, Fetch –

The causes of delays and methods for improving them are explained by dividing the components of live streaming shown in Figure 2-2 into three stages: (1) stream generation, (2) transmission/relay, and (3) reception.

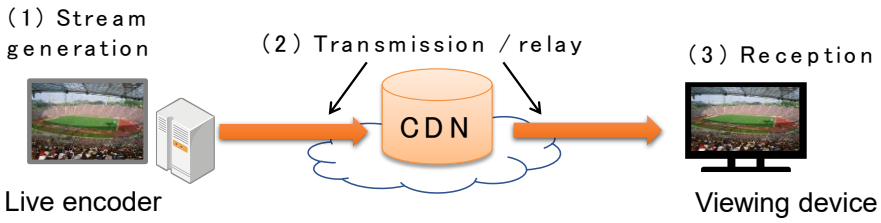


Figure 2-2: Live streaming components

(1) Stream generation

As shown in Figure 2-3, the MP4 format used for segments has a format called a Box structure, which concatenates the "data size, data type, and data" from the beginning. Therefore, the "size" at the beginning of the Box is not determined until the data is completely created, and transmission is not possible. This is the root cause of delays, and the larger the data, the longer the waiting time. In other words, delays can be reduced by reducing the "data." Figure 2-4 shows two methods for reducing the size of data.

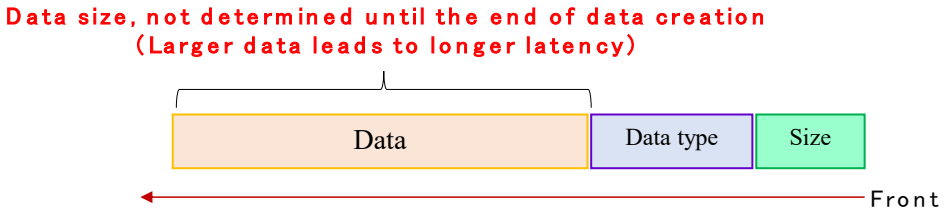


Figure 2-3: Basic MP4 format

Figure 2-4(1) shows a method for finely dividing the segment file itself. For example, dividing a 6-second segment into three 2-second files can reduce latency by one-third. However, because segments are generally composed of GOPs (Group of Pictures), the GOP size must also be reduced. Reducing the GOP size leads to a degradation of image quality, so a practical minimum is approximately 0.5 seconds, the same as in broadcasting. Furthermore, the increased number of segment files increases the number of HTTP requests from viewing devices, which can increase the load on the CDN and lead to reduced viewing stability. Figure 2-4(2) shows a method

for finely dividing the contents of segment files. CMAF was standardized with this type of operation in mind. While segment files are still composed of GOPs, the data can be handled in a format called "CMAF chunks," which divides the GOPs into smaller units, such as frames. This allows transmission of CMAF chunks without waiting for the entire segment file to be completed, potentially reducing the delay in live stream generation to the level of a few frames. Furthermore, because the number of segment files remains the same, a decrease in viewing stability due to an increase in the number of requests from viewing devices can be avoided.

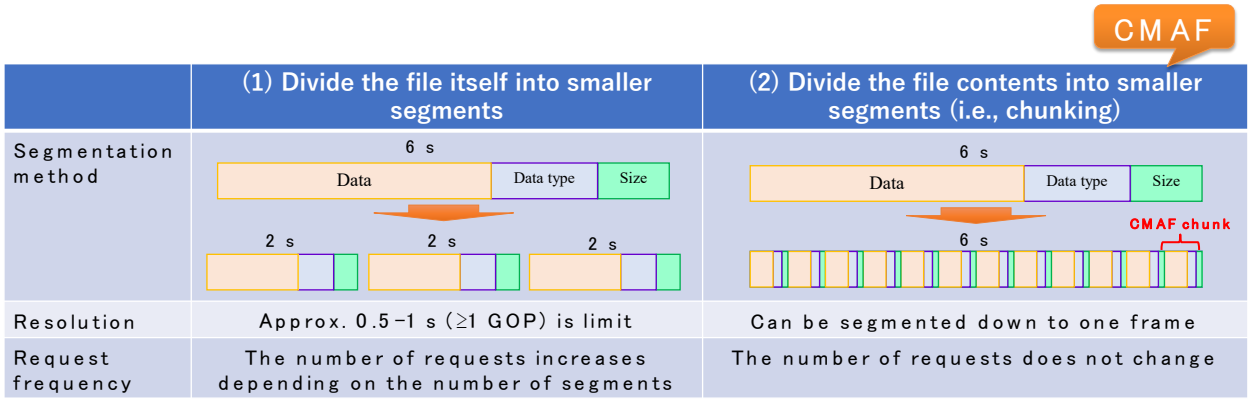


Figure 2-4: Comparison different data segmentation methods

(2) Transmission/relay

The HTTP data structure consists of an HTTP header, which is metadata, and a message body, which corresponds to the data to be transmitted. Normally, the HTTP header specifies the overall "size" of the data, as shown in Figure 2-5(1). Therefore, even if the data is divided into CMAF chunks, it cannot be transmitted until the entire segment is complete. To address this, the HTTP chunk transmission method (CTE: Chunked Transfer Encoding) is used, which sets the HTTP header parameter Transfer-Encoding to "chunked" (Figure 2-5(2)). This method allows for multiple transmissions of "chunks" consisting of "size" and "data" in a single chunk, even after an HTTP connection is established. This method is highly compatible with CMAF chunk-based transmission. By transmitting HTTP chunks consistently from the encoder to the CDN and viewing device, this method enables delivery with the lowest possible latency.

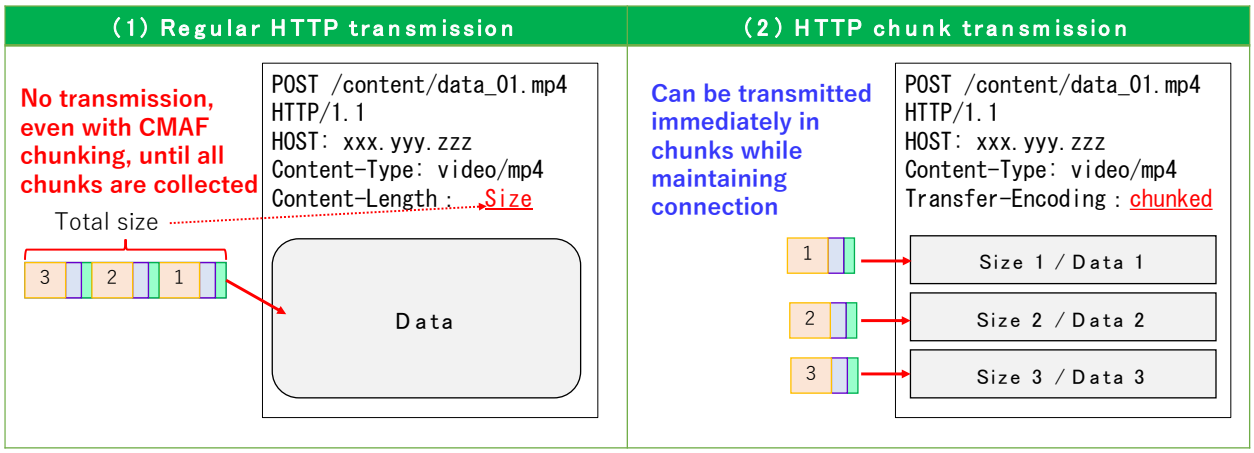


Figure 2-5: Comparison between HTTP transmission and relay methods

(3) Reception

The XMLHTTPRequest API (Application Programming Interface), which has long been used for HTTP communication in JavaScript that constitutes web applications, is designed to not process received data until the entire file has been received. As a result, even if data is transmitted one chunk at a time, as shown in Figure 2-6(1), data cannot be input into the receive buffer until the entire segment file has arrived. In contrast, the Fetch API, which was introduced around 2015, is designed to process data in smaller increments, allowing data to be input into the buffer sequentially by CMAF chunk, as shown in Figure 2-6(2). This not only shortens the wait time before playback begins, but also eliminates unnecessary wait time and allows data to be continuously input into the buffer. This eliminates the need to store unnecessary segments in the buffer in case of buffer depletion, thereby further reducing latency.

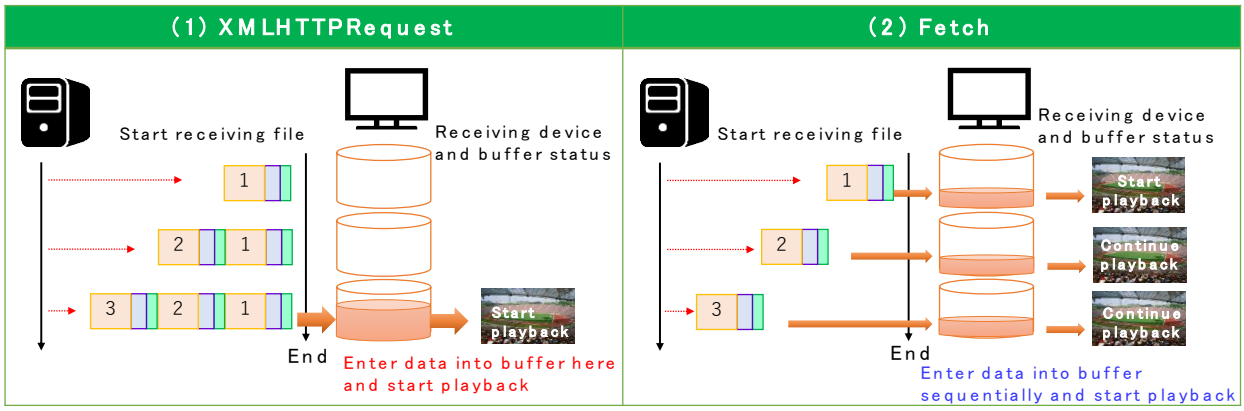


Figure 2-6: Comparison between the HTTP communication API and the receiving device buffer status

The combination of these three elements is called CMAF-ULL (Ultra Low Latency) and can be used with MPEG-DASH and the community-based HLS implementation, called LHLS. With standard streaming, segments are accessible only once they are fully created on the server. However, servers that support CMAF-ULL also allow access to segments while they are being created. The manifest is identical to standard streaming, except for a statement that allows access to the URLs of segments being created. The frequency of manifest updates is unaffected by the number of CMAF chunks. This allows for low latency depending on the granularity of the CMAF chunks. Viewing devices that do not support CMAF-ULL can still receive the stream as if it were a standard stream.

Meanwhile, Apple has developed a low-latency specification for HLS called LLHLS (Low Latency HLS). With this method, in addition to the URLs for segments, the manifest also contains the URLs for each CMAF chunk, and viewing devices must make individual HTTP requests for each CMAF chunk in order to receive the content with low latency. Since the number of CMAF chunks increases, the number of manifest updates and viewing device requests increases, meaning that chunking cannot be performed as finely as with CMAF-ULL. However, this method enables low-latency delivery even on servers that do not support CMAF-ULL, and by making requests on a segment-by-segment basis, viewing devices that do not support LLHLS can receive the content as normal HLS.

CMAF-ULL has been used in a service that delivers video from different angles to smartphones and PCs with the same latency as broadcast, enabling users to view broadcast and online video in tandem. NHK STRL is experimentally applying it to a cloud-based linear distribution system. This system is capable of delivering 4K video end-to-end, from encoding to viewing device, with a latency of about 2 seconds, making it a transmission method with sufficient low latency to be used for simultaneous distribution between broadcast and the Internet.

2.2.2.3 Adaptive Bitrate Control Technology

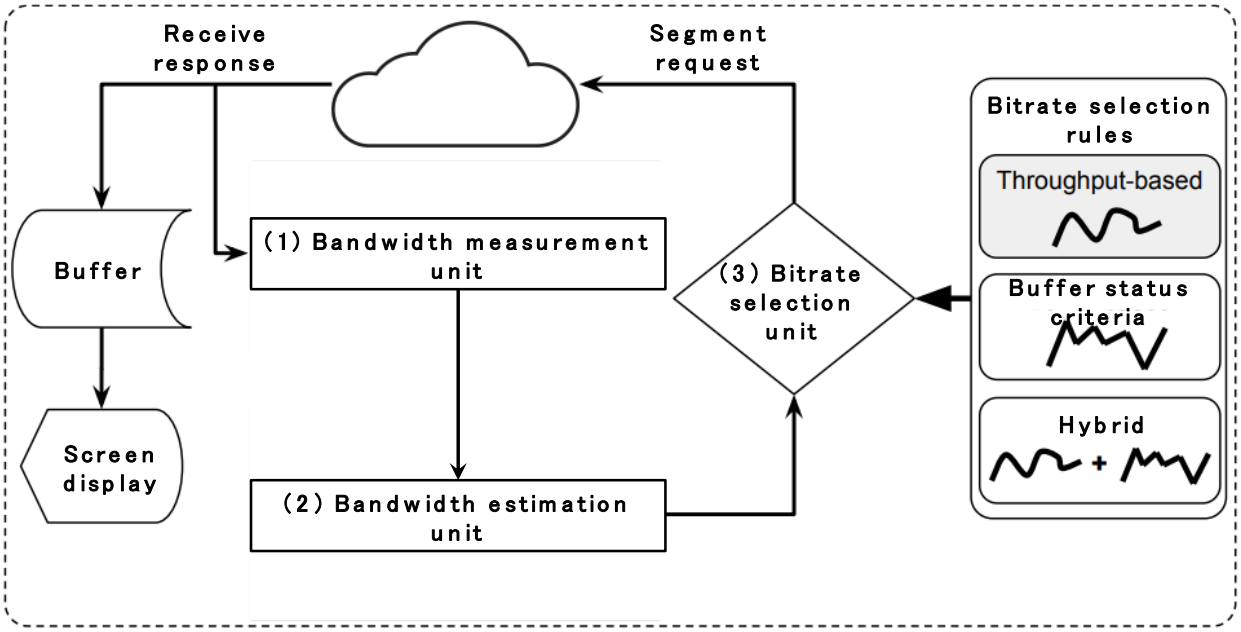
Adaptive bitrate (ABR) control technology is an extremely important feature that determines video quality and the smoothness of interruptions on viewing devices. The reason viewing devices require large buffers is because, due to factors such as network congestion, there is no guarantee that segments will arrive on time. For example, if six seconds pass while receiving a six-second segment, it is difficult to decide whether to wait a little longer until the segment is complete or to give up and cancel the current segment and request a new segment with a lower bitrate for the same time slot. Therefore, the current practice is to start playback with several segments buffered, thereby improving stability at the expense of low latency. This

often occurs because segments with a higher bitrate are requested than the available network bandwidth is available. Conversely, as long as the available network bandwidth is properly understood and segments with a lower bitrate are received, segment arrival times will be stable and viewing will be uninterrupted, allowing for minimal buffering. In other words, improved stability and low latency are synonymous.

Various ABR control technologies have been proposed. As shown in Figure 2-7, their basic configuration consists of a bandwidth measurement unit (Figure 2-7(1)) that measures the currently available network bandwidth; a bandwidth estimation unit (Figure 2-7(2)) that uses the bandwidth measurement results to predict the available network bandwidth for the next request; and a bitrate selection unit (Figure 2-7(3)) that determines which bitrate to request from the estimated bandwidth among the multiple bitrates offered as ABR. When watching pre-recorded videos such as VoD (Video on Demand), the Transmission Control Protocol (TCP) maximizes the available bandwidth when receiving segments. Therefore, available bandwidth can be calculated relatively easily from the relationship between the "data volume" of a segment and the "time from the start of reception to arrival." However, the situation is different for low-latency live streaming. For example, it takes six seconds to encode a six-second segment, so it also takes six seconds to receive it. When bandwidth is estimated using the same method as VoD, if the encoding bitrate is 6 Mbps, the available bandwidth will be calculated as 6 Mbps, and if it is 0.5 Mbps, it will be calculated as 0.5 Mbps. Therefore, an ARB control algorithm for low-latency live streaming, which differs from VoD, is needed, and various proposals have been made. Based on the method shown in Figure 2-7 (1) and (2), which measures bandwidth while taking into account the short latency between chunks in segment transmission, thereby improving the accuracy of bandwidth measurement and bandwidth prediction compared to segment-level measurement, another method has been proposed, shown in Figure 2-7(3), which introduces a neural network-based algorithm based on bandwidth measurements, delay, buffer size, and QoE (Quality of Experience) values, and controls buffer size by controlling playback speed. Furthermore, a method has been proposed that selects bitrates using online convex optimization based on delay and buffer size without explicitly measuring or estimating bandwidth. These algorithms have been incorporated into the open-source MPEG-DASH player dash.js and HLS player hls.js for evaluation, and the evaluation environment has been made public.

As another approach, given the difficulty of accurately grasping network properties on viewing devices, discussions have been underway at the Internet Engineering Task Force (IETF) since 2024 on standardizing mechanisms for securely communicating

network properties to viewing devices. Various studies are expected to continue in the future to provide a comfortable viewing experience.



(Source) https://doi.org/10.1145/3304112.3325611

Figure 2-7: Basic ABR control configuration

2.2.2.4 Push-based Low-latency Delivery Method: WebRTC, Media over QUIC

WebRTC

Web Real-Time Communication (WebRTC), which enables real-time video and audio communication between web browsers, is an effective technology for reducing latency. The IETF has standardized the communication protocol, and the World Wide Web Consortium (W3C), a web standards organization, has standardized the web browser API. It enables transmission with a latency of just a few hundred milliseconds and has been widely used in web conferencing tools such as Zoom, Microsoft Teams, and Google Meet in recent years. NHK STRL has also developed a system that enables interactive viewing of 360-degree streaming content on television. It processes video in response to user input in a cloud renderer and transmits the content to the television with low latency using WebRTC. While this system was previously considered unsuitable for large-scale distribution due to its inability to utilize a standard CDN, it has been demonstrated to reach tens of thousands of users by connecting multiple servers using a Selective Forwarding Unit (SFU) function to relay media streams. On the other hand, because the implementation of the web browsers used as viewing devices is specialized for real-time two-way communication, issues arise that depend on the implementation, such as the phenomenon of skipping

immediately when there is a delay. Stability issues have also been pointed out, such as the difficulty of controlling the quality of presentation to the user when used for video viewing, which is one-way communication.

QUIC

Additionally, progress is being made in standardizing communication protocols utilizing QUIC (Quick UDP Internet Connections), which combines low latency and reliability by incorporating a TCP-like control mechanism into UDP, which is fast but does not guarantee data delivery. QUIC speeds connection establishment, encrypts communications using Transport Layer Security (TLS), and prevents head-of-line blocking (HoL), a phenomenon in which missing IP packets in TCP prevent subsequent data from being processed even if it arrives. To incorporate these advantages into HTTP, the IETF standardized HTTP/3, the third major version of HTTP, which replaces TCP with QUIC as the transport layer, in 2022. Similarly, the IETF and W3C are working on standardizing WebTransport, which is based on HTTP/3 and enables low-latency bidirectional communication, with the aim of leveraging the benefits of QUIC for WebSocket, a standard for bidirectional communication between web browsers and servers.

NHK STRL low-latency delivery technology using WebTransport

In 2023, NHK STRL developed a low-latency delivery technology that combines WebTransport-based push delivery with server-side delivery quality control. Figure 2-8 shows the experimental system configuration. In this system, a live encoder converts video streams of multiple qualities into CMAF chunks on a frame-by-frame basis and transmits them to an origin server in the cloud using CTE. The origin server immediately relays the received CMAF chunks to the streaming server connected to the viewing device, which then pushes them to the viewing device using WebTransport, achieving low-latency delivery. By incorporating the origin server's relay function into a Pub/Sub messaging model, which can dynamically increase or decrease the number of data destinations, a configuration has been created that allows the number of streaming servers to be increased or decreased depending on the scale of delivery. Another unique feature of this system is that, unlike the method using application layer parameters described in Section 2.2.1.3, they attempt to improve estimation accuracy by using QUIC layer communication parameters for network bandwidth estimation in server-side quality control. This method estimates the available transmission bandwidth based on QUIC congestion control information when transmitting key frames, which contain the largest amount of information within a video GOP, and selects and distributes the video stream with the highest quality below the estimated value, thereby achieving stable, high-quality distribution. Using

the configuration shown in Figure 2-8, they conducted a distribution experiment by setting the receive buffer time of Device 1 to 300 ms and periodically applying bandwidth restrictions to the network. As shown in Figure 2-9, they confirmed that the delay from the camera video to the viewing screen was approximately 400 ms. Furthermore, as shown in Figure 2-10, they confirmed that the bandwidth estimate calculated by the server was close to the bandwidth restriction value, and that the distribution quality could be controlled to the maximum quality that did not exceed the bandwidth estimate.

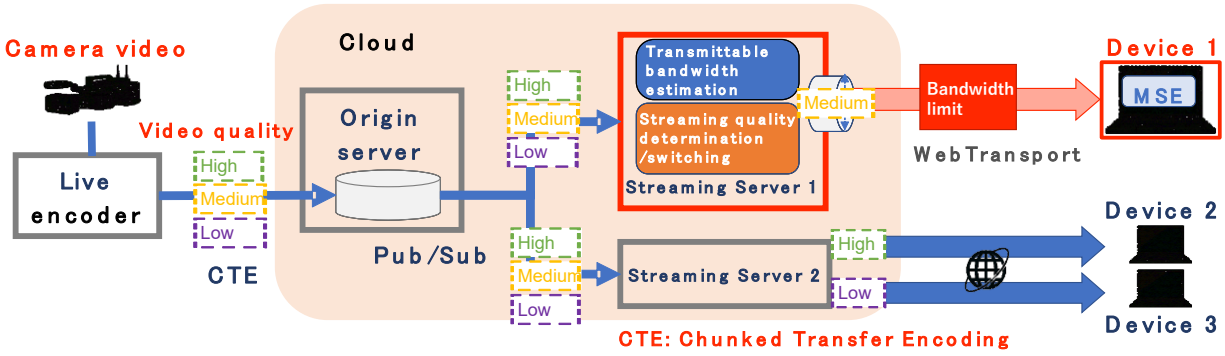


Figure 2-8: Configuration of the low-latency streaming system (NHK STRL)

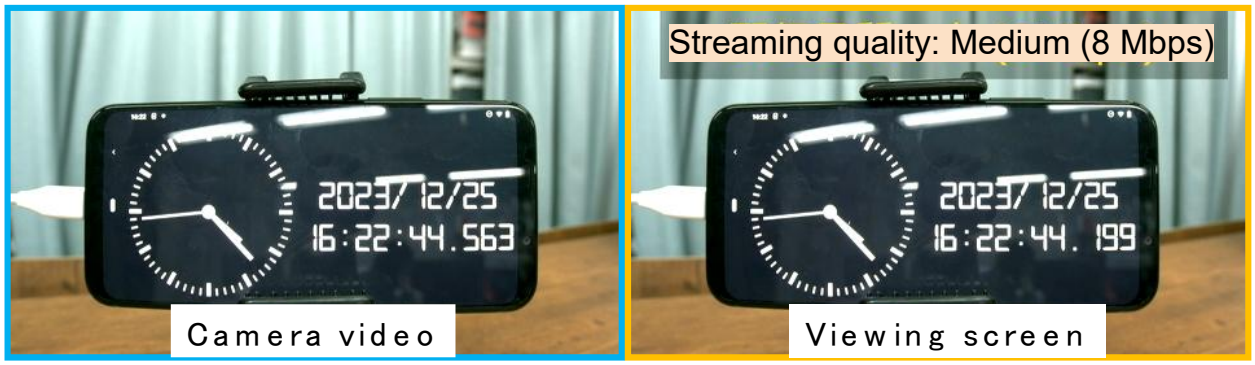


Figure 2-9: Camera video and viewing screen (NHK STRL)

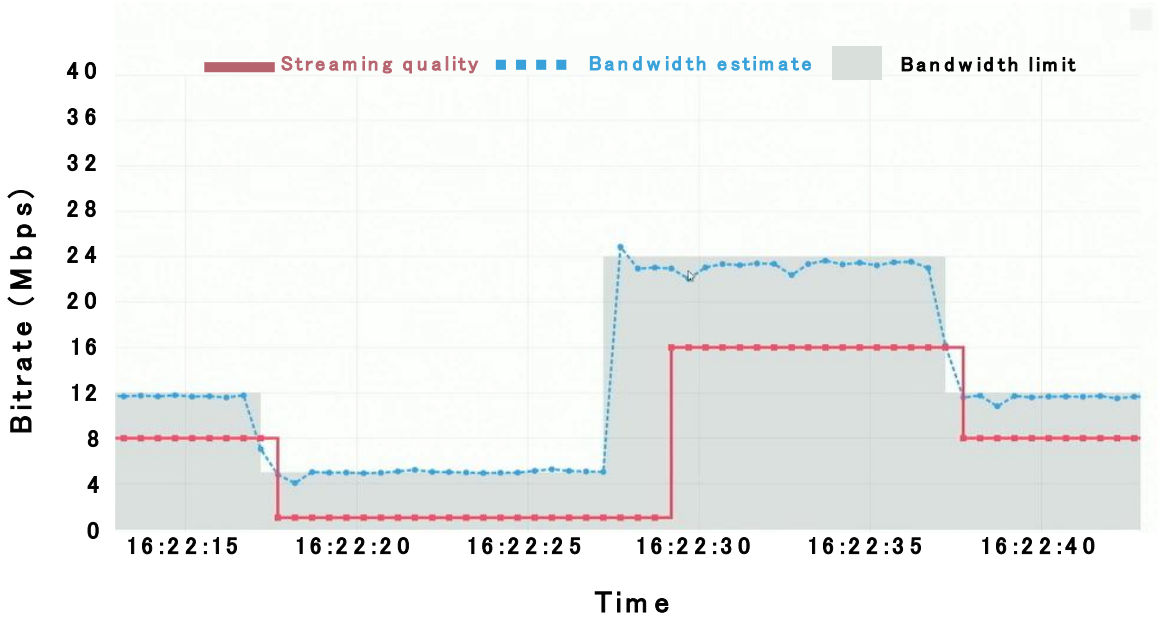


Figure 2-10: Bandwidth estimate and delivery quality trends with time (NHK STRL)

Media over QUIC

Another notable trend is the progress in standardizing MOQ (Media over QUIC), a low-latency media distribution method for use cases such as live streaming, online games, and conferences. It utilizes QUIC for all flows, from uploading live video (Figure 2-11(1)), relaying between servers (Figure 2-11(2)), and distribution to devices (Figure 2-11(3)). MOQ is based on QUIC-based protocol proposals such as RUSH, a live video uploading method by Facebook (Meta), Warp, a low-latency live streaming method by Twitch, and QUICR, a data relay method between devices and servers by Cisco. Figure 2-12 shows the protocol stack. Currently, two separate drafts are underway: MOQT (Media over QUIC Transport), which defines media transport methods over QUIC and WebTransport, and WARP Streaming Format, which defines streaming formats. Open-source implementation and testing are also underway. Video players will be developed using MSE (Media Source Extensions), a video playback control API also used in MPEG-DASH and HLS, and WebCodecs, an API capable of processing video frame-by-frame, currently being standardized by the W3C. However, features such as user presentation quality control will need to be designed, developed, and incorporated by the service provider. Open-source implementations incorporating these features are likely to emerge in the future. It will be interesting to see which will become the mainstream for media distribution: WebRTC, which has a 10-year track record despite its limited implementation flexibility, or MOQ, which has promising future developments.

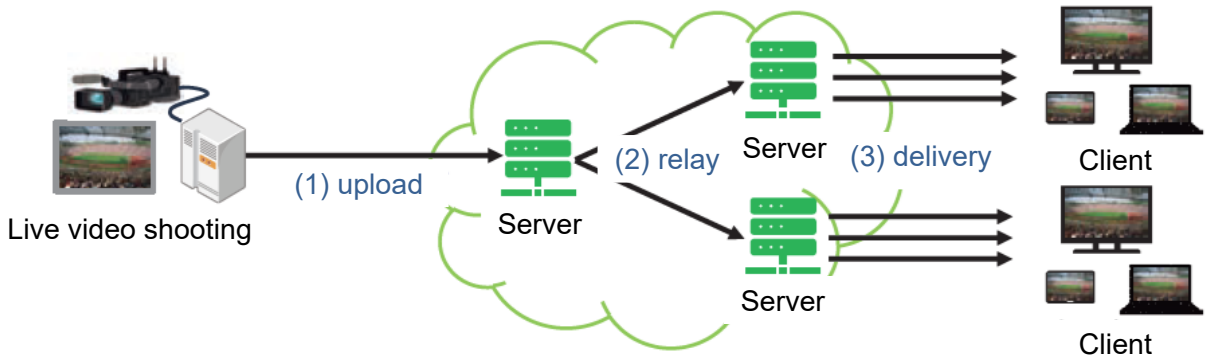
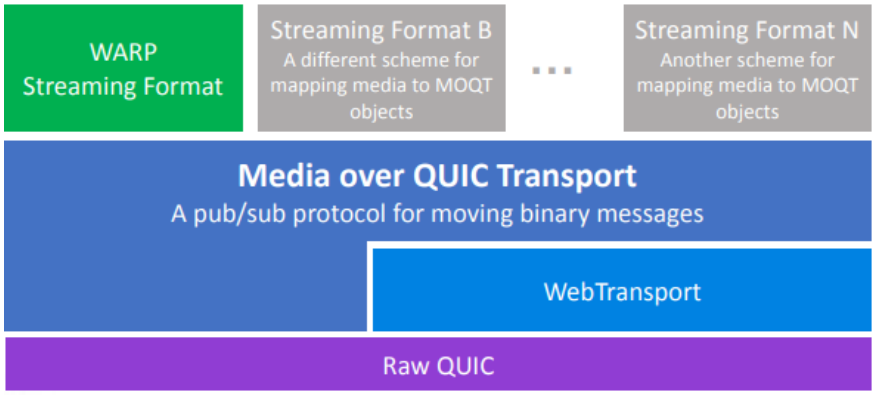


Figure 2-11: Components of Media-over-QUIC-based media delivery



（Source）https://datatracker.ietf.org/meeting/interim-2023-moq-08/materials/slides-interim-2023-moq-08-sessa-warp-streaming-format-00

Figure 2-12: Media over QUIC protocol stack

2.2.2.5 Video Player Technology - Media Source Extensions / Managed Media Source -

This section introduces trends in video playback technology for web browsers. Currently, most video streaming sites use MSE, a playback control API that began standardization at the W3C in 2013. MSE allows service providers to develop video players as web apps, potentially enabling a common viewing environment across a variety of devices, including PCs, smartphones, and TVs. However, among major devices, only the iPhone lacks MSE and instead implements a proprietary player via a web browser, preventing a common viewing environment. Apple cites high power consumption as the primary reason for not incorporating MSE. As this situation persisted, Apple announced a new API, Managed Media Source (MMS), in June 2023,

which improves upon MSE. It claims to reduce power consumption by improving the network and memory control mechanisms in MSE and is available in iOS 17.2 and later. Although the two APIs have different names, their usage is similar, making it possible to make existing MSE-compatible video players compatible with MMS with only minor modifications. This has finally made it possible to create a common viewing environment that includes the iPhone (Figure 2-13). MMS has been formally integrated into the MSE v2 specification as an alternative option alongside the traditional MediaSource, with ongoing efforts focused on expanding browser implementation and ensuring interoperability.

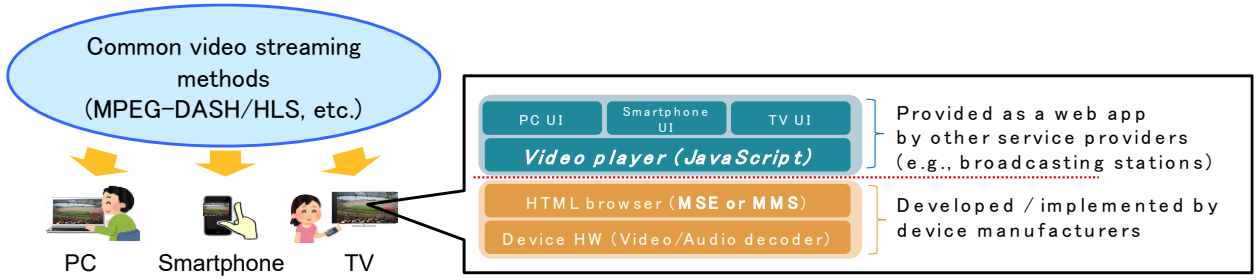


Figure 2-13: Overall structure of a video player that can be used across multiple devices using MSE/MMS

Until now, iPhones only supported HLS, but MMS has enabled support for a variety of video distribution formats, including MPEG-DASH. In fact, NHK STRL has confirmed that MPEG-DASH video playback on iPhones can be performed by adapting basjoo.js, their open-source MPEG-DASH video player, to MMS. They are also developing and testing a technology that inserts trigger signals (Media Timed Events: MTEs) into video streams at any timing and sends push notifications to viewing devices to instantly display emergency information. Utilizing MMS on iPhones will enable the testing of such technologies in the same way as on other devices, and it is expected to enable the proactive adoption of new technologies related to video viewing control.

2.2.3 Ensuring the Reliability of Content

In the information space on the Internet, inaccurate or false information (fake news) can be intentionally or unintentionally disseminated. In particular, using generative AI, anyone can easily create fake videos impersonating broadcasters. Advances in generative AI technology have improved the quality of fake videos year by year, making it easy for anyone to create high-quality fake videos impersonating broadcasters. This has made it difficult to distinguish between accurate information provided by broadcasters and false information. As a result, users are spreading fake videos on social media, believing them to be true. While it is easy to identify the

sender of a message using traditional broadcasting services over radio waves, the Internet is an open world where anyone can become a sender, making it difficult to identify the sender. For this reason, ensuring the reliability of content has become a key issue for Internet services provided by broadcasters. This subsection explains "content provenance technology", one means of solving this problem.

2.2.3.1 Content Provenance Technology

Content provenance technology, which embeds provenance information (such as the source and production process) into content and presents it to users, began to be considered around 2018. For broadcasters and other content providers, this information serves as proof of their origin, allowing users to determine the reliability of the content. For provenance information to be effective in combating disinformation and misinformation, widespread adoption of provenance information attachment technology is required, and provenance information must be attached to a wide range of content circulating online. To address this issue, the Coalition for Content Provenance and Authenticity (C2PA), an international standards organization for content origin and authenticity, was established with the aim of formulating and disseminating common technical specifications for content provenance technology, and the technical specifications have been made public. As shown in Figure 2-14, in C2PA, content creators attach provenance information and digital signatures to content at each stage of the process, such as capturing, editing, and publishing. Users can verify the digital signatures to check for tampering with the content and provenance information, and determine the authenticity of the content based on the provenance information and signer information.

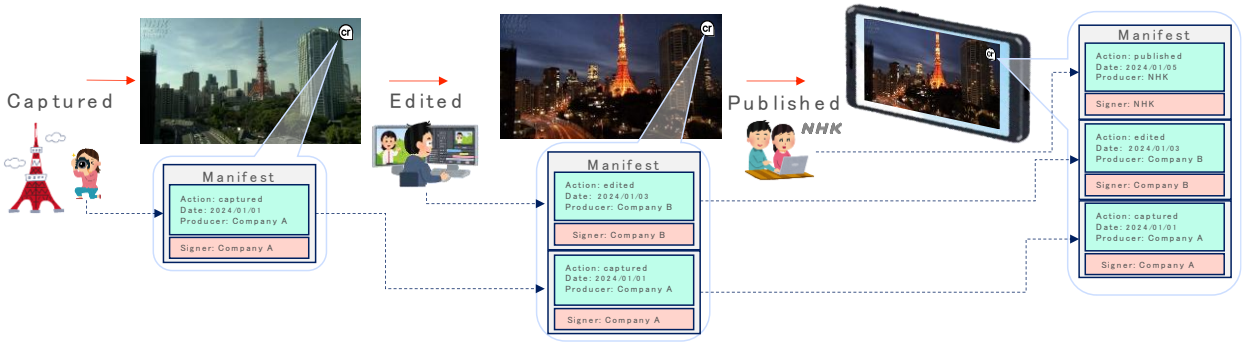


Figure 2-14: Flow of attaching and presenting provenance information

2.2.3.2 Overview of C2PA

C2PA is an international standards organization established in February 2021 by Adobe, Microsoft, the BBC, and others to develop standards for content origin and

authenticity. Two organizations served as the foundation for C2PA's founding. The first was the Content Authenticity Initiative (CAI), established by Adobe, Twitter, and others. The aim was to develop tools that display content origin (creator), editing history, copyright, and other attribution information throughout the content's lifecycle, from capturing to viewing, thereby providing users with information to assess its authenticity. Currently, CAI are developing tools based on the C2PA standard and providing open-source software to promote the adoption of C2PA standard technology. The other is Project Origin, established by the BBC, Microsoft, and others. The aim is to eliminate disinformation and misinformation on social media by verifying the origin (sender) of news content and ensuring that the content has not been altered from its origin to viewing. These efforts were integrated and C2PA was established as one of the standardization projects of the Joint Development Foundation, an umbrella organization of The Linux Foundation. Its participants include many domestic and international companies involved in content production and distribution, such as broadcasters, camera manufacturers, and IT companies, all of which are interested in providing reliable information over the Internet. C2PA develops technical specifications based on the requirements and use cases established by CAI and Project Origin, and these three organizations have a close relationship.

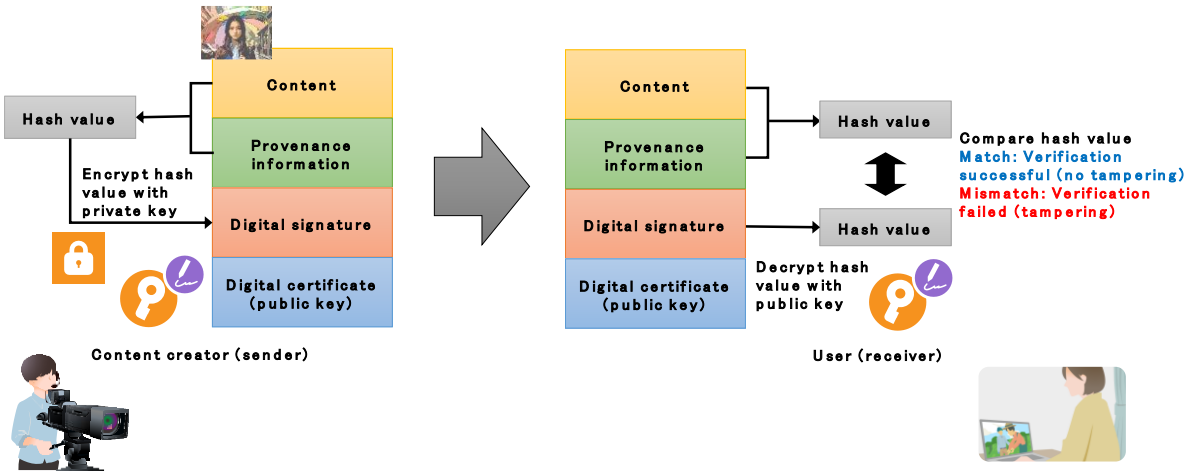


Figure 2-15: Procedure for attaching and verifying provenance information using a digital signature

The C2PA technical specifications stipulate methods for attaching, verifying, and presenting provenance information. Digital signatures are used to embed metadata into the content in a tamper-resistant format, that records who performed actions on the content, such as capturing, editing, and publishing, and when. When new actions are performed on content with provenance information, newly generated provenance information can be added, providing the user with provenance information showing the entire process of the content until it reaches the user. The provenance information

includes the public key certificate used to generate the digital signature, allowing users to detect tampering with the content and provenance information by verifying the signature with the public key included in the certificate (Figure 2-15). The C2PA specification enables users to verify that the content and provenance information have not been tampered with and that the provenance information was signed by an entity associated with a valid certificate. However, the presence or absence of provenance information does not by itself determine the reliability of the content or the trustworthiness of the person or organization that attached the provenance; users must make their own judgment based on the provenance information and the relevant trust framework.

2.2.3.3 C2PA Research and Development Examples

To implement the C2PA system, each hardware or software of content producers, distributors and users viewing the content must be C2PA-compatible. Sony Corporation has released consumer and professional cameras that support the C2PA standard. These cameras can add signed provenance information to videos at the time of capture, and the provenance information can be verified and displayed on a verification website provided by Sony. Adobe has released Premiere Pro, a video editing software that supports C2PA. When video content is edited using this software, provenance information indicating the editing process is added to the content. Furthermore, content edited using the generative AI tool "Adobe Firefly" is also added with provenance information indicating the use of generative AI. OpenAI and Google have also released generative AI tools "Sora" and "Veo", respectively, that can add provenance information when videos are created using these tools. In this way, an environment is being established in which C2PA provenance information can be added to content at each stage of the content production workflow, including capturing and editing. Meanwhile, it is also important to establish an environment in which provenance information can be verified and displayed when users view content with provenance information. To identify issues in the entire ecosystem and each element based on C2PA, and to investigate and verify the important factors for users to actually determine the trustworthiness of content, NHK STRL developed a prototype system that attaches C2PA-compliant provenance information to streaming video content, as well as a prototype video player that verifies and presents provenance information in real time while the content is playing. For the provenance information attachment system, they implemented a function to add provenance information to streaming video content in MPEG-DASH format using a Rust library published by CAI. For the video player, they incorporated a provenance information verification function into their MPEG-DASH video player, basjoo.js, using a JavaScript library published by CAI. They also added a process to present the verification results

to the user. For the user presentation process, they incorporated the following four functions to provide easy-to-understand information on factors for determining the trustworthiness of content. This player can be run on both PCs and smart TVs.

- Visual indication of the presence or absence of provenance information

When playing content with provenance information, the official C2PA icon, the cr icon, is displayed in the upper right corner of the screen to indicate to the user that provenance information is available (Figure 2-16(a)). When playing content without provenance information, the cr icon is not displayed, allowing the user to see at a glance that the content does not have provenance information.

- Display of verification results using the seek bar

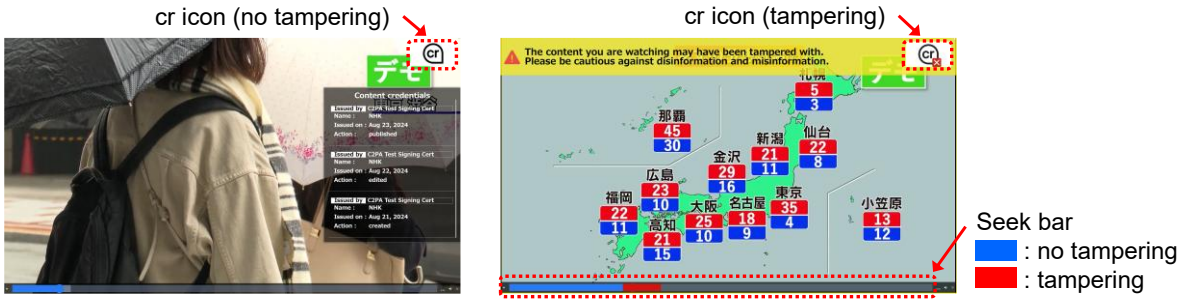
The verification results for whether the video content has been tampered with can be confirmed on the seek bar (Figure 2-16(b)). The prototype player is capable of detecting tampering for each MPEG-DASH segment and presents the verification results to the user in an easy-to-understand manner by displaying segments that were successfully verified in blue, segments where tampering was detected in red, and unplayed segments in gray. In addition, the player also has a function that notifies the user of the tampering in advance when it loads a tampered segment, even before playback, allowing the user to remain calm and take appropriate action.

- Providing provenance information

Upon user request (by clicking the CR icon or pressing a button on the remote control), the provenance information of the currently playing content can be presented (Figure 2-16(a)). By actually checking the provenance information that has been successfully verified, the source and production process of the content can be understood, and this can be used as information to determine the reliability of the content.

- Detecting and alerting to tampering

If segment tampering is detected, the user will be notified using text and the CR icon (Figure 2-16(b)). If the content being played has been tampered with, the user will be notified that the information may be fake or incorrect, which can encourage them to watch the content carefully or stop watching.



(a) CR icon and provenance information (b) Seek bar and warning

Figure 2-16: Example of a C2PA-compliant video-player screen

Several video players that support C2PA verification have been developed, but they are implemented as standalone applications, which may make it difficult for users to determine whether the displayed provenance information and verification results are trustworthy. If a malicious or tampered video player displays fake provenance information or verification results, users may be unable to correctly assess the authenticity of the content. To address this issue, NHK STRL developed a prototype Web browser with a built-in function for verifying content provenance. By performing provenance verification within the browser, the system can provide more robust verification and stronger protection against application tampering and spoofed verification results.

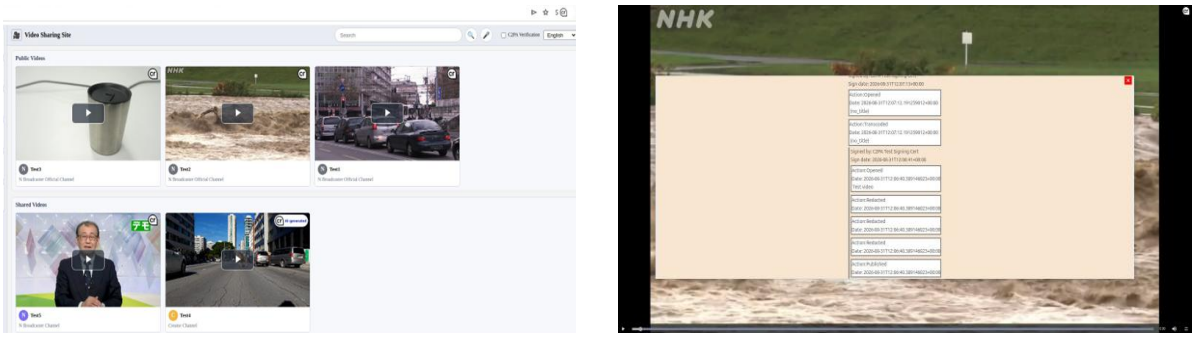


Figure 2-17: Example of a C2PA-compliant web-browser screen

In news production environments, there is the risk that video materials obtained from external sources may contain fake content generated using generative AI, and that news programs produced using such materials could subsequently be broadcast and/or distributed. Consequently, externally acquired video assets need

to be examined to determine whether they are suitable for use in broadcasting and distribution, creating a substantial operational burden. To address this problem, NHK STRL developed a prototype video management system that automatically classifies video materials based on attached content provenance information, thereby helping reduce the workload at production sites (Figure 2-18). This system classifies incoming video material into five categories: camera-captured, generative AI-assisted, tampering detected, no provenance information, and other. The classification results are shown using icons representing those categories, helping users quickly and easily understand the status of each asset. This system is expected to reduce the need for fully manual checks when determining whether video materials can be used. NHK introduced this classification function into its newsroom in February 2026.

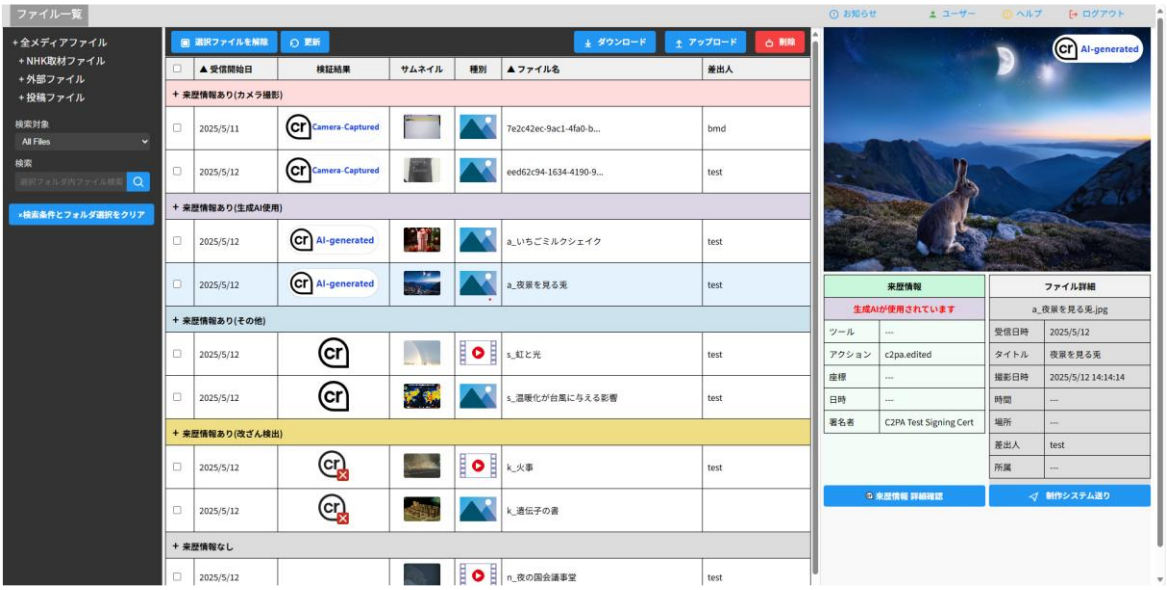


Figure 2-18: Video management system

2.3 Progress of ChinaDRM Technical Standards and Industrialization

An update in this report period includes the approval of Recommendation ITU-T J.1043 “Digital rights management for video and audio content distribution – Compliance and robustness rules” in July 2026, which completes the ChinaDRM international standard series (ITU-T J.1040 to J.1043) covering the entire audiovisual content distribution chain, from requirements and system architecture to client and compliance/robustness rules.

2.3.1 Standardization Status of ChinaDRM Technology

To promote high-security-level copyright protection for audiovisual content, the National Radio and Television Administration of China has issued a digital rights management standard system for audiovisual content distribution, releasing six industry standards. These standards cover multiple aspects including technical requirements, system integration, testing methods, and compliance testing, providing comprehensive technical support for digital rights management in audiovisual content distribution. The published standards are as follows.

- GY/T 277-2019 Technical specification of digital rights management for video audio content distribution
- GY/T 333-2020 Digital rights management for video audio content distribution— Digital rights management system integration for digital cable television
- GY/T 334-2020 Digital rights management of video audio content distribution— Digital rights management system integration for OTT TV
- GY/T 246-2020 Digital rights management for video audio content distribution— Digital rights management system integration for IPTV
- GY/T 335-2020 Digital rights management for video audio content distribution— Standard compliance test
- GY/T 336-2020 Digital rights management of video audio content distribution— System compliant requirements

On the basis of the aforementioned standards, to guide industry entities such as audiovisual content providers, service providers, smart terminal equipment and chip manufacturers, and DRM technology providers in accelerating the application and implementation of DRM technical standards, as well as strengthening copyright protection for audiovisual content, the National Radio and Television Administration issued the "Implementation Guidelines for Digital Rights Management (DRM) Technology in Audiovisual Content Distribution (2023 Edition)" on December 4, 2023. These guidelines provide direction for audiovisual content providers and service providers to achieve encrypted distribution and secure authorization of audiovisual content, as well as for smart terminal equipment and chip manufacturers to integrate and develop DRM client functionalities that comply with industry standards. As of 2026, the following ChinaDRM-related technical standards have been approved by ITU-T, specifically:

- ITU-T J.1040 Digital rights management for video and audio content distribution - Requirements (https://handle.itu.int/11.1002/1000/16192).

- ITU-T J.1041 Digital rights management for video and audio content distribution - System Architecture (https://handle.itu.int/11.1002/1000/16262).
- ITU-T J.1042 Digital rights management for video and audio content distribution - Client (https://handle.itu.int/11.1002/1000/16263).
- ITU-T J.1043 Digital rights management for video and audio content distribution – Compliance and robustness rules (https://handle.itu.int/11.1002/1000/16569).

With the approval of ITU-T J.1043 in July 2026, the ChinaDRM international standard series (J.1040 to J.1043), covering the entire audiovisual content distribution chain from requirements and system architecture to client and compliance/robustness rules, has been completed [1].

2.3.2 Industrial Application Status of ChinaDRM

In the industrialization and application of ChinaDRM technical standards, China has established a comprehensive industrial support system encompassing four key aspects: research and development production, security evaluation, service certification, and key management.

In terms of research and development production, the ChinaDRM Laboratory of the Academy of Broadcasting Science has developed a unified DRM client SDK to facilitate the rapid deployment of DRM across various smart terminals. Regarding security evaluation, the ChinaDRM Laboratory conducts assessments of DRM technologies and products to ensure their compliance with standards and interoperability. For key management, ChinaDRM has established a DRM Trust Management Center, which ensures mutual trust between DRM servers and clients through legal agreements and a unified digital certificate technical framework. In the area of service certification, the Service Certification Center of the Academy of Broadcasting Science carries out Digital Rights Management (DRM) service certification to guarantee the secure and effective deployment of DRM technical standards across the industry.

As of 2025, the Chinese market has 29 DRM server products, 28 DRM client chips, and 22 DRM client devices that comply with the standards. Over 260 million terminal devices, including smart TVs, smart set-top boxes, mobile terminals, and in-vehicle entertainment systems, have integrated DRM functionality. Seven audiovisual equipment manufacturers have built DRM systems that meet industry standards and have passed the Digital Rights Management (DRM) service certification.

2.3.3 Next Steps and Recommendations

In the context of the global audio-visual industry's digitalization and ultra-high-definition development, while new technologies and business models are driving the prosperous development of the global audio-visual industry, audio-visual piracy is also showing new and diversified trends. The digitalized, networked, and globalized black-industry piracy is the biggest challenge to global copyright protection. New types of audio-visual consumption models such as short video editing, re-creation, and the application of generative artificial intelligence, have sparked new copyright disputes, which are accelerating the erosion of the copyright interests of the professional, high-quality audio-visual content creation and distribution industry chain. The end-to-end DRM ecosystem for global audio-visual content still exhibits shortcomings and weaknesses. The deployment of DRM technology at low security levels is a particularly vulnerable spot for piracy attacks. Driven by the profits of piracy, DRM cracking techniques continue to be explored and become more and more sophisticated.

Faced with the development of new technologies and business models, all parties in the global media industry chain should jointly explore solutions. We should adhere to the principles of openness, cooperation, and mutual benefit, take copyright protection as the core goal, and prioritize the healthy development of the global audio-visual industry chain. Together, we should safeguard the international audio-visual copyright protection ecosystem.

In the future, all parties in China's audio-visual copyright protection industry chain will continue to deepen exchanges and cooperation with their international counterparts. China will discuss the evolution of DRM technology, strengthen its implementation, and explore the path of international audio-visual copyright protection ecosystem evolution, which features continuous technological innovation, improving security levels, and expanding protection scopes. China will contribute to building an open, trustworthy, cooperative, and mutually beneficial international digital copyright protection ecosystem.

Reference

[1] https://www.nrta.gov.cn/art/2026/8/3/art_114_73795.html

2.4 Cybersecurity

Major updates in this report period include an update of Table 2-1 to reflect the current versions of the guidelines and frameworks, with the addition of the MPA Content Security Best Practices / Trusted Partner Network and related EBU

recommendations (R 141, R 144, R 145 and R 146). The incident reports in 2.4.2 have been replaced with two cases from 2026: the satellite transmission hijacking of several television news channels in Pakistan and the data breach at Mediaworks Hungary. Section 2.4.3 now summarizes cyber threat trends based on the ENISA Threat Landscape 2025 and the Verizon Data Breach Investigations Report 2026.

2.4.1 Major Cybersecurity Guidelines and Frameworks

As broadcast infrastructures become increasingly software-based and interconnected, the importance of robust cybersecurity measures has grown significantly. Broadcasters should prioritize cybersecurity not only to protect content and operations but also to maintain public trust and regulatory compliance.

A range of influential guidelines and frameworks have been developed globally to help broadcasters implement effective security measures, ensure regulatory compliance, and protect critical infrastructure. Developed by international broadcasting unions, industry-specific working groups, and standardization organizations, these frameworks reflect diverse regional and operational needs. Table 2-1 lists the key guidelines and frameworks that can serve as reference points for ABU members seeking to strengthen their cybersecurity. The table has been updated for this year's report to reflect current versions and to add two entries, the Motion Picture Association content security framework, and the wider set of EBU recommendations beyond R 143.

Table 2-1: Major guidelines and frameworks for cybersecurity

Organization	Overview of guidelines/Frameworks
World Broadcasting Unions (WBU)	**WBU Cybersecurity Recommendations for Media Vendors' Systems, Software and Services** Developed through a collaboration of major broadcast unions (including the EBU, NABA, and ABU), these recommendations provide a set of security requirements that broadcasters should expect from their vendors. They are widely referenced as an international standard for procurement. https://worldbroadcastingunions.org/wp-content/uploads/2022/05/WBU-Cybersecurity-Recommendations-for-Media-Vendors-2022-03-30.pdf
European Broadcasting Union (EBU)	**EBU R 143: Cybersecurity for media vendor systems, software & services** This is one of the most widely recognized recommendations in the industry. It defines minimum security requirements for media systems and services, and is regularly updated to reflect modern trends like the shift to IP-based systems and the use of cloud (SaaS) products. It covers a broad range of topics, from vulnerability management to access control. https://tech.ebu.ch/publications/r143 **Related EBU recommendations:**

	R 141 – Mitigation of distributed denial of service (DDoS) attacks; R 144 – Cybersecurity governance for media companies, which defines the five-level maturity model; R 145 – Mitigation of ransomware and malware attacks; R 146 – Cloud security for media companies. The EBU Media Cybersecurity group also publishes guidance on security maturity benchmarking, secure file ingest and secure software development lifecycles. https://tech.ebu.ch/groups/mcs
North American Broadcasters Association (NABA)	**Essential Guide to Broadcast Cybersecurity** This guide provides practical advice for North American broadcasters. It addresses specific regional concerns, offering best practices for securing the Emergency Alert System (EAS) and concrete recommendations for using cloud services (SaaS/PaaS/IaaS). https://www.nab.org/cybersecurity/broadcasterResources.asp
Motion Picture Association (MPA) / Trusted Partner Network (TPN)	**MPA Content Security Best Practices (v5.3.1, 7 August 2025)** An information security management system control framework derived from and mapped to ISO/IEC 27001:2022, ISO/IEC 27002:2022 and the NIST CSF, addressing content security across the media and entertainment supply chain. The Trusted Partner Network, owned and operated by the MPA, implements these best practices through self-attestation and third-party assessments. TPN assessment has become a contractual requirement for companies handling content for major studios and streaming services, and more than 1000 production, editorial, post-production and distribution companies participate. Relevant to ABU members that produce or post-produce content for international distribution. https://www.ttpn.org/
ICT-ISAC Japan	**ICT-ISAC Broadcast Equipment Cybersecurity Guidelines** ICT-ISAC Japan has developed specialized cybersecurity guidelines for broadcast equipment through its Broadcast Equipment Cyberattack Countermeasure Working Group (WG). These guidelines, first published in 2018, address the unique challenges of securing broadcasting systems, which prioritize high availability and often operate on legacy or isolated infrastructure. The framework emphasizes practical, incremental security measures tailored to broadcasting environments, such as secure network segmentation, endpoint protection, and vulnerability management for systems running general-purpose OS like Windows and Linux. https://www.soumu.go.jp/main_content/000859328.pdf
ISO/IEC	**ISO/IEC 27001, ISO/IEC 27002** The ISO/IEC 27001 standard provides companies of any size and from all sectors of activity with guidance for establishing, implementing, maintaining and continually improving an information security management system. https://www.iso.org/standard/27001 ISO/IEC 27002 provides best practices to implement the management system defined by ISO/IEC 27001 focused on cybersecurity. https://www.iso.org/standard/75652.html
National Institute of Standards and Technology (NIST)	**NIST Cybersecurity Framework (CSF)** While not specific to broadcasting, the NIST CSF is the foundational framework for cybersecurity risk management across critical infrastructure sectors worldwide. It provides a

	common language and a systematic approach by organizing activities into five core functions: **Identify, Protect, Detect, Respond, and Recover**. Many broadcasters use the CSF as the basis for building and evaluating their own security programs. https://www.nist.gov/cyberframework
Center for Internet Security (CIS)	**CIS Controls** The CIS Controls are a set of practical, prioritized guidelines published by the non-profit organization, the Center for Internet Security (CIS). They provide a list of concrete actions that are most effective against cyberattacks, which has the advantage of making it clear where to start. The controls are also designed to be implemented in phases, allowing organizations to tackle them incrementally according to their size and maturity level. https://www.cisecurity.org/controls

2.4.2 Recent Incidents at Media Organizations

2.4.2.1 Satellite transmission hijacking in Pakistan, March 2026 [1]-[3]

On the evening of Sunday 1 March 2026, several of Pakistan's major television news channels, including Geo News, ARY News and Samaa TV, suffered unauthorized disruptions to their satellite transmissions. Hostile messages were briefly displayed on air during high-audience evening bulletins before normal programming resumed. The affected broadcasters confirmed that the disruptions involved their satellite feeds and were not editorial decisions, and at least one network stated that its websites and social media streams were unaffected.

The Managing Director of Geo News stated publicly that the channel had faced hacking attempts against its PakSat satellite feed for approximately 24 hours before the incident, and that the message aired had no connection with the broadcaster. Monitoring of live broadcasts indicated that similar unauthorized messages appeared across multiple channels within a short time frame, suggesting coordinated interference with transmission infrastructure rather than an isolated technical fault. No group publicly claimed responsibility, and no detailed technical findings or attribution had been published by the authorities at the time of writing.

The Pakistan Electronic Media Regulatory Authority (PEMRA) issued an alert to licensees in March 2026. Following further incidents, the Government and the National Computer Emergency Response Team (NCERT) engaged with news channels in July 2026 on cybersecurity protocols and coordination between regulators, security experts and media organizations. PEMRA subsequently directed all satellite television licensees to submit a detailed cybersecurity implementation roadmap within three working days and to complete key measures by 4 August 2026. Licensees were required to provide timelines for third-party cybersecurity audits, for the installation or outsourcing of a Security Operations Centre (SOC) and Security Information and

Event Management (SIEM) capability, and for the appointment of a Chief Information Security Officer (CISO).

2.4.2.2 Mediaworks Hungary, April–May 2026 [4]

Mediaworks Hungary, one of the largest media groups in Hungary, disclosed on 4 May 2026 that it had been the victim of a serious attack on 30 April 2026. The World Leaks cyber-extortion group claimed responsibility. Approximately 15 million files, amounting to some 8.5 terabytes, were exfiltrated and subsequently published on the dark web. Material reviewed by other outlets was reported to include payroll records, contracts, financial statements, internal communications and substantial volumes of personal data including names, addresses and bank account details. Hungary's National Authority for Data Protection and Freedom of Information opened an ex officio investigation.

2.4.3 Cyber Threat Trends

According to ENISA Threat Landscape 2025 and Verizon Data Breach Investigation Report 2026, phishing and social engineering remain the dominant route into an organization, while unpatched vulnerabilities and compromised third parties are the fastest-growing ones. Both reports also note that attackers are increasingly using AI to make social engineering more effective; and the actors most active against public-sector organizations are state-aligned and ideologically motivated groups whose campaigns follow the news agenda. This reinforces the incidents reported in 2.4.2. The following two sub-sections summarize the key points of the two reports.

2.4.3.1 ENISA Threat Landscape 2025 [5]

Published in October 2025, based on 4875 incidents recorded in the EU between 1 July 2024 and 30 June 2025. The geographic scope is European, but the actors and techniques are global, and the report is the most rigorous public analysis of activity against public-sector organizations.

Phishing and Vulnerability Exploitation Are the Primary Causes of Intrusions

Phishing accounts for 60% of initial intrusion vectors, followed by the exploitation of technical vulnerabilities (21.3%). Notably, approximately 70% of vulnerability exploitation cases result in actual system compromise.

The Prominence of Hacktivism and DDoS Attacks

DDoS attacks account for 76.7% of recorded incidents, while attacks by hacktivists make up approximately 79% of all incidents. However, many of these attacks are symbolic in nature, and their actual impact is relatively limited.

Structural Changes in Cybercrime and Ransomware

Ransomware accounts for 81.1% of cybercrime incidents. While law enforcement actions have disrupted major groups, new Ransomware-as-a-Service (RaaS) programs and variants are becoming increasingly decentralized and diversified.

Concentration on Government and Infrastructure Targets, and Supply Chain Risks

The most frequently targeted sector is government (38.2%), followed by transportation and digital infrastructure. State-sponsored threat actors are intensifying supply chain attacks targeting IT service providers and open-source ecosystems.

Abuse of Generative AI and Emerging Attack Techniques

AI is used in more than 80% of observed social engineering activities. The development of custom malicious AI tools and malware distribution sites disguised as popular AI services are expanding the cyberattack surface surrounding AI.

2.4.3.2 Verizon Data Breach Investigation Report 2026 [6]

Published in April 2026, analyzing confirmed breaches contributed worldwide. This year is notable for a shift in the principal means of initial access.

Vulnerability Exploitation Surge

Software vulnerability exploitation became the leading initial entry point (31%), surpassing credential abuse (13%). Meanwhile, critical vulnerability remediation rates fell to 26%, with resolution time extending to 43 days.

Ransomware & Third-Party Risks

Ransomware featured in 48% of breaches, though 69% of victims refused ransom demands, driving down median payouts. Breaches involving third-party suppliers surged by 60%, representing 48% of total incidents.

Mobile Social Engineering

Human involvement contributed to 62% of breaches. Mobile-centric entry points (voice, SMS) achieved a 40% higher click rate than traditional email phishing. Pretexting accounted for 6% of breaches.

Generative AI in External Attacks

Threat actors increasingly leverage GenAI across multiple kill-chain phases (target selection, automated tooling). However, AI primarily accelerates existing, known attack techniques rather than creating novel attack methods.

Shadow AI & Data Exposure

Employee adoption of AI on work devices reached 45%, with 67% using personal accounts. Unsanctioned AI usage became a top Data Loss Prevention (DLP) violation, exposing sensitive source code (28%) and technical documentation.

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[6] https://www.verizon.com/business/resources/reports/dbir/

Annex 3

Satellite Broadcasting (D/SB)

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This annex describes technologies on the latest satellite systems for UHDTV broadcasting and specifications of the latest satellite broadcasting systems. It also describes the latest topics on advanced satellite broadcasting technologies.

3.1 ITU-R Documents Related to Satellite Broadcasting Systems

3.1.1 Radio Regulations

ARTICLE 23 Section 2 "Broadcasting-satellite services"

APPENDIX 30 "Provisions for all services and associated Plans and List for the broadcasting-satellite service in the frequency bands 11.7-12.2 GHz (in Region 3), 11.7-12.5GHz (in Region 1) and 12.2-12.7 GHz (in Region 2)"

APPENDIX 30A "Provisions and associated Plans and List for feeder links for the broadcasting-satellite service (11.7-12.5GHz in Region 1, 12.2-12.7 GHz in Region 2 and 11.7-12.2 GHz in Region 3) in the frequency bands 14.5-14.8 GHz and 17.3-18.1 GHz in Regions 1 and 3, and 17.3-17.8 GHz in Region 2"

RESOLUTION 506 "Use by space stations in the broadcasting-satellite service operating in the 12 GHz frequency bands allocated to the broadcasting-satellite service of the geostationary-satellite orbit and no other"

RESOLUTION 507 "Establishment of agreements and associated plans for the broadcasting-satellite service"

RESOLUTION 528 "Introduction of the broadcasting-satellite service (sound) systems and complementary terrestrial broadcasting in the frequency bands allocated to these services within the range 1-3 GHz."

RESOLUTION 536 "Operation of broadcasting satellites serving other countries."

RESOLUTION 548 "Application of the grouping concept in Appendices 30 and 30A in Regions 1 and 3"

RESOLUTION 552 "Long-term access to and development in the frequency band 21.4-22 GHz in Regions 1 and 3"

RESOLUTION 553 "Additional regulatory measures for broadcasting-satellite networks in the frequency band and 21.4-22 GHz in Regions 1 and 3 for the enhancement of equitable access to this frequency band"

RESOLUTION 554 "Application of pfd masks to coordination under No. 9.7 for broadcasting-satellite service networks in the band 21.4-22 GHz in Regions 1 and 3"

RESOLUTION 558 "Protection of implemented broadcasting-satellite service networks in the orbital arc of the geostationary-satellite orbit between 37.2°W and 10°E in

the frequency band 11.7-12.2 GHz”

RESOLUTION 559 “Additional temporary regulatory measures following the deletion of part of Annex 7 to Appendix 30 by WRC-19”

3.1.2 Recommendations (https://www.itu.int/rec/R-REC-BO/en)

BO.1213 “Reference receiving Earth station antenna pattern for the broadcasting-satellite service in the 11.7-12.75 GHz band”

BO.1408 “Transmission system for advanced multimedia services provided by integrated services digital broadcasting in a broadcasting-satellite channel”

BO.1443 “Reference BSS earth station antenna patterns for use in interference assessment involving non-GSO satellites in frequency bands covered by RR Appendix 30”

BO.1516 “Digital multiprogramme television systems for use by satellites operating in the 11/12 GHz frequency range”

BO.1659 “Mitigation techniques for rain attenuation for broadcasting-satellite service systems in frequency bands between 17.3 GHz and 42.5 GHz”

BO.1696 “Methodologies for determining the availability performance for digital multi-programme BSS systems, and their associated feeder links operating in the planned bands”

BO.1724 “Interactive satellite broadcasting systems (television, sound and data)”

BO.1774 “Use of satellite and terrestrial broadcast infrastructures for public warning, disaster mitigation and relief”

BO.1784 “Digital satellite broadcasting system with flexible configuration (television, sound and data)”

BO.1900 “Reference receive earth station antenna pattern for the broadcasting-satellite service in the band 21.4-22 GHz in Regions 1 and 3”

BO.2063 “Alternative BSS earth station antenna radiation pattern for 12 GHz BSS bands with effective apertures in the range 55-75 cm”

BO.2098 “Transmission system for UHDTV satellite broadcasting”

3.1.3 Reports (https://www.itu.int/pub/R-REP-BO/en)

BO.2007 “Considerations for the introduction of broadcasting-satellite service of high-definition television and ultra-high-definition television systems in the band 21.4-22 GHz”

BO.2071 “Broadcasting-satellite service system parameters between 17.3 GHz and 42.5 GHz and associated feeder links”

BO.2101 “Digital satellite broadcasting system (television, sound and data) with flexible configuration”

BO.2102 “Multiple-feed BSS receiving antennas”

BO.2397 “Satellite transmission for UHDTV satellite broadcasting”

BO.2465 "Assessment on limitations mentioned Annex 7 to RR Appendix 30 (Rev.WRC-15) in the 11.7-12.7 GHz band for the GSO broadcasting-satellite service in all Regions"

BO.2497 "Characteristics and effectiveness of frequency sharing criteria for the broadcasting-satellite service in Regions 1 and 3 subject to RR Appendix 30"

3.2 Development of Layered Division Multiplex Transmission

NHK STRL is developing a satellite broadcasting system with layered division multiplex (LDM) that multiplexes multiple modulation signals in the same channel with different power levels with the aim of providing services with flexibility in accordance with changes in the receiving environment due to rain attenuation, etc. as a next-generation satellite broadcasting system. The LDM transmission consists of an upper layer (UL) with high power and a lower layer (LL) with low power, and it enables signals to be transmitted with different bitrates and robustness in the same channel. It is useful for broadcasters to maintain broadcasting services provided by UL signal with a robust transmission parameter during heavy rainfall.

NHK STRL has prototyped an LDM-based modulator and demodulator for satellite broadcasting in the 21-GHz band. The 21-GHz-band satellite broadcasting allocated to the frequency band of 21.4–22.0 GHz in ITU-R Regions 1 and 3 is expected to be utilized as transmission channels for new broadcasting services with large capacity. Then, two 300-MHz-class wideband transponders are assumed in the 21-GHz band and a wideband LDM-based modulator and demodulator with the nominal symbol rate of 250 Mbaud were developed shown in Figure 3-1.



Modulator Demodulator Spectrum

Figure 3-1: Wideband LDM-based modulator and demodulator

During NHK STRL Open House 2026, the satellite transmission of a free-viewpoint augmented reality (AR) content [1], in which three-dimensional objects viewable from arbitrary viewpoints are composited and displayed in real space was examined by using the LDM-based modulator and demodulator in the 21-GHz band shown in Figure 3-2. Using the LDM scheme, the video and audio objects composing free-viewpoint AR are allocated to two signals, the UL and LL. Even if radio waves are attenuated owing to heavy rainfall, viewing can continue with content composed of objects assigned to the UL signal. In this demonstration, standard-resolution videos

and audio objects were allocated to UL and high-resolution video objects were allocated to LL signals, respectively.

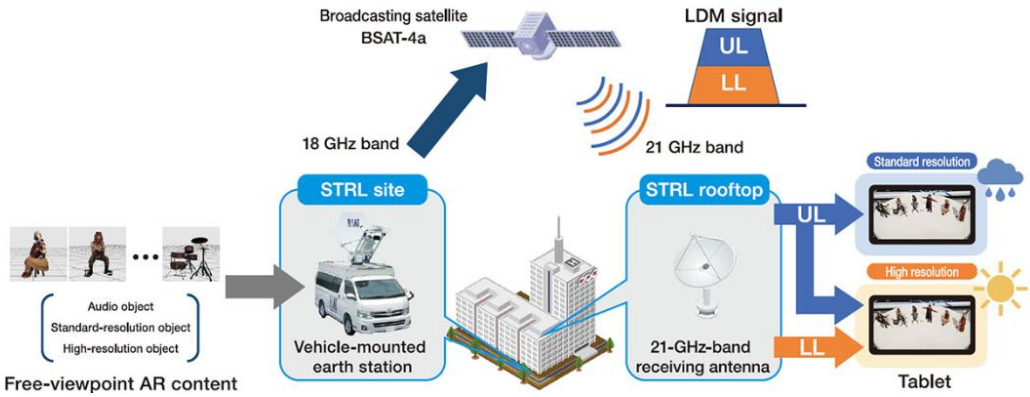


Figure 3-2: Image of advanced satellite broadcasting system for 8K program with LDM transmission and multi-layer coding of VVC

References

[1] NHK STRL OPEN HOUSE 2026, "Transmission of Large-Capacity Content via 21-GHz-Band Broadcasting Satellites". https://www.nhk.or.jp/strl/english/open2026/tenji/13/index.html

3.3 Development of L-band Broadcast over GEO Satellite (BOG) services

A trial of 5G Broadcast Service from a L-band geosynchronous satellite to a retail smartphone with software updates was conducted in October 2024 successfully utilizing by the Astrum Mobile Inc. based in Singapore and Qualcomm Technologies [1]. It utilized Asiastar geosynchronous satellite with an Asia Pacific wide service coverage and 3GPP 5G NTN (Non-Terrestrial Networks) standard as defined in ETSI TS 103 720 featuring a satellite-to-device 5G Broadcast service. It demonstrated broadcast services of live TV and online gaming broadcasts, OTT content push, and emergency broadcast services.

In addition, technical specification 3GPP Release 19, version 19.1.0 in TS 36.102 and TS 36.108 designates a new operating band 1467-1492 MHz for geosynchronous satellite operations in Region 3, Asia Pacific in November 2025 supported by Academy of Broadcasting Science, China (ABS), European Broadcasting Union (EBU), Singapore University of Technology & Design (SUTD), Astrum Mobile Inc. and so on.

This frequency band is included in the existing BSS (broadcasting satellite service) defined in ITU Radio Regulations.

Astrum Mobile Inc. had a workshop and gave a presentation at ABU DBS 2026.

Reference

[1] Astrum Mobile, press release "Astrum Mobile and Qualcomm Completes Joint Trial of the World's 1st 5G Broadcast Using a Geo Satellite", https://www.astrumspaceinc.com/press/astrum-mobile-and-qualcomm-completes-joint-trial-of-the-worlds-1st-5g-broadcast-using-a-geo-satellite/

3.4 Native IP Delivery over Satellite: DVB-NIP

DVB Native IP (DVB-NIP) is an end-to-end native IP broadcast system for DVB broadcast bearers. It was published as ETSI TS 103 876 V1.1.1 in September 2024 [1]. It enables delivery of OTT-format content over satellite (DVB-S2/DVB-S2X) or terrestrial (DVB-T2) networks. It combines DVB-I for service discovery, DVB-DASH, DVB multicast ABR (DVB-MABR) and Generic Stream Encapsulation (GSE), so that broadcast and internet-delivered services can be handled on one IP-based platform and received on IP devices through a home gateway [1].

At DVB World 2026, participants saw potential for DVB-NIP in bridging the digital divide, while noting that further work is needed on DRM and addressable advertising [2].

3.4.1 Deployments

Peru (IRTP): To avoid vendor lock-in, Peru's national public broadcaster, IRTP, selected the DVB-NIP standard to extend its coverage from 72% to the entire country. In March 2024, IRTP partnered with Eutelsat to deliver 12 free-to-air live channels and educational content via satellite. Implemented by the SKYflow consortium, the system uses set-top boxes as DVB-NIP gateways to redistribute content over local IP networks. While live television operations began in early 2024, a planned second phase for distance-learning file delivery has stalled due to a lack of interest from the Ministry of Education. [3][4][5]

Consequently, the deployment of receivers has been driven mainly by professional and academic organizations, such as the Colegio de Ingenieros del Perú (CIP), rather than IRTP itself. These groups have been installing "Smart DTH" kits in remote, high-altitude regions, which distribute TV and VOD content over local Wi-Fi without requiring internet access or monthly fees. However, only about 300 terminals were reported to have been installed by early 2026. [6][7]

Eutelsat: In August 2025, Eutelsat selected ENENSYS to power its first next-generation DTH platform based on DVB-NIP. The platform, built on the ENENSYS StarStream solution, delivers linear TV, video-on-demand and educational content using multicast ABR. It has been deployed at Eutelsat's Rambouillet teleport and is ready to provide DTH services worldwide. A live demonstration of the platform was presented on the Eutelsat stand at IBC2025 (12–15 September 2025) [8]. A white paper published by Eutelsat describes the standard as ready for commercial deployment. It cites proofs of concept and trials including DTH trials by RAI via the HOTBIRD satellites, content delivery to hotels by Sky Italia and crew-welfare streaming on ships, and lists an ecosystem of platform, gateway, application and TV-set vendors [9].

3.4.2 5G-EMERGE Project

5G-EMERGE is an industry-led project coordinated by the EBU and supported by ESA [10][11]. It aims to develop an open, multi-tenant, native-IP ecosystem that integrates satellite distribution into online media delivery. Content is carried over satellite using DVB-S2X, DVB-NIP, DVB-MABR and GSE to edge nodes — home gateways, vehicles and 4G/5G base stations — which deliver it to users using 3GPP 5G specifications [10][12].

In Phase 1 (Q4 2022 to Q4 2024), testbeds were established in Geneva (EBU), Luxembourg (SES) and Luleå (Arctic Space) [10], and demonstrators for direct-to-home, direct-to-vehicle and direct-to-edge use cases were deployed in several European countries. In tests with the terrestrial internet connection throttled to 2 Mbit/s, the satellite-fed local edge could still serve the highest-quality streams to several devices simultaneously, and a maritime solution was considered close to market [12].

Phase 2 was signed in Paris on 13 November 2024 and runs to Q4 2026 [13]. It adds direct-to-device multicast and broadcast services and will explore integration with 5G NR non-terrestrial networks (NR-NTN) [11]. Partners include broadcasters such as RAI and BFBS and satellite operators including Eutelsat/OneWeb, SES and Viasat [13]. The EBU demonstrated the solution at MWC 2025, delivering content by 5G NR unicast, 5G multicast or 5G broadcast according to the configuration of the base station [11].

During the reporting period, the project published a third white paper, on its architecture and innovations, in March 2026, and two further white papers in September 2026, on the deployment of the BFBS Smart Edge in austere and

disrupted environments and on sustainable media delivery [14]. At IBC2026 the project was showcased on the EBU stand as "hybrid satellite and 5G edge delivery for resilient, efficient media streaming across Europe", with partners including EBU, ESA, RAI, SRG, BFBS and Arctic Space [15].

References

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[10] ESA, "5G-EMERGE", project page. https://resilience.esa.int/archives/projects/5gemerge

[11] EBU, "EBU showcases 5G-EMERGE media streaming solution at MWC25", March 2025. https://tech.ebu.ch/news/2025/03/ebu-showcases-5g-emerge-media-streaming-solution-at-mwc25

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Annex 4

Digital Sound Broadcasting Systems (D/DSBS)

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This Annex reports the current standards for digital sound broadcasting systems, the latest developments in standardization, and trends. The reporting period saw one change of direct editorial consequence for this Annex: the frequency scope of Recommendation ITU-R BS.1114 was narrowed from 30-3000 MHz to 30-300 MHz. Section 4.1 has been updated accordingly. Regional activity during the period was concentrated in Asia and the Pacific, with significant progress in China, Indonesia, India and Thailand, which is reported in Section 4.3.

4.1 Digital Sound Broadcasting Systems within Frequency Range 30-300 MHz

The Recommendation ITU-R BS.1114-13 describes several systems for terrestrial digital sound broadcasting (DSB) to vehicular, portable, and fixed receivers within the frequency range 30-300 MHz. It details the main features of these systems, including source coding, channel coding, modulation, transmission structure, and the quality of service thresholds. The Recommendation remains the primary reference for administrations selecting a DSB system.

4.1.1 Revision of Recommendation ITU-R BS.1114

Recommendation ITU-R BS.1114-13 was approved on 25 November 2025 and posted by the ITU on 11 December 2025. It supersedes BS.1114-12 (01/2022), which was the version referenced in the 2025 report of this Topic Area.

The most significant change is to the title and scope of the Recommendation. The frequency range has been narrowed from "30–3000 MHz" to "30–300 MHz", and the title has been reworded from "Systems for terrestrial digital sound broadcasting…" to "Systems for digital terrestrial sound broadcasting to vehicular, portable and fixed receivers in the frequency range 30-300 MHz". The revised scope reflects operational reality: none of the systems described in the Recommendation is deployed or field-tested above 300 MHz, all of them operating in VHF Bands I, II and III. Digital sound broadcasting in the 1400–2700 MHz range remains addressed by Recommendations ITU-R BO.789 and ITU-R BO.1130 and is outside the scope of BS.1114.

No system was added or removed. The frequency bands cited in the "considering" section of BS.1114-13 are summarized in Table 4-1.

Table 4-1: Systems described in Recommendation ITU-R BS.1114-13

System	Designation and reference standard	Frequency bands in which the system has been field-tested / demonstrated
System A	DAB (Eureka 147), ETSI EN 300 401	174–300 MHz
System F	ISDB-TSB (Japan)	188–192 MHz
System C	IBOC / HD Radio, NRSC-5 (USA)	88–108 MHz
System G	DRM, ETSI ES 201 980 (Mode E)	VHF Band I 47–68 MHz; Band II 87.5–108 MHz; Band III 174–230 MHz
System H	CDR, GY/T 268.1-2013 (China)	88–108 MHz
System I	RAVIS, GOST R 54309-2011 (Russian Federation)	66–74 MHz and 87.5–108 MHz

4.1.2 Technical Highlights

Audio Quality & Codecs

- Bitrates: 8–800 kbit/s
- Codecs: MPEG-2 Layer II, MPEG-4 HE-AAC v2, DRA+, HD Codec
- Multichannel Support: Most systems support 5.1 surround sound

Spectrum Efficiency

- All systems outperform FM in spectral use
- Modulation schemes: OFDM, COFDM, QAM
- Support for single frequency networks (SFNs)

Robustness

- Designed for multipath and shadowing environments
- Use of time/frequency interleaving, on-channel repeaters

Receiver Flexibility

- Dynamic multiplex reconfiguration
- OSI model compliance
- PAD (Programme Associated Data), EPG, traffic info
- Emphasis on low-cost, multiband, multi-standard receivers

4.1.3 System-Specific Insights

4.1.3.1 Digital System A (DAB) – Eureka 147

- Purpose & Features: Designed for satellite and terrestrial broadcasting

with a focus on low-cost, multi-service digital radio. It supports vehicular, portable, and fixed reception, with strong performance in urban multipath environments using on-channel repeaters. Offers high-quality audio, data services, and conditional access. Efficient in spectrum and power usage via OFDM and error correction.

- Standardization: ETSI EN 300 401.
- Audio Coding: Initially MPEG Layer II, now DAB+ with MPEG-4 HE-AACv2 (8–384 kbit/s).
- Modulation & Channel Coding: DQPSK OFDM with convolutional coding; UEP for MPEG-2, uniform for MPEG-4.
- Interleaving: Time (16 frames) and frequency interleaving.
- Program Associated Data: 0.33–64 kbit/s for dynamic labels, HTML, JPEG.

4.1.3.2 Digital System F (ISDB-TSB)

- Purpose & Features: Japanese system for robust, flexible multimedia broadcasting over terrestrial networks. Uses BST-OFDM, 2D interleaving, and concatenated error correction. Shares physical layer with ISDB-T and transport layer with MPEG-2 systems. Supports TMCC for receiver control and low-power portable devices.
- Standardization: ARIB STD-B29 (Japan).
- Audio Coding: MPEG-2 Layer II, AC-3, MPEG-2 AAC (CD quality at 144 kbit/s).
- Modulation & Channel Coding: OFDM with DQPSK, QPSK, 16-QAM, 64-QAM; RS (204,188) + punctured convolutional codes.
- Interleaving: Byte, bit, symbol-wise time, and frequency interleaving.

4.1.3.3 Digital System C (IBOC)

- Purpose & Features: Enables analogue-digital simulcasting in FM band for smooth transition. Offers improved multipath performance and CD-quality audio. Supports data-casting and flexible bit allocation. Operates in Hybrid (analogue + digital) or All Digital modes. Uses Diversity Delay for seamless analogue-digital switching and supports SFN with GPS sync.
- Standardization: NRSC-5 (USA).
- Audio Coding: HD Codec (HDC), supports multichannel.
- Modulation & Channel Coding: OFDM with convolutional codes (2/9 to

4/5).

- Interleaving: Time and frequency interleaving tailored to channel use.
- Program Associated Data: Opportunistic, no audio quality loss.

4.1.3.4 Digital System G (DRM)

- Purpose & Features: Digital-only system for all analogue sound broadcasting bands. Supports smooth analogue-digital transition and defines DRM+ for VHF. Offers CD-quality audio, data services, and dynamic multiplexing. Uses FAC, SDC, and MSC for service management and seamless frequency switching.
- Standardization: ETSI ES 201 980.
- Audio Coding: MPEG-4 AAC with SBR, PS, MPS.
- Modulation & Channel Coding: Punctured convolutional codes with 4-QAM/16-QAM; supports EEP and UEP.
- Interleaving: Cell interleaving for time-frequency robustness.
- Program Associated Data: Text messages, packet delivery with FEC.

4.1.3.5 Digital System H (CDR)

- Purpose & Features: Chinese system for FM band digital transition. Supports simulcast and post-analogue switch-off modes. Offers CD/5.1 audio, data services, and SFN. Flexible spectrum modes (100/200 kHz) and supports spectrum sharing with FM.
- Standardization: GY/T 268.1-2013 (China).
- Audio Coding: DRA+, HE-AAC, AVS audio.
- Modulation & Channel Coding: OFDM with LDPC for MSD; convolutional for SDI/SI. Supports QPSK, 16QAM, 64QAM.
- Interleaving: 2D frequency-time, block bit, and sub-carrier interleaving.
- Program Associated Data: Dynamic labels, EPG, advanced text services.

4.1.3.6 Digital System I (RAVIS)

- Purpose & Features: Russian system for high-quality sound and multimedia in VHF bands. Digital-only, supports video, images, EPG, and localized SFN broadcasting. Designed for mobile reception up to 200 km/h and offers short delay and high-quality AV services.
- Standardization: GOST R 54309-2011 (Russia).

- Audio/Video Coding: HE-AAC (SBR, PS, MPS); H.264/AVC, H.265/HEVC.
- Modulation & Channel Coding: OFDM; MSC uses QPSK/16QAM/64QAM; Low Bitrate Channel uses QPSK; Reliable Data Channel uses BPSK. BCH + LDPC coding.
- Interleaving: Bit, cell, block, and frequency interleaving.
- Program Associated Data: Video, audio, images, traffic, EPG.

4.1.4 Deployment Considerations

System Selection: Based on regional needs, spectrum availability, and receiver market

Transition Strategy: Hybrid modes (System C, H) support gradual migration

Interoperability: Systems like F and G align with TV broadcasting standards

Receiver Design: Multi-standard, upgradable, low-cost devices encouraged

4.2 Digital Sound Broadcasting Systems below 30 MHz

Recommendation ITU-R BS.1514-3 (05/2025) defines the technical basis for terrestrial digital sound broadcasting (DSB) systems operating below 30 MHz and remains in force unchanged throughout the reporting period.

Two systems are recognized:

- **DRM**: Designed for global use in long-wave (LF), medium-wave (MF), and short-wave (HF) bands.
- **IBOC DSB**: Primarily developed for use in North America, especially in the MF band.

4.2.1 Digital Radio Mondiale (DRM) System

Digital Radio Mondiale (DRM) is a fully digital broadcasting system designed for operation below 30 MHz, including LF, MF, and HF. It uses steep spectral shoulders to confine its signal within a 9 or 10 kHz channel, enabling efficient spectrum use and minimizing adjacent channel interference. The system supports multiple modes, making it adaptable for different frequency bands and propagation conditions. DRM employs advanced audio coding (xHE-AAC and AAC+SBR) to deliver high-quality sound even under challenging conditions. It uses OFDM and QAM modulation combined with forward error correction and time interleaving to ensure robust transmission. The system is modular and scalable, allowing for wider bandwidths and flexible allocation between audio and data services. DRM also includes Emergency

Warning Functionality (EWF), which supports alarm signaling, automatic frequency switching, and text-based alerts via Journaline.

4.2.2 IBOC DSB System

IBOC DSB is designed to operate in the MF band and supports both hybrid and all-digital modes. In hybrid mode, it allows simultaneous transmission of analogue and digital signals within the same channel, facilitating a smooth transition from analogue to digital broadcasting. The system uses AAC with SBR for audio coding, offering FM-like stereo quality. Its layered codec structure enables graceful degradation and extended coverage through a blend function that switches seamlessly to analogue or backup digital signals when needed. IBOC DSB employs OFDM and QAM modulation with advanced error protection and interleaving. It supports data broadcasting at rates between 4 and 16 kbit/s, with flexible trade-offs between audio and data quality. The system is compatible with existing AM transmitters and does not require new spectrum allocations, making it highly efficient and practical for gradual deployment.

4.3 Regional Developments and Deployment Trends

Digital sound broadcasting activity during the reporting period was concentrated in the Asia-Pacific region. Four member countries showed developments of direct interest to the ABU membership.

4.3.1 China

As reported in 2025, the National Radio and Television Administration (NRTA) of China issued industry standard GY/T 423-2025, "Technical Specifications for Medium and Short-Wave Digital Sound Broadcasting", on 29 July 2025, announced publicly on 1 August 2025 [1]. The standard adopts DRM as the technical basis for digital sound broadcasting in the MF and HF bands. The present reporting period has been characterized by the move from standardization to implementation.

Industry ecosystem at CCBN 2026: The China Content Broadcasting Network (CCBN) exhibition, organized by the Academy of Broadcasting Science (ABS) and NRTA and held at the China National Convention Centre in Beijing in April 2026, gave DRM a prominent position as China works towards the national mandate and roll-out of the DRM and the domestically developed China Digital Radio (CDR) for domestic coverage [2].

Domestic and international suppliers presented professional solutions covering the complete broadcast chain for both the DRM standard and the GY/T 423-2025 specification: head-end content servers, multichannel modulators, monitoring and

measurement receivers, digital retrofit solutions for upgrading existing analogue transmitters, and software-defined-radio implementations for consumer, mobile-handset and automotive use. A combined DRM and CDR receiver module was reported to be in mass production for Chinese broadcasters, with car-radio variants under evaluation by the automotive market. The Administrative Bureau of Radio Stations demonstrated the data-carrying capability of DRM in the shortwave band by conveying BeiDou satellite differential correction data (DGNSS), showing shortwave to be a viable primary or backup link for high-precision positioning data. On 24 April 2026, the Radio Station Administration Bureau of NRTA, together with the Communication University of China and other partners, launched a Shortwave Broadcasting Innovation Initiative.

In-vehicle reception: A joint project by the Ministry of Industry and Information Technology (MIIT) and NRTA to establish a mandatory national standard for an on-board radio broadcast receiving system was announced in September 2024 with a stated duration of 22 months, covering functional and performance requirements for terminals and antennas and the associated testing and evaluation framework. No standard had been published at the time of writing, and the project appears to remain in development; the DRM Consortium reported in May 2026 that standardization of in-vehicle emergency broadcasting reception was being worked on in China. The intent, as described when the project was announced, is to require vehicles sold in China to be capable of receiving DRM in the MF and HF bands — the bands covered by GY/T 423-2025 — and CDR in the FM band, and to accelerate the roll-out of the broadcast infrastructure needed for both. Emergency broadcasting is cited as the principal justification, the responsible department of NRTA having pointed to the in-vehicle receiver requirements of the European Union, Japan, Saudi Arabia and the United Arab Emirates, and to the AM Radio for Every Vehicle Act in the United States, as comparable measures. ABU members considering receiver mandates may wish to monitor the outcome, as it would represent the largest single automotive digital-radio requirement in the region.

4.3.2 Indonesia

Indonesia issued its national digital radio policy in August 2023, selecting DRM alongside DAB+ in a complementary approach. Ministerial Decrees No. 4 and No. 416 of 2024 allocated DRM to the HF band (2.3–26 MHz), the MW band (526.5–1606.5 kHz), VHF Band II (87–108 MHz) and VHF Band III (174–202 MHz), and DAB+ to VHF Band III (202–230 MHz); a national spectrum masterplan defines 326 digital radio service areas. By May 2026 Radio Republik Indonesia (RRI) had DRM services on air in the FM band from nine sites nationwide, all equipped with content servers

supporting Emergency Warning Functionality, and the Ministry (Komdigi) was preparing the corresponding receiver regulation [3][4].

The DRM Consortium General Assembly 2026 was held in Jakarta on 5–6 May 2026, hosted by RRI. This was the first time the Consortium held its annual General Assembly in the Asia-Pacific region and the first time it partnered with a major regional broadcaster to do so, which the ABU noted as an indicator of the region's growing weight in digital radio [4]. More than 100 participants attended in person and online, the open session drawing representatives of RRI and of private broadcasters, of the Ministry and regulator, and of the receiver-manufacturing and automotive industries. The multi-standard receiver platform capable of supporting both DRM and DAB+ on a single device was demonstrated as near market-ready to serve dual-standard markets like Indonesia. Developments in Indonesia, the current status of DRM in India and progress in China following its adoption of DRM as a national standard for the MF and HF bands attracted particular interest; the Consortium attributes the recent acceleration of dual-standard receiver development to the adoption of DRM in Indonesia, South Africa and China. The meeting also saw the launch of version 6 of the DRM Handbook, available as a free download.

Interest in the Indonesian model is extending across the South Pacific: a delegation from Papua New Guinea visited RRI Yogyakarta on 18–19 May 2026 for a technical exchange on Indonesia's implementation of digital radio [5]. This is a development the Topic Area recommends following, as it may indicate a wider Pacific interest in a DRM-based approach to large-area coverage.

4.3.3 India

All India Radio (AIR) / Prasar Bharati has already adopted and rolled out DRM nationwide for its large-area services in the MF and HF bands. In its October 2025 recommendations the Telecom Regulatory Authority of India (TRAI) records that Prasar Bharati operates 35 medium-wave and 3 short-wave DRM transmitters in the AM band, and estimates that around 6 million cars are equipped with an AM-band DRM receiver, noting that these receivers can be upgraded to receive digital radio in the FM band [6]. The same figures appear in a reply by the Ministry of Information and Broadcasting to the Lok Sabha, which adds that a further three digital-ready medium-wave transmitters have been upgraded to DRM and that the transmitters can operate in digital or analogue mode and simulcast in both [7].

The open question for India is the FM band. On 3 October 2025 TRAI issued its Recommendations on Formulating a Digital Radio Broadcast Policy for private broadcasters, recommending the adoption of a single national digital radio technology standard in VHF Band II (88–108 MHz). It observed that the technology-neutral

approach adopted in its 2018 recommendations had produced no implementation in more than seven years, and that continuing to leave the choice to market forces would prolong uncertainty for broadcasters, receiver manufacturers, and listeners. TRAI compared DRM and HD Radio in its own Table 3.2, which characterises the HD Radio standard as proprietary and DRM as open, but concluded that the comparison "does not establish a basis for selecting one technology over the other by the Authority". The choice therefore remains open, and TRAI recommended instead that:

- the Government should select a suitable digital radio technology for deployment in India, either by consulting the main stakeholders — radio broadcasters and receiver manufacturers — or by incorporating the selection into the spectrum auction, in which bidders would declare their preferred technology in a first stage and the majority preference would be adopted country-wide and counter-offered to the remaining bidders;
- frequency planning for each technology should be carried out by the Ministry of Information and Broadcasting before the auction and made public; and
- the selection of technology should be concluded before financial bidding in the spectrum auction begins.

Against this background, the DRM Consortium and its supporters advanced the case for DRM during the reporting period under the banner "One Nation, One Standard". At BES Expo 2026 a dedicated event on 30 January presented the case to the Minister and Vice-Minister of Information and Broadcasting, the CEO of Prasar Bharati and senior broadcasters, emphasising DRM as an open standard with full technology access [8].

4.3.4 Thailand’s Frequency Planning for DAB+

The 2025 report described Thailand’s DAB+ frequency planning, under which the country was reorganized from 77 provinces into 10 regions and 34 allocation areas in the 174–230 MHz band, using DAB+ with MPEG-4 HE-AAC v2. Developments during the reporting period concern receiver regulation, trial licensing and the approach to network licensing.

- The National Broadcasting and Telecommunications Commission (NBTC) published its technical standard for digital broadcasting radio receivers, NBTC BS 3004-2567, on 31 October 2024. Compliance became mandatory on 28 February 2025 for digital broadcasting radio receivers generally, and on 31 October 2025 for receivers installed in new vehicles [9].

- Having announced the criteria for temporary testing and experimentation permits, the NBTC at its meeting of 26 March 2025 approved two operator groups to conduct DAB+ testing for six months [10].
- DAB+ transmissions continue in four regional areas — Chon Buri, Chiang Mai, Khon Kaen and Songkhla — reaching approximately 7 million people, or over 10 percent of the population, with 17 DAB+ services carried on the trial multiplex.
- The NBTC has approved the DAB+ frequency plan as 34 service areas (9 local and 25 regional), each multiplex being able to carry approximately 18 radio services, and has held a forum on the criteria and procedures for licensing the DAB+ network. As of mid-2026 the Office of the NBTC intended to issue a call for multiplex operators and to hold bidding for digital radio network licences during 2026 [11]. The award of network licences would mark Thailand's transition from trial to regular DAB+ service.

4.3.5 Africa: New DAB+ Deployments

Although outside the ABU area, three developments in Africa during the reporting period are noted here.

- Kenya entered digital sound broadcasting with the launch of its first DAB+ pilot on 13 February 2026, World Radio Day. Mast Rental Services became the first operator to launch a DAB+ trial network, carrying 14 radio programmes within the Nairobi coverage area under the Communications Authority of Kenya [12].
- Senegal advanced from pilot to operation: on 10 September 2026 the Autorité de Régulation des Télécommunications et des Postes (ARTP) formally transferred responsibility for the DAB+ infrastructure to TDS SA — Télédiffusion du Sénégal, the national broadcast transmission operator, which carries the multiplexing, transport and transmission of the country's digital terrestrial television and radio services — following completion of the pilot programme. TDS SA operates two DAB+ multiplexes, making Senegal the first francophone country in sub-Saharan Africa to make digital radio available to operators [13].
- In June 2026, the Independent Communications Authority of South Africa (ICASA) invited nominations for ten members of a Digital Sound Broadcasting Technical Advisory Group (DTAG), provided for under the Digital Sound Broadcasting Services Regulations, 2021. Its brief covers

frequency planning for DSB multiplexes, a licensing framework, type approval, and a national standard [14].

4.3.6 Receiver Developments Reported at IBC 2026

The receiver side of the ecosystem, which underlies the regional deployments described above and the mandate discussion in 4.4, advanced visibly towards the end of the reporting period. At IBC2026 in Amsterdam, held from 12 to 15 September 2026, the DRM Consortium reported progress in four areas: new receivers and receiver solutions, many of them supporting multiple standards; the geographic spread of DRM, assisted by its Emergency Warning Functionality and by e-learning applications; technical support for implementation of the standard and for receiver manufacturing; and a new cooperation with UNESCO on a distance-learning project [15]. A portable multi-standard receiver covering medium wave through VHF Band II, and receiving AM, FM and DRM, was reported to be in production and shipping. Multi-standard reception of DRM and DAB+ in VHF Band III was also reported as advancing; this is the configuration relevant to Indonesia (4.3.2) and to any member that adopts both standards.

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4.4 Receiver Mandates in Vehicles

A distinct policy theme emerged during the reporting period in two major markets: whether the presence of a broadcast radio receiver in a new vehicle should be a legal requirement. This is of direct interest to this Topic Area because a receiver mandate determines, more decisively than transmission-side standardization, whether a digital sound broadcasting service can reach its audience. Both initiatives are argued primarily on grounds of emergency resilience.

4.4.1 European Union: the Digital Networks Act

Under Article 113 and Annex XI of the European Electronic Communications Code, a car radio receiver fitted to a new vehicle of category M placed on the Union market since December 2020 must be capable of receiving digital terrestrial radio — in Europe, in practice DAB+. The Digital Networks Act (DNA), now in the European legislative process, will inherit these provisions. On 8 September 2026 WorldDAB and Broadcast Networks Europe called for them to be strengthened [1]: the present rules govern the capability of a receiver that is fitted, but do not guarantee that one is fitted at all, and some models are now reaching the market without broadcast radio. The two organizations therefore seek a requirement for broadcast reception in every new vehicle placed on the EU market. The earliest final EU agreement is expected at the end of 2027.

4.4.2 United States: the AM Radio for Every Vehicle Act

The AM Radio for Every Vehicle Act (H.R. 979 / S. 315, 119th Congress) passed the United States House of Representatives by voice vote on 15 September 2026 [2]. It would require the Department of Transportation to make a rule obliging new passenger vehicles to carry, as standard equipment, a device able to receive "AM stations or digital audio AM stations"; the version passed includes an eight-year sunset provision. The bill must still pass the Senate and be signed by the President, who has indicated support, and is opposed by vehicle manufacturers and by the Consumer Technology Association. Because the wording covers digital audio AM stations, the requirement extends to digital sound broadcasting systems within the scope of Recommendation ITU-R BS.1514-3 and is not confined to analogue reception.

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