MIC Japan

Development of next-generation DTTB system in Japan

SET eXPerience 2021

Outline

1. Requirements for next-generation DTTB system
2. Studies on next-generation DTTB system
3. Comparison and Evaluation of Video and Audio Coding methods

   (1) Video Coding Evaluation

   (2) Audio Coding Evaluation
4. Deliberation Schedule

1. Requirements for next-generation DTTB system

Basic concepts

1. To prepare common features based on technical conditions related to ISDB-T and ISDB-S3 for next-generation DTTB system where technically appropriate.
2. To ensure feasibility and expandability, with consideration for future technology trends.
3. To ensure UHD television broadcasting services and multifunctional, diverse and flexible services.
4. To ensure compatibility with other digital broadcast media and support IBB services.

*It is necessary to carefully consider how next-generation DTTB system is introduced.

Main requirements

Remarks:
DTTB: Digital Terrestrial Television Broadcasting

System	・Enable a range of image quality services based on high image and sound quality, and immersive services. ・Take into account broadcasting services for different audiences, such as the elderly and the disabled. ・Take into account the transmission of activation control signals to target receivers in the event of an emergency, such as EWBS and the broadcasting of emergency information. ・Ensure that receiving equipment (antennas and cables) is to the largest extent possible compatible with existing equipment.
Quality (Example: Video)	・Able to change video formats and bit rates according to broadcast service. ・Consider demand for UHDTV (HDR video) services, while maintaining highest possible image quality.
Technical method	・Use video input formats and high-efficiency and high-quality encoding methods applicable to UHDTV. ・Use methods that are consistent with international standards. ・Use coding methods that can flexibly cope with various requirements, including multi-channel audio broadcasting. ・Use methods suitable for transmission of high bit rate services such as UHDTV. ・Consider the operability of relay networks, such as easy switching between national and local broadcasts. ・Use modulation techniques that maximize transmission capacity for effective use of frequency and transmission of various services including UHDTV.

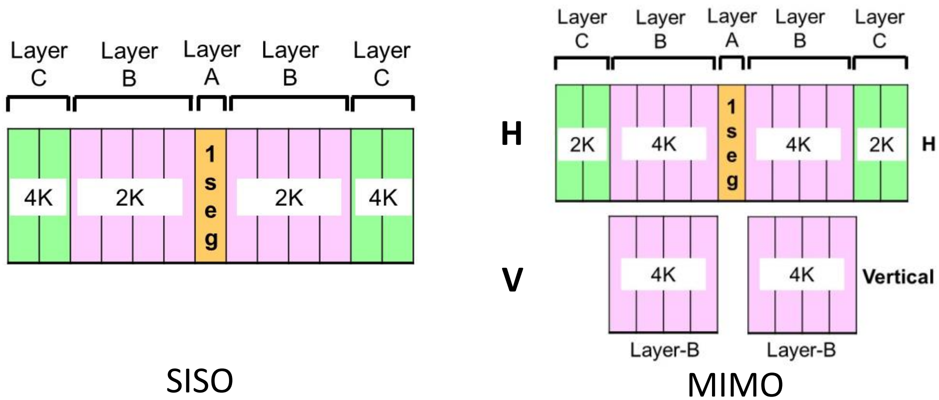
2. 1 Studies on next-generation DTTB system

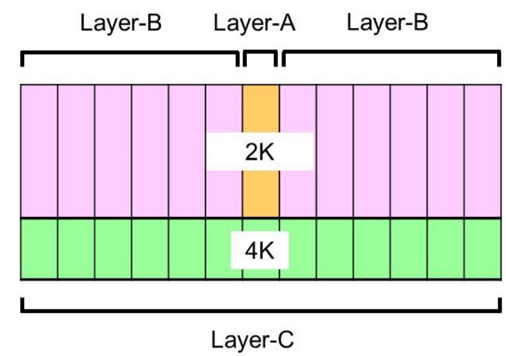
- Studies have been undertaken into 2 methods for introducing a system in the same channel used as existing 2K services, and 1 method for introducing a system in a different channel that is not used for existing 2K services.

CASE 1: Next-generation DTTB systems in same channel (possibly during transition period)

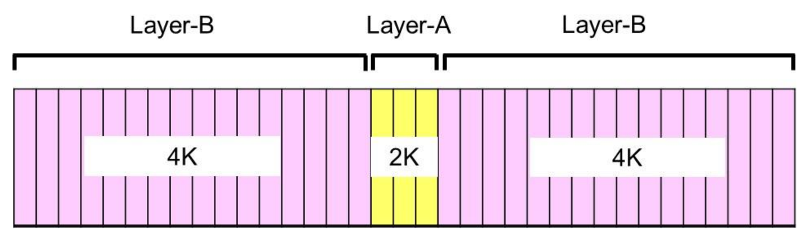
<u>3-layered 13-segment division</u>
Each ISDB-T segment (total 13 seg) is allocated to 2K or 4K services (SISO and MIMO)

<u>LDM</u>
Multiplexing 4K signals (low power) for existing 2K signals (high power)





CASE 2: Next-generation DTTB system in a different channel

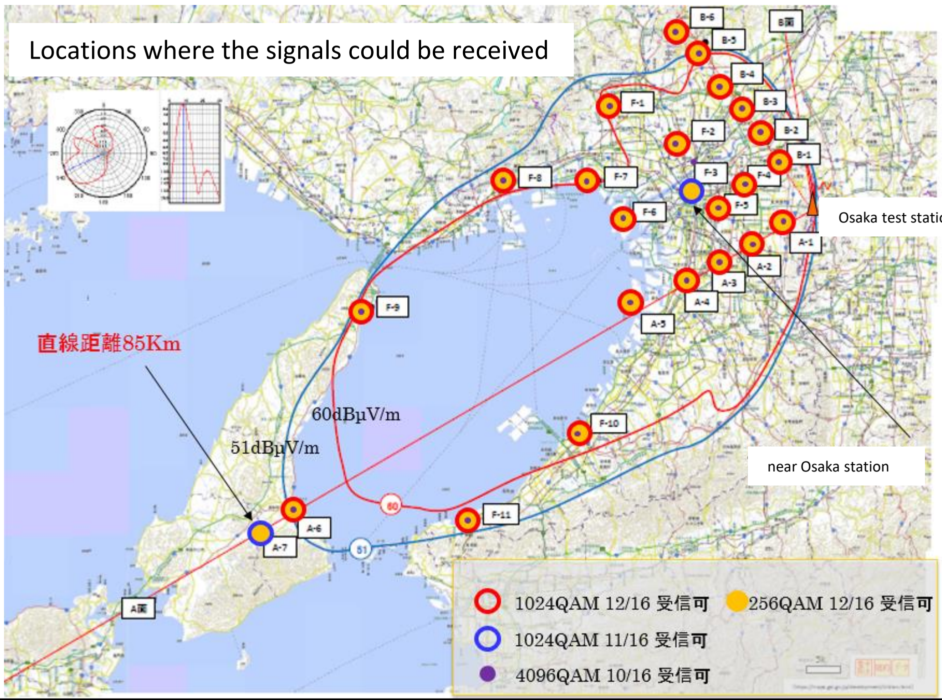


<u>35-Segment division</u>
Frequency band is divided into 35-segments.

The "Advanced ISDB-T" is a system using 35-segment division technology, and is one of the options to be selected as the next-generation DTTB standard of Japan.

2. 2　3-layered 13-segment division (same channel)

- Measurements of 2K signals and 4K signals in the coverage of the Osaka test station.
- Study on appropriate modulation schemes and coding when in service.
- Study on appropriate relay techniques and introduction steps for 3-layered 13-segment division



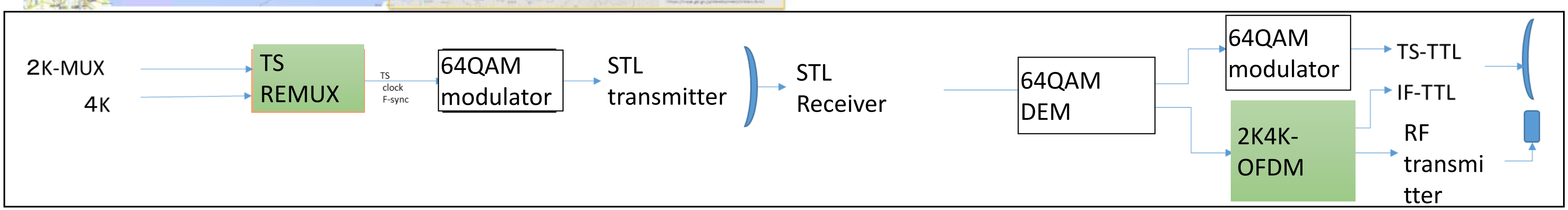
Average required receiving power and MER (4K SISO)

Modulation	Ave. required receiving power [dBm]	MER[dB]
1024QAM NUC 12/16	-75.8 [-75.1]	23.7 [23.2]
256QAM NUC 12/16	-80.5 [-79.9]	19.0 [18.4]

[ ] : lab test value

Required C/N and transmission capacity for each modulation(SISO)

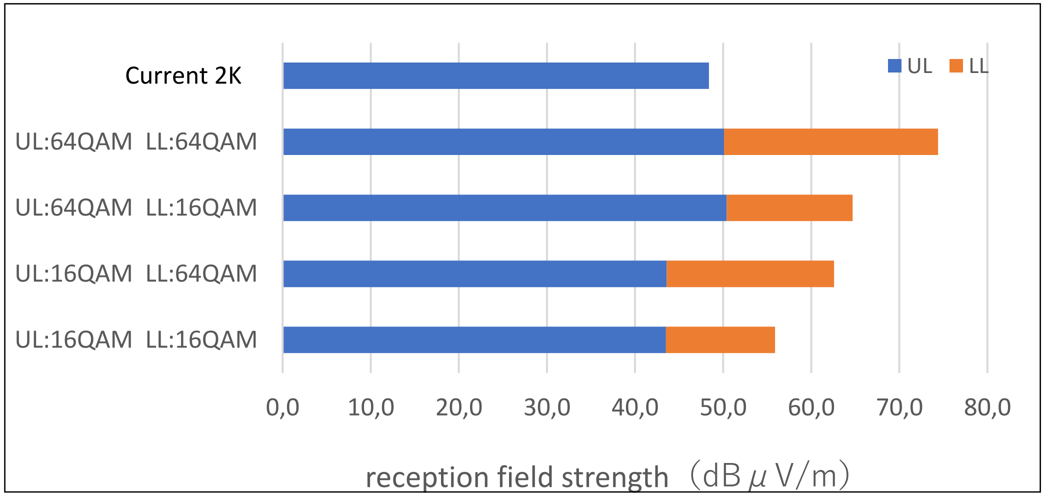
Modulation for 4K	Coding ratio	Required C/N[dB]	capacity [Mbps]
256QAM NUC	13/16	22.6	8.77
256QAM NUC	14/16	24.2	9.44
1024QAM NUC	11/16	23.9	9.27
1024QAM NUC	12/16	25.9	10.12



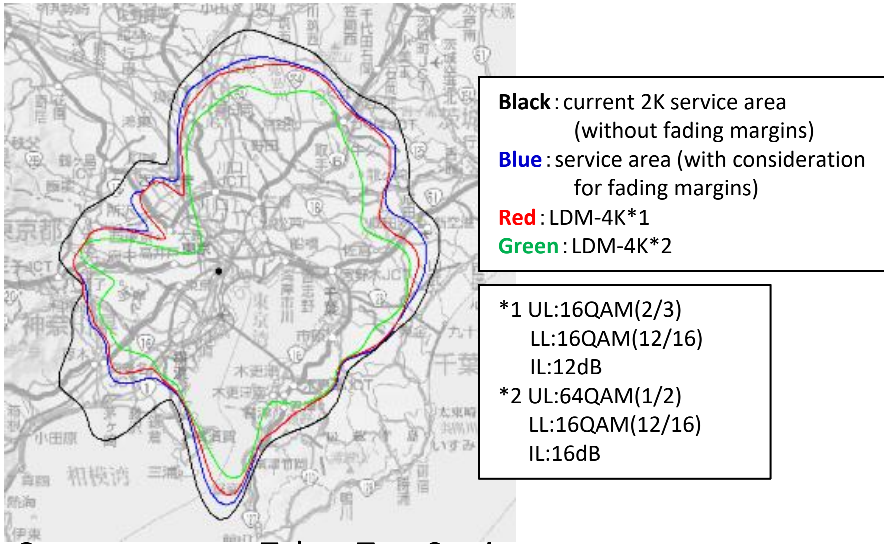
Example that uses current STL/TTL transmitter（SISO）

2. 3 LDM (same channel)

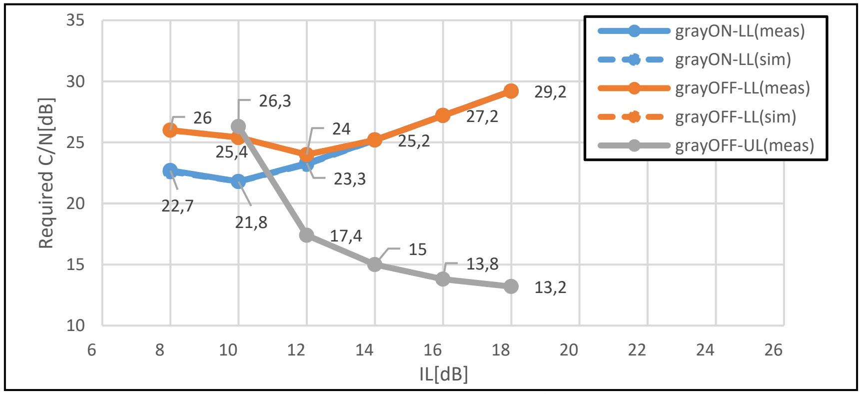
- Confirmation of LL reception characteristics enhancement by gray coding and successive interference cancellation (SIC).
- Study on parameters for practical operation while observing radio propagation characteristics.
- Study on appropriate relay techniques and SFN feasibility.



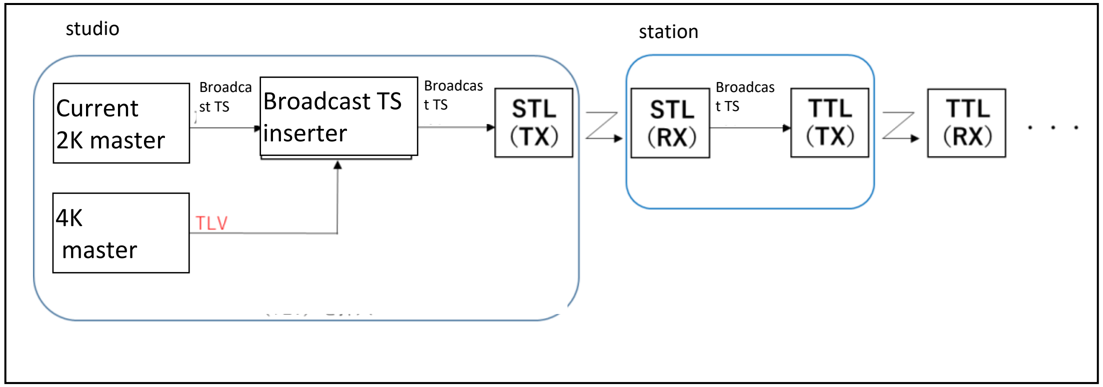
Required reception field strength of current 2K and LDM



Contour map at Tokyo Test Station



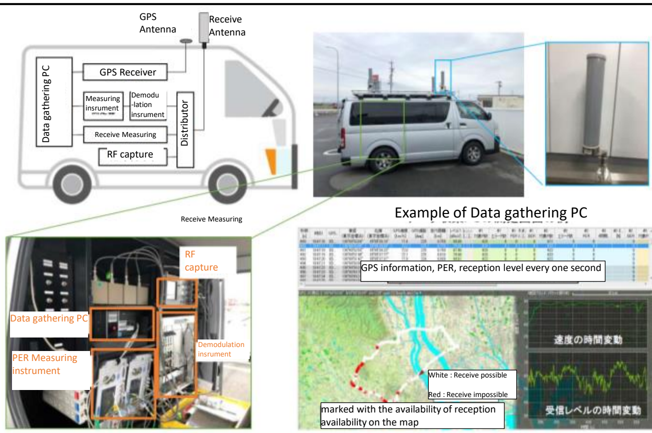
Improvement of required C/N by gray coding



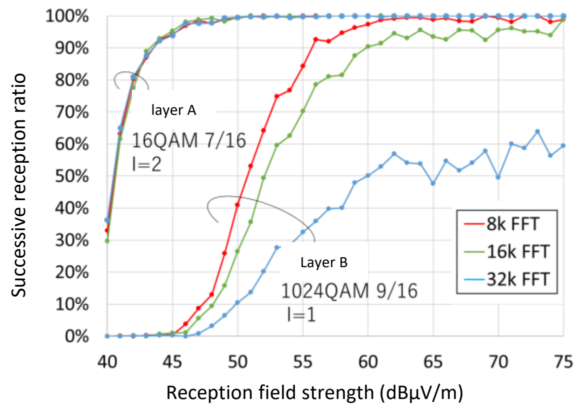
Example diagram of STL/TTL relay network for LDM

2. 4 35-segment division (Advanced ISDB-T)

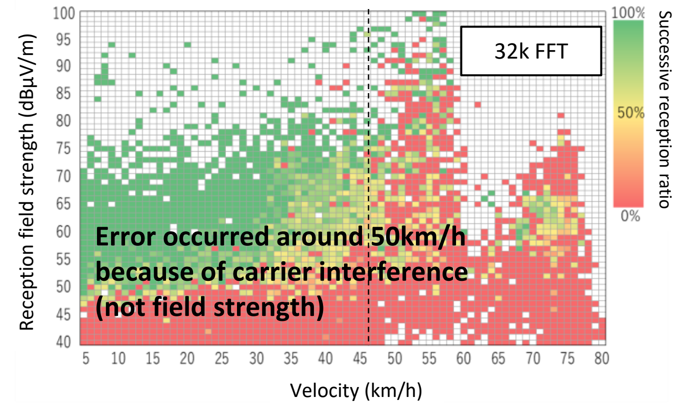
- Measurements of fixed/mobile reception characteristics in test field.
- Comparison between the results of simulation/laboratory tests and field tests.
- SFN field evaluation.



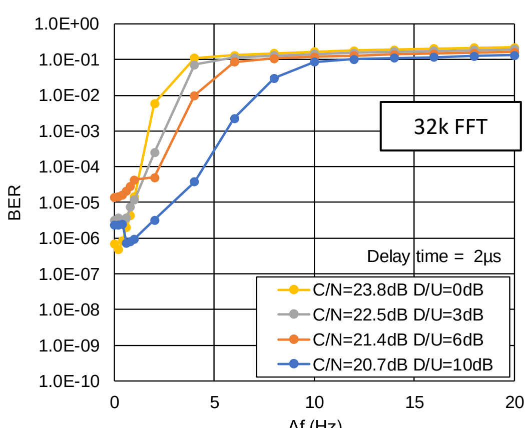
Mobile reception test



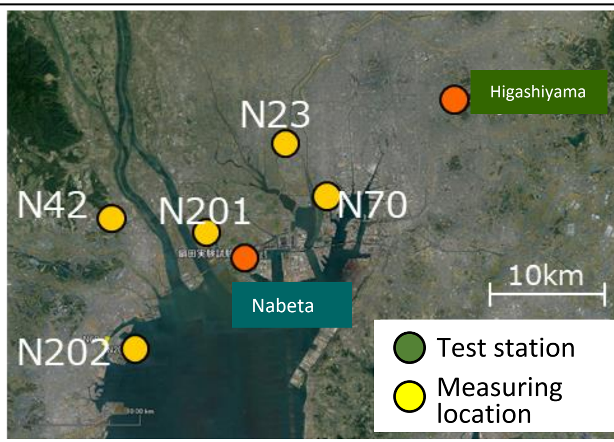
Successive reception ratio by FFT size



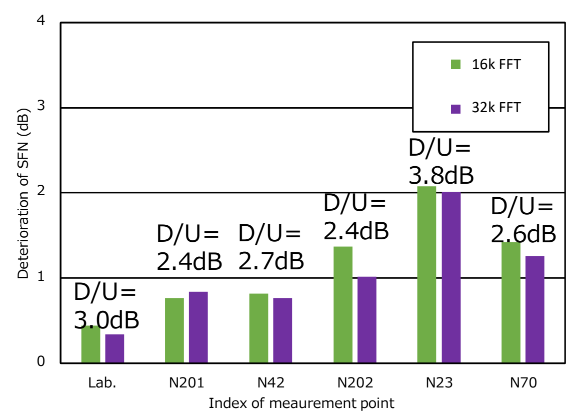
Successive reception ratio by velocity (layer B)



BER characteristics by frequency drift simulation result



Test stations and measuring locations



Deterioration of SFN（mode4,5）

3. (1)-1 Requirements for Video Coding

- Next-generation DTTB system requirements, in terms of video technical methods, mandate those which are suitable for the transmission of high bit rate services such as UHDTV.
- Video coding with high compression capability is required to realize terrestrial services such as UHDTV (4K).
- VVC, AV1 and EVC with standardized high compression capability were compared.

①[VVC](MPEG/ITU-T standardized in 2020)

・Succeeding method for HEVC

・The stability of standards for JVET (Joint Video Experts Team), which has standardized VVC, has been proved high, after a series of meetings and discussions MIC and various Japanese operators.

②[AV1](AOMedia standardized in 2018)

・Video coding which is royalty-free and was developed by internet companies

・Major companies have participated in AOMedia, a standard entity of AV1, and AOMedia which reflect the latest technologies.

③[EVC](MPEG standardized in 2020)

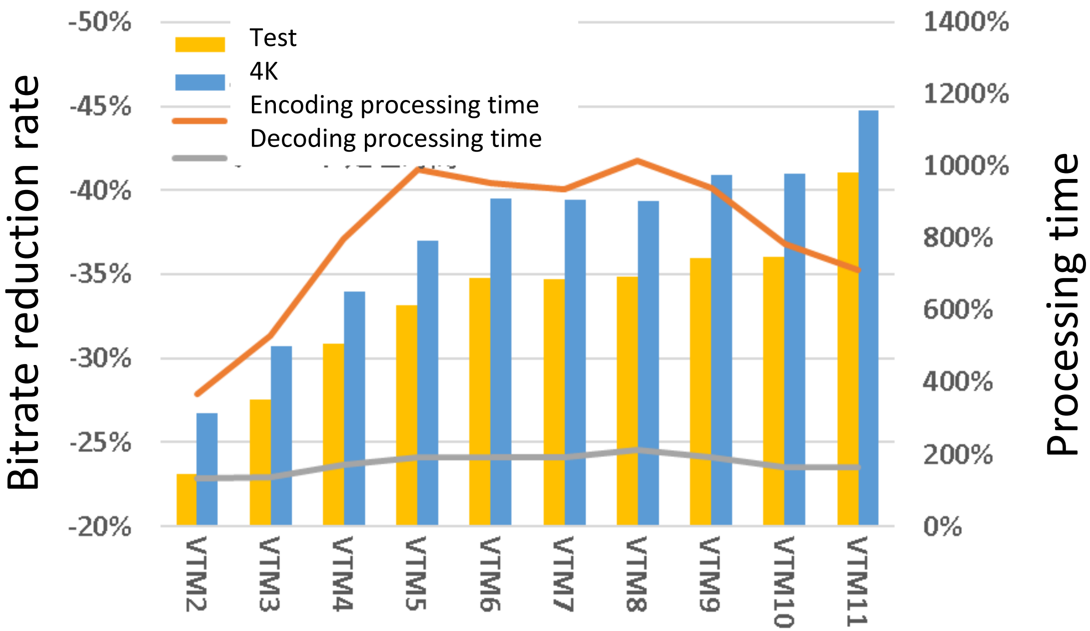
・ License-friendly objective.

・The base tool set is composed of technologies whose patents have expired or technologies that are freely available.

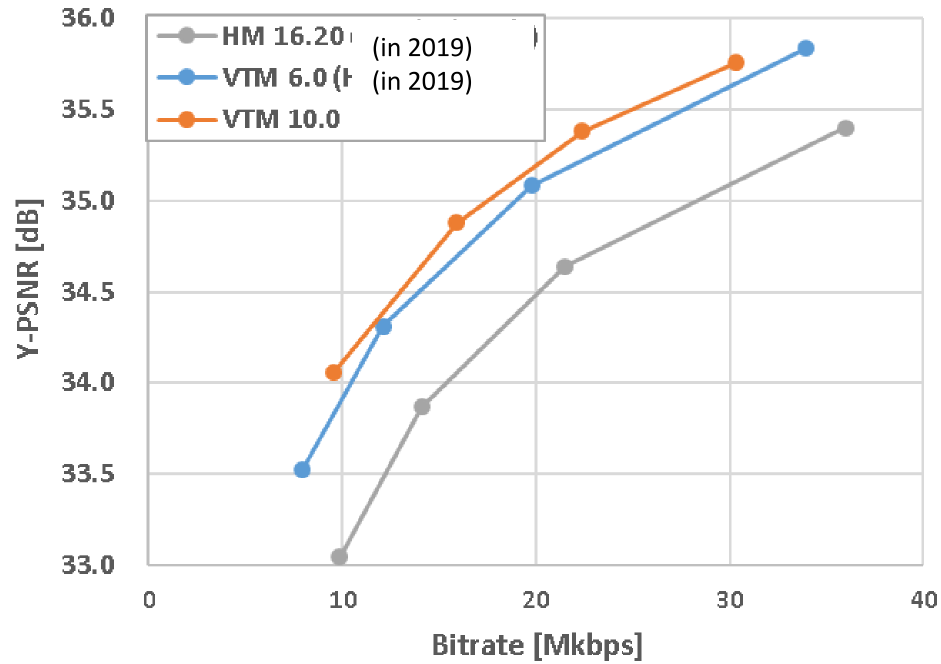
・Limited number of companies have participated in EVC standards.

3. (1)-2 VVC

- VVC is a succeeding method for HEVC and was standardized in July 2020 (MPEG-I Part3 / H.266).
- The latest VVC test model (VTM11) achieved a bit rate reduction of more than 40% at the HEVC ratio.
- Compression capability was improved and encoding time shortened by modifying VTM.
- There are de jure standards for ITU-T, so the stability of the standards is high.



Improvement of bit rate reduction and processing time comparison
（by enhancing VTC compared with HEVC）



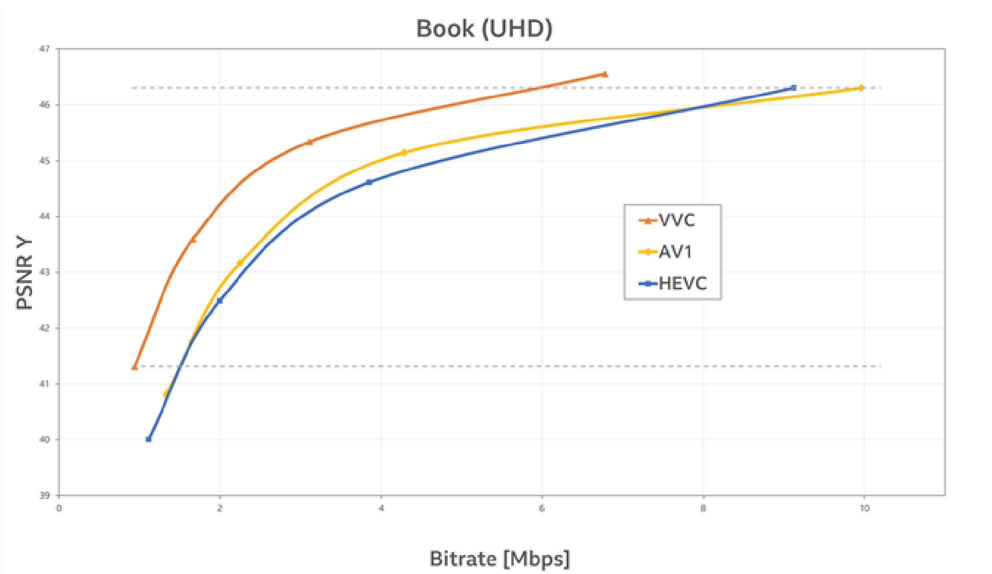
Compression capability improvement comparison by
Enhancing VTM and tool simplification

3. (1)-3 「AV1」

- AV1 is a method of video coding which is royalty-free, and was standardized by AOMedia in 2018.
- In video coding, there is a one-pass method with priority for processing time and a two-pass method with priority for compression capabilities. Real-time performance is required for broadcast applications, so a one-pass method was used in the comparison verification.
  (The two-pass method was also used in part of the comparison for compression capability.)
- As a result of comparing AV1 and VVC, it was confirmed that VVC had higher compression capabilities and higher subjectivity quality evaluation.

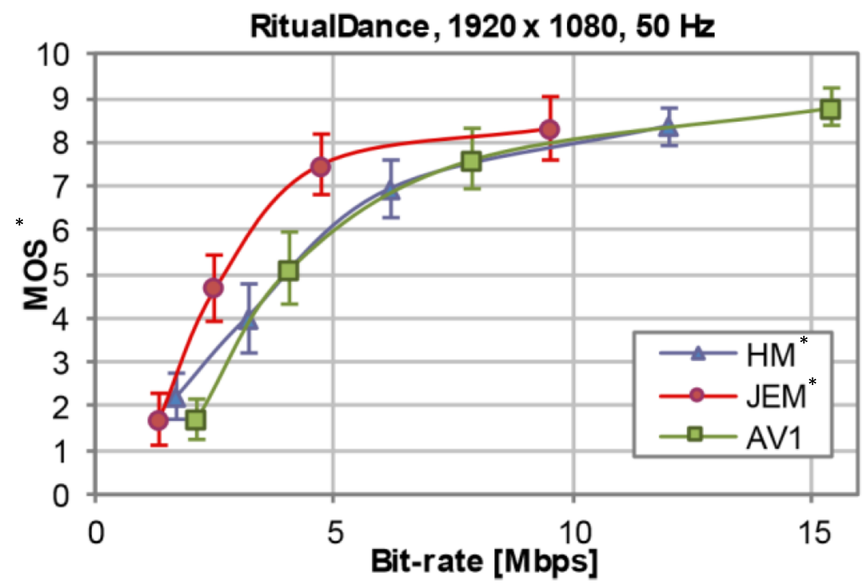
※ One pass : Perform compression processing once to prioritize processing time
Two pass : Perform compression processing twice to prioritize compression performance

Comparison of AV1 and VVC



Comparison of compression capabilities

* VVC(VTM4.0), AV1(v1.0.0、one-pass method)



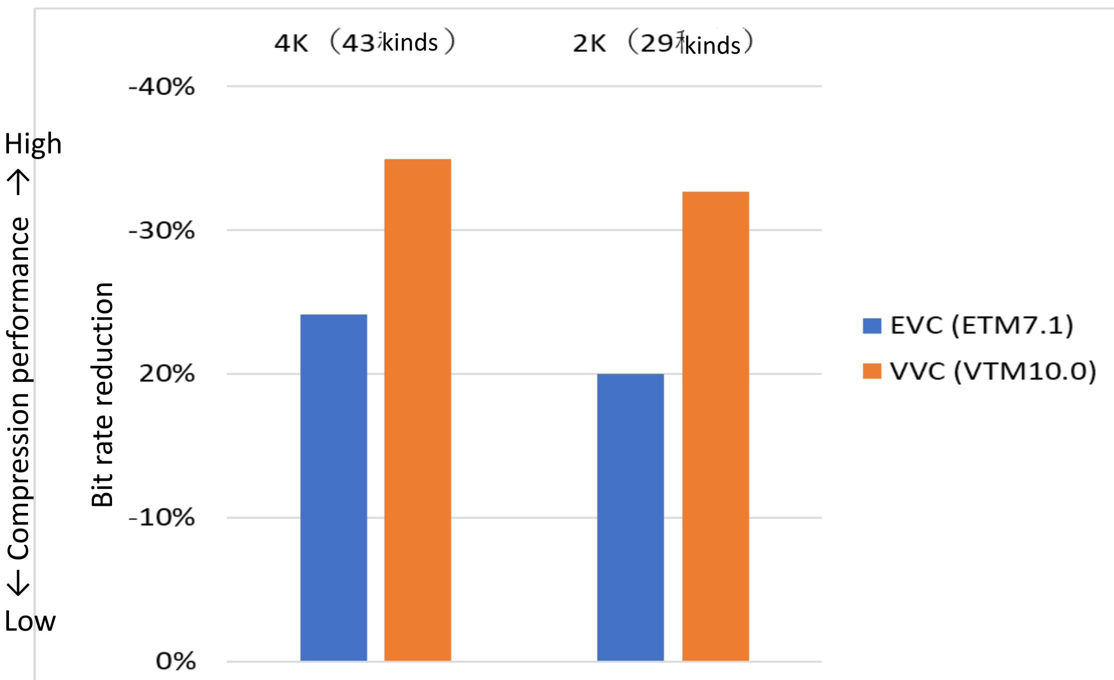
Result of subjectivity quality evaluation

* HM (HEVC test Model) : HEVC test Model
* JEM(Joint Exploration Model) : predecessor of VTM
* MOS (Mean Opinion Score) : average Opinion Score

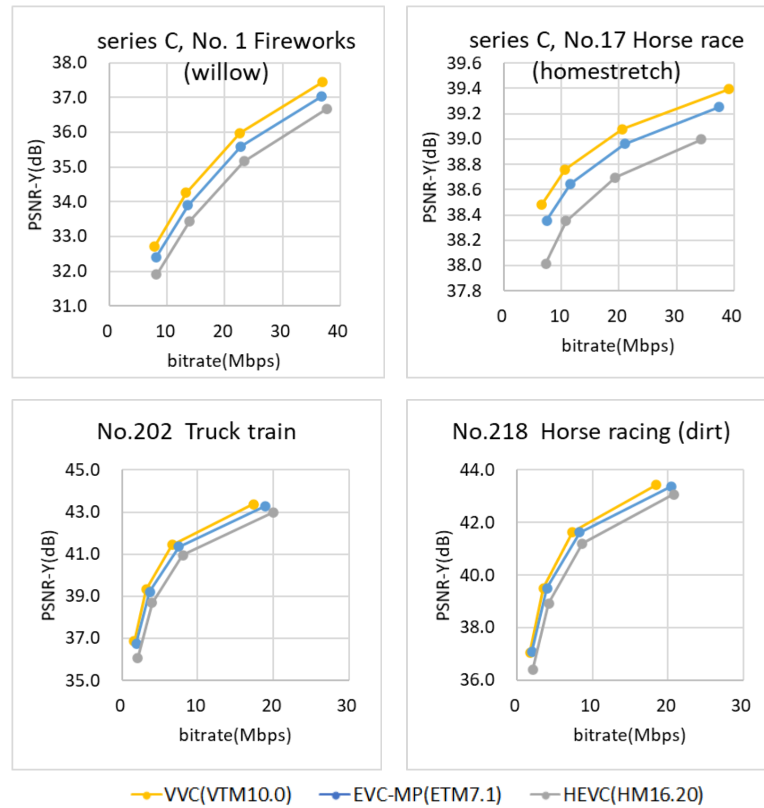
3. (1)-4 「EVC」

- License-friendly objective, and EVC was standardized as MPEG-5 Part 1 in October 2020.
- The base tool set is composed of technologies whose patents have expired or technologies that are freely available.
- License is necessary when using main profile with high compression capability.
- As a result of comparing EVC and VVC, it was confirmed that VVC had higher compression capabilities.

Comparison of EVC and VVC



Compression efficiency comparison



Compression capability comparison
(Top : 4K HDR. Bottom : 2K SDR)

3. (1)-5 Video Coding Evaluation

- VVC, AV1 and EVC were evaluated.
- The compression capabilities of VVC were higher than other video coding technologies.
- Shorter EVC processing time than other video coding technologies has been confirmed, however it is expected that the VVC processing time can be improved by modifying the text model.
- Stability of standardization is important considering use in receivers.
- Based on the results above, VVC has an advantage compared to other video coding methods.

① Compression capabilities: VVC is better than other video coding technologies.

Comparison of VVC and AV1(%: compared to HEVC(HM 16.10))

Contents	VVC (VTM v4.0)	AV1 (v1.0.0)
4K	−35.28%	−1.31%
2K	−26.70%	2.50%

Comparison of VVC and EVC (% : compared to HEVC(HM 16.20))

Contents	VVC (VTM v10.0)	EVC (ETM v7.1)
4K	−34.95%	−24.09%
2K	−32.66%	−19.99%

② Processing time: EVC processing time is shorter than other video coding technologies.

Processing time (encoding) of VVC, AV1 and EVC with compression capability（% : compared to HEVC（HM 16.18））

		VVC (VTM v4.0)	AV1 (v1.0.0)	EVC (ETMv1.0)
Processing time（encoding)		855%	732%	443%
Compression capability	PSNR Y	−29.32%	−18.72%	−16.63%
	PSNR U	−28.69%	−27.52%	−7.64%
	PSNR V	−29.08%	−26.79%	−8.69%

* Y : luminosity　U, V : color element

③Stability of standardization: VVC and EVC are de jure standards. On the other hand, AV1 is a standard which gives priority to the latest technologies over stability.

3. (2)-1 Audio Coding Requirements

- Next-generation DTTB system requirements, in terms of audio technical methods, mandates those that can flexibly cope with various requirements, including multi-channel audio broadcasting.
- In recent years, multiple encoding methods corresponding to object-based audio (OBA) have been standardized.
- Based on the above, the following four audio coding methods were compared.

1. MPEG-4 AAC (MPEG standardized in 2000)
   - Adaptive transform coding using auditory characteristics (for new 4K・8K)
   - OBA unsupported.
2. MPEG-H 3D Audio (MPEG standardized in 2015)
   - The latest MPEG audio coding.
   - OBA supported.
3. Enhanced AC-3 (ETSI standardized in 2005)
   - Audio coding widely used for current broadcast and internet delivery services.
   - OBA supported since 2016.
4. AC-4 (ETSI standardized in 2015)
   - The latest audio coding with multifunctionality and high efficiency.
   - OBA supported.

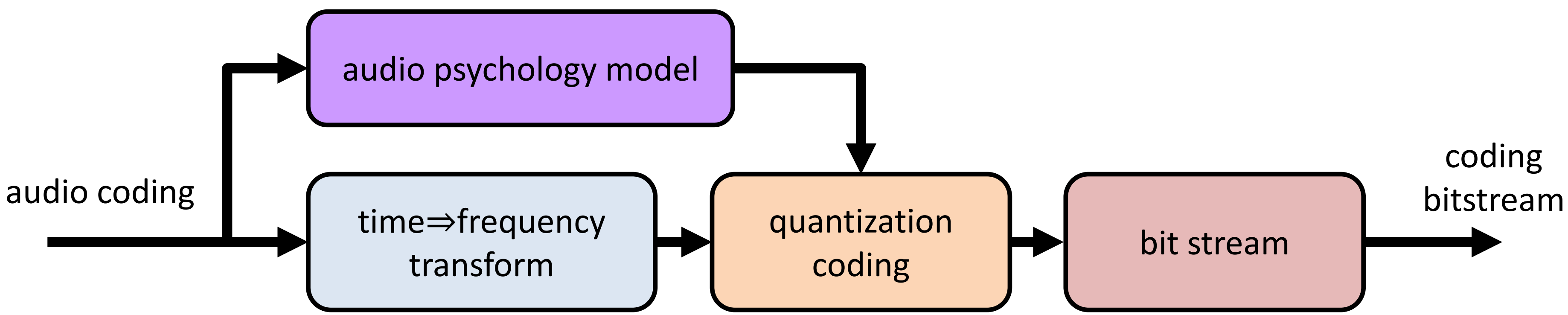
＊MPEG: Moving Picture Experts Group
＊ETSI: European Telecommunications Standards Institute

3. (2)-2 MPEG-4 AAC

Adaptive transform coding using auditory characteristics (MPEG standardized in 2000)

- For new 4K・8K.
- Corresponding to multichannel(MPEG-2 AAC：Max 7.1ch, MPEG-4 AAC：Max 22.2ch).
- 144kbps/stereo, 1.4Mbps/22.2ch (evaluated by ARIB).
- OBA unsupported.

Audio coding diagram ＊Using auditory characteristics



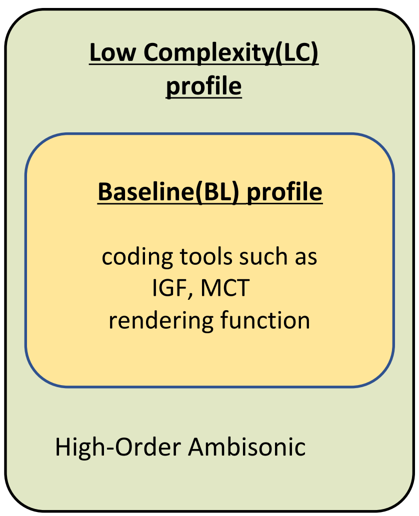
3. (2)-3 MPEG-H 3D Audio

The latest audio coding for MPEG (MPEG standardized in 2015)

- 768kbps/22.2ch(compression capability of about 50% compared to MPEG-4 AAC)*
- Baseline (BL) profile that can use only basic coding tools and Low Complexity (LC) profile that can use advanced coding tools are available.
- MPEG-H 3D Audio has been adopted for ATSC3.0/DVB broadcast standards. 4K terrestrial broadcasting using LC profile started in South Korea in 2017.
- MPEG-H 3D Audio was adopted in Brazil for broadcast standards (2K) in 2019 and is used commercially already.
- OBA supported.

* N19407, MPEG-H 3D Audio Baseline Profile Verification Test Report

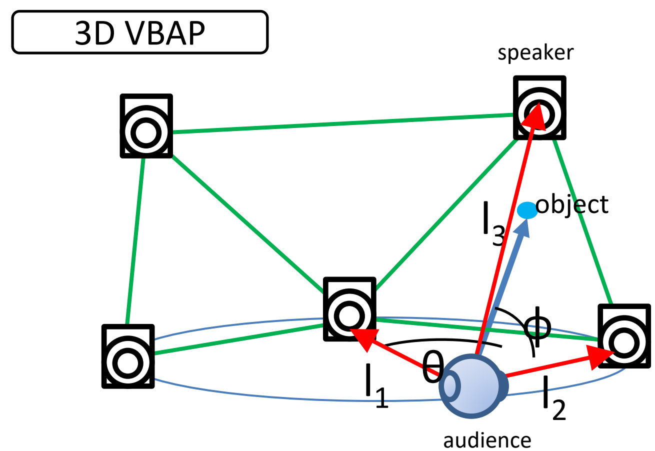
MPEG-H 3D Audio profile



* High-Order Ambisonics are a format of AR/VR audio coding

MPEG-H 3D Audio OBA

MPEG-H maps audio objects according to the speaker arrangement on the receiver side by means based on the polar coordinates of 3D VBAP.



* VBAP: Vector Based. Amplitude Panning

3. (2)-4 Enhanced AC-3, AC-4

Enhanced AC-3

Audio coding widely used in current broadcast and internet delivery services.

- Enhanced AC-3 was standardized by ETSI in 2005 as a channel-based audio coding corresponding to up to 7.1 ch.
- Enhanced AC-3 has been used for terrestrial broadcasts (2K) in Europe and Brazil, etc.
- Enhanced AC-3 has been used for domestic Hybridcast.
- Enhanced AC-3 has supported OBA since 2016.

AC-4

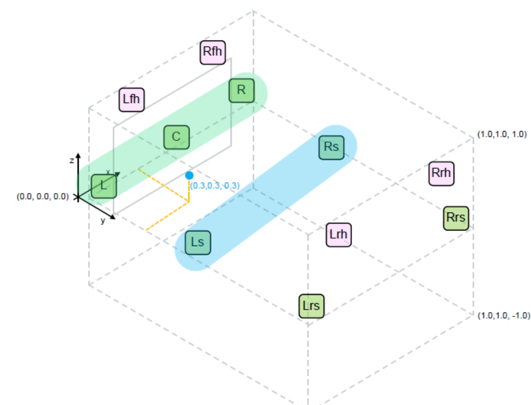
Audio coding with multifunction and high efficiency (ETSI standardized in 2015)

- AC-4 was adopted in ATSC 3.0/DVB.
- AC-4 was adopted for broadcast standards (2K) as one of the Europe and Brazil.
- 4K terrestrial broadcast using AC-4 started in USA.
- 192kbps/5.1ch, 288kbps/7.1.4ch
- AC-4 is equipped with television receivers and smartphones.
- AC-4 supports OBA.

AC-4 OBA

AC-4 maps audio objects according to the speaker arrangement on the receiver side by means based on the orthogonal coordinates of Triple Balance Panner.

Triple Balance Panner

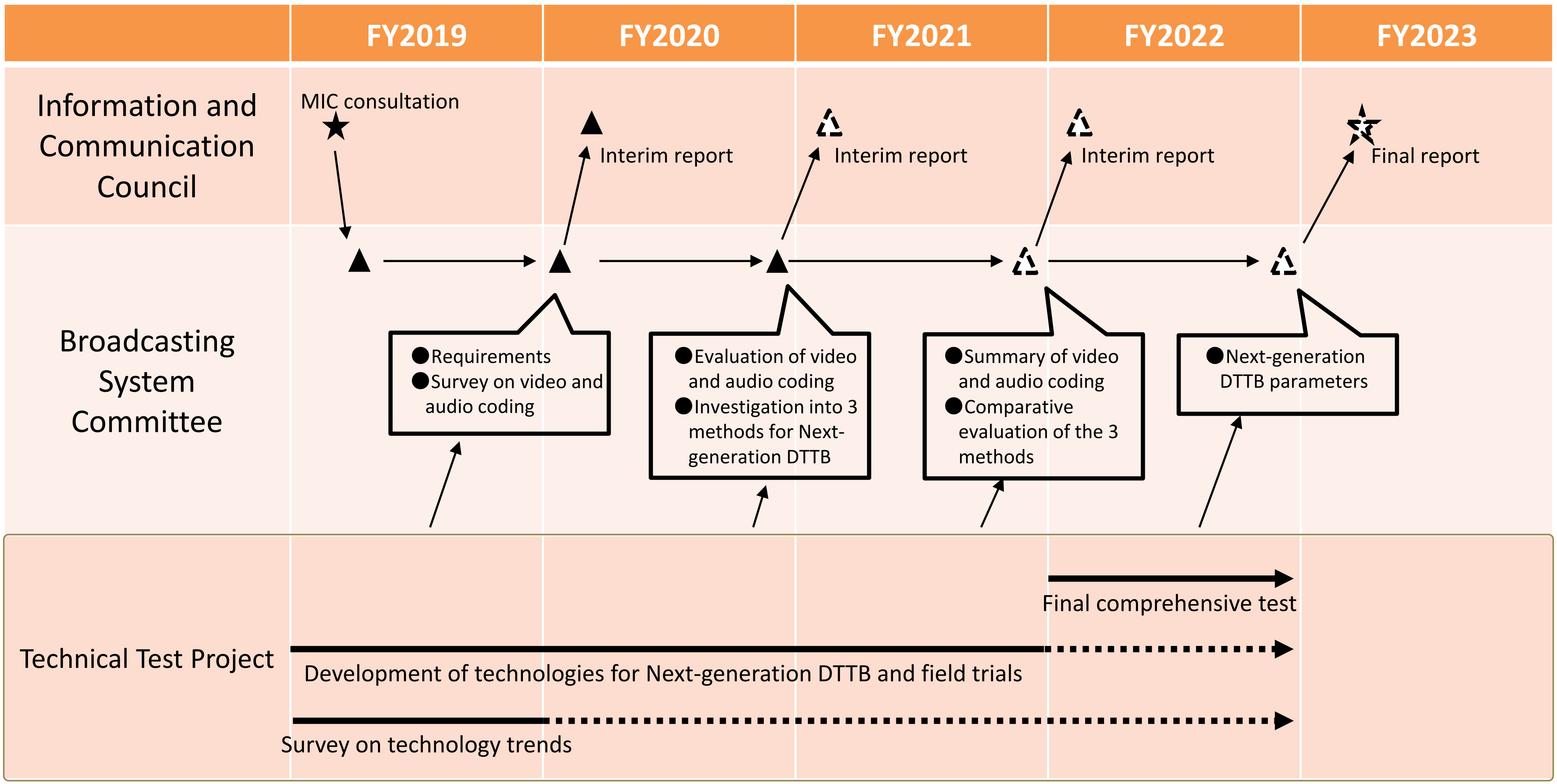


3. (2)-5 Audio Coding Evaluation

- MPEG-4 AAC, MPEG-H 3D Audio, Enhanced AC-3, AC-4 were evaluated.
- Each coding has high compression capabilities and handles multi-channel audio broadcasting.
- Object-based audio (OBA) is preferable for Next-generation DTTB.
- Calculating required bit rate by subjective quality assessment, etc., is to be carried out.

Item	MPEG-4 AAC	MPEG-H 3D Audio	Enhanced AC-3	AC-4
Adopted by	ARIB, DVB	ATSC 3.0, DVB, SBTVD	ATSC, DVB, SBTVD	ATSC 3.0, DVB, SBTVD
Standard entity	MPEG	MPEG	ETSI	ETSI
License	RAND license			
In service	Satellite broadcasting TV Terrestrial broadcasting TV	TV, STB, sound bar, AVR (Korea)	TV, STB, smartphone, sound bar, AVR	TV, STB, smartphone, sound bar, AVR
OBA	×	○	○	○
Number of audio signals	24 (e.g. 22.2ch)	Level3 :16 (e.g. 7.1.4+4obj) 24 (only mono object) Level4: 28 (e.g. 22.2ch + 4obj)	16 (e.g. 7.1.4 + 4obj)	Level3 :18 (e.g. 7.1.4 + 6obj)
Function	Channel-based/ Volume adjusting (limited)	Object-based Clarification Volume adjusting	Object-based Clarification Volume adjusting (limited)	Object-based Clarification Volume adjusting
Compression capability	144kbps (stereo) / 320kbps (5.1ch) / 1.4Mbps (22.2ch)	768kbps (22.2ch)	192kbps(stereo)	96kbps (stereo)/ 192kbps (5.1ch) / 288kbps (7.1.4)
IP streaming/ Mobile standard	3GPP/DASH-IF/ Hybridcast	3GPP/DASH-IF/HbbTV	DASH-IF/HbbTV/ Hybridcast	DASH-IF/HbbTV
HDMI standard	IEC 61937-6 IEC 61937-11	IEC 61937-13	IEC 61937-3	IEC 61937-14 (possibly IEC61937-9)

4. Deliberation Schedule



ISDB-T

Muito Obrigado!

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