



BRAZILIAN DIGITAL
TERRESTRIAL TV
FORUM

CfP Phase 2 / Testing and Evaluation: TV 3.0 Project

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1 Introduction

The SBTVD Forum was created by the Brazilian Presidential Decree # 5 820 / 2006, to advise the Brazilian Government regarding policies and technical issues related to the approval of technical innovations, specifications, development, and implementation of the Brazilian Digital Terrestrial Television System (SBTVD). The SBTVD Forum is composed of representatives of the broadcasting, academia, transmission, reception, and software industry sectors, and has the participation of Brazilian Government representatives as non-voting members.

Free-to-air terrestrial television is the main audiovisual distribution platform in Brazil, covering almost all Brazilian households and used in more than 70% of them. It secures to most of the Brazilian population a free-of-charge, universal and democratic access to information and entertainment, made by Brazilians for Brazilians. It is, therefore, an important social cohesion, national, and cultural identity factor.

For its first generation Digital Terrestrial Television system, after thorough testing and careful studies, the Brazilian Government adopted in June 2006 the ISDB-T standard, incorporating technological innovations that were deemed relevant, such as MPEG-4 AVC (H.264) video coding, MPEG-4 AAC audio coding, an appropriate closed caption character set for the Brazilian Portuguese, and a new middleware for interactive applications (Ginga).

The SBTVD Forum developed the first SBTVD standards, that were published in 2007, allowing the official opening of transmissions in that same year. Since then, the standards have been continuously revised and updated by the Forum. The technological innovations proposed by Brazil were incorporated into the International ISDB-T standard, which is currently adopted by 20 countries.

In 2016, Brazil started a safe and gradual analog TV switch-off process, that was designed to assure that no one would be deprived of the terrestrial free-to-air TV. The process was divided into two stages: in the first stage (2016 to 2019) the analog television switch-off was performed in all the state capitals, metropolitan areas, and other areas where it was required to release the 700 MHz band; on the second stage (up to 2023) the analog television switch-off would be performed in the remaining of the country. During the first stage, 1 362 cities in 47 different clusters were impacted, accounting for nearly 128 million people (62% of the population). More than 12 million Digital TV reception kits were distributed for low-income families. The analog switch-off had no significant impact on the free-to-air terrestrial TV audience. Regarding the second stage, the remaining 38% of the population (more than 79 million people) is distributed in 4 208 cities. After the implementation of Digital Terrestrial Television Brazil adopted an industrial policy that determined that all flat-panel TVs manufactured from 2012 must have an integrated Digital TV receiver and from 2013 no more CRT TVs were manufactured. Therefore, it is anticipated, based on the expected product lifetimes, that by 2023 Brazil would have nearly all its TV sets already equipped with an integrated Digital TV receiver, thus facilitating the analog television switch-off without additional Digital TV reception kits distribution.

As the Brazilian digital television switch-over began, the SBTVD Forum started considering the next steps for the evolution of the Brazilian Television. The analog TV (that we conventionally call "TV 1.0"), which started in Brazil in 1950, was black and white with monophonic sound. Then, some backward-compatible improvements (that we conventionally call "TV 1.5"), such as color (in the 1970s), stereo sound and closed caption (in the 1980s) were added to it. From 2007, the first generation of Digital Terrestrial Television (that we conventionally call "TV 2.0") was introduced in Brazil, bringing high-definition video, surround sound, mobile reception, and interactivity. Since then, the technological landscape has changed a lot. The rhythm of development and introduction of innovations is increasingly accelerated. These innovations create new consumption habits and increase the expectations of technological services users regarding the quality and convenience of these services. Since the introduction of SBTVD, new immersive audio and video formats have emerged, and are already present in the new TV sets available in the market. The TV sets currently available have resolution and contrast greater than those supported in the first generation SBTVD standard. That is the opposite of the market situation when Digital TV was launched in Brazil, as the HDTV sets offer was very low. The availability and the speed of Internet access in Brazil, especially in metropolitan areas, increased significantly, enabling the consumption of on-demand audiovisual content. This connectivity is already in use by TV sets (Smart TVs) and by broadcasters' Over-The-Top (OTT) offers. However, in the first generation SBTVD standard, there was not an integration between the broadcasting service and the Internet content offer. Furthermore, new techniques for signal coding, transport, and modulation were also developed, allowing greater efficiency in audiovisual transmission. Many Digital Terrestrial Television systems have also been evolving, including in this evolution not only enhancements in quality and efficiency but also new convergent services between the broadcasting and the Internet. Based on this technological landscape, the SBTVD Forum recognized the necessity to evolve the SBTVD. It also acknowledged that changing the physical layer, the transport layer, and/or audiovisual coding would not be backward-compatible. Nevertheless, the transition to a new generation of Digital Terrestrial Television is a long process, based on the investments required for both broadcasters and consumers and the expected life span of TV transmitters and receivers. It was, therefore, deemed necessary to increase the life span of the existing Digital Terrestrial Television system as much as possible through a backward-compatible evolution (a project we called "TV 2.5") and to start the development of the next generation Digital Terrestrial Television system (the project we called "TV 3.0").

The "TV 2.5" project comprised two aspects: broadcast-broadband integration and audiovisual quality. The first aspect involved the development of a new receiver profile for the middleware Ginga (receiver profile D, a.k.a. "DTV Play"), addressing use cases such as on-demand video, synchronized companion device, audiovisual enhancement over the Internet, and targeted content. The second aspect was addressed through the introduction of three new optional immersive audio codecs (MPEG-H Audio, E-AC-3 JOC, and AC-4) while retaining MPEG-4 AAC main audio for backward-compatibility, and through the introduction of two new optional HDR video formats (SL-HDR1 dynamic metadata and HLG "preferred transfer characteristics" signaling) while keeping MPEG-4 AVC (H.264) / 8-bit / BT.709 / 1080i for backward-compatibility. The revision of the SBTVD standards containing both "TV 2.5" aspects has already been published (available at <https://forumsbtvd.org.br/legislacao-e-normas-tecnicas/normas-tecnicas-da-tv-digital/english/>).

For the "TV 3.0" project, the SBTVD Forum, after agreeing on its requirements (use cases and corresponding technical specifications), decided to release a Call for Proposals (available at <https://forumsbtvd.org.br/wp-content/uploads/2020/07/SBTVDTV-3-0-CfP.pdf>) for any interested organization to submit its proposed candidate technologies for any of the system components or sub-components. The new system is expected to start operating in the next few years, but based on the Brazilian experience on the transition from analog to digital television, the complete transition from the current SBTVD to the TV 3.0 is expected to last at least 15+ years.

As described in the aforementioned Call for Proposals document, the response to this Call for Proposals is divided into two phases.

Phase 1 responses comprise the identification of each proposed candidate technology and appropriate contact persons and filling the compliance form of the appropriate components or sub-components corresponding to the proposed candidate technology. Please note that if the proponent is a for-profit organization, SBTVD Forum membership will be required for the submission of the proposal. Responses shall be provided using the online form available at <https://forms.gle/6DUWE9bFVbHFou4n8>.

Phase 2 responses comprise providing the full specification of the proposed candidate technology, adhering to the SBTVD Forum Intellectual Property Rights Policy, and the additional requirements considering general information and resources needed for evaluating and comparing the proposed candidate technologies.

This document provides further information and requirements for Phase 2, along with the test procedures for evaluating and comparing the proposals of candidate technologies and instructions on providing Phase 2 responses.

2 Glossary

2.0	stereo (two full-bandwidth channels) sound
3D	Three-Dimensional
3DoF	Three Degrees of Freedom
5.1	surround (five full-bandwidth channels and one low-frequency effects channel) sound
5.1 + 4H	3D (five full-bandwidth channels, one low-frequency effects channel, and four overhead channels) sound
6DoF	Six Degrees of Freedom
A/V	Audio / Video
ABNT	<i>Associação Brasileira de Normas Técnicas</i> (Brazilian Technical Standards Association)
ADM	Audio Definition Model (as defined in the Recommendation ITU-R BS.2076-2)
API	Application Programming Interface
AR	Augmented Reality
AWGN	Additive White Gaussian Noise

BD	Bjøntegaard Delta
BER	Bit Error Rate
BW64	Broadcast Wave 64-bit
C/N	Carrier-to-Noise ratio
DCI	Digital Cinema Initiatives
DM	Dynamic Mapping
DTH	Direct-To-Home
DTT	Digital Terrestrial Television
DTTB	Digital Terrestrial Television Broadcasting
FER	Frame Error Rate
fps	frames per second
GPS	Global Positioning System
HDMI	High-Definition Multimedia Interface
HDR	High Dynamic Range
HEVC	High Efficiency Video Coding
HLG	Hybrid Log-Gamma
HOA	Higher-Order Ambisonics
HW	Hardware
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol

IPTV	Internet Protocol Television
ISDB-T	Integrated Services Digital Broadcasting-Terrestrial
ITU	International Telecommunications Union
MER	Modulation Error Rate
MFN	Multi-Frequency Network
MIMO	Multiple-Input and Multiple-Output
MOS	Mean Opinion Score
MUSHRA	MULTiple Stimuli with Hidden Reference and Anchor
MS-SSIM	Multi-Scale Structural Similarity Index Measure
NBR	<i>Norma Brasileira Regulamentadora</i> (Brazilian National Standard)
NTP	Network Time Protocol
OASIS	Organization for the Advancement of Structured Information Standards
OFDM	Orthogonal Frequency-Division Multiplexing
OTA	Over-the-air (broadcast delivery)
OTT	Over-the-top (internet delivery)
P1dB	1 dB compression point
PCap	Packet Capture
PNG	Portable Network Graphics
PPS	Pulse Per Second
PQ	Perceptual Quantizer

PR	Protection Ratio
PSNR	Peak Signal to Noise Ratio
QEF	Quasi Error Free
QP	Quantization Parameter
reuse-1	the use of the same RF channel by independent stations covering adjacent service areas
RF	Radio Frequency
RF64	RIFF/WAVE Format 64-bit
SBTVD	<i>Sistema Brasileiro de Televisão Digital</i> (Brazilian Digital Television System)
SDI	Serial Digital Interface
SDO	Standards Developing Organization
SDR	Standard Dynamic Range
SFN	Single-Frequency Network
SISO	Single-Input and Single-Output
STB	Set-Top Box
SW	Software
TIFF	Tagged Image File Format
TOV	Threshold Of Visibility
UHF	Ultra High Frequency
VHF	Very High Frequency
VR	Virtual Reality

WCG Wide Color Gamut

wPSNR Weighted PSNR

XR eXtended Reality

YUV uncompressed ("raw") video file format, using one luma component (Y) and two chrominance components (U and V)

3 TV 3.0 Architecture

The TV 3.0 system components described in this document reflect the reference TV 3.0 architecture, as depicted in Figure 1.

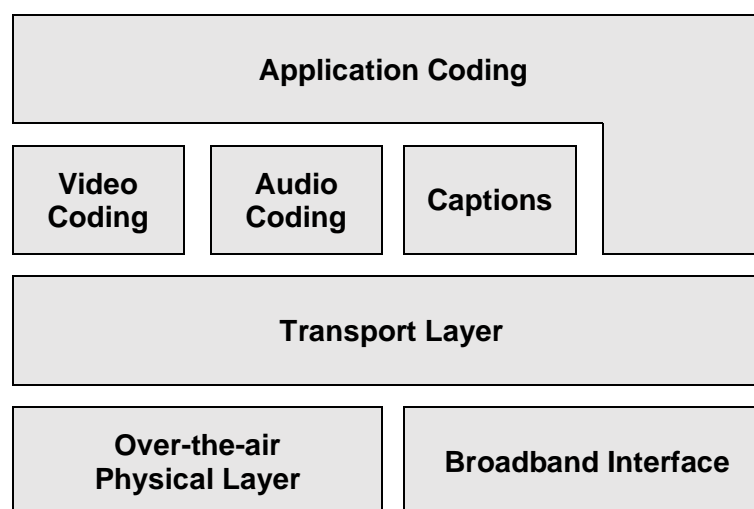


Figure 1: TV 3.0 Architecture

For further information about TV 3.0 architecture, please refer to the TV 3.0 Call for Proposals document.

4 TV 3.0 Testing and Evaluation

Subsection 4.1 introduces TV 3.0 general testing and evaluation aspects, and the following subsections (4.2 to 4.7) introduce the specific testing and evaluation aspects of each system component, as described in the TV 3.0 Architecture (see Section 3).

4.1 General Aspects

Per convention, this document adopts the following definitions:

- **shall**: this word, or terms “required” or “must”, indicates specific provisions that are to be followed strictly (no deviation is permitted).
- **shall not**: this phrase, or the phrase “must not”, indicates specific provisions that are absolutely prohibited.
- **should**: this word, or the adjective “recommended”, indicates that a certain course of action is preferred but not necessarily required.
- **should not**: this word, or the adjective “not recommended”, indicates that a certain possibility or course of action is undesirable but not prohibited.

The proposals of candidate technologies will be tested and evaluated against the requirements set in the TV 3.0 Call for Proposals document, by the SBTVD Forum appointed Test Labs, according to the procedures established in this document.

The proponents are also encouraged to submit detailed information about the features that exceed the TV 3.0 requirements.

Additional tests and evaluations can be performed by the SBTVD Forum, at its own discretion.

All Test Labs will be required to implement a procedural recording subsystem. Full HD video (i.e., spatial resolution 1 920 x 1 080 pixels) and audio will be captured in real-time for documenting and auditing purposes. A/V Camera shall focus on a scene that includes all the test setup and lab analysts. The procedural recording is a separate subsystem that does not interfere with any other test subsystem.

The Test Lab cannot be a proponent organization. All the tests shall be executed by a group of at least two lab analysts. The lab analysts shall not have a personal or working relationship with the proponents.

The proponents shall make available all the resources (documentation, hardware, software, etc.) needed for evaluating and comparing the proposed candidate technologies, as specified in Subsections 4.2 to 4.7 for each system component or sub-component. In the case of Video and Audio Coding proposed candidate technologies that use profiles and/or levels to constrain the set of tools and parameters that can be used, the proponent shall clearly indicate the appropriate profile and/or level to fulfill the TV 3.0 Project requirements. For those proposed candidate technologies, all testing and evaluation will be performed using only the profile and/or level indicated by the proponent. Unless otherwise specified, the required equipment can be implemented and provided as a combination of multiple hardware and/or software modules, provided that it enables the specified test with the appropriate interfaces. Likewise, multiple required equipment can be implemented in a single module and this is acceptable as long as all tests can be accomplished.

The tests that assess minimum technical specifications not indicated in the TV 3.0 Call for Proposals document as "required" for neither over-the-air delivery nor for Internet delivery are optional. Therefore, the proponent may not provide the resources that are specific for these tests, if the proposed technology does not meet these "desirable" or "recommended" minimum technical specifications. Proponents of the Physical Layer, Transport Layer, Audio Coding and Captions shall meet all the minimum technical specifications required in the respective component and shall provide at least all the resources needed for the tests that are not optional. Proponents of the Video Coding may address only a set of the sub-components as specified in 4.4 and provide the corresponding resources. Proponents of the Application Coding can address a subset of the minimum technical specifications as specified in 4.7 and provide the corresponding resources. The failure in providing the hardware and/or software resources needed for tests that assess the required minimum technical specifications shall be indicated in the Test Lab report. The fulfillment of these specifications shall be considered as "not verified" in the test results. If the resources needed for a test are partially provided, this shall also be indicated in the Test Lab report. The corresponding minimum technical specifications assessed by that test can be considered as "partially fulfilled" if the partial test results are satisfactory. Regardless of the test verification, all minimum technical specifications shall also be independently verified in the "Documentation Analysis".

The proponent test resources will be provided to the SBTVD Forum, which will make them available to the appropriate Test Lab. The Test Lab may be required by the proponent to sign specific license agreements for using the test resources provided. The proponents and the Test Lab analysts shall not interact directly, except during presentations, training, and support sessions arranged by the SBTVD Forum. Any further communication required shall be intermediated by the SBTVD Forum. SBTVD Forum will provide an efficient communication channel that works 24/7.

The proponents are encouraged (and in some cases required) to implement the test setups and perform the test procedures as specified in this document. The proponent's test results report should be sent to the SBTVD Forum to enable cross-checking the results.

Test Labs will cross-check if proponents' results can be reproduced. If results differ, the Test Lab shall inform the proponent (through SBTVD Forum intermediation) and make a reasonable effort to clarify the issue. The Test Lab is responsible for the publication of final test results.

As indicated in the TV 3.0 Call for Proposals document, the proponent's documentation for Phase 2 shall also include the full specification of the proposed candidate technology (GT3 and GT4) and adhering to the SBTVD Forum Intellectual Property Rights Policy (GI3). GT3, GT4, and GI3 are repeated here for the convenience of the reader:

GT3. All technical proposals shall be fully specified, preferably in technical standards of internationally recognized SDOs.

GT4. The full specification of the technical proposal shall be made available for the SBTVD Forum free of charge.

GI3. All technical proposals licensing or any other form of commercialization shall adhere to fair, reasonable, and non-discriminatory terms, as specified in the SBTVD Forum Intellectual Property Rights Policy (see the TV 3.0 Call for Proposals document, Annex A).

All proponents are also required to commit to contributing with SBTVD Forum on drafting the TV 3.0 normative specifications and implementing its conformity assessment tests (reference implementations, reference streams, test suites, etc.) if their proposed candidate technologies are fully or partially adopted.

The failure to submit Phase 1 and/or Phase 2 responses before their deadlines, or to make all the required documentation and all the resources needed for testing and evaluation procedures arrive in time in the SBTVD Forum, according to the schedule detailed in Section 5, may cause the proposal not to be considered by SBTVD Forum.

The testing and evaluation reports produced by the Test Labs are going to be made publicly available by the SBTVD Forum. They are supposed to support the SBTVD Forum decision on which proposed candidate technologies to recommend for adoption by the Brazilian Government for the next generation Digital Terrestrial Television system. It should be noted, however, that these reports will address only the technical aspects of the proposed candidate technologies, while the SBTVD Forum decision (and ultimately, the Brazilian Government decision), will also take into account commercial and intellectual property aspects.

It should also be noted that, although the Test Labs will test and evaluate each system component individually, for the SBTVD Forum to be able to recommend a set of candidate technologies for adoption, all of them should meet all the requirements established in the TV 3.0 Call for Proposals document, they should be interoperable, they should be technically and commercially viable, and the TV 3.0 system resulting from that combination of technologies should be able to transport simultaneously at least:

- in a single 6 MHz channel:
 - one 1080p60 HDR video;
 - one 5.1+4H + 2 mono objects main audio;
 - one stereo second language (separate full mix);
 - one stereo audio description (separate full mix);
 - one closed caption;
 - one emergency information as a separate caption stream;
 - one sign language interpreter video as a second video stream or one sign language gloss as a separate caption stream; and
 - one interactive application.

- in a second 6 MHz channel (when using channel bonding):
 - one video enhancement layer (from 1080p60 HDR to 2160p60 HDR).

If these conditions are not met, the SBTVD Forum may relax some of the requirements established in the TV 3.0 Call for Proposals document, extend the process deadlines, and/or release a second Call for Proposals (not necessarily encompassing all the system components or sub-components).

4.2 Over-the-air Physical Layer

The over-the-air physical layer requirements set in the TV 3.0 Call for Proposals document, against which the proposals of candidate technologies will be tested and evaluated, are repeated here for the convenience of the reader. For further details, please refer to the TV 3.0 Call for Proposals document.

use case		minimum technical specification		over-the-air delivery	
PL1	Enable side-by-side operation with existing ISDB-T systems in the same frequency bands, with minimum impact over existing network planning.	PL1.1.1	frequency band	174-216 MHz	required
		PL1.1.2		174-230 MHz	not required for Brazil, but may be useful for other countries that may wish to adopt the same DTTB system
		PL1.1.3		470-698 MHz	required
		PL1.1.4		other frequency bands	desirable to provide more flexibility to the system
		PL1.2.1	channel bandwidth	6 MHz	required
		PL1.2.2		7 MHz	not required for Brazil, but may be useful for other countries that may wish to adopt the same DTTB system
		PL1.2.3		8 MHz	
		PL1.2.4		other channel bandwidths	desirable to provide more flexibility to the system
		PL1.3	co-channel PR (wanted: ISDB-T / unwanted: TV 3.0)	≤ 19 dB	required
		PL1.4	adjacent-channel PR (wanted: ISDB-T / unwanted: TV 3.0)	≤ -36 dB	required

use case		minimum technical specification			over-the-air delivery
PL2	Enable scalable broadcast network deployment (in terms of coverage and capacity), flexible frequency reuse with spatial content segmentation (reuse-1), and the most efficient spectrum use possible, targeting both fixed indoor and mobile (high-speed) outdoor reception.	PL2.1	MIMO	2x2	required
		PL2.2	multi-RF channel transmission	channel bonding - content is spread over two or more RF channels	support to bonding at least 2 channels is required
		PL2.3	high-speed reception	120 km/h	required
		PL2.4	spectrum efficiency	bit/s/Hz @ C/N ≤ 0 dB in Rayleigh channel	higher is better
PL3	Provide "wake-up" capability for compatible receivers in case of an emergency warning.	PL3.1	"wake-up" capability		required
PL4	Enable future extensions to the physical layer (e.g. to support new modulation schemes).	PL4.1	extensibility		required

PL-AR1. Provide free of charge reference modulator and demodulator (hardware or software-defined radio) with its corresponding documentation, strictly for temporary technical evaluation of the SBTVD Forum (non-commercial usage).

PL-AR2. Provide information about available implementations of the modulator and demodulator, the latter both for professional (broadcast) and consumer electronic applications.

PL-AR3. Provide some reference information about the demodulator for TV sets manufacturing.

The proponent's physical layer system will be evaluated in two steps. The "steps" referred here are the "Laboratory Tests" and the "Field Tests". The proponent of the physical layer shall make available prototype or commercial equipment for the evaluation, as defined in the following subsections.

4.2.1 Conditions for Laboratory Test

4.2.1.1 Equipment to be provided by the proponent

The technology proponent shall deliver, for the laboratory tests purpose, a set of 2 Exciters and 2 Receivers. The Exciters and Receivers shall be capable of MIMO operation. The Exciter shall be equipped with baseband input with Internet Protocol (IP) interface, two Intermediate Frequency (IF) outputs of 44 MHz, due to Multiple Input Multiple Output (MIMO) operation, and Radio Frequency (RF) outputs at VHF (174 to 216 MHz) and UHF (470 to 698 MHz) frequency bands.

The Receiver shall have a baseband output with an IP interface and shall be equipped with an interface to allow the measurement of Bit Error Rate (BER) / Frame Error Rate (FER) or indication of the detection of the receiving threshold of Quasi Error Free (QEF) point. The proponent should specify the QEF quality target point. Also, the Receiver shall have a universal interface, such as Ethernet or USB, to allow connection to a PC to deliver information sufficient to display the constellation of the received modulated signal, as well as the measurement of Modulation Error Rate (MER), through an application software provided by the proponent.

The technology proponent shall prepare an appropriate set of test streams for the laboratory tests.

To allow the configuration of the test stream during the laboratory tests, it is requested to the proponent to provide the system multiplexer (using the IP-based Transport Layer technology selected by the proponent).

If the proposed system requires for synchronization purpose interface different than 10 MHz and 1 PPS, provided by ordinary GPS receivers, as the Network Time Protocol (NTP), it is requested to provide a GPS receiver with NTP Time Server.

4.2.1.2 General test parameters and setups

All the tests will be conducted only for modulation parameters that allow Carrier to Noise Ratio (C/N) ≤ 0 dB in a Rayleigh payload channel. The tests will be conducted in the Modulation Codification (MODCOD) parameter with negative values of C/N near to 0 dB, in the condition of the environment defined as RF1 in the Channel Ensembles, presented in 4.2.1.3, in Single Input Single Output (SISO) configuration. The test should be repeated in case the proposed system utilizes a special transmission channel for configuration. These parameters will be established by the technology proponent.

The Laboratory Tests are divided into two sets. The Device Verification (DV) tests and System Evaluation (SE) tests. The DV tests are conducted with the intention to verify the basic characteristics of the sample Exciter device itself in order to give assurance of no significant interference, during the on-site field evaluation tests, on the other TV channels already in operation, and have no intention to be an evaluation item of the candidate TV 3.0 system. The SE tests shall be used to evaluate and classify the results.

4.2.1.3 Propagation channel models – Channel Ensembles

In most of the system evaluation test item, the Exciter IF or RF output signal will be submitted to a fading, by emulating the real propagation conditions through the use of Fading Simulators. A set of six (6) propagation channel models was defined:

- a) Single Path Rayleigh;
- b) Outdoor to Indoor or Pedestrian – A;
- c) Outdoor to Indoor or Pedestrian – B;

- d) Vehicular – A;
- e) Vehicular – B;
- f) Modified Typical Urban – 6.

The configuration for the fading simulators for the channel ensembles is presented in the tables: Table 1 to Table 6.

The term TBC inside the Tables means “To Be Calculated”. The value of the phase of the tap shall be calculated in function of the RF frequency being in use for the test, in case the simulator does not allow to input directly the speed.

Table 1: Channel Ensemble RF1 – Single path Rayleigh

Reference	Channel Model Designation	Fading Simulator Set Up						Remarks	
RF1	Single Path Rayleigh	Speed of 3 Km/h at RF - Doppler in Hz depending on the RF frequency - round up value in Hz for first decimal.							
			Path 1	Path 2	Path 3	Path 4	Path 5		Path 6
		Profile	Doppler	N/A	N/A	N/A	N/A		N/A
		Path Loss (dB)	0	N/A	N/A	N/A	N/A		N/A
		Delay (μ s)	0	N/A	N/A	N/A	N/A		N/A
		Phase (Hz)	TBC	N/A	N/A	N/A	N/A		

Table 2: Channel Ensemble RF2A – Outdoor to Indoor or Pedestrian A

Reference	Channel Model Designation	Fading Simulator Set Up						Remarks	
RF2A	Outdoor to Indoor or Pedestrian A	Speed of 3 Km/h at RF - Doppler in Hz depending on the RF frequency - round up value in Hz for first decimal.						ITU-R M.1225	
			Path 1	Path 2	Path 3	Path 4	Path 5		Path 6
		Profile	Rayleigh	Rayleigh	Rayleigh	Rayleigh	Rayleigh		Rayleigh
		Path Loss (dB)	0.0	-9.7	-19.2	-22.8	N/A		N/A
		Delay (μ s)	0.00	0.11	0.19	0.41	N/A		N/A
		Phase (Hz)	TBC	TBC	TBC	TBC	N/A	N/A	

Table 3: Channel Ensemble RF2B – Outdoor to Indoor or Pedestrian B

Reference	Channel Model Designation	Fading Simulator Set Up						Remarks	
RF2B	Outdoor to Indoor or Pedestrian B	Speed of 3 Km/h at RF - Doppler in Hz depending on the RF frequency - round up value in Hz for first decimal.						ITU-R M.1225	
			Path 1	Path 2	Path 3	Path 4	Path 5		Path 6
		Profile	Rayleigh	Rayleigh	Rayleigh	Rayleigh	Rayleigh		Rayleigh
		Path Loss (dB)	0.0	-0.9	-4.9	-8.0	-7.8		23.9
		Delay (μ s)	0.00	0.20	0.80	1.20	2.30		3.70
		Phase (Hz)	TBC	TBC	TBC	TBC	TBC		TBC

Table 4: Channel Ensemble RF 3A – Vehicular A

Reference	Channel Model Designation	Fading Simulator Set Up						Remarks	
RF3A	Vehicular A	Speed of 120 Km/h at RF - Doppler in Hz depending on the RF frequency - round up value in Hz for first decimal.						ITU-R M.1225	
			Path 1	Path 2	Path 3	Path 4	Path 5		Path 6
		Profile	Rayleigh	Rayleigh	Rayleigh	Rayleigh	Rayleigh		Rayleigh
		Path Loss (dB)	0.0	-1.0	-9.0	-10.0	-15.0		-20.0
		Delay (μ s)	0.00	0.31	0.71	1.09	1.73		2.51
		Phase (Hz)	TBC	TBC	TBC	TBC	TBC		TBC

Table 5: Channel Ensemble RF 3B – Vehicular B

Reference	Channel Model Designation	Fading Simulator Set Up						Remarks	
RF3B	Vehicular B	Speed of 120 Km/h at RF - Doppler in Hz depending on the RF frequency - round up value in Hz for first decimal.						ITU-R M.1225	
			Path 1	Path 2	Path 3	Path 4	Path 5		Path 6
		Profile	Rayleigh	Rayleigh	Rayleigh	Rayleigh	Rayleigh		Rayleigh
		Path Loss (dB)	-2.5	0.0	-12.8	-10.0	-25.2		-16.0
		Delay (μ s)	0.0	0.3	8.9	12.9	17.1		20.0
		Phase (Hz)	TBC	TBC	TBC	TBC	TBC		TBC

Table 6: Channel Ensemble RF4 – Modified Typical Urban 6

Reference	Channel Model Designation	Fading Simulator Set Up						Remarks	
RF4	Modified Typical Urban 6	Speed of 120 Km/h at RF - Doppler in Hz depending on the RF frequency - round up value in Hz for first decimal.						COST 207	
			Path 1	Path 2	Path 3	Path 4	Path 5		Path 6
		Profile	Rayleigh	Rayleigh	Rayleigh	Rayleigh	Rayleigh		Rayleigh
		Path Loss (dB)	3.0	0.0	2.0	6.0	8.0		10.0
		Delay (µs)	0.0	0.2	0.5	1.6	2.3		5.0
	Phase (Hz)	TBC	TBC	TBC	TBC	TBC	TBC		

4.2.1.4 MIMO setup

For the test item to be conducted in the MIMO configuration, the set up shown in Figure 2 to Figure 4 should be used.

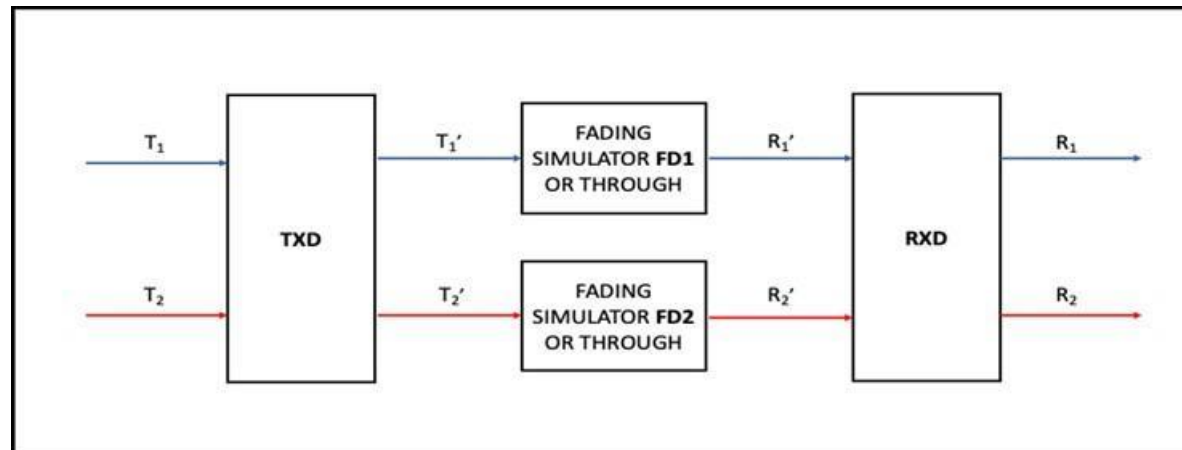


Figure 2: MIMO setup

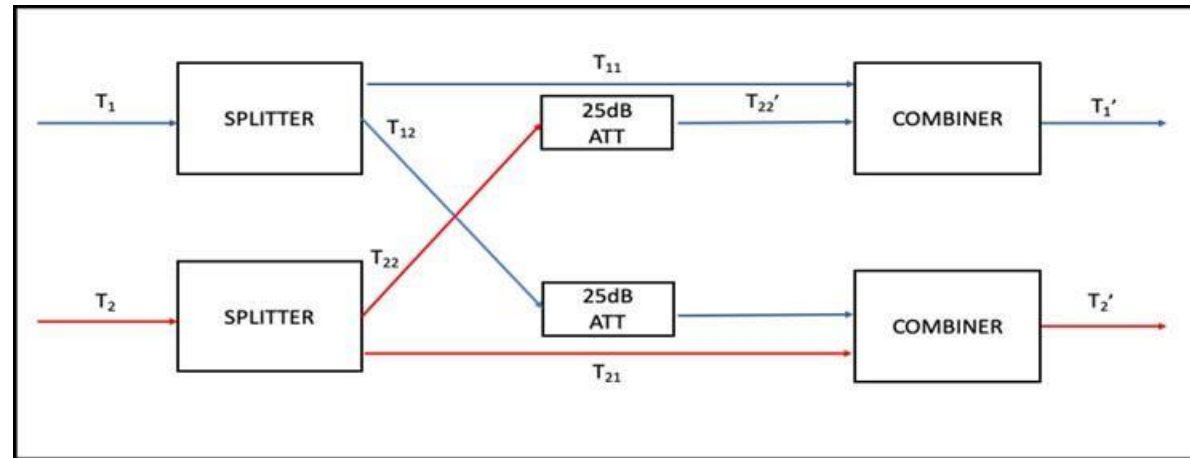


Figure 3: Setup of TXD – Transmitting antenna cross-polarization discrimination

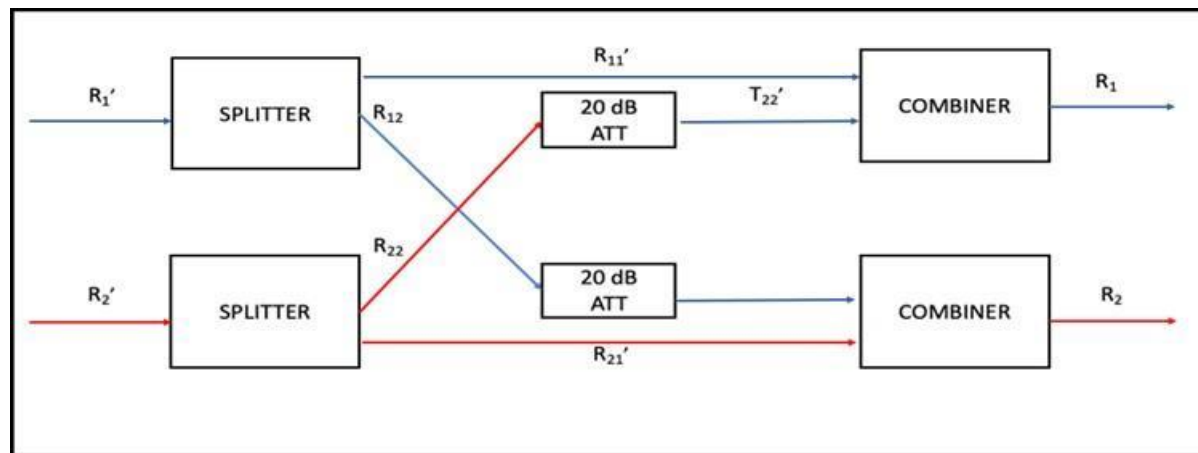


Figure 4: Receiving antenna cross-polarization discrimination

4.2.1.5 Basic SISO/MIMO setup

Figure 5 shows the “Basic SISO setup” that is used in the SISO configuration tests. The details of the block named “Basic SISO setup” in the specific test setup refer to Figure 5.

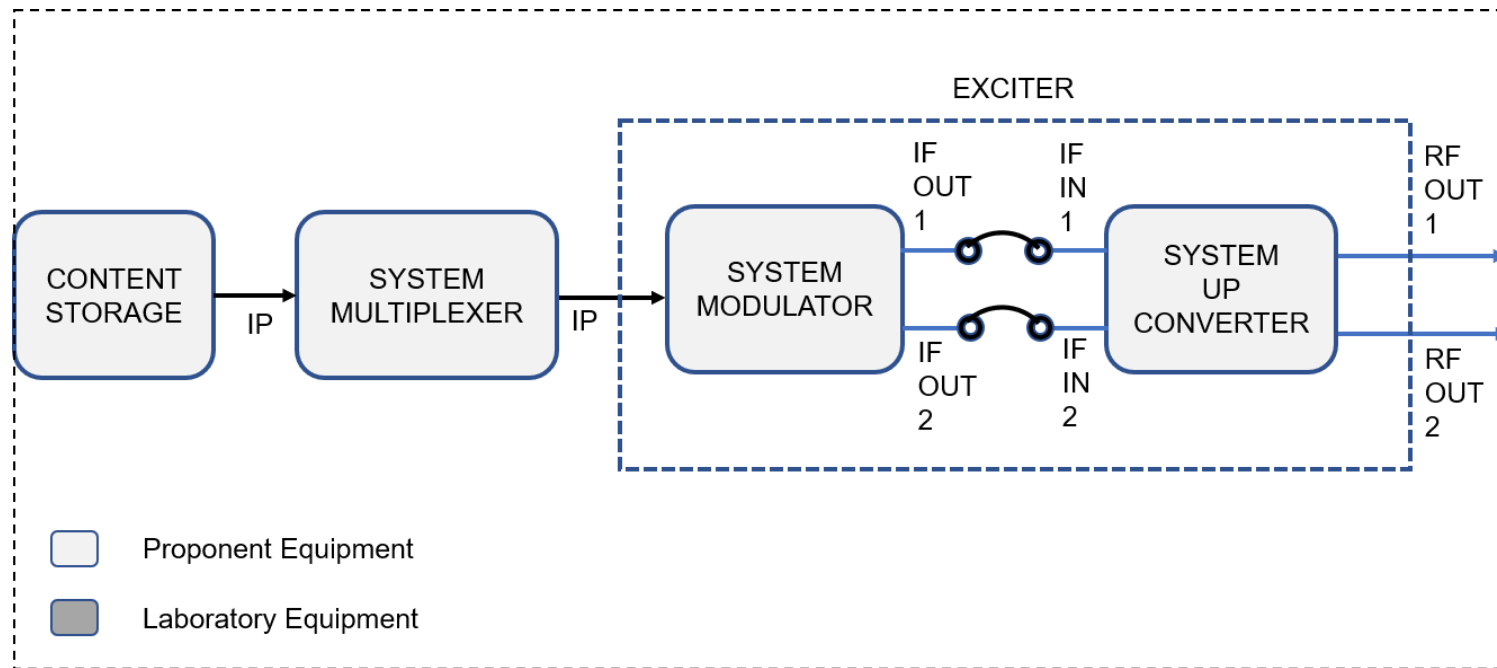


Figure 5: Basic SISO setup

Figure 6 shows the “Basic MIMO setup” that is used in the MIMO configuration tests. The details of the block named “Basic MIMO setup” in the specific test set up refer to Figure 6.

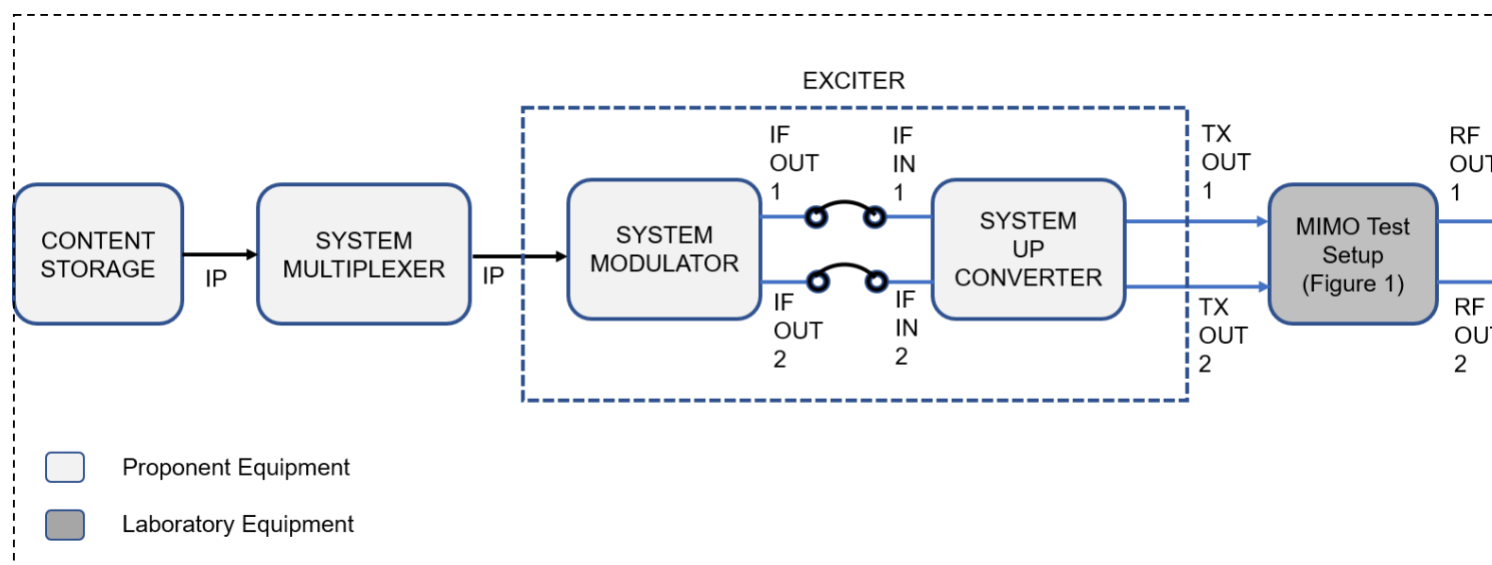


Figure 6: Basic MIMO setup

The same convention of “Proponent Equipment” and “Laboratory Equipment” used in Figure 5 and Figure 6 will be used throughout Section 4.2.

In the “Basic SISO/MIMO setup”, the block “Content Storage” shall be a PC with multiple IP streams content using the IP-based Transport Layer technology selected by the proponent, with appropriate video, audio, and data content (using content and technologies selected by the proponent) for the tests. The Exciter shall have 2 coaxial 75 Ω impedance IF Output, for MIMO operation, operating at 44 MHz frequency. In general, IF OUT 1 and IF OUT 2 should be directly connected to IF IN 1 and IF IN 2, respectively, with a U-Link.

4.2.2 Conditions for Field Test

4.2.2.1 Infrastructure available in the field

Transmission Frequency: 566–572 MHz (UHF channel 30 in Brazil)

602–608 MHz (UHF channel 36 in Brazil)

Transmitting antenna systems

Connector: EIA

Combiner: Manifold with bandpass filters

Gain (per polarization): 8.9 dBd

Half-power vertical beamwidth: 27°

Front-to-back ratio > 20 dB

VSWR < 1.1:1

Cross-polarization discrimination: 30 dB

Max power: 5 kW

Arrangement 1

Type: circular arrangement of 2 horizontal / vertical 1 meter high dual-polarized panels (1 level, 2 faces at 90°)

Arrangement 2

Type: circular arrangement of 2 +45° / -45° 1 meter high dual-polarized panels (1 level, 2 faces at 90°)

Equipment shelters

Construction: Masonry

Cooling: Air Conditioning

Electric power: three-phase, 127 V / 220 V, 60 Hz, with UPS (Uninterruptible Power Supply) and diesel generator set

Transmitter Site 1 (Morro do Sumaré - Rio de Janeiro - RJ - Brazil)

Latitude: 22° 57' 05" S

Longitude: 43° 14' 14" W

Transmitting antenna (arrangement 1 and arrangement 2)

Height: 80 m above ground level

Azimuth: 215°

Cable loss: 3 dB

Transmitter Site 2 (Igreja Nossa Senhora da Penna - Rio de Janeiro - RJ - Brazil)

Latitude: 22° 56' 29" S

Longitude: 43° 20' 54" W

Transmitting antenna (arrangement 1 and arrangement 2)

Height: 15 m above ground level

Azimuth: 180°

Cable loss: 1 dB

4.2.2.2 Equipment available in the stations

Transmitter Site 1 (Morro do Sumaré - Rio de Janeiro - RJ - Brazil)

Power amplifiers: NEC DLP-240 (200 W OFDM RMS per polarization per channel)

2-way combiner: NEC TXG-240

Input connector: BNC

Input RF level: -7 dBm (OFDM RMS)

Frequency range: 474–858 MHz

Gain: 60.8 dB

Transmitter Site 2 (Igreja Nossa Senhora da Penna - Rio de Janeiro - RJ - Brazil)

Power amplifiers: NEC DLP-120 (100 W OFDM RMS per polarization per channel)

2-way combiner: NEC HPC-1056

Input connector: BNC

Input RF level: -7 dBm (OFDM RMS)

Frequency range: 474–858 MHz

Gain: 57.8 dB

NOTE: The proponent can send its own power amplifiers and 2-way combiners to be used in the test if it wishes. In this case, the output power must be in the range between 100 and 500 W OFDM RMS and the transmission frequencies available for the test must be observed, as specified in 4.2.2.1.

4.2.2.3 Equipment to be provided by the proponent

The technology proponent shall deliver, for the field tests purpose, a set of two (2) Multiplexers (using the IP-based Transport Layer technology selected by the proponent), two (2) Exciters, two (2) Receivers, and a set of four (4) MIMO receiving antennas – two (2) antennas referred as “MIMO Indoor Antenna” (one horizontal / vertical dual-polarized antenna and one +45° / -45° dual-polarized antenna) that may have some directivity, and two (2) antennas referred as “MIMO Omnidirectional Antenna” (one horizontal / vertical dual-polarized antenna and one +45° / -45° dual-polarized antenna) for drive tests purpose, considered adequate by the technology proponent for the proposed system. The proponent shall provide a complete characterization of all the antennas provided (including impedance, gain, frequency response, horizontal / vertical diagrams, cross-polarization discrimination, and, if it is an active antenna, its noise figure and P1dB). The SBTVD Forum may also use other indoor MIMO antennas manufactured by other providers, for reference.

The Exciters should be equipped with linearization circuits to interface with the power amplifiers specified in 4.2.2.2 unless the proponent decides to provide its own power amplifiers and 2-way combiners to be used in the test.

The technology proponent shall provide the RF Capturing Device adapted for MIMO signal recording.

The conduction of the field tests will require a special test tool for the drive test, specified in 4.2.4.4.

The special test tool should be a PC with application software, provided by the technology proponent, to be connected to the Receiver. The PC shall monitor and record modulation parameters - to be determined according to the modulation technology used by the proposed technology, errored bits, errored packets, total quantity of packets received in the one-second interval, C/N of the channel being received, received level, and others parameters according to the proposed technology. The data should be refreshed at each one-second interval.

A GPS system consisting of a GPS antenna, a GPS receiver, and a PC with application software shall be prepared. In the PC date, hour, car speed, longitude, latitude, number of locked GPS satellites, GPS satellite signal quality, orientation, channel lock state shall be collected and recorded, at each one-second interval.

4.2.3 Laboratory Tests

The laboratory tests shall be conducted using the test streams provided by the technology proponent, as informed in 4.2.1.1. In all tests, there is a need to supply the specified equipment, both the equipment under test and the test equipment, the synchronization signal of 10 MHz and 1 PPS / NTP. Such connections are not presented in the test setups, to simplify the figures.

4.2.3.1 Device Verification Tests

Five test items were established for the device (Exciter) verification. All the tests shall be conducted in the parameters established in Table 7.

Table 7: Device test parameters configuration

Transmission Configuration	Channel and Level
SISO	VHF Ch 10 and UHF Ch 33, at the maximum nominal output power

4.2.3.1.1 RF frequency accuracy (precision)

The RF frequency precision should be measured with an RF frequency counter. The Devices Under Test (DUT) as well as the frequency counter shall be connected to GPS 10 MHz reference. Refer to Figure 7 for the test set up.

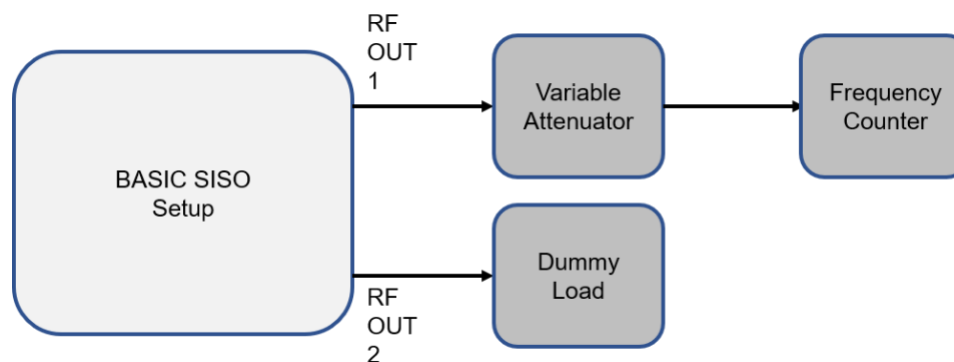


Figure 7: RF frequency accuracy test setup

The test results shall be recorded according to the Table 8 template.

Table 8: Template for recording RF frequency accuracy (precision) results

Channel	Measured Frequency	Deviation (ppm)
10 (192-198 MHz)		
33 (584-590 MHz)		

4.2.3.1.2 Phase noise of local oscillators

The phase noise of the Local oscillator should be measured at the Local Oscillator 50 Ω monitor output. Alternatively, if the Local Oscillator does not have a 50 Ω monitor output, it can be measured at the RF OUT. In the latter case, the modulator shall have a Continuous Wave (CW) output setting. Figure 8 shows the test set up for the measurement at the RF OUT. The Variable Attenuator should be adjusted for a level adequate to the Spectrum Analyzer in use. Care should be taken to adjust the Sweep Bandwidth, Resolution Bandwidth, and Sweep Time for this measurement.

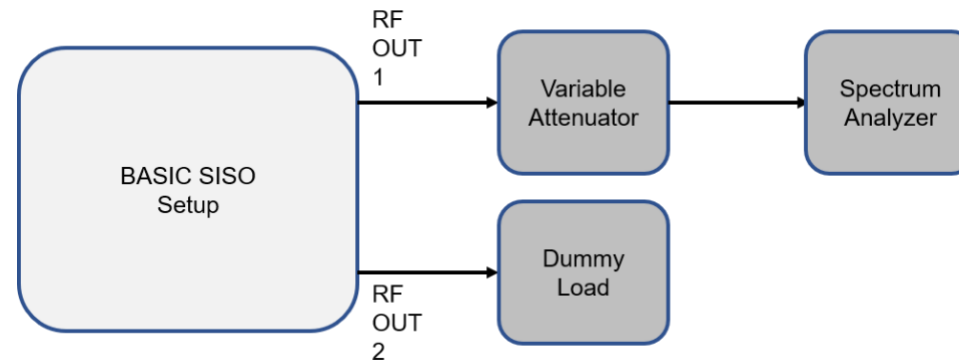


Figure 8: RF OUT spectrum test setup

Capture the Spectrum Analyzer display picture for channels 10 and 33.

4.2.3.1.3 RF/IF signal power

The RF/IF signal power shall be measured at the IF OUT1 or RF OUT 2. In the case of RF signal power, the measurement shall be done at the RF OUT 1 using the Figure 8 test set up without the Variable Attenuator. In the case of IF signal power, use the test set up in Figure 9. The loss of the Impedance Adaptor should be measured beforehand and subtracted from the result in the IF signal power measured.

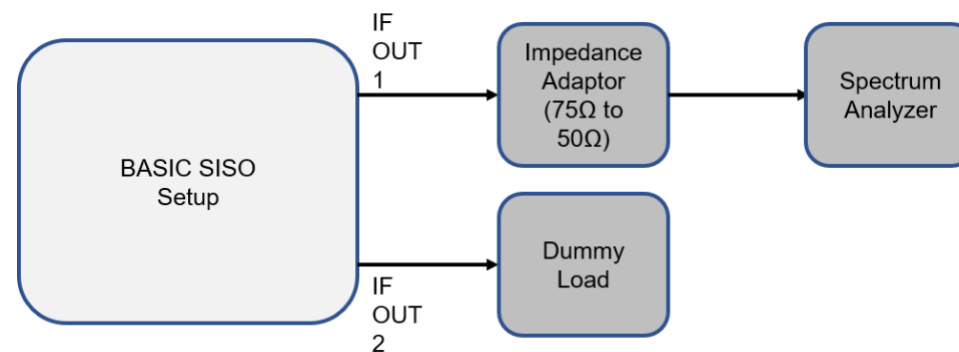


Figure 9: IF signal power test setup

Record the RF/IF signal power test results according to the Table 9 template.

Table 9: Template for recording RF/IF signal power measurement results

Channel	Measured Power (dBm)
IF (41-47 MHz)	
10	
33	

4.2.3.1.4 RF out of band emissions and linearity characterization (Spectrum Mask)

The RF out-of-band emissions and the spectrum mask shall be measured using the test setup of Figure 8.

The RF out-of-band emissions measurement and specifications shall be in conformance to the ITU-R Recommendation SM.1541-6 (Unwanted emissions in the out-of-band domain), specifically its Annex 6 (OoB domain emission limits for television broadcasting systems).

At this point, there is no spectrum mask defined for TV 3.0, which will depend upon the technology and the specifications of the proposed Physical Layer. The proponent shall propose an emission spectrum mask at the Exciter RF OUT. In any case, the specifications PL1.3 and PL1.4 must be satisfied.

Capture the Spectrum Analyzer display picture for channels 10 and 33.

4.2.3.1.5 I/Q analysis – Constellation and MER

The Physical Layer proponent should provide for SBTVD Forum a Test Tool for the measurement of Constellation and MER. The Test Tool should be an Application Software to be installed on a PC to be connected by a universal interface (USB, Ethernet, etc.) to the Receiver provided by the proponent. Figure 10 shows the test setup.

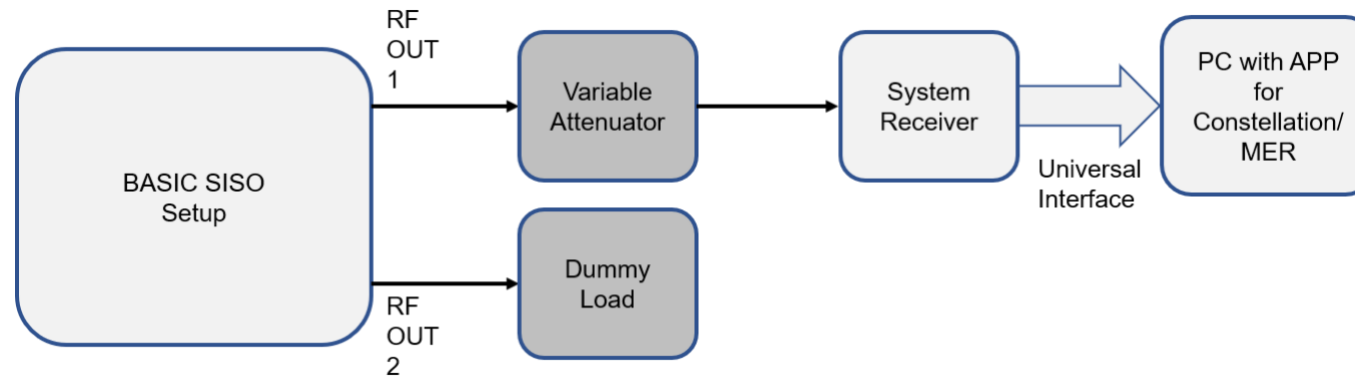


Figure 10: Constellation and MER test setup

Capture the application display picture for channels 10 and 33.

4.2.3.2 Evaluation Tests

4.2.3.2.1 C/N - Carrier power vs AWGN

The C/N – Carrier Power vs AWGN test shall be conducted with SISO and MIMO configurations for the VHF Ch 7, 13 and UHF Ch 14, 33, 51, and System Receiver RF IN 1 and RF IN 2 levels of -28, -53, -68, -83 dBm.

The test setup for the SISO configuration is shown in Figure 11, and for MIMO configuration in Figure 12.

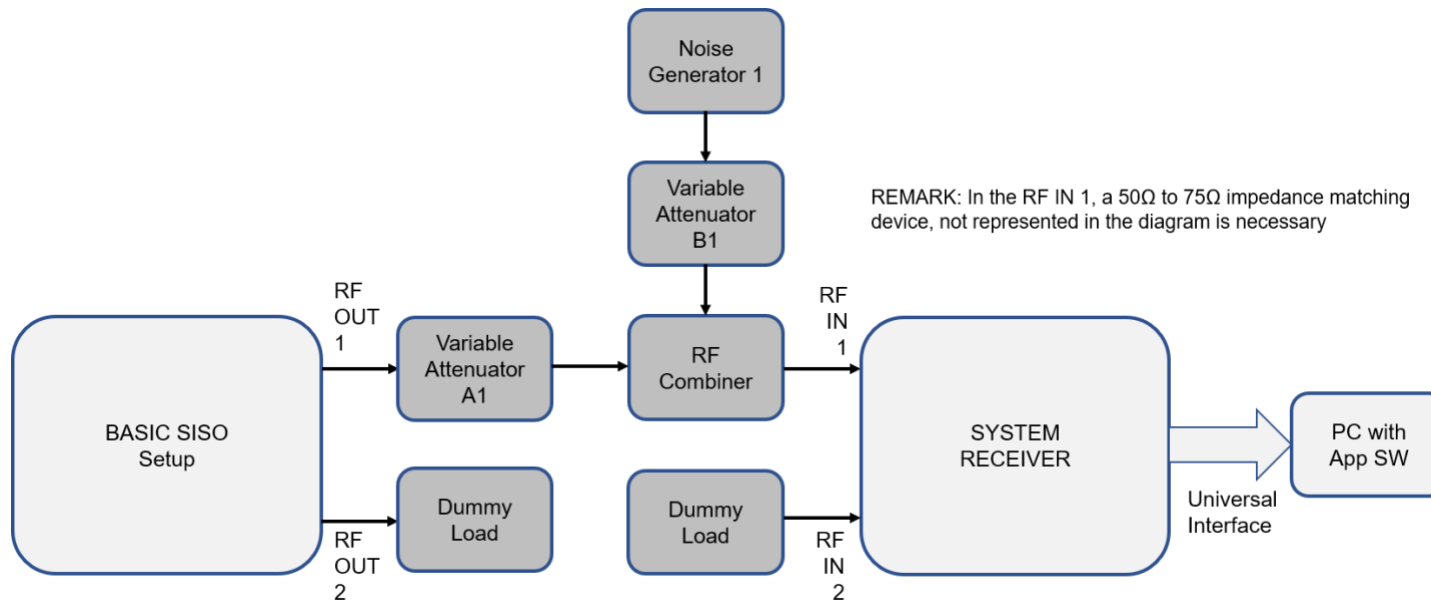


Figure 11: C/N – Carrier power vs AWGN test setup for SISO configuration

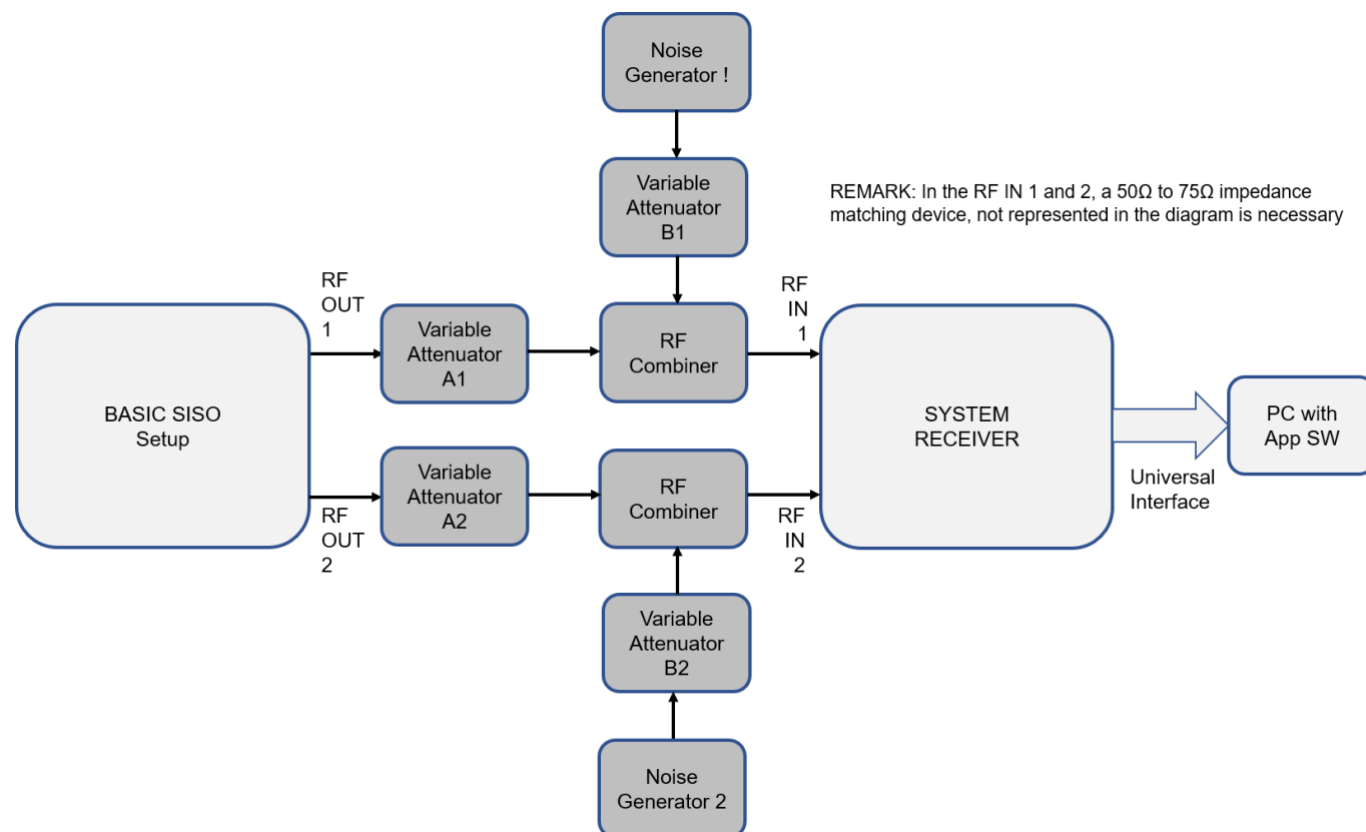


Figure 12: C/N – Carrier power vs AWGN test setup for MIMO configuration

Test Procedure (for SISO and MIMO):

- Configure the modulation parameters to one of the configurations that offers $C/N \leq 0$ dB, set the maximum output level, and set to the VHF Ch 7;
- Register the modulation parameters used and the corresponding net bitrate;
- Set AWGN Noise Generator frequency to the selected channel, and maximum output power, and the Variable Attenuator B1 (and B2) to the maximum attenuation;
- Adjust the Variable Attenuator A1 (and A2) in order to obtain -28 dBm in the RF IN1 (and RF IN2) of the System Receiver;

- e) Start to reduce the attenuation of the Variable Attenuator A1 (and simultaneously and synchronized attenuation of A2), in steps of 0.1 dB, up to the receiver QEF;
- f) Register the input level of RF IN 1 (and RF IN 2 – which must be the same value of RF IN 1), 0.1 dB before the QEF point, and compute the C/N;
- g) Register the C/N (dB) computed according to the template in Table 10 (apply the same template for SISO and for MIMO);
- h) Repeat the test for other channels, and levels specified in step (a);
- i) Repeat the test for other modulation configurations.

Table 10: Template for recording C/N – Carrier power vs AWGN test results (SISO or MIMO)

Channel	RF IN Level (dBm)	C/N (dB)
7	-28	
	-53	
	-68	
	-83	
.	.	.
.	.	.
.	.	.
51	-28	
	-53	
	-68	
	-83	

4.2.3.2.2 C/N - Carrier power vs Rayleigh and AWGN

The C/N – Carrier Power vs Rayleigh and AWGN test shall be conducted with SISO and MIMO configurations for the VHF Ch 7, 13 and UHF Ch 14, 33, 51, and System Receiver RF IN 1 and RF IN 2 levels -28, -53, -68, -83 dBm.

The test set up for the SISO configuration is shown in Figure 13, and for MIMO configuration in Figure 14.

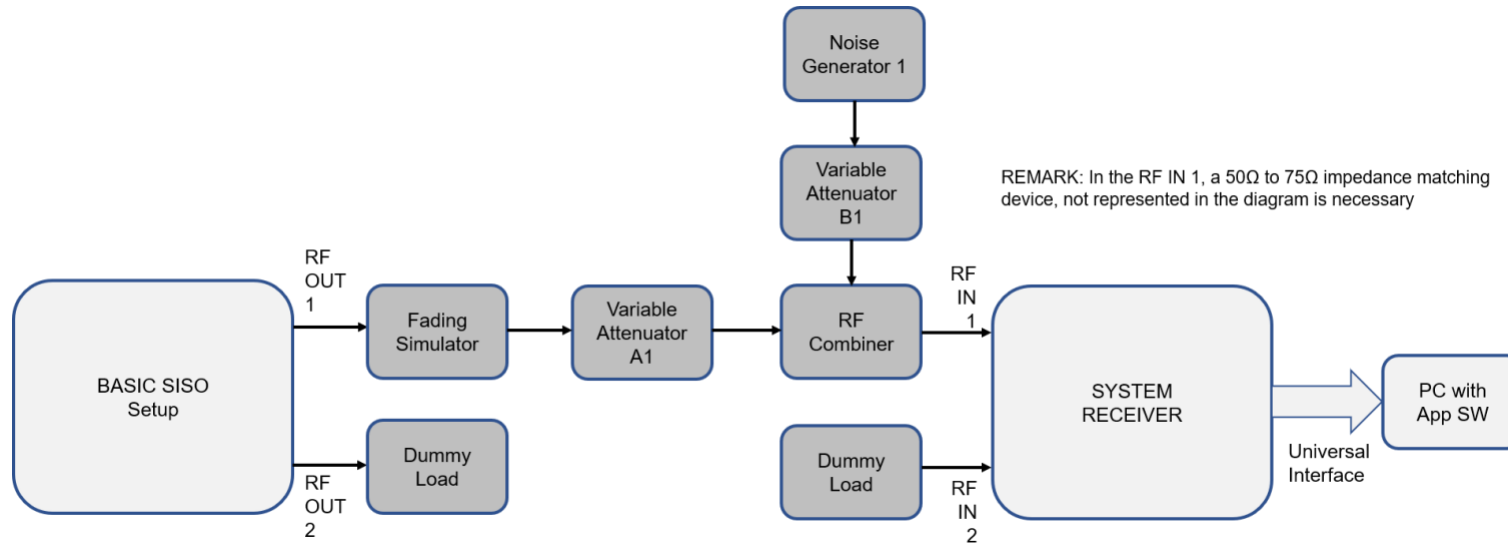


Figure 13: C/N – Carrier power vs Rayleigh and AWGN test setup for SISO configuration

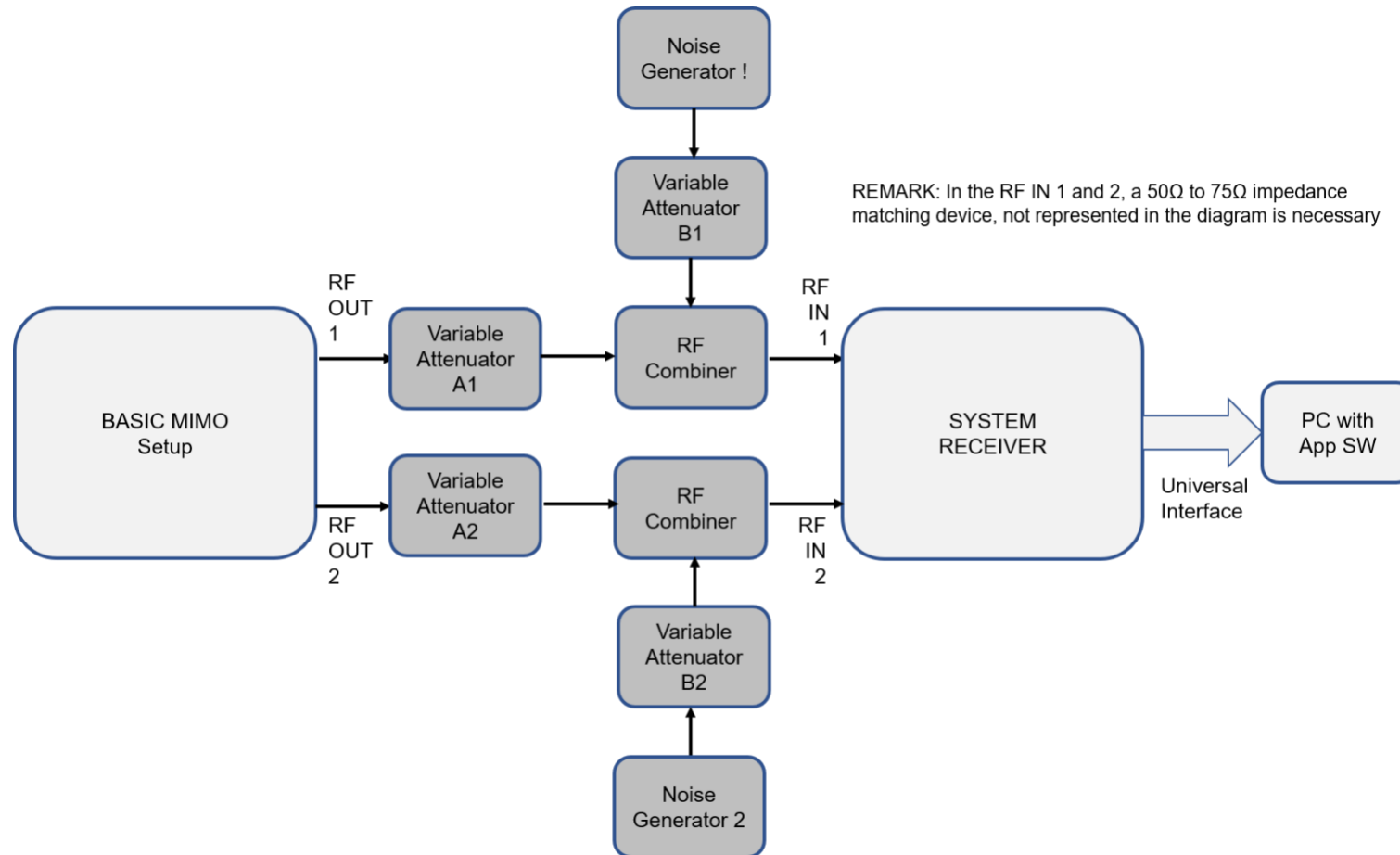


Figure 14: C/N – Carrier power vs Rayleigh and AWGN test setup for MIMO configuration

Test Procedure (for SISO):

- a) For SISO configuration the tests shall be conducted for Fading Simulator configured in RF1, RF2A, RF2B, RF3A, RF3B, and RF4, presented in Table 1 to Table 6;
- b) Start setting the configuration of the Fading Simulator to the channel ensemble RF1;
- c) Configure the modulation parameters to one of the configurations that offers $C/N \leq 0$ dB, set the maximum output level, and set to the VHF Ch 7;

- d) Register the modulation parameters used and the corresponding net bitrate;
- e) Set AWGN Noise Generator frequency to the selected channel, and maximum output power, and the Variable Attenuator B1 to the maximum attenuation;
- f) Adjust the Variable Attenuator A1 in order to obtain -28 dBm in the RF IN1 of the System Receiver;
- g) Start to reduce the attenuation of the Variable Attenuator B1, in steps of 0.1 dB, up to the receiver QEF;
- h) Register the thermal noise input level at RF IN 1 (and RF IN 2 – which must be the same value of RF IN 1), 0.1 dB before the QEF point, using a Spectrum Analyzer with channel power set to the system bandwidth, and compute the C/N;
- i) Register the C/N (dB) computed in the table of test results (use the template shown in Table 10), prepared for the corresponding channel ensemble;
- j) Repeat the test for other channels, and levels specified in the step "b";
- k) Repeat the test for other modulation configurations;
- l) Repeat the test for other channel ensembles.

Test Procedure (for MIMO):

- a) For MIMO configuration the tests shall be conducted for Fading Simulator FD1 and FD2, both configured for the same RF2A and repeated for RF2B, RF3A, and RF3B. These channel ensembles configurations are presented in Table 2 to Table 5. The channel ensembles chosen corresponds for fixed indoor antenna and mobile outdoor environments, which are the main receiving environment targets for TV 3.0;

NOTE: The propagation impairments applied to both MIMO channels are completely correlated. It does not represent the real environment but should be one case to analyze. If the proponent has a more representative propagation model for laboratory testing to propose, the SBTVD Forum is willing to study it. Performing such a test will depend on the availability of the corresponding simulator.

- b) Start the testing session with channel ensemble RF2A;
- c) Configure the modulation parameters to one of the configurations that offers $C/N \leq 0$ dB, set the maximum output level, and set to the VHF Ch 7;
- d) Register the modulation parameters used and the corresponding net bitrate;

- e) Set AWGN Noise Generator frequency to the selected channel, and maximum output power, and the Variable Attenuator B1 (and B2) to the maximum attenuation;
- f) Adjust the Variable Attenuator A1 and A2 in order to obtain -28 dBm in the RF IN1 and RF IN2 of the System Receiver;
- g) Start to reduce the attenuation of the Variable Attenuator B1, and simultaneously and synchronously attenuate B2, in steps of 0.1 dB, up to the receiver QEF;
- h) Register the thermal noise input level at RF IN 1 (and RF IN 2 – which must be the same value of RF IN 1), 0.1 dB before the QEF point, using a Spectrum Analyzer with channel power set to the system bandwidth, and compute the C/N;
- i) Register the C/N (dB) computed in the table of test results (use the template shown in Table 10), prepared for the corresponding channel ensemble;
- j) Repeat the test for other channels, and levels specified in the step "b";
- k) Repeat the test for other modulation configurations;
- l) Repeat the test for another channel ensembles.

4.2.3.2.3 Receiver maximum and minimum level

The receiver maximum and minimum level test shall be conducted with SISO and MIMO configurations for the VHF Ch 7, 13, and UHF Ch 14, 33, 51.

The test set up for the SISO configuration is shown in Figure 15, and for MIMO configuration in Figure 16.

REMARK: In the RF IN 1, a 50Ω to 75Ω impedance matching device, not represented in the diagram is necessary

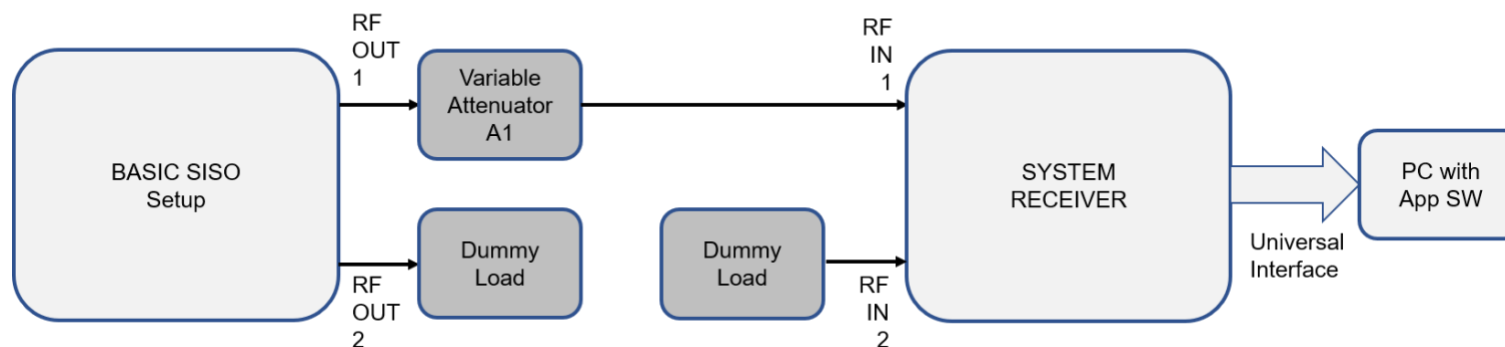


Figure 15: SISO configuration test set up for maximum and minimum level

REMARK: In the RF IN 1 and 2, a 50Ω to 75Ω impedance matching device, not represented in the diagram is necessary

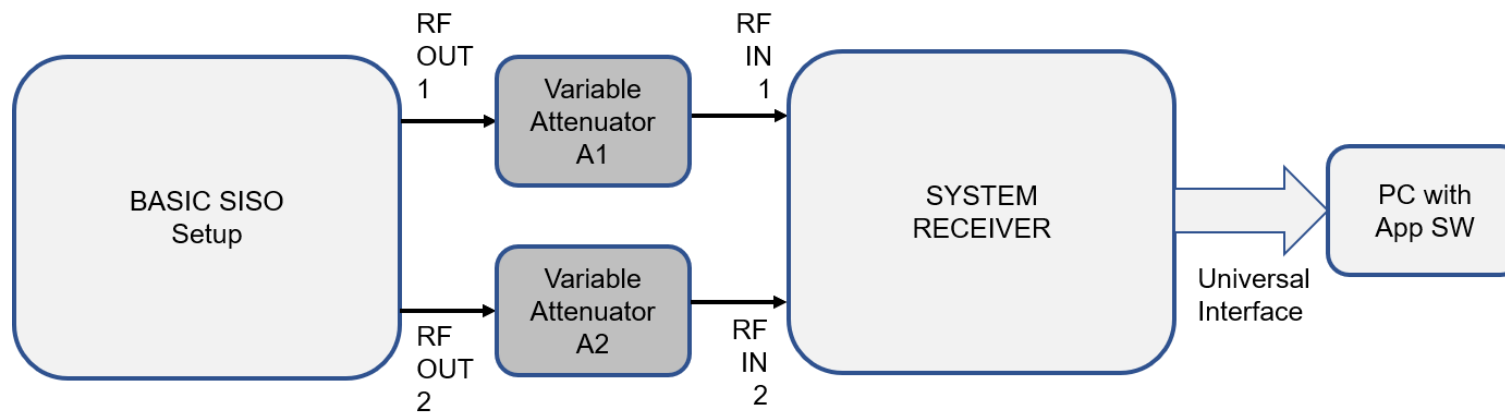


Figure 16: MIMO configuration test setup for maximum and minimum level

Test Procedure (for SISO and MIMO) for maximum level:

- a) Configure the modulation parameters to one of the configurations that offers $C/N \leq 0$ dB, set the maximum output level, and set to the VHF Ch 7;

- b) Register the modulation parameters used and the corresponding net bitrate;
- c) Adjust the Variable Attenuator A1 (and A2) in order to obtain -28 dBm in the RF IN1 (and RF IN2) of the System Receiver;
- d) Start to reduce the attenuation of the Variable Attenuator A1 (and simultaneously and synchronized attenuation of A2), in steps of 0.1 dB, up to the receiver QEF;
- e) Register the input level of RF IN 1 (and RF IN 2 – which must be the same value of RF IN 1), 0.1 dB before the QEF point, as the maximum level;
- f) Repeat the test for another channel;
- g) Repeat the test for other modulation configurations.

Test Procedure (for SISO and MIMO) for minimum level:

- a) Configure the modulation parameters to one of the configurations that offers $C/N \leq 0$ dB, set the maximum output level, and set to the VHF Ch 7;
- b) Register the modulation parameters used and the corresponding net bitrate;
- c) Adjust the Variable Attenuator A1 (and A2) in order to obtain -28 dBm in the RF IN1 (and RF IN2) of the System Receiver;
- d) Start to raise the attenuation of the Variable Attenuator A1 (and simultaneously and synchronized attenuation of A2), in steps of 0.1 dB, up to the receiver QEF;
- e) Register the input level of RF IN 1 (and RF IN 2 – which must be the same value of RF IN 1), 0.1 dB before the QEF point, as the minimum level;
- f) Repeat the test for other channels;
- g) Repeat the test for other modulation configurations.

4.2.3.2.4 Co-channel Interference with own system

The Co-channel interference with own system test shall be conducted with SISO and MIMO configurations for the VHF Ch 10 and UHF Ch 33, and System Receiver RF IN 1 and RF IN 2 levels of -53 dBm.

The test set up for the SISO configuration is shown in Figure 17, and for MIMO configuration in Figure 18.

The test shall be conducted with two different contents and the complete time synchronization between the desired and undesired signal, as well as without time synchronization between the signals.

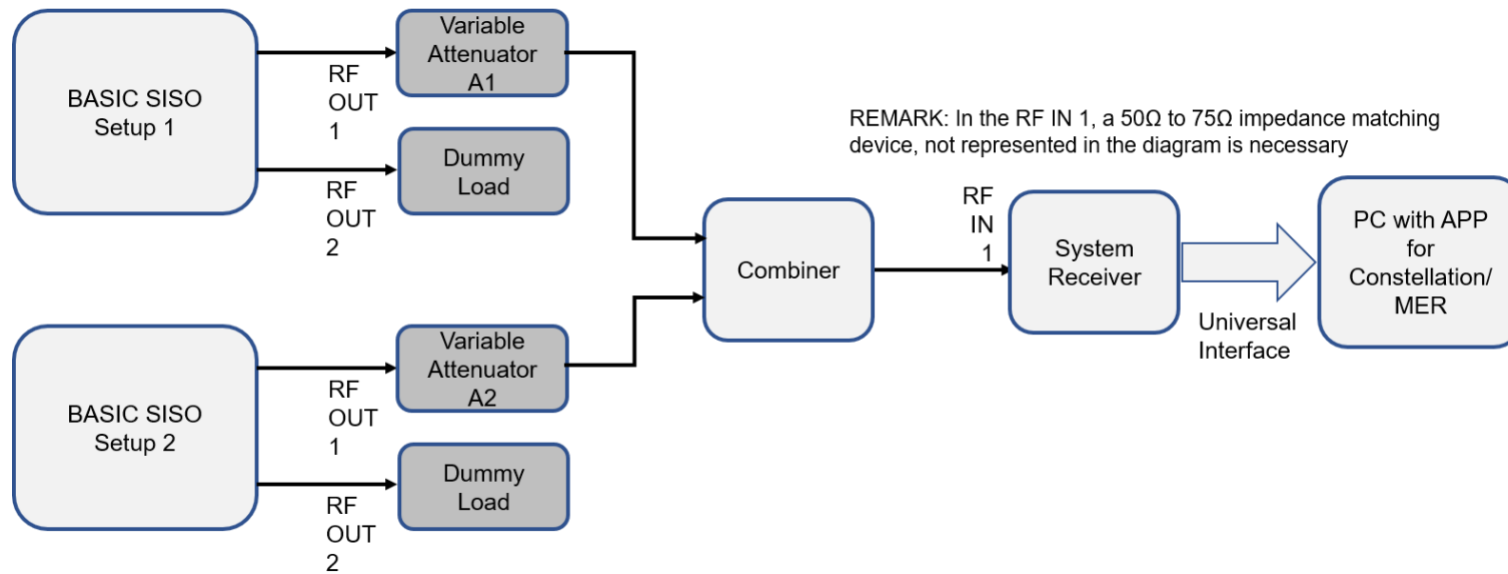


Figure 17: SISO configuration co-channel interference with own system test setup

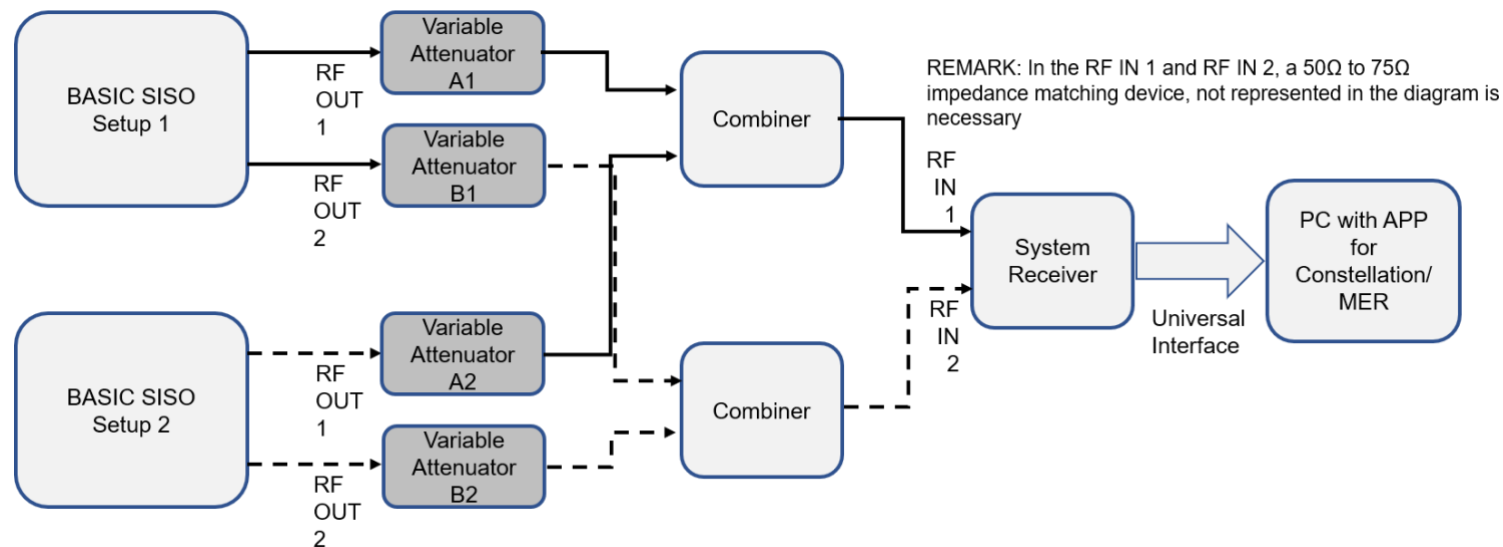


Figure 18: MIMO configuration co-channel interference with own system test setup

Test Procedure for SISO and MIMO:

- a) Start the test with complete synchronization between the desired and undesired signals;
- b) Configure the modulation parameters to one of the configurations that offers $C/N \leq 0$ dB, and set both of Exciter to the maximum output level and to the VHF Ch 10;
- c) Register the modulation parameters used and the corresponding net bitrate;
- d) Consider the output of Exciter of “Basic SISO SETUP 1” as desired (D) signal and of the output of “Basic SISO SETUP 2” as undesired or interference (U) signal;
- e) Set Variable Attenuator A1 (and A2) in order that the RF IN 1 (and RF IN 2) input level be -53 dBm. This is the Signal D level;
- f) Start decreasing Variable Attenuator B1 (and synchronously B2), at 0.1 dB steps, until the receiver reaches the QEF.
- g) Set the Variable Attenuator A1 (and A2) to the maximum attenuation and measure with a Spectrum Analyzer the level at RF IN 1 (and RF IN 2) of the U signal;
- h) Compute the receiver D/U and register in the test result table. Use the template of Table 11;

- i) Repeat the test for UHF Ch 33;
- j) Repeat all the tests with the undesired signal without time synchronization.

Table 11: Template for test results of co-channel interference of own system

Channel Number	D/U (dB)
10	
33	

4.2.3.2.5 Co-channel and adjacent channel interference (at $N\pm 1$ and $N\pm 2$ channels) to ISDB-T

The co-channel interference test with ISDB-T shall be conducted with the proposed system in SISO configuration and for the desired ISDB-T signal (D) at VHF Ch 10 and UHF Ch 33, with desired ISDB-T receiver input level of -53 dBm.

The test set up is shown in Figure 19.

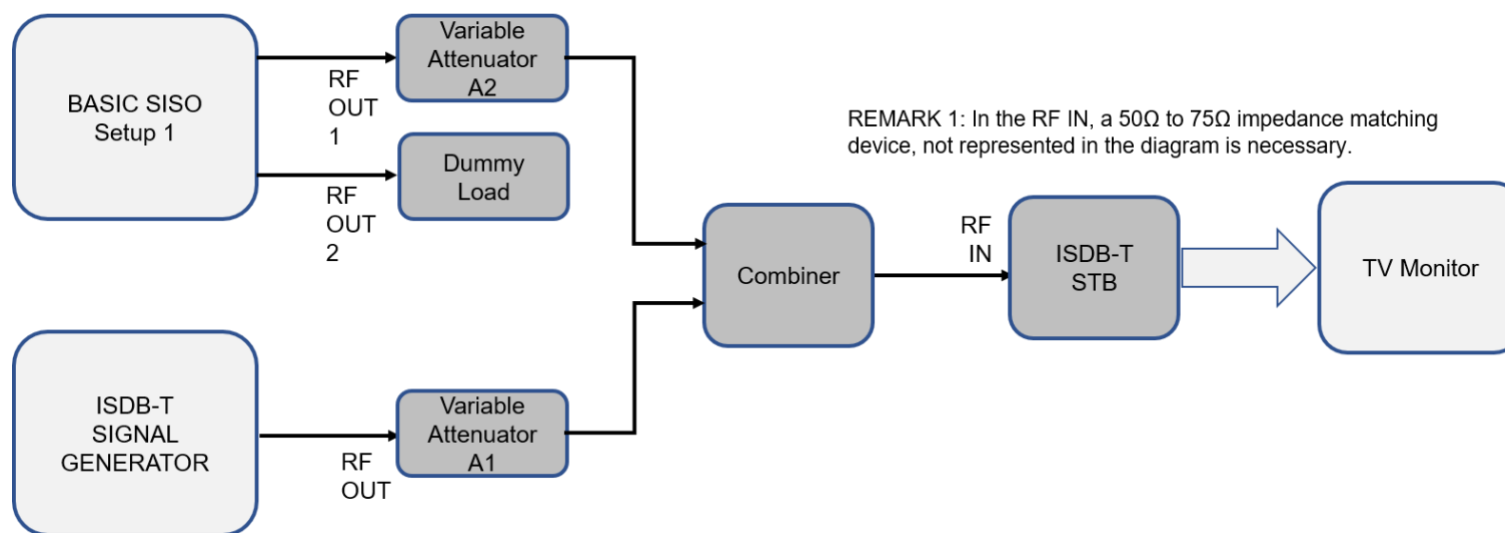


Figure 19: Test setup for co-channel and adjacent channel interference (at $N\pm 1$ and $N\pm 2$ channels) with ISDB-T

Test procedure:

- a) The ISDB-T desired signal should be a dynamic zone plate and set to Ch 10;

- b) Configure the ISDB-T signal generator for: Mode 3, 1 x Layer A = 13 segments, 64QAM, CR = 3/4, GI = 1/8, I = 0;
- c) Configure the modulation parameters of the proposed TV 3.0 system to one of the configurations that offers $C/N \leq 0$ dB, and set both of Exciter to the maximum output level and to the VHF Ch 10. This is the undesired or interfering signal (U);
- d) Register the modulation parameters used and the corresponding net bitrate;
- e) Adjust Variable Attenuator A2 to maximum attenuation;
- f) Adjust Variable Attenuator A1 in order that the level of the D signal be -53 dBm in the input of the ISDB-T STB;
- g) Adjust the Variable Attenuator A2, of the U signal, decreasing its attenuation until the Threshold of Visibility (TOV) condition is reached;
- h) Adjust the Variable Attenuator A1, of the D signal, to the maximum attenuation and read the level of the interfering channel in the Signal Analyzer. This is the "U (dBm)" level;
- i) Compute the D/U ratio for the co-channel interference for Ch 10 and register in the test result table. Use the template shown in Table 12.
- j) For the adjacent channel interference tests, set the desired signal (D) to the channel 10, and the interfering signal (U) to the channel 9, for (N-1), or channel 8, for (N-2), for the lower adjacent channel interference test, or to the channel 11, for (N+1), or channel 12, for (N+2), for the upper adjacent channel interference tests;
- k) Adjust Variable Attenuator A2 to maximum attenuation;
- l) Adjust Variable Attenuator A1 and set the receiver input level of D signal to -53 dBm using a Signal Analyzer;
- m) Adjust Variable Attenuator A2, corresponding to the U signal, decreasing its attenuation until the TOV condition is reached;
- n) Adjust Variable Attenuator A1 to the maximum attenuation and read the level of the interfering channel in the Signal Analyzer. This is the "U (dBm)" level;
- o) Compute the D/U ratio for the adjacent channel interference for Ch 10 and register in the test result table. Use the template shown in Table 12;
- p) Repeat the test for the D signal set to Ch 33 and the U signal to Ch 31 to 35.

Table 12: Template for results of co-channel and adjacent channel interference to ISDB-T

Protection Ratio D/U (dB)		
Desired Channel	Interferer Channel	Receiver D/U (dB)
VHF (Digital CH in Test – CH 10)	CH8	
	CH9	
	CH10	
	CH11	
	CH12	
UHF (Digital CH in Test – CH33)	CH31	
	CH32	
	CH33	
	CH34	
	CH35	

4.2.3.2.6 Impulse noise

The impulse noise interference test shall be performed with SISO configuration, in VHF Ch 10 and UHF Ch 33, and the desired signal level at RF IN 1 of the System Receiver at -53 dBm.

The test shall be conducted with an Impulse Noise Generator, which switches ON and OFF an AWGN noise creating periodic bursts of impulse noise. The interferent impulse noise has a variable pulse width P_w of 1 μ s to 900 μ s and the impulse noise repetition period T of 10 ms (100 Hz). The equivalent noise power N_{eq} is obtained by measuring the power of the AWGN noise, at 6 MHz of bandwidth, before noise switching.

The test setup is shown in Figure 20.

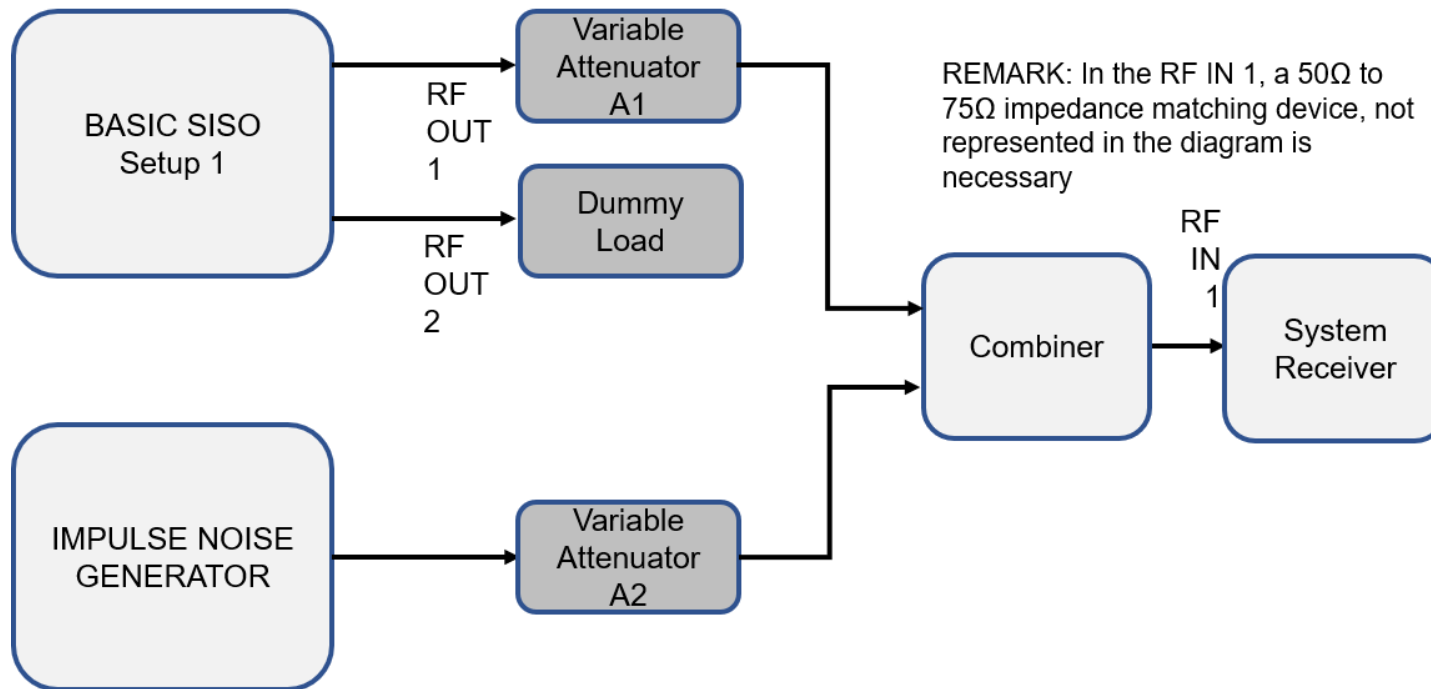


Figure 20: Impulse noise test setup

The impulse noise pulse patterns used are shown in Table 13.

Table 13: Impulse noise pulse patterns

Noise Type	Model	Pulse Spacing (μs)	Burst Duration (pulses per burst)	Burst Duration (μs)	Effective Burst Duration
N1	Central Heating 2	25 \pm 10	6	75.25 – 175.25	1500 ns
N2	Central Heating 3	2 \pm 0.5	2	1.75 – 2.75	500 ns
N3	Gas Range Ignition	1.5 \pm 0.5	20	19.25 – 38.25	5000 ns
N4	Dishwasher	12.5 \pm 2.5	10	90.25 – 135.25	2500 ns
N5	Fluorescent lights	25 \pm 20	2	5.25 – 45.25	500 ns
N6	Traffic 3A	7.5 \pm 2.5	2	5.25 – 10.25	500 ns
N7	Traffic 3B	N/A	1	N/A	250 ns
N8	Variable Impulse Noise	10 000	1	N/A	1 – 900 μs

Test procedure:

- a) Configure the modulation parameters to one of the configurations that offers $C/N \leq 0$ dB, and set the Exciter to the maximum output level and to the VHF Ch 10;
- b) Register the modulation parameters used and the corresponding net bitrate;
- c) Adjust the Variable Attenuator A2 to maximum attenuation;
- d) Adjust the Variable Attenuator A1 in order that the desired signal level (D) in the RF IN 1 of the System Receiver be -53 dBm;
- e) Set the Impulse Noise Generator to the maximum output power of AWGN, and then set the impulse noise pulse pattern noise type to N1;
- f) Start decreasing the attenuation of Variable Attenuator A2, in steps of 0.1 dB, until the System Receiver reaches the QEF;
- g) Set the Variable Attenuator A1 to maximum attenuation, stop the switching of the AWGN signal in the Impulse Signal Generator, and measure the N_{eq} with a Spectrum Analyzer in channel power mode with 6 MHz bandwidth;
- h) Register the C/N_{eq} , which is the difference between -53 dBm – TV signal power and N_{eq} , in the test result template as shown in Table 14;

- i) Continue the test for other impulse noise pulse pattern noise types until N7;
- j) For the impulse noise pulse pattern noise type N8, it is suggested to use the effective burst duration value of 1 μ s, then 10 μ s, 20 μ s, in steps of 10 μ s until 100 μ s. Then in steps of 50 μ s until 500 μ s. After 500 μ s, steps of 100 μ s are suggested;
- k) Repeat the test for UHF Ch 33.

Table 14: Template for impulse noise test result

VHF Ch 10		UHF Ch 33	
Noise Type	C/Neq (dB)	P _w (μ s)	C/Neq (dB)
N1			
N2			
N3			
N4			
N5			
N6			
N7			
N8 (1 μ s)			
N8 (10 μ s)			
N8 (20 μ s)			
...			
N8 (100 μ s)			
N8 (150 μ s)			
...			
N8 (500 μ s)			
N8 (600 μ s)			
...			
N8 (900 μ s)			

4.2.3.2.7 Single echo static multipath interference

The single echo static multipath interference shall be conducted for SISO configuration, for VHF Ch 10 and UHF Ch 33, and receiving input level of -53 dBm. Measurement of Echo Attenuation for receiving threshold QEF shall be performed for Echo Delay between -1000 μ s and +1000 μ s.

To execute this test, access to the IF frequency of 44 MHz will be necessary. So, the U-Link connected between IF OUT 1 and IF IN 1, in the “Basic SISO setup” of Figure 5, should be removed, and the connection to the Fading Simulator established, as shown in the test set up of Figure 21.

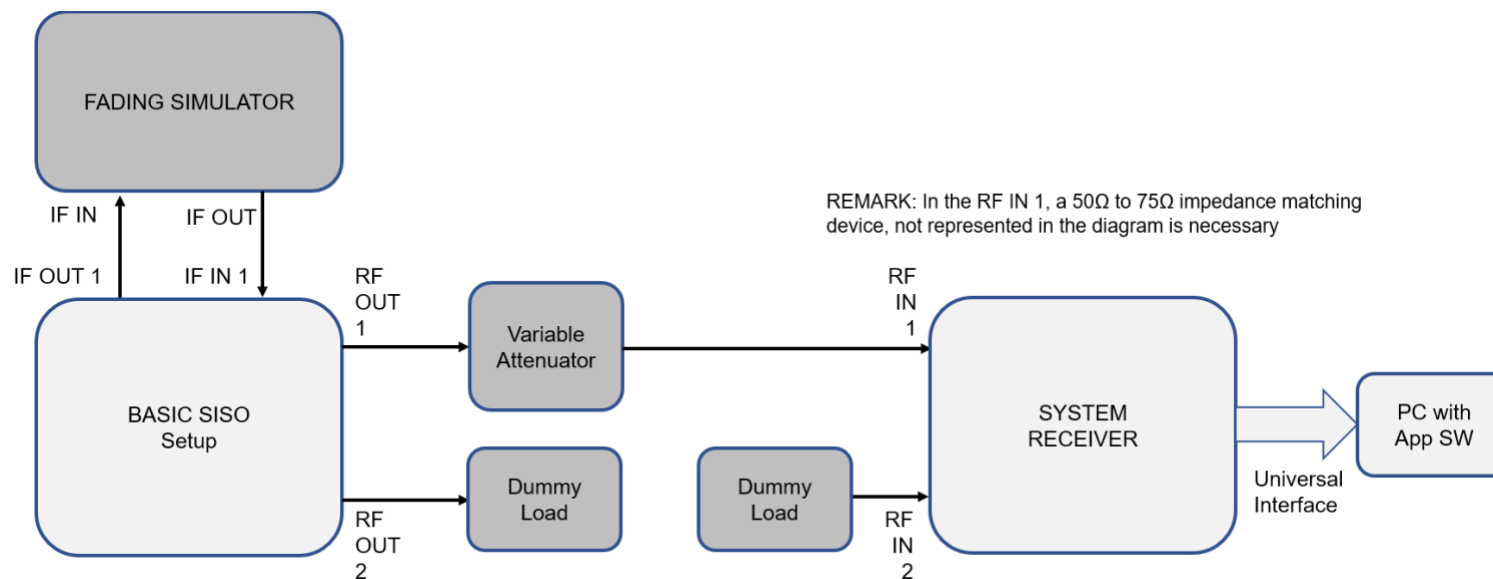


Figure 21: Single echo static multipath interference test setup

Test Procedure:

- a) Configure the modulation parameters to one of the configurations that offers $C/N \leq 0$ dB, and set the Exciter to the maximum output level and to the VHF Ch 10;

NOTE: Considering that the proposed system modulation is based on the OFDM modulation, the system should work without any error with a pre-echo or post-echo interference of the same level, for interference signal delay inside the guard interval. Some OFDM receivers implement equalizers to improve the performance in multipath environments.

- b) Register the modulation parameters used and the corresponding net bitrate;

- c) Set the Fading Simulator to work with the 2 paths: the first path should be considered as the main signal and the second path the interference signal, which delay and level should be varied in relation to the main signal. To start the test, set attenuation, delays, and phases of both signals to zero (0), without any impairment as fading, doppler, or noise;
- d) Adjust the Variable Attenuator in order to obtain a receiving level of -53 dBm in the RF IN 1 input;
- e) Just note that the receiver works properly without any error in such a situation;
- f) Then, apply delays (post-echo or pre-echo), inferior to the guard interval (set in the modulator) to the interference path of the Fading Simulator, and verify that the receiver works without any error;
- g) Register these results (0 dB Echo Attenuation) in the test result table. Use the template shown in Table 15;
- h) Continue the test applying delays (pre-echo or post-echo) above the guard interval of the modulation. To start the measurements set maximum attenuation on the interference path of the Fading Simulator. Then start setting delays with 50 μ s displacement over the guard interval time. Then, reduce the interference path attenuation in steps of 0.1 dB, until the receiver reaches the QEF. Register the attenuation value of the interference path as Echo Attenuation in the correspondent delay row, in the test result table;
- i) For delays values exceeding the triple of the guard interval, it is recommended to set delays in 100 μ s step;
- j) Repeat the test for other modulation parameters recommended by the system proponent.

Table 15: Template for single echo static multipath interference test results

Pre-Echo		Post-Echo	
Delay (μ s)	Echo Attenuation (dB)	Delay (μ s)	Echo Attenuation (dB)
0	0.0	0	0.0
-20	0.0	20	0.0
-40	0.0	40	0.0
-63	0.0	63	0.0
-65		65	
-70		70	
-100		100	
--150		150	
-200		200	
-300		300	
-400		400	
-500		500	
.		.	
.		.	
-1000		1000	

4.2.3.2.8 Channel bonding

The channel bonding tests shall be performed in MIMO configuration with 2 Exciters, one operating in the VHF Ch 10 and other in UHF Ch 33, and the receiving input level of -53 dBm.

The test setup is shown in Figure 22.

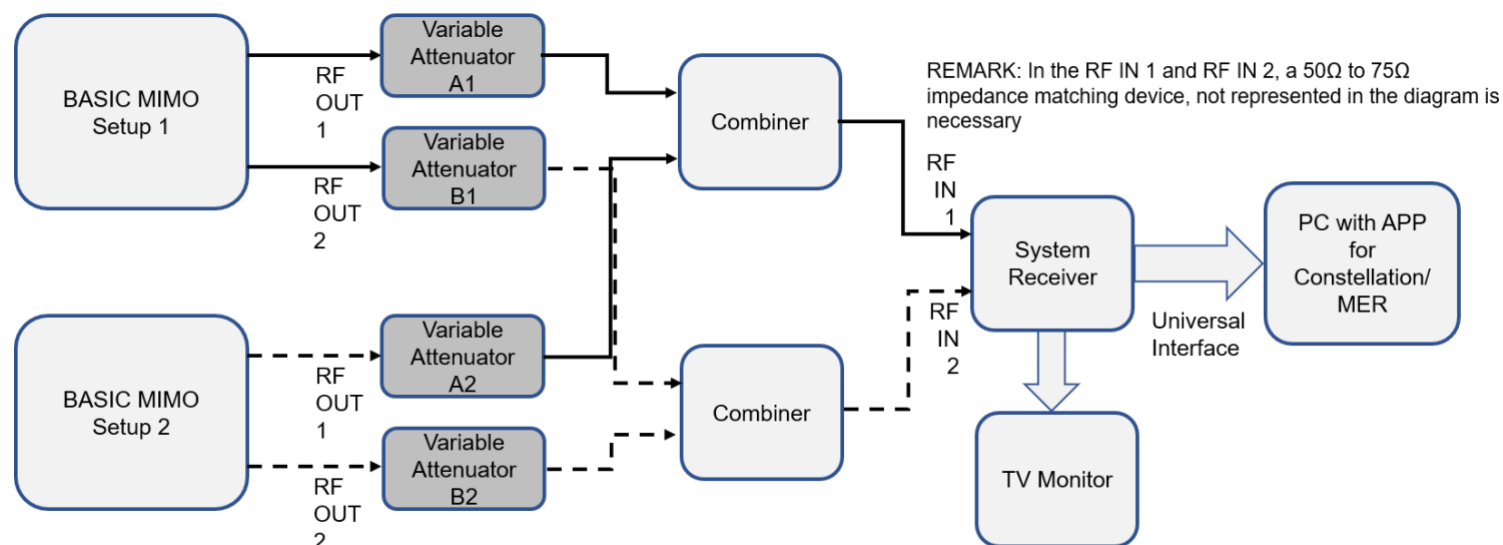


Figure 22: Test setup for channel bonding and channel identification stability

Test procedure:

- Set the special stream provided by the proponent in the Content Storage of the “Basic MIMO setup” and the Multiplexer settings for channel bonding operation with the modulation parameters chosen for the test (provided that $C/N \leq 0$ dB);
- Configure the modulation parameters for the channel bonding operation, and set the Exciter of the “Basic MIMO setup 1” to the VHF Ch 10, and the Exciter of the “Basic MIMO setup 2” to the VHF Ch 33. Both Exciter power output shall be set to the maximum;
- Register the modulation parameters used and the corresponding net bitrate;
- Adjust the Variable Attenuators to have each of the 4 signal levels at each RF IN input of the System Receiver to -53 dBm;
- Configure the System Receiver to operate in channel bonding with Ch 10 and Ch 33;
- Confirm that the receiver operates normally, without any error, and observe that the video, audio, and data are reproduced perfectly;
- In the PC with the application software provided by the proponent, check the video and audio bit rates.

4.2.3.2.9 Channel identification stability in frequency reuse-1 condition

The channel identification stability tests shall be conducted in MIMO configuration with 2 Exciters, both operating in the VHF Ch 10 (or UHF Ch 33), and the receiving input level of -53 dBm for each Exciter RF signals.

Use the test setup shown in Figure 22.

Test procedure:

- a) Set the different content streams for the “Basic MIMO setup” and in the Multiplexer set one station identification as A, and other as B;
- b) Configure the modulation parameters of both “Basic MIMO setup” to the same configuration that offers $C/N \leq 0$ dB, and set the Exciters to the maximum output level and to the VHF Ch 10;
- c) Register the modulation parameters used and the corresponding net bitrate;
- d) Adjust the Variable Attenuators to have each of the 4 signal levels at each RF IN input of the System Receiver to -53 dBm;
- e) Set the System Receiver to open the signal of the station identified as A, and verify in the TV Monitor that the video and audio corresponding to station A is reproduced adequately;
- f) Verify that the reproduction of station A content is reproduced normally for 1 hour;
- g) Set the System Receiver to open the signal of the station identified as B, and verify in the TV Monitor that the video and audio corresponding to station B is reproduced adequately;
- h) Verify that the reproduction of station B content is reproduced normally for 1 hour.

4.2.3.2.10 FM Radio (88 to 108 MHz) Interference

The FM interference test shall be performed with the proposed TV 3.0 system in SISO configuration, and intends to measure the QEF level of the System Receiver for various power levels of DTV signal (-80, -70, -60, -50, -40, -30 and -20 dBm) for VHF channels 7, 13 and UHF channels 15, 33, and 50, as a function of FM interference signal strength.

In this test, an FM Signal Generator will be used. The Generator reproduces a composed FM Radio signal, consisting of 34 FM radio channels - between the channels 201 to 300 (88 to 108 MHz). Each FM signal is modulated by a 1 kHz single tone, with an FM deviation of 75 kHz RMS. Each one of the single tone signals modulating the FM carriers has a random phase. Figure 23 shows the FM Signal Generator output spectrum.

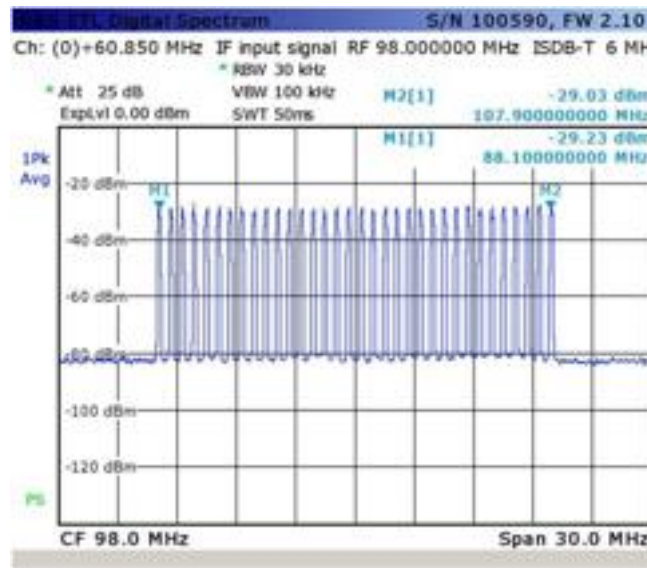


Figure 23: Generated FM Radio signal between 88 to 108 MHz

The test set up is shown in Figure 24.

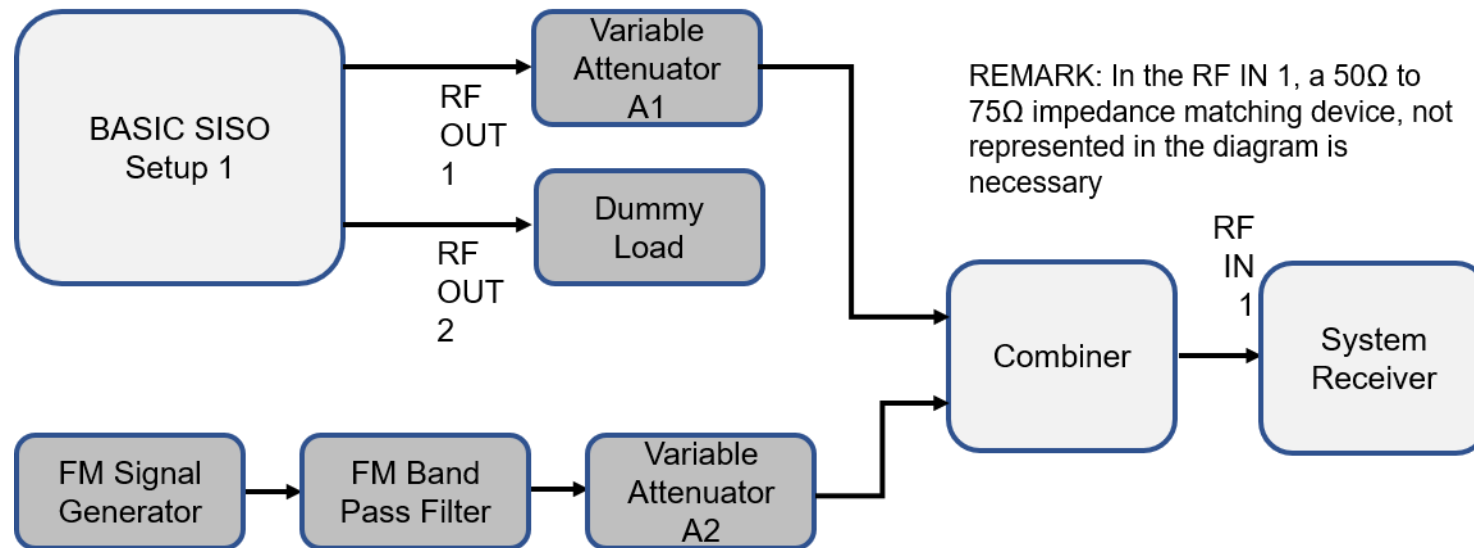


Figure 24: FM interference test setup

Test procedure:

- a) Configure the modulation parameters to one of the configurations that offers $C/N \leq 0$ dB, and set the Exciter to the maximum output level and to the VHF Ch 7;
- b) Register the modulation parameters used and the corresponding net bitrate;
- c) Adjust Variable Attenuator A2 to maximum attenuation;
- d) Adjust Variable Attenuator A1, to obtain -80 dBm in the RF IN 1 input of the System Receiver;
- e) Start reducing the attenuation of Variable Attenuator A2, in steps of 0.1 dB until the System Receiver reach QEF;
- f) Register the QEF level in the corresponding cell of the template shown in Table 16;
- g) Repeat the test for other TV levels of Table 16;
- h) Repeat the test for other VHF and UHF channels.

Table 16: Template for FM interference test results

TV Level (dBm)	TV VHF		TV UHF		
	CH 7	CH 13	CH 15	CH 33	CH 50
	QEF Level (dBm)				
-20					
-30					
-40					
-50					
-60					
-70					
-80					

4.2.4 Field Tests

4.2.4.1 Scope

There will be 4 types of evaluation to be conducted in the field, which are classified as:

a) **Coverage Measurement**

Conducted by using MIMO Indoor antennas, placed at approximately 2 m height above ground. Measurements made along radials, arcs, grids, and clusters and selected indoor environments. A sample containing a large number of measurements needs to be taken to develop statistically significant results. The indoor MIMO antenna provided by the technology proponent shall be used, but SBTVD Forum may use MIMO indoor antennas of other providers, as reference.

b) **Service Measurement**

Process of determining the conditions under which digital television signals can be received and decoded under various actual operating conditions. The MIMO Indoor antenna provided by the technology proponent and others should be used. Use recording equipment to obtain signal level, carrier-to-noise ratio, margin-to-threshold, error rate, and other information. The MIMO Indoor antenna provided by the technology proponent shall be used, but SBTVD Forum may use another MIMO Indoor antenna of other providers, as reference.

c) **Drive Test**

For the drive tests, the proponent shall provide a GPS receiver capable of delivering the position information to a notebook PC. Also, the proponent shall provide a receiver capable of delivering the relevant information to a notebook PC. The MIMO Omnidirectional antenna provided by the technology proponent shall be used, but SBTVD Forum may use MIMO Omnidirectional antennas of other providers, as reference.

d) **RF Capturing**

For determination of channel characterization. Accomplished by detailed measurements of signal characteristics including effects of channel impairments such as level variations, impulse noise, in-band interference, and multipath. The MIMO Indoor antenna provided by the technology proponent shall be used, but SBTVD Forum may use MIMO Indoor antennas of other providers, as reference.

The field tests shall be conducted in Multi-Frequency Network (MFN), Single-Frequency Network (SFN) – with the stations transmitting different contents, and MIMO configuration, in the Rio de Janeiro city, using the available channels 30 (566-572 MHz) and 36 (602-608 MHz). A test car will be prepared for the Coverage Measurements, Service Measurements, and RF Capturing. Rooms for indoor tests for such measurements shall also be prepared. A second test car shall conduct the Drive Test.

The test setups to be used in the field tests are shown in Figure 25, Figure 26, and Figure 27.

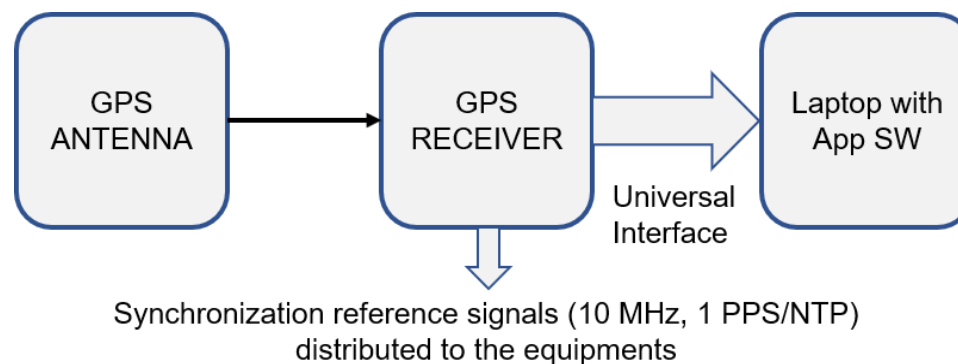


Figure 25: GPS signal receiving setup

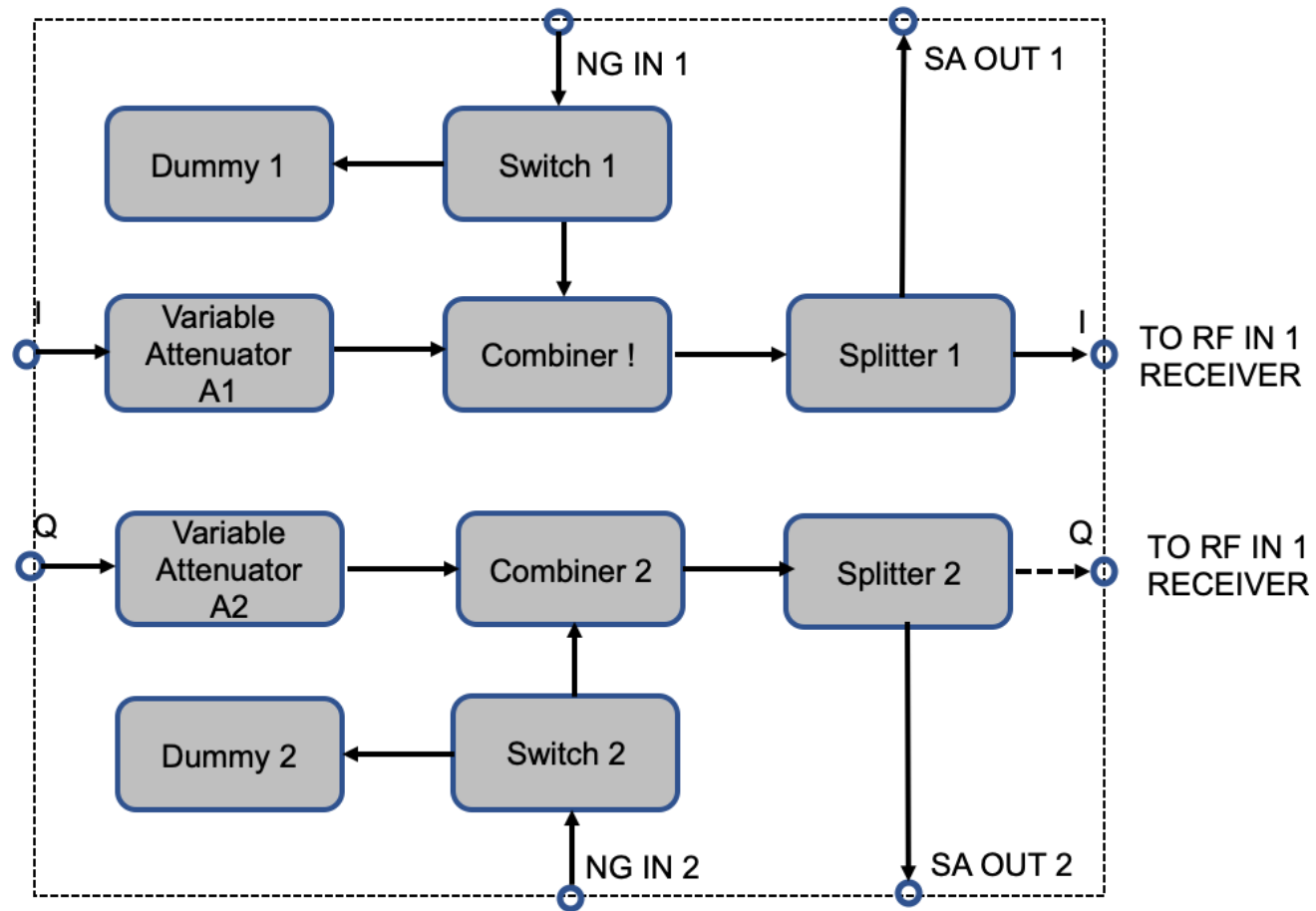


Figure 26: Field test sub-set

NOTE: The terms "I" and "Q" represents the MIMO antenna output cross-polarized signals, to be tested using both horizontal / vertical and +45° / -45° polarization.

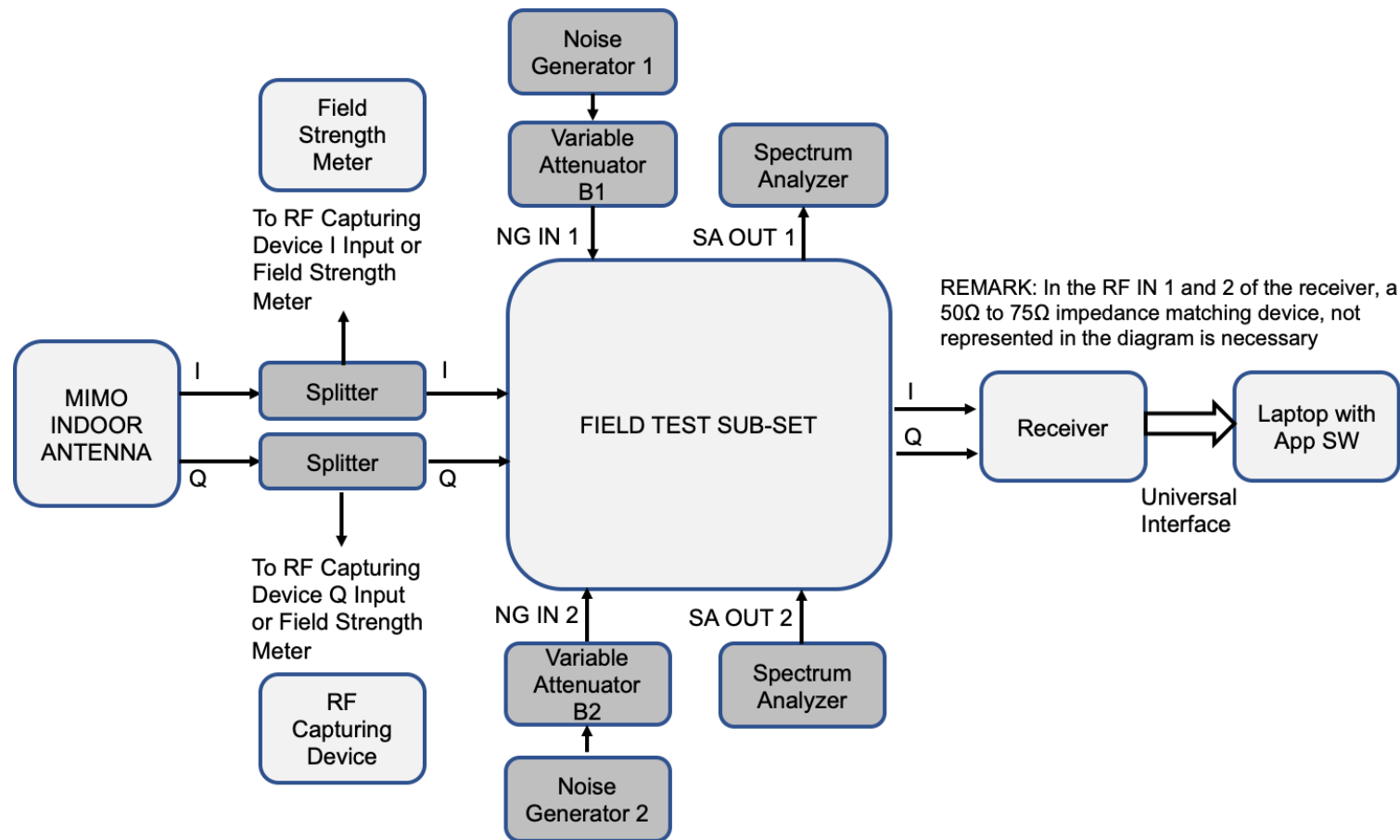


Figure 27: Field test setup

The field test setup of Figure 27 shall be applied to the Test Vehicle and the rooms arranged for indoor tests. In the Test Vehicle, the MIMO Indoor Antenna and the GPS Antennas will be securely mounted above the Test Vehicle and connected to the equipment inside the vehicle by coaxial cables. In the test rooms, the MIMO Indoor Antenna shall stay inside the room, and the GPS antenna in a position for best GPS signal reception, being outside the room if necessary.

The reference signal for synchronization, generated by the GPS signal receiving set up of Figure 25, is not shown in Figure 27, just for simplifying the figure.

4.2.4.2 Coverage Measurement

The coverage measurement tests shall be conducted with the test vehicle parked or inside a room.

For the coverage measurements, the Variable Attenuators A1 and A2 in Figure 26 (Field test sub-set) shall be set to minimum attenuation, except for system margin measurements. The Variable Attenuators B1 and B2 are set to the maximum attenuation, except for C/N measurements.

The test points should be selected in compliance with the ITU-R Report BT.2035-2.

The measurements to be conducted are:

- a) Distance and bearing to transmitting antenna location;
- b) Ground elevation at measuring location;
- c) Date, time of the day, topography, traffic, and weather observations should be noted;
- d) Spectrum analyzer data of the DTTB receiver signal spectrum (for each major measurement set, including for Variable Attenuators A1 and A2 in minimum attenuation);
- e) Field Strength (minimum, maximum, and median value) (dB μ V/m);
- f) System margin. The input RF signal shall be attenuated in a controlled manner until TOV is reached;
- g) C/N ratio at TOV for best reception and for maximum field strength (random noise added in a controlled manner by adjusting Variable Attenuators B1 and B2).

4.2.4.3 Service Measurement

The service measurement test shall be conducted in parallel to the coverage measurement. All the data collected for the coverage measurement is processed for the analysis of service measurements. Additional tests are specified as:

- a) Noise floor;
- b) If the reception conditions in the location are not good and errors occur, annotate the BER or FER;
- c) Delay profile. If the Application Software installed in the Laptop PC, provided by the technology proponent, is capable to provide such data;
- d) Measurement of video, audio, and data transmission bitrates at MIMO and MIMO plus Channel Bonding;

- e) Verification of stability of channel identification, with the receiver tuned to a station identified as A, in a location receiving the signal of station identified as B, transmitting in the same frequency as A, but with different content and with similar receiving level.

NOTE: To adjust the receiving levels of A station and B station, replace the MIMO Indoor Antenna by two directional antennas (one for each polarization), and adjust the receiving level of both stations by controlling the azimuth of each antenna and adjusting the Variable Attenuators A1 and A2 to minimum attenuation. When a similar reception level is achieved, fix the antenna positions. The observation interval time shall be one hour. The stability of reception shall be verified even in a condition of level variations of both signals in the Receiver input.

4.2.4.4 Drive Test

The drive tests shall be conducted with a test vehicle in movement, with the MIMO Omnidirectional antenna and GPS antenna fixed securely above the vehicle, and connected to the respective Receivers, inside the vehicle through coaxial cables.

The vehicle setup is shown in Figure 28.

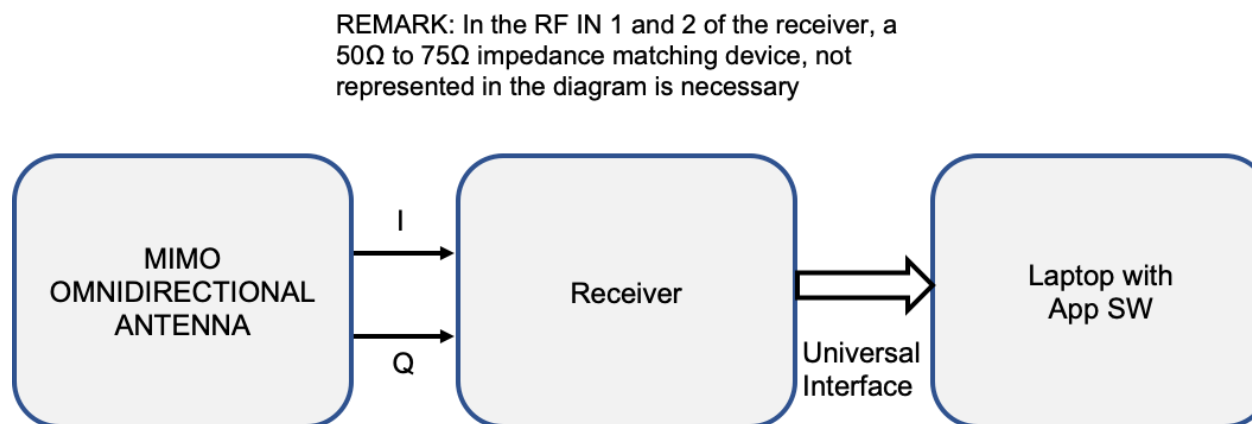


Figure 28: Drive test vehicle setup

NOTE: The setup of Figure 28 does not show the GPS receiving signal set up shown in Figure 25. The GPS reference signals shall be distributed to the Receivers and the Laptop PC with application software.

The vehicle moves around the city and collects Digital TV signal quality data and GPS information into the Laptop PC hard drive. The data are retrieved in the Laboratory, analyzed and maps with localization and Digital TV signal quality are registered.

The data registered by the Laptop PC are:

- a) For GPS information: date, hour, car speed, longitude, latitude, number of locked GPS satellites, GPS satellite signal quality, orientation, channel lock state, shall be collected and recorded, at each one-second interval;
- b) For receiving signal quality: modulation parameters - to be determined according to the modulation technology used by the proposed technology, errored bits, errored packets, total quantity of packets received in the one-second interval, C/N of the channel being received, received level, and others parameters according to the proposed technology. The data should be refreshed at each one-second interval.

4.2.4.5 RF Capturing

The RF capturing in the field will be only possible with the availability of an RF capturing device for the MIMO system.

One alternative is the use of 2 RF capturing devices, one for each antenna polarization output, that allows synchronized operation.

The SBTVD Forum will determine the locations for the RF capturing, which should be done with Test Vehicle stationed or inside in a room. Each capturing should have a duration of at least 20 seconds.

4.3 Transport Layer

The transport layer requirements set in the TV 3.0 Call for Proposals document, against which the proposals of candidate technologies will be tested and evaluated, are repeated here for the convenience of the reader. For further details, please refer to the TV 3.0 Call for Proposals document.

use case		minimum technical specification			over-the-air delivery	Internet delivery
TL1	Enable frame-accurate synchronization of video, audio, and data, either carried on the same platform (e.g. over-the-air) or mixed on different distribution platforms (e.g. DTT, cable, IPTV, DTH satellite, fixed broadband, 4G/5G mobile broadband) for seamless dynamic content replacement or for using audio/video/data enhancement layers.	TL1.1	single platform audio/video/data sync	frame-accurate	required	required
		TL1.2	multi-platform audio/video/data sync	frame-accurate	required	required
TL2	Facilitate content rebroadcasting over different distribution platforms (e.g. DTT, cable, IPTV, DTH satellite, fixed broadband, 4G/5G mobile broadband) and for the home network. Support non-real-time media (download/push).	TL2.1	IPv4-based transport		required	required
		TL2.2	IPv6-based transport		desirable	required

use case		minimum technical specification		over-the-air delivery	Internet delivery	
TL3	Enable reliable and efficient multiplexing (low latency, error detection with low-overhead, avoiding unnecessary metadata duplication).	TL3.1	latency	ms	lower is better	lower is better
		TL3.2	error detection		required	required
		TL3.3	overhead	%	lower is better	lower is better
		TL3.4	avoid unnecessary metadata duplication		recommended	recommended
TL4	Enable Internet content delivery with encryption.	TL4.1	encryption support		not required	required
TL5	Enable the identification of the TV network, the originating station, and the transmission station.	TL5.1	identification of the TV network, the originating station, and the transmission station		required	N/A
TL6	Provide appropriate signaling of whether the channel transports emergency warnings (over-the-air or by the Internet) or not.	TL6.1	provide appropriate signaling of whether the channel transports emergency warnings (over-the-air or by the Internet) or not		required	required
TL7	Provide Internet-based "wake-up" capability for compatible receivers in case of an emergency warning.	TL7.1	Internet-based "wake-up" capability		N/A	desirable
TL8	Support as much as possible the same Alerting Protocol used by the Brazilian Government, or a similar one.	TL8.1	support OASIS Common Alerting Protocol 1.2 required elements		required	required

use case		minimum technical specification		over-the-air delivery	Internet delivery
TL9	Enable flexible geographic targeting for emergency warnings.	TL9.1	countrywide alert (with country identification)	required	required
		TL9.2	list of up to 14 federative units within a country to be alerted (with country identification) (at least 27 federative unit codes) (federative unit codes list should be updatable over-the-air and by Internet)	required	required
		TL9.3	list of up to 14 federative units within a country not to be alerted (with country identification) (at least 27 federative unit codes) (federative unit codes list should be updatable over-the-air and by Internet)	required	required
		TL9.4	list of up to 427 municipalities within a federative unit to be alerted (with country and federative unit identification) (at least 5 570 municipality codes) (municipality codes list should be updatable over-the-air and by Internet)	required	required
		TL9.5	list of up to 427 municipalities within a federative unit not to be alerted (with country and federative unit identification) (at least 5 570 municipality codes) (municipality codes list should be updatable over-the-air and by Internet)	required	required
		TL9.6	list of up to 1 000 postal codes entries to be alerted (with country identification) (including individual entries and ranges) (supporting wildcard characters) (Brazilian postal code format: 8 numeric digits)	required	required
		TL9.7	list of up to 1 000 postal codes entries to be alerted (with country identification) (including individual entries and ranges) (supporting wildcard characters) (other postal code formats, up to 10 alphanumeric digits)	not required for Brazil, but may be useful for other countries that may wish to adopt the same DTTB system	
TL10	Enable future extensions to the transport layer (e.g. to support transporting new audio, video, and data formats).	TL10.1	extensibility	required	required

TL-AR1. Provide free of charge reference multiplexer and demultiplexer (software or hardware) with its corresponding documentation, strictly for temporary technical evaluation of the SBTVD Forum (non-commercial usage).

TL-AR2. Provide information about available implementations of the multiplexer and demultiplexer, the latter both for professional (broadcast) and consumer electronic applications.

TL-AR3. Provide some reference information about the demultiplexer for TV sets manufacturing.

The proponent's transport layer system will be evaluated in two steps. The “steps” referred here are “System Tests” (ST) and the “System Verifications” (SV). The proponent of the transport layer shall make available prototype or commercial equipment for the evaluation, as defined in the following subsections.

4.3.1 Conditions for tests

4.3.1.1 Equipment to be provided by the proponent

For testing purposes, the proponent shall deliver to the laboratory, at least 1 MUX, 1 DEMUX, 1 Transport Analyzer, and 1 A/V Decoder with 2 SDI output channels. Depending on the proponent's system, it is possible that some of the equipment is integrated into a single module and this is acceptable as long as all tests can be accomplished. Also, if any of the equipment does not fulfill all requirements, additional HW/SW must be provided so that all tests can be executed. Thus, if any of the equipment does not have enough inputs or outputs, the proponent must provide more than 1 module, or if it does not have any of the requested features or is not able to make any measurement requested, the proponent must come up with another solution to make this measurement possible, providing extra HW/SW.

Features needed for each equipment are described in the topics below.

- MUX: Gigabit ethernet interface and access to its Operational System (OS) if available;
- DEMUX: Gigabit ethernet interface and access to its OS if available;
- Transport Analyzer: Gigabit ethernet interface, overhead percentage measurement;
- A/V Decoder: Gigabit ethernet interface and two SDI outputs. Capable of decoding 2 IP streams simultaneously.

4.3.1.2 Files to be provided by the proponent

- MUX configuration files for all tests;
- Packet Capture (PCap) files for all test cases;
- Video server files, SW, and/or executable programs needed.

4.3.1.3 Laboratory's equipment

The Laboratory shall have the following equipment to perform the tests:

- 1 PCap Payout;
- 1 Video Server;
- 1 Time Source (Local NTP Server);
- 1 Network / OTA delay Emulator;
- 1 Gigabit Ethernet Switch / Router;
- 1 Controller Computer / Laptop;
- 2 Monitors;
- 1 A/V Recorder with 2 channels.

The Time Source is a Local NTP Server, but if a GPS is necessary it must be provided by the proponent.

The Network / OTA delay Emulator can delay the ethernet packets, limit bandwidth, and corrupt data at any ethernet connection (destination IP address and/or port).

The A/V Recorder must be able to record two SDI streams simultaneously.

4.3.1.4 General test conditions

- Every packet under test shall be monitored to measure the latency in each device;
- All signal generated shall be checked in the Transport Analyzer;
- Test content containing an HEVC video with burnt-in timecode and spatial resolution of 1 920 x 1 080 pixels (Full HD), temporal resolution of 59.94 frames per second, at 15 Mbps CBR ($\pm 5\%$), and a MPEG-4 AAC LC stereo audio, at 192 kbps CBR ($\pm 5\%$).

4.3.1.5 Testing cases

- a) **Over-The-Air (OTA):** A single test content stream, containing video and audio content, is delivered, simulating an OTA transmission, from the PCap Playback.
- b) **Targeted advertising:** The A/V decoder switches from OTA delivery to OTT delivery. The PCap file for the OTA delivery must contain a transition from a TV Show content to a General Advertising content, which is played in case of low internet bandwidth and the proponent must inform the timecode of the first frame for the Advertising (General and Targeted). The Targeted Advertising stream comes from a file or URL from the Video Server. Figure 29 shows the targeted advertising expected timeline depending on internet availability / bandwidth.

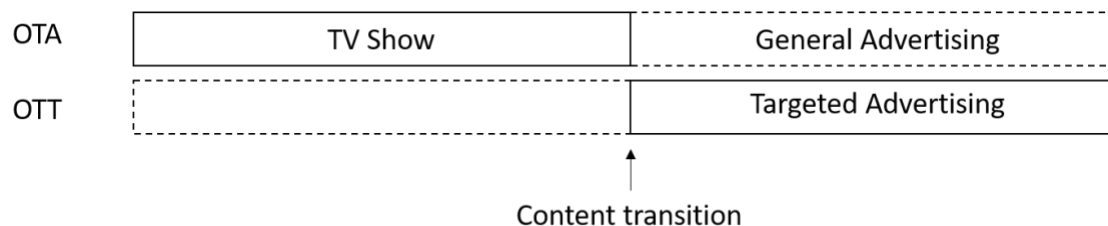


Figure 29: Target advertising timeline

- c) **Live Streaming:** The A/V decoder switches from OTA delivery to OTT delivery. The PCap file(s) must contain two streams, one with a low bit rate content for the OTA delivery and another with a high bit rate content for the OTT delivery. Content shall switch whenever the internet bandwidth is not limited. Figure 30 shows the expected timeline when internet bandwidth is not limited.

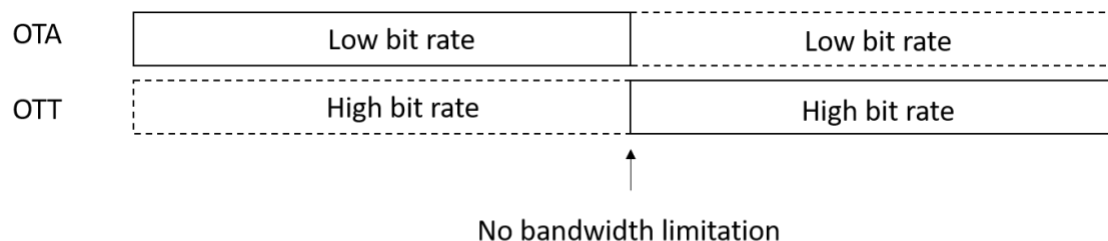


Figure 30: Live stream timeline

- d) **OTT audio:** A/V content is delivered OTA and audio content in another language is delivered by the OTT. All contents for this test shall come from one PCap file and the MUX shall generate the OTA and OTT streams. The file should be an A/V Lip-Sync Test Pattern and Audio 1 and Audio 2 shall have different levels. Audio selection should be done on the DEMUX. Figure 31 shows the timeline of additional audio delivered OTT.

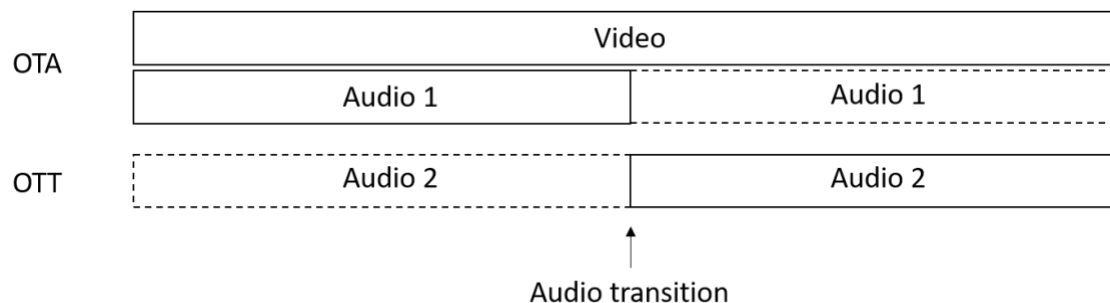


Figure 31: Additional audio over OTT timeline

- e) **Multi-view:** the same scene from different angles, where one of them is delivered OTA to a TV, and the other one is delivered by the internet (OTT) to a mobile device (e.g. a soccer game). Playout’s output feeds three streams to the MUX: one for OTA and the others for OTT. The DEMUX must have the functionality to switch between views 2 and 3 according to the user’s choice. For testing purposes, all 3 streams must be different from each other. Figure 32 shows the timeline for OTA and OTT deliveries, which should be displayed on different monitors.

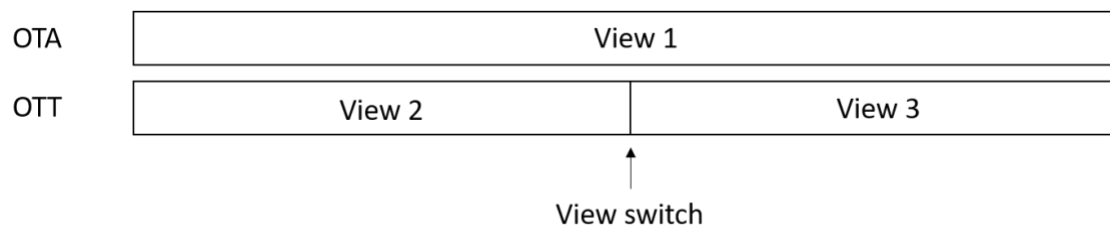


Figure 32: Timeline for two monitors: one OTA and one OTT

4.3.1.6 Setup for tests

Figure 33 presents a general setup that shall be used for all tests from this procedure. Please note that not necessarily all output equipment will be used at every test, each one of them will specify at their own sections which equipment will be used to provide the requested results. Also, additional equipment can be added to this setup, considering the provisions on 4.3.2.1.1. Figure 34 to Figure 36 show the Logical configurations used in the tests.

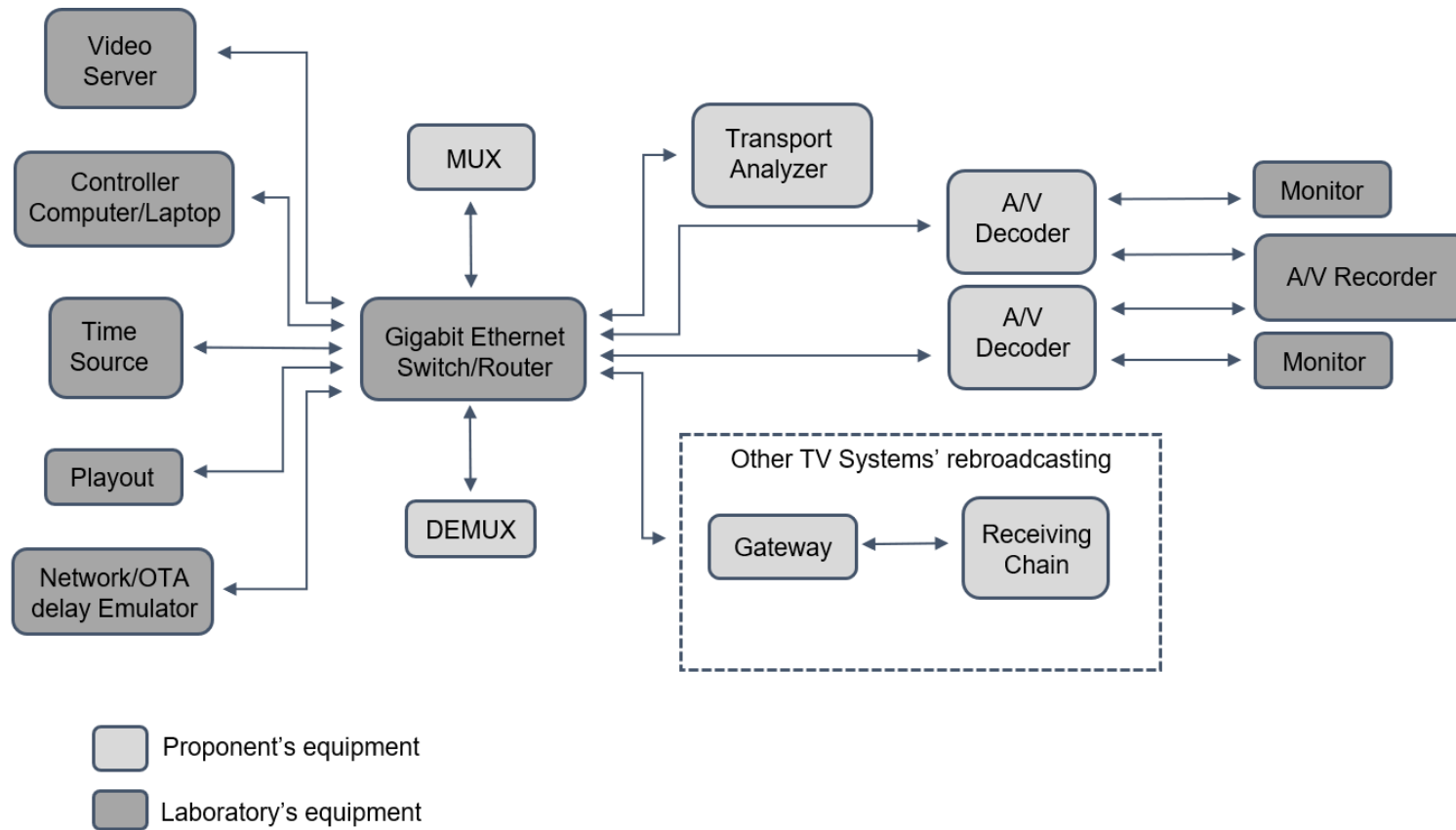


Figure 33: Physical diagram of the test setup

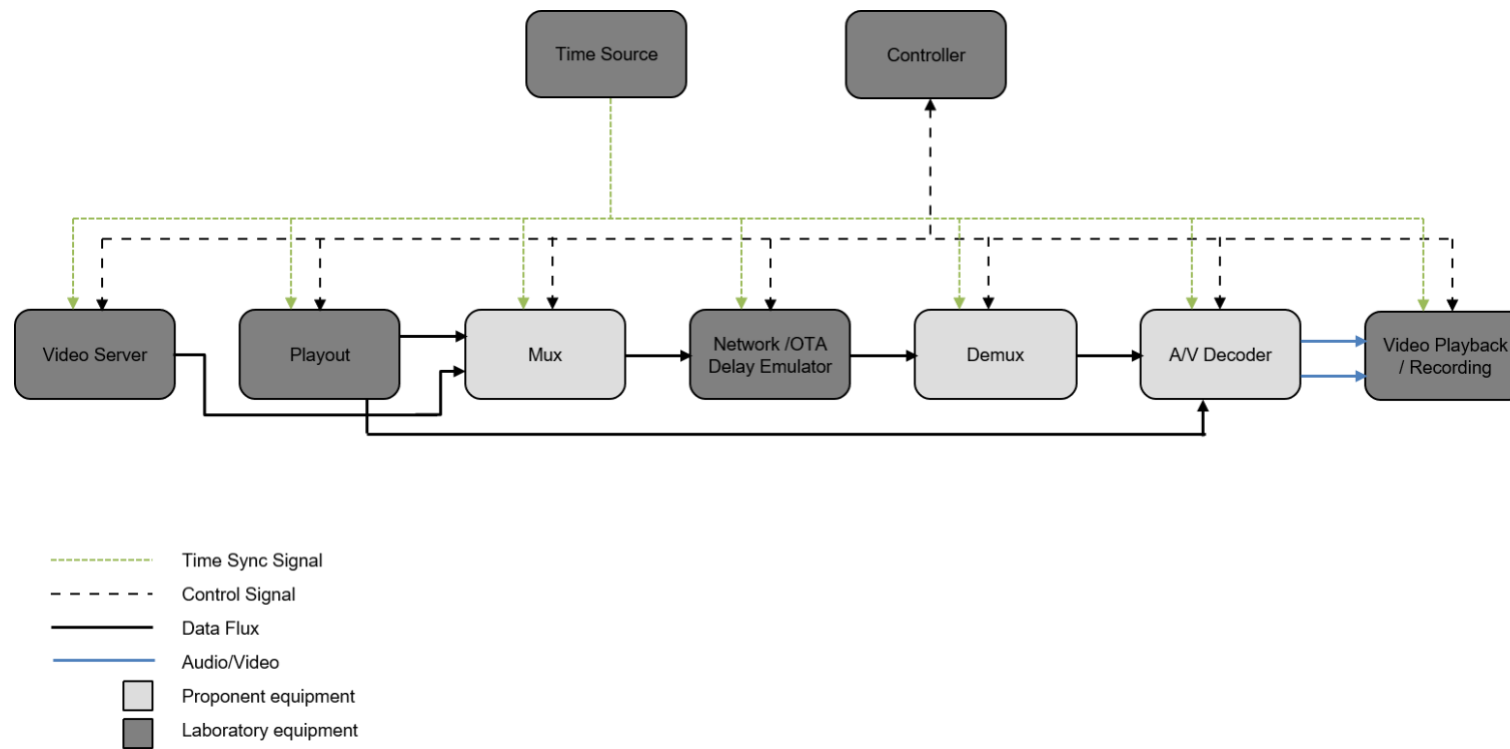


Figure 34: Logical configuration for video playback/recording

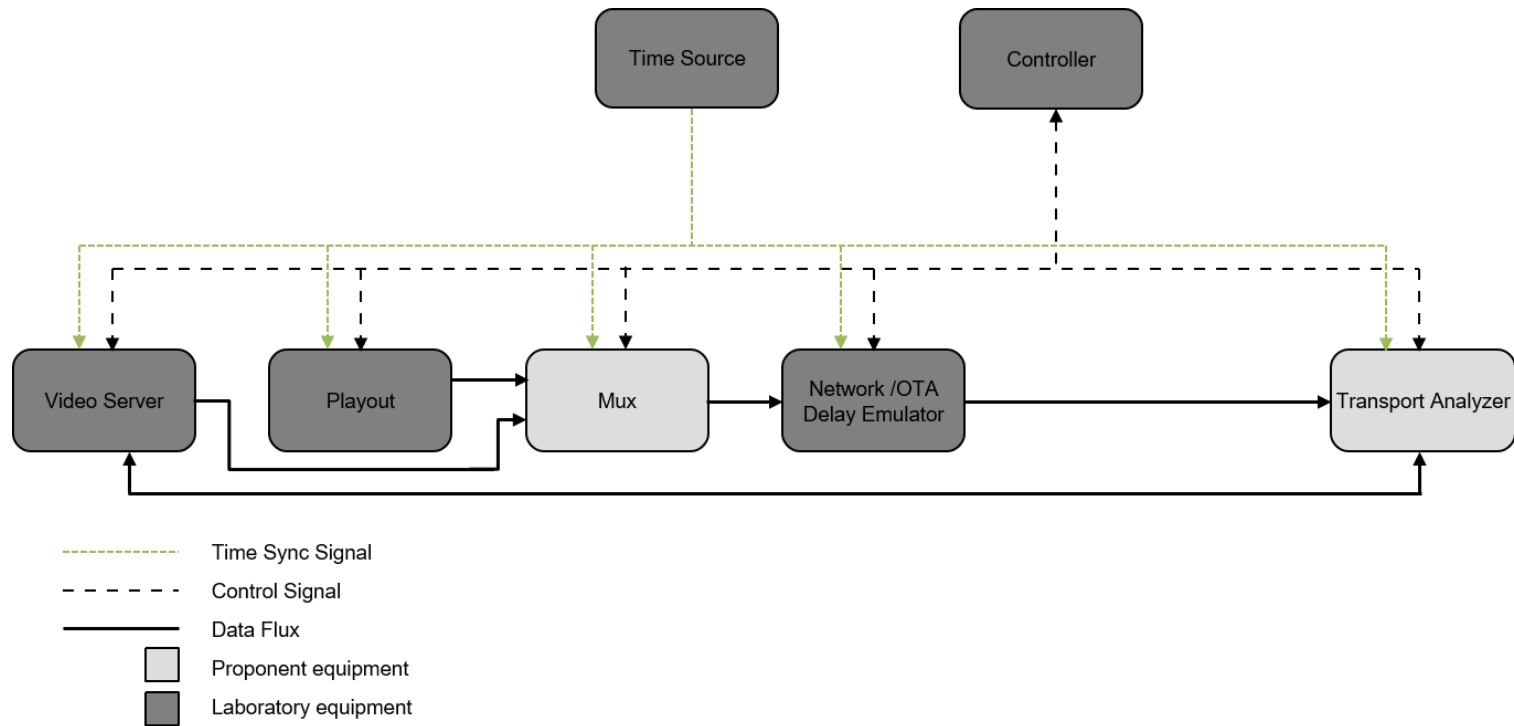


Figure 35: Logical configuration for the Transport Analyzer

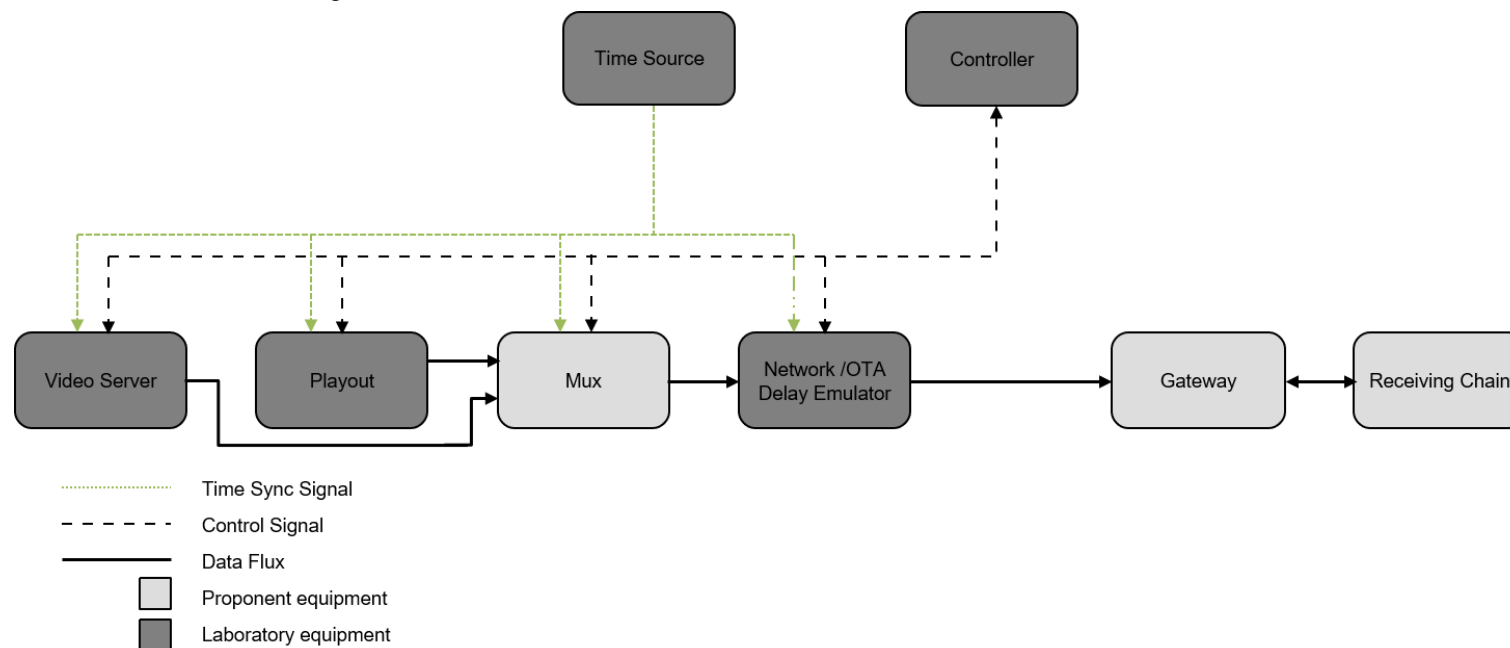


Figure 36: Logical configuration for rebroadcasting

4.3.2 Laboratory Tests

4.3.2.1 System Tests

4.3.2.1.1 Enable frame-accurate synchronization of video, audio, and data for single or multi-platform (TL1.1 and TL1.2)

Cases "b", "c", "d" and "e" shall be considered for this test.

For the single platform configurations, synchronization will be observed considering the moment when the OTT content replaces or enhances the OTA content.

For the multi-platform configuration, all media shall be synchronized from the beginning of the transmission.

The system will be stressed by delaying both OTA and OTT streams (one at a time) with the Network/OTA delay emulator and will be tested under different configurations. Also, the proponent must inform the maximum latency supported (or buffer size).

Each case shall be tested with no added delay and maximum delay informed by the proponent. If the system is not synchronized at maximum delay informed by the proponent, the laboratory shall conduct the test by reducing the delay until frame-accuracy can be observed. If in any of these configurations the result is not frame-accurate, the delay in frames shall be reported.

The A/V Decoder output(s) shall be recorded and analyzed using the timecode as a reference.

Test procedure:

- a) Play the PCap file(s) test case in the playout system;
- b) Configure all equipment;
- c) Adjust the Network/OTA delay Emulator;
- d) Check Transport Analyzer information (flags, alarms, signaling, etc.);
- e) Start to record A/V Decoder output(s);
 - For the Targeted Advertising test case, check if OTA General Advertising is played when no bandwidth is available for OTT, then restart the test with no bandwidth limitation;
 - For the Live Streaming case, check if Full HD content is displayed until the end of the stream when no bandwidth is available, then restart the test with no bandwidth limitation;
 - For the OTT audio and the Multi-view cases, switch content being streamed at any moment during the stream.
- f) Stop recording a few seconds after the transition occurs;
- g) Repeat this procedure for all cases and conditions.

After running all tests, recordings shall be analyzed on an editing video software (recorded from SDI) to check for synchronization, as described in the topics below:

- **Targeted Advertising:** Check if the OTT Targeted Advertising stream starts right after the last frame from the OTA stream or if any frame was lost;
- **Live Streaming:** Check if any frame was lost when video switches to OTT;
- **OTT Audio:** Check if A/V synchronism remains after transition by observing the lip-sync stream pattern;

- **Multi-view:** Both OTA and OTT streams shall be compared, and synchronization shall be verified after and before the transition.

All results shall be recorded according to the template in Table 17.

Table 17: Template for synchronization test results

Case	Stream delayed	Latency (ms)	Result
b) Targeted Advertising	OTA	0	
		max	
	OTT	0	
		max	
c) Live Streaming	OTA	0	
		max	
	OTT	0	
		max	
d) OTT Audio	OTA	0	
		max	
	OTT	0	
		max	
e) Multi-view	OTA	0	
		max	
	OTT	0	
		max	

4.3.2.1.2 Multiplexing latency (TL3.1)

The latency of both OTA and OTT deliveries shall be measured in milliseconds (ms), considering different content cases and the results will be recorded according to the template in Table 18.

The SDI A/V decoder outputs from the Playout and the DEMUX will be recorded so that the latency can be measured comparing the timecode of each file.

The IP streams under test are monitored to measure their latency since the input of the MUX until A/V decoder input.

The following test procedure shall be conducted for testing cases "a" and "e":

- a) Play the PCap file(s) test case in the playout system;
- b) Configure all equipment;
- c) Check Transport Analyzer information (flags, alarms, signaling, etc.);
- d) Record A/V Decoder outputs for a few seconds.

Recorded files shall be analyzed on a video editing software and the latency shall be measured by comparing their timecodes. Results shall be recorded according to the template in Table 18.

Table 18: Template for multiplexing latency results

Testing case	Delivery method	Latency (ms)
a) OTA	OTA	
e) Multi-view	OTA	
	OTT	

4.3.2.1.3 Measure % of Overhead (TL3.3)

Overhead percentage of both OTA and OTT deliveries shall be measured for cases "a", "b", "c", and "e" with the Transport Analyzer, and the results will be recorded according to the template in Table 19. If the Transport Analyzer is not able to provide this measurement, the proponent must provide an equivalent method for this test.

The following test procedure shall be conducted for testing cases "a", "b", "c" and "e":

- a. Play the PCap file(s) test case in the playout system;
- b. Configure all equipment;
- c. Adjust the Network / OTA delay Emulator;
- d. Check Transport Analyzer information (flags, alarms, signaling, etc.) and the Overhead.

Table 19: Template for overhead percentage measurements

Testing case	Delivery method	Overhead (%)
a) OTA	OTA	
b) Target Advertisement	OTA	
	OTT	
c) Live Streaming	OTA	
	OTT	
e) Multi-view	OTA	
	OTT	

4.3.2.2 System Verification

4.3.2.2.1 Check ease to rebroadcast content over different distribution platforms (TL2.1 and TL2.2)

The proponent shall provide any available equipment or method that facilitates rebroadcasting, such as a UDP stream from the MUX or a converter.

The following test procedure shall be conducted for the testing case "a":

- a. Play the PCap file(s) test case in the playout system;
- b. Configure all equipment;
- c. Adjust the Network / OTA delay Emulator;
- d. Check Transport Analyzer information (flags, alarms, signaling, etc.).

4.3.2.2.2 Check error detection mechanism in over the air delivery as well as in the internet delivery (TL3.2)

Packet errors must be shown on the Transport Analyzer, or by any other HW / SW provided by the proponent. Packets will be corrupted for this test.

The following test procedure shall be conducted for the testing cases "a", "b", "c", and "e":

- a. Play the PCap file(s) test case in the playout system;
- b. Configure all equipment;

- c. Adjust the Network / OTA delay Emulator and corrupt packets;
- d. Check Transport Analyzer information (flags, alarms, signaling, etc.).

4.3.2.2.3 Check if it avoids unnecessary metadata duplication (TL3.4)

The proponent shall demonstrate how its system avoids unnecessary metadata duplication and provide a verification method.

4.3.2.2.4 Check internet content delivery with encryption (TL4.1)

The Transport Analyzer must show if the content is encrypted and the A/V Decoder must be able to decode the encrypted content. The proponent must provide a PCap file similar to the case "e", but with view 3 being an encrypted content.

The following test procedure shall be conducted for the requested file:

- a. Play the PCap file(s) test case in the playout system;
- b. Configure all equipment;
- c. Adjust the Network / OTA delay Emulator;
- d. Check Transport Analyzer information (flags, alarms, signaling, etc.) if the internet content is encrypted;
- e. Check if the encrypted content was decrypted and decoded.

4.3.2.2.5 Check the possibility of TV network, originating station, and transmission station identification (TL5.1)

The proponent must inform which fields in the tables are responsible for this information and it will be observed on the Transport Analyzer.

The following test procedure shall be conducted for the testing case "a":

- a. Play the PCap file(s) test case in the playout system;
- b. Configure all equipment;
- c. Adjust the Network / OTA delay Emulator;

- d. Check Transport Analyzer information (flags, alarms, signaling, etc.), including TV network, originating station, and the transmission station identification information as specified by the proponent.

4.3.2.2.6 Check the emergency warning message transmission signaling (TL6.1)

The emergency warning must be enabled/disabled on the MUX and the Transport Analyzer must show it.

The following test procedure shall be conducted for the testing case "a":

- a. Play the PCap file(s) test case in the playout system;
- b. Configure all equipment;
- c. Adjust the Network / OTA delay Emulator;
- d. Enable/Disable emergency warning message in the MUX;
- e. Check Transport Analyzer information (flags, alarms, signaling, etc.), including the emergency warning message as specified by the proponent.

4.3.2.2.7 Check internet-based wake-up capability (TL7.1)

The wake-up must be enabled / disabled on the MUX and the Transport Analyzer must show it. The proponent must provide the MUX configuration file that signalizes the wake-up.

The following test procedure shall be conducted for the testing case "a":

- a. Play the PCap file(s) test case in the playout system;
- b. Configure all equipment;
- c. Adjust the Network / OTA delay Emulator;
- d. Enable / Disable Alert Protocol in the MUX;
- e. Check Transport Analyzer information (flags, alarms, signaling, etc.), including wake-up flags and/or fields.

4.3.2.2.8 Check Support as much as possible the same Alerting Protocol used by the Brazilian Government, or a similar one (TL8.1)

The proponent must inform and detail which fields in the tables are responsible for this information and it will be observed on the Transport Analyzer. If it is a similar protocol, the proponent must detail the similarities and differences between the Alert Protocol used by the Brazilian Government and the proponent's proposed one. The MUX configuration file must be provided.

The following test procedure shall be conducted for the testing case "a":

- a. Play the PCap file(s) test case in the playout system;
- b. Configure all equipment;
- c. Adjust the Network / OTA delay Emulator;
- d. Enable / Disable Alert Protocol in the MUX;
- e. Check Transport Analyzer information (flags, alarms, signaling, etc.) and information of Alert Protocol.

4.3.2.2.9 Check flexible geographic targeting for emergency warnings (TL9.1 – TL9.7)

The proponent must inform which fields in the tables are responsible for this information and it will be observed on the Transport Analyzer.

The following test procedure shall be conducted for the testing case "a":

- a. Play the PCap file(s) test case in the playout system;
- b. Configure all equipment;
- c. Adjust the Network / OTA delay Emulator;
- d. Enable / Disable geographic targeting for emergency warnings in the MUX;
- e. Check Transport Analyzer information (flags, alarms, signaling, etc.), including geographic targeting for emergency warnings.

4.3.2.2.10 Check future extensions to the transport layer (TL10.1)

The proponent must provide information about how current formats are signaled and if / how future upgrades can be signaled (number of bits used by the field and/or its syntax / format).

4.4 Video Coding

The video coding requirements set in the TV 3.0 Call for Proposals document, against which the proposals of candidate technologies will be tested and evaluated, are repeated here for the convenience of the reader. For further details, please refer to the TV 3.0 Call for Proposals document.

use case		minimum technical specification			over-the-air delivery	Internet delivery
VC1	Provide improved video resolution, adequate to consumer electronics display evolution.	VC1.1.1	resolution	7 680 x 4 320	not required	required
		VC1.1.2		5 120 x 2 880	recommended	recommended
		VC1.1.3		3 840 x 2 160	required	required
		VC1.1.4		2 560 x 1 440	recommended	recommended
		VC1.1.5		1 920 x 1 080	required	required
		VC1.1.6		1 280 x 720	required	required
		VC1.2	scanning	progressive	required	required
		VC1.3	aspect ratio	16:9	required	required
		VC1.4	sampling	YCbCr 4:2:0	required	required
VC2	Provide improved video dynamic range and color space, adequate to consumer electronics display evolution.	VC2.1	bit depth	10-bit/component	required	required
		VC2.2.1	dynamic range	HDR	required	required
		VC2.2.2		HDR Dynamic Mapping	desirable	required
		VC2.2.3		SDR	not required	required
		VC2.3	colorimetry	WCG (Rec. ITU-R BT.2020 / BT.2100)	required	required

use case		minimum technical specification			over-the-air delivery	Internet delivery
VC3	Provide sharp images (reducing motion blur), even on content with fast motion (e.g. sports, action movies).	VC3.1.1	frame rate	120 fps	recommended	required
		VC3.1.2		119.88 fps (120/1.001)	recommended	required
		VC3.1.3		60 fps	recommended	required
		VC3.1.4		59.94 fps (60/1.001)	required	required
		VC3.1.5		30 fps	not required	required
		VC3.1.6		29.97 fps (30/1.001)	not required	required
		VC3.1.7		24 fps	not required	required
		VC3.1.8		23.976 fps (24/1.001)	not required	required
		VC3.1.9		100 fps	not required for Brazil, but may be useful for 50Hz countries that may wish to adopt the same DTTB system	
		VC3.1.10		50 fps		
		VC3.1.11		25 fps		
VC4	Provide state-of-the-art coding efficiency, to allow better quality video in limited capacity channels (over-the-air or Internet).	VC4.1	bit rate	Mbps @ MOS 4 or equivalent objective metric	lower is better	lower is better
VC5	Provide live video with minimum end-to-end latency.	VC5.1	real-time encoding		required	required
		VC5.2	latency	ms	lower is better	lower is better

use case		minimum technical specification		over-the-air delivery	Internet delivery	
VC6	Enable second video stream with a sign language interpreter to be optionally activated by the user (to be rendered at the side of the main video, that should be proportionally downscaled to fit the horizontal space left, with no overlap; an optional background still image can be defined by the broadcaster).	VC6.1.1	resolution	2 160 x 3 840 (when using 7 680 x 4 320 main video)	not required	required
		VC6.1.2		1 440 x 2 560 (when using 5 120 x 2 880 main video)	recommended	recommended
		VC6.1.3		1 080 x 1 920 (when using 3 840 x 2 160 main video)	required	required
		VC6.1.4		720 x 1 280 (when using 2 560 x 1 440 main video)	recommended	recommended
		VC6.1.5		540 x 960 (when using 1 920 x 1080 main video)	required	required
		VC6.1.6		360 x 640 (when using 1 280 x 720 main video)	required	required
		VC6.2	scanning	progressive	required	required
		VC6.3	aspect ratio	9:16	required	required
		VC6.4	sampling	YCbCr 4:2:0	required	required
		VC6.5	alpha blending		required	required
		VC6.6	bit depth	10-bit/component	required	required
		VC6.7.1	dynamic range	HDR	required	required
		VC6.7.2		HDR Dynamic Mapping	desirable	required
		VC6.7.3		SDR	not required	required
		VC6.8	colorimetry	WCG (Rec. ITU-R BT.2020 / BT.2100)	required	required
		VC6.9.1	frame rate	30 fps	recommended	required
		VC6.9.2		29.97 fps (30/1.001)	required	required
		VC6.9.3		24 fps	not required	required
		VC6.9.4		23.976 (24/1.001)	not required	required
		VC6.9.5		25 fps	not required for Brazil, but may be useful for 50Hz countries that may wish to adopt the same DTTB system	
VC6.10	bit rate	Mbps @ MOS 4 or equivalent objective metric	lower is better	lower is better		
VC6.11	real-time encoding		required	required		
VC6.12	latency	ms	lower is better	lower is better		

use case		minimum technical specification		over-the-air delivery	Internet delivery	
VC7	Enable emergency warning information delivery using sign language video.	VC7.1	emergency warning information sign language video	desirable	desirable	
VC8	Enable new immersive video services.	VC8.1	VR / AR / XR / 3DoF / 6DoF support	desirable	desirable	
VC9	Enable seamless decoding and A/V alignment.	VC9.1	seamless and frame-accurate stream splicing or ad-insertion at any time instance, even if some of the streams come from different distribution platforms (e.g. switch between over-the-air and Internet delivery)	required	required	
VC10	Enable interoperability with different distribution platforms (e.g. DTT, cable, IPTV, DTH satellite, fixed broadband, 4G/5G mobile broadband, home network).	VC10.1	interoperability with different distribution platforms	required	required	
VC11	Enable scalability (e.g. to improve over-the-air video quality with an Internet-delivered enhancement layer) and extensibility (support new settings and/or features in the future, in a backward-compatible way).	VC11.1.1.	scalability	spatial	required	required
		VC11.1.2.		temporal	recommended	recommended
		VC11.1.3.		quality (bit rate)	recommended	required
		VC11.2	extensibility	required	required	

VC-AR1. Provide free of charge test content (consecutively numbered TIFF files ^{#1}) with the required technical specification, strictly for technical evaluation of the SBTVD Forum (non-commercial usage). The content shall not contain commercial brands.

VC-AR2. Provide free of charge reference encoder and decoder (software or hardware) with its corresponding documentation, strictly for temporary technical evaluation of the SBTVD Forum (non-commercial usage).

VC-AR3. Provide information about available implementations of the encoder and decoder, the latter both for professional (broadcast) and consumer electronic applications.

VC-AR4. Provide some reference information about the decoder for TV sets manufacturing.

NOTE #1: The provided free of charge test content format shall be Planar YUV files instead of consecutively numbered TIFF files as informed in VC-AR1.

The assessment methodology for video systems is divided into three main evaluation steps: Documentation Analysis, Subjective Quality Assessment Reports, and Features and Objective Performance Evaluation.

In the subsequent subsections, the following definitions are adopted:

- **real-time:** this phrase indicates that encoding and/or decoding is executed concurrently as audio/video content is being delivered to a system under test by a playout system and, after the decoding process, is displayed in an audio or video monitor.

- **non-real-time**: this phrase, or the phrase “file-based”, indicates that encoding and/or decoding is executed after audio/video content is received (normally as a file). Non-real-time encoding and/or decoding shall be done only with single-pass encoding and/or decoding.
- **source content**: this phrase indicates uncompressed audio or video content that is used to feed the system under test.
- **processed content**: this phrase indicates uncompressed audio or video content after being processed by the system under test.

4.4.1 Documentation analysis

Each received proposal for the video system shall be analyzed in detail to map what the proponent's system can achieve in conformance with the TV 3.0 Call for Proposals requirements.

Proponents shall provide detailed documentation on how their system works and how it conforms with the specified requirements for the video system. Proponents are encouraged to submit additional information about features from the proposed video system that may enrich the overall video quality of experience and are not a current requirement in the TV 3.0 Call for Proposals document.

At the end of the documentation analysis, the Test Lab shall produce a report consolidating all the analyzed requirements for the video system classified as “*Fulfilled*”, “*Partially Fulfilled*” and “*Not Fulfilled*”. Test Lab analysts shall include in that report a detailed explanation of all requirements classified as “*Fulfilled*”, “*Partially Fulfilled*” and “*Not Fulfilled*”.

The evaluation report shall present the results per video sub-component (Video Base Layer Codec, Video Enhancement Codec, HDR Dynamic Mapping Codec, VR Codec, and Emergency Warning System manager).

4.4.2 Subjective quality assessment reports

The SBTVD Forum does not intend to perform any subjective video quality assessment. Each proponent shall send its own subjective quality assessment reports as described in this section.

Each proposal for video sub-components Video Base Layer Codec, Video Enhancement Codec, HDR Dynamic Mapping Codec, and VR Codec shall provide subjective qualitative and quantitative reports assessing codec's performance results. Those reports shall include data from video subjective test procedures in compliance with directives from the Recommendations ITU-R BT.500, ITU-T P.910, or ITU-R BT.2095, submitted to or produced by international standardization organizations for the evaluation of the proponent's video system. Reports from independent test labs or proponent test labs can also be submitted. In the latter case, SBTVD Forum members can request the description of the statistical tools used for the analysis and the content files used in the subjective test (both source and processed content) to allow cross-checking the results. The proponent shall grant, in a timely manner, a free of charge content license for its own content and provide information on how third-party content could be licensed (if applicable).

Subjective quality assessment reports are not required for the video sub-component Emergency Warning System manager.

4.4.3 Features and objective performance evaluation

Each proponent shall provide the required equipment and test content to allow the Test Lab to verify the compliance of the proponent's system regarding the requirements set in the TV 3.0 Call for Proposals and its performance, through the test procedures described in this section.

At the end of this step, the appointed Test Lab shall produce a report consolidating all the results obtained from the analyzed requirements for the video system classified as “*Fulfilled*”, “*Partially Fulfilled*” and “*Not Fulfilled*”. Test Lab analysts shall include in that report a detailed explanation of all requirements classified as “*Fulfilled*”, “*Partially Fulfilled*” and “*Not Fulfilled*”.

The evaluation report shall present the results per video sub-component (Video Base Layer Codec, Video Enhancement Codec, HDR Dynamic Mapping Codec, VR Codec, and Emergency Warning System manager).

For the evaluation of the proposed video sub-components Video Base Layer Codec, Video Enhancement Codec, and HDR Dynamic Mapping Codec, a common set of test content shall be used by the Test Lab. The test content items shall be provided free of charge by the proponents as a raw material using a single YUV file per test content. All raw material shall contain a text file summarizing its characteristics. SBTVD Forum members are also encouraged to provide additional free of charge video test content in the same format. Content licenses shall be free of charge but may describe usage conditions. The Test Lab and the SBTVD Forum will select the appropriate content from the submitted pool of content. The SBTVD Forum will select at least one element submitted by each proponent in assembling the common content set for each test case (to be used in testing all proponent systems). The result of that work is a number of critical test data sets: one for SDR, one for static HLG HDR, one for static PQ HDR, and one for HDR Dynamic Mapping. Test Lab and the SBTVD Forum will then fix bitrates individually for each content item and each test condition using HEVC fixed QP per picture type. QP values to be used are 22, 27, 32, and 37. The QPs are chosen in a manner that HEVC produces results from high quality (QP = 22) to poor quality (QP = 37), allowing to evaluate the performance of the new codecs. The result of that work is a spreadsheet with individual bitrates as the basis for all tests, further named bitrate spreadsheet. The subsequent test descriptions will reference the QPs. All test data sets will be made available to proponents for encoding.

For video sub-components Virtual Reality (VR) Codec, and Emergency Warning System manager, proponents shall demonstrate the proposed system capabilities using only their own test content and setup.

Video test content shall not make any reference to commercial brands and should contain a diverse set of ordinary broadcast program characteristics. Video test contents should contain scenes with diverse light (indoor/outdoor/mixed, sunny and cloudy), colorful sharp scenes, rapid camera motion scenes (pan, tilt, and zoom), scenes under natural or unnatural illumination, scenes partially or not using computer graphics (like graphics or text overlays), scenes with movement elements (people and/or objects), detailed and diverse scene elements (like people and/or objects) and scenes with facial closed-up with or without rich detail background. The duration of each video test content item shall be:

- a. For the sub-components Video Base Layer Codec, and Video Enhancement Codec:
 - i. SDR: 10 seconds;

- ii. Static HLG HDR: 10 seconds; and
 - iii. Static PQ HDR: 10 seconds.
- b. For the sub-component HDR Dynamic Mapping Codec:
- i. HDR Dynamic Mapping: between 30 seconds and 3 minutes.
- c. For the sub-component VR Codec: between 10 seconds and 3 minutes.
- d. For the sub-component Emergency Warning System manager: between 2 and 3 minutes.

Test content items with 10 seconds duration shall contain only one scene. Video test content items matching all the characteristics specified in the relevant tests for each video sub-component shall be provided by the proponents and other SBTVD members. For each configuration, the test set must contain at least 3 different test items.

Table 20 shows the mapping between video test content file IDs, their characteristics, and related Test Case IDs.

Table 20: Video test contents and related Test Cases

File #	TC ID	Transfer Characteristics	Width	Height	FPS	Duration [s]
01	1.1	HLG	1 280	720	59.94	10
02	1.1, 2.2, 11.2, 11.3	HLG (downscaled version of file #04)	1 920	1 080	59.94	10
03	1.1	HLG	2 560	1 440	59.94	10
04	1.1, 11.1, 11.4	HLG	3 840	2 160	59.94	10
05	1.1	HLG	5 120	2 880	59.94	10
06	1.1	HLG	7 680	4 320	59.94	10
07	1.2	PQ	1 280	720	59.94	10
08	1.2, 2.3	PQ (downscaled version of file #10)	1 920	1 080	59.94	10
09	1.2	PQ	2 560	1 440	59.94	10
10	1.2, 11.5	PQ	3 840	2 160	59.94	10
11	1.2	PQ	5 120	2 880	59.94	10
12	1.2	PQ	7 680	4 320	59.94	10
13	2.1, 3.1	SDR	1 920	1 080	59.94	10

File #	TC ID	Transfer Characteristics	Width	Height	FPS	Duration [s]
14	2.4	PQ	1 920	1 080	< 60.00 #1	≤ 180 #2
15	2.5	PQ	1 920	1 080	59.94	30 #3
16	2.6	PQ	1 920	1 080	59.94	30 #3
17	3.1	SDR	1 920	1 080	120.00	10
18	3.1	SDR	1 920	1 080	119.88	10
19	3.1	SDR	1 920	1 080	60.00	10
20	3.1	SDR	1 920	1 080	30.0	10
21	3.1	SDR	1 920	1 080	29.97	10
22	3.1	SDR	1 920	1 080	24.00	10
23	3.1	SDR	1 920	1 080	23.98	10
24	5.1	HLG	1 920	1 080	59.94	30
25	6.1	HLG	540	960	29.97	10
26	6.1	HLG	360	640	29.97	10
27	6.2	PQ	540	960	29.97	10
28	6.2	PQ	360	640	29.97	10

NOTE #1: The frame rate for this video test content shall comply with technical specifications from use case VC3 and be less than 60 fps.

NOTE #2: For this video test content, proponents can provide one sequence of duration equal to 180 seconds or up to 4 sequences as long as the sum of all sequences' duration is equal or less than 180 seconds.

NOTE #3: For this video test content, proponents can provide one sequence of duration equal to 30 seconds or up to 4 different single frame sequences.

All proposed video systems shall be evaluated using the same Test Lab room environment. This room shall have adequate illumination and shall reproduce ordinary living room characteristics as much as possible, taking into account the general viewing conditions guidance of the Recommendation ITU-R BT.500.

For the video sub-components Video Base Layer Codec, Video Enhancement Codec, and HDR Dynamic Mapping Codec evaluation, one of the four video test setups (illustrated from Figure 37 to Figure 40 with their respective mandatory elements) shall be used, according to the test. Instructions about setup selection are provided in each video test description. Additional monitoring elements may be added to those setups by the Test Lab or by the SBTVD Forum. Nevertheless, those additional elements information shall be informed to all proponents before the test execution.

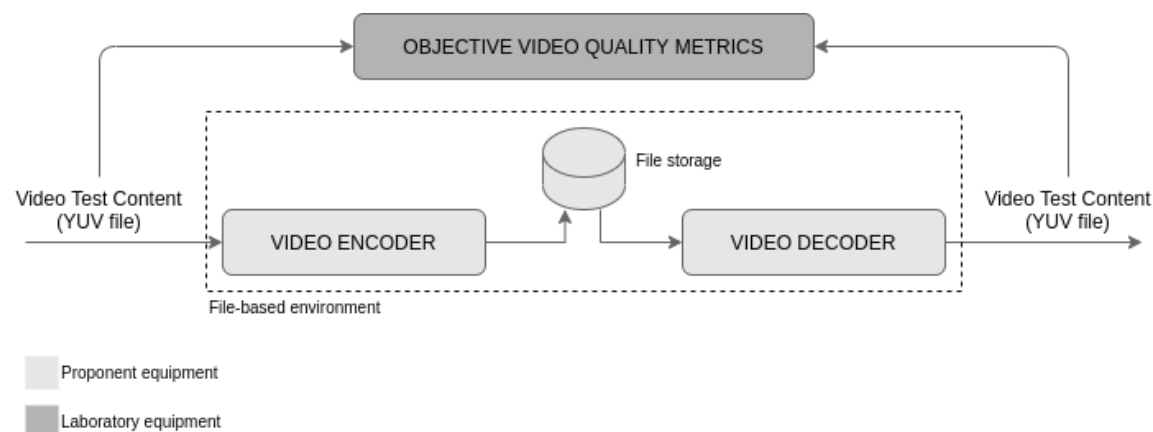


Figure 37: Video Base Layer Codec and Video Enhancement Codec test setup for non-real-time encoding / decoding

For Video Base Layer Codec and Video Enhancement Codec evaluations using the non-real-time encoding / decoding setup, all equipment (hardware and software) are the proponent's responsibility, except the objective video quality metrics software (HDRMetrics utility from HDRTools version 0.19.1, available at <https://gitlab.com/standards/HDRTools>) and its related hardware, that shall be Test Lab's responsibility. Video Encoder and Video Decoder can each consist of more than one device, implementing functions such as format converters, and compression/decompression functions. The transport layer between the video encoder and the video decoder can be selected by the proponent as long as the interoperability between the encoder and the decoder is ensured. The video encoder shall accept uncompressed video content as a single YUV file per test content item and in accordance with test content characteristics specified in each Test Case where the non-real-time video test setup is required. The video decoder shall provide processed video content as a single YUV file per test content item. The encoded bitstream generated by the encoder and the YUV file generated by the decoder shall be stored by Test Lab to facilitate cross-checking the results or any further analysis if needed.

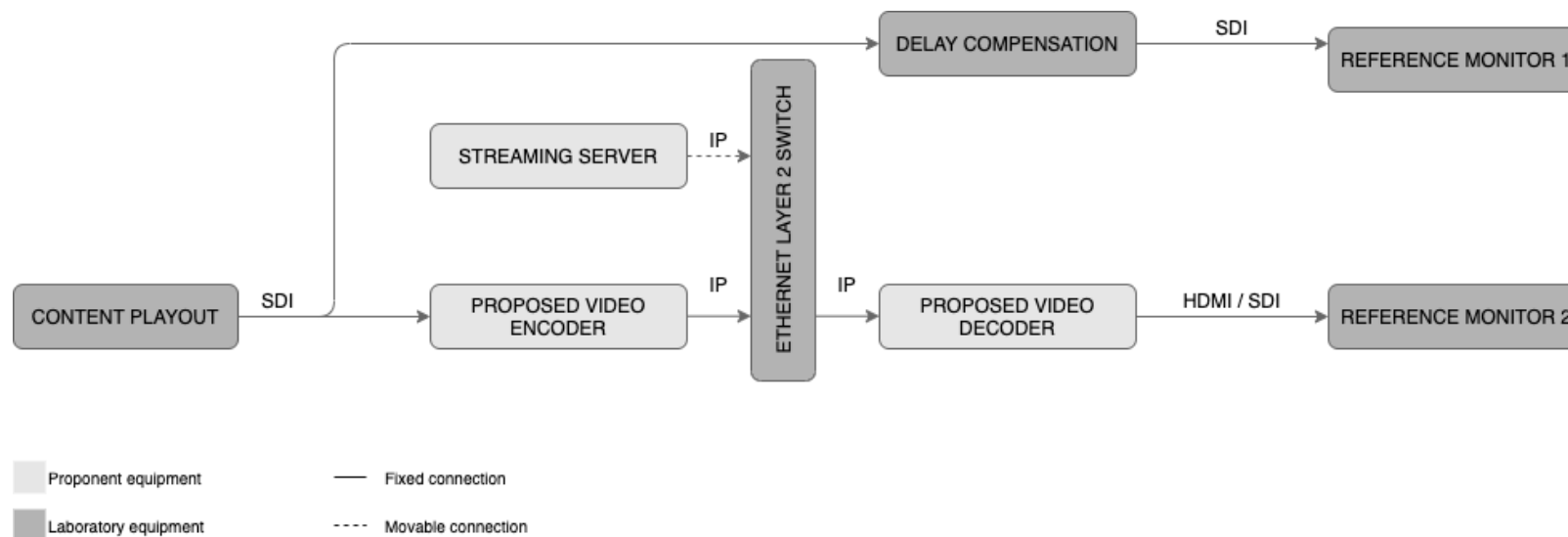


Figure 38: Video Base Layer Codec test setup for real-time encoding / decoding

For Video Base Layer Codec evaluations using real-time encoding/decoding, an SDI interface shall be used to feed the video encoder. The video encoder output interface shall use IP version 4 over Ethernet (IEEE 802.3). The IP-based transport layer protocol shall be chosen by the proponent. In the normal operation of this setup, the Streaming Server shall remain disconnected from the Ethernet Layer 2 Switch. When necessary, particular Test Cases provide instructions about the Streaming Server connection. For the video decoder, the input interface shall accept IP version 4 over Ethernet (IEEE 802.3) and the video output interface shall use HDMI or SDI. Content payout in this setup shall be capable of playing uncompressed video content over the SDI interface. In this setup, the reference monitors shall support the resolution of 1 920 x 1 080 pixels, temporal resolution up to 60 frames per second, WCG (Rec. ITU-R BT.2020 / BT.2100, with color space reproduction greater than or equal to DCI-P3), dynamic range SDR, HLG10 and PQ10, and have an SDI input interface, an HDMI input interface (or use an HDMI to SDI converter), and a peak luminance greater than or equal to 1 000 cd/m². Professional reference monitors are recommended. Both reference monitors should be of the same model.

For Video Base Layer Codec and Video Enhancement Codec evaluations using non-real-time encoding/decoding, Test Lab analysts shall evaluate the Source and Processed video (YUV files) using objective video quality metrics: PSNR (Peak Signal to Noise Ratio), wPSNR (Weighted PSNR), and MS-SSIM (Multi-Scale Structural Similarity Index Measure). From this point on of the document, the expression “video quality metrics” will be used to refer to these three objective video quality metrics. The values for Y-PSNR, U-PSNR, V-PSNR, Y-wPSNR, U-wPSNR, V-wPSNR, Y-MS-SSIM, U-MS-SSIM, and V-MS-SSIM shall be measured per frame and as well as the mean values for each test content item. For SDR sequences and Static HLG HDR sequences, the PSNR and MS-SSIM metrics will be used and for Static PQ HDR sequences, the PSNR, wPSNR, and MS-SSIM metrics will be used. Those video quality metrics shall be implemented by Test Lab using the HDRMetrics utility from HDRTools and computer resources of their own. Further instructions regarding the execution of those metrics are provided in the Test Procedure field for each Test Case.

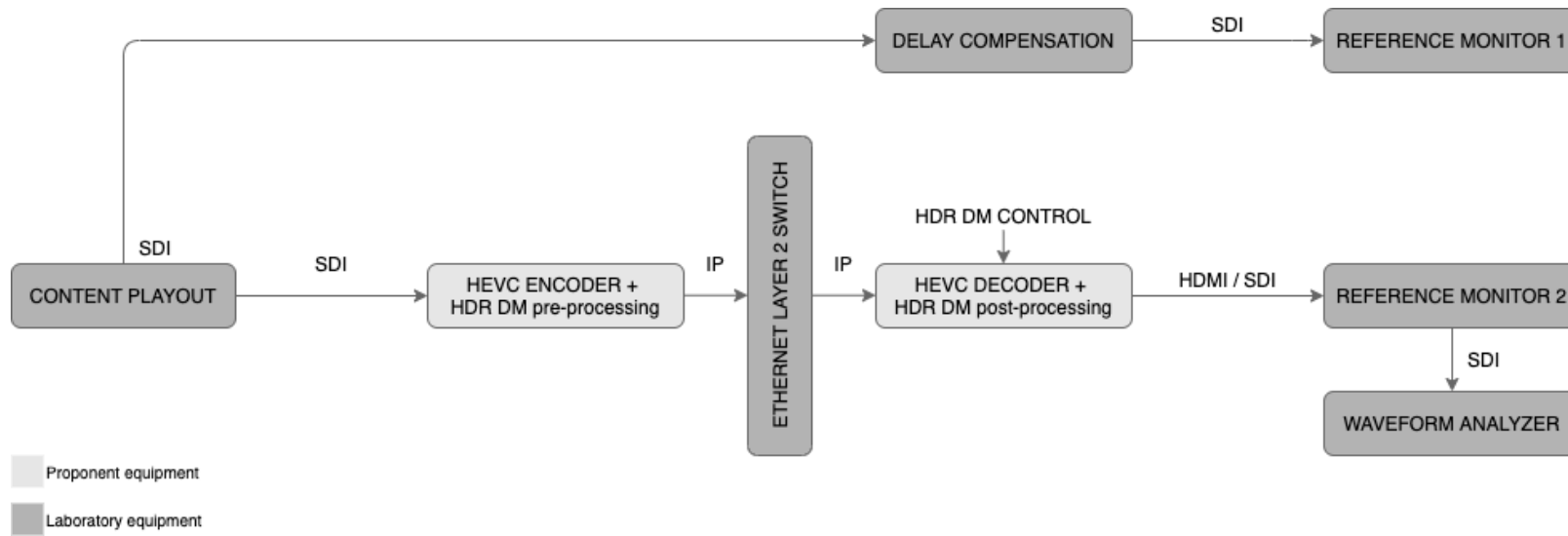


Figure 39: HDR Dynamic Mapping Codec real-time test setup

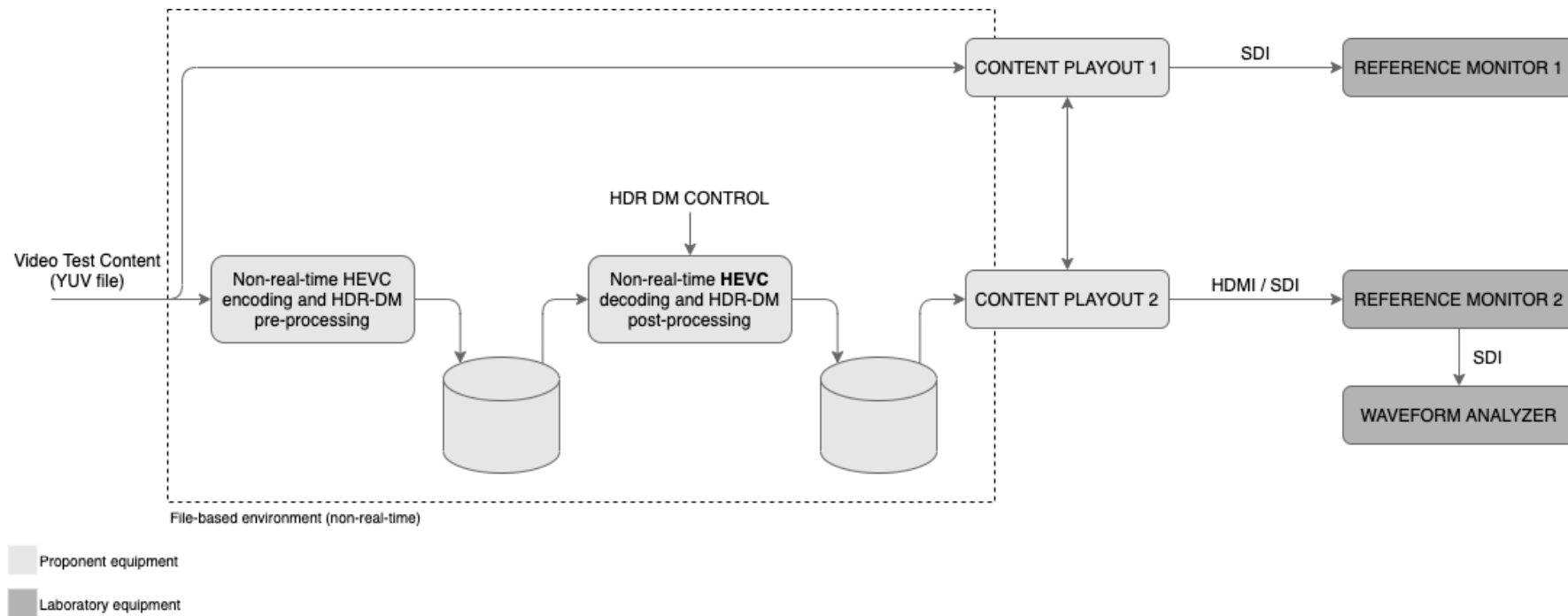


Figure 40: HDR Dynamic Mapping Codec non-real-time test setup

Table 21 shows the mapping between video sub-components and Test Case ID.

Table 21: Video sub-components and related Test Cases

Test Number	Video Base Layer Codec	Video Enhancement Codec	HDR DM Codec	VR Codec	EWS
Test 1	TC1.1 and TC1.2	---	---	---	---
Test 2	TC2.1 to TC2.3	---	TC2.4 to TC2.6	---	---
Test 3	TC3.1	---	---	---	---
Test 4	TC1.1 and TC1.2	---	---	---	---
Test 5	TC5.1	---	---	---	---
Test 6	TC6.1 and TC6.2	---	---	---	---
Test 7	---	---	---	---	TC7.1
Test 8	---	---	---	TC8.1	---
Test 9	TC9.1	---	---	---	---
Test 10	TC9.1	---	---	---	---
Test 11	---	TC11.1 to TC11.5	---	---	---

Evaluation reports from the Test Lab shall present results of sub-components based on the mapping in Table 21.

HEVC reference software (HM version 16.22, available at <https://vcgit.hhi.fraunhofer.de/jct-vc/HM>) will be used as the anchor codec (baseline for comparison) to calculate the PSNR-based, wPSNR-based, and MS-SSIM-based Bjøntegaard Delta rates (BD-rates) for all the proposed Video Codecs (Video Base Layer Codec and Video Enhancement Codec sub-components).

Proponents shall deliver, where applicable, all objective test results to the SBTVD Forum, i.e., all file-based encoded sequences, md5 checksums for decoded sequences, and metrics results in the form of spreadsheets and rate distortions diagrams. The SBTVD Forum will make available a filename scheme and appropriate file storage space for upload.

For the Video Base Layer Codec and Video Enhancement Codec sub-components, HEVC will be used as the anchor codec and the Test Lab will produce all anchor results for reference.

4.4.3.1 Test 1 (Video resolution)

Each proponent's system performance shall be evaluated for the following capabilities:

Test Case ID	TC1.1
Test Type	Objective

Test Case ID	TC1.1
Test Description	<p>Requirements VC1.1.1, VC1.1.2, VC1.1.3, VC1.1.4, VC1.1.5, VC1.1.6, VC1.2, VC1.3, VC1.4, and VC4.1:</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to encode and decode the source video contents for each specific spatial resolution and target bitrates. 2. Each pair of source/processed video content in this test shall be evaluated by video quality metrics. The results shall be registered by Test Lab analysts. <p>This test shall produce baseline data for comparison between HEVC performance and proposed video codecs. Test Lab shall execute TC1.1 using HEVC codec (i.e., HEVC reference software, HM version 16.22).</p>
Test Setup	Non-real-time setup as shown in Figure 37.
Test Content	<p>Test items common characteristics:</p> <ol style="list-style-type: none"> 1. Progressive scanning; 2. Aspect ratio 16:9; 3. Sampling YCbCr 4:2:0; 4. Bit depth 10 bit per component; 5. Colorimetry Wide Color Gamut Recommendation ITU-R BT.2100; 6. Dynamic range HLG HDR from HLG HDR test set; 7. Temporal resolution 59.94 frames per second.
Test Bitrate	<p>To determine the four target bitrates for each test content item, the item is to be encoded using HM 16.22 with fixed Quantization Parameter (QP) values of 22, 27, 32, and 37. The correspondent maximum bitrates (see bitrate spreadsheet) shall be used in fixed bitrate mode, with a tolerance of $\pm 10\%$, with HM 16.22 as the anchor. Specified spatial resolutions are:</p> <ol style="list-style-type: none"> 1. 1 280 x 720 pixels 2. 1 920 x 1 080 pixels 3. 2 560 x 1 440 pixels 4. 3 840 x 2 160 pixels 5. 5 120 x 2 880 pixels 6. 7 680 x 4 320 pixels

Test Case ID	TC1.1
Test Procedure	<p>Codec configuration:</p> <ol style="list-style-type: none"> 1. RAP period: 64 frames; 2. RAP picture type: CRA; 3. All other parameters to be set shall be informed by the proponent and registered by Test Lab. <p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Take the Test Item presented as a YUV file, encode it at the desired QP or bitrate (see the Test Bitrate description) and store the output stream. 2. Decode the stored output stream and deliver the result, processed content, as a YUV file. 3. Analyze processed content and related Test Item form using video quality metrics. Register video quality metrics scores. <p>Summarize registered video quality metrics scores in spreadsheets and graphics. Provide Y, U, V PSNR-based, and MS-SSIM-based rate distortions diagrams of codec under test compared to the HEVC anchor codec.</p>

Test Case ID	TC1.2
Test Type	Objective
Test Description	<p>Requirements VC1.1.1, VC1.1.2, VC1.1.3, VC1.1.4, VC1.1.5, VC1.1.6, VC1.2, VC1.3, VC1.4, and VC4.1:</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to encode and decode the source video contents for each specific spatial resolution and target bitrates. 2. Each pair of source/processed video content in this test shall be evaluated by video quality metrics. The results shall be registered by Test Lab analysts. <p>This test shall produce baseline data for comparison between HEVC performance and proposed video codecs. Test Lab shall execute TC1.1 using HEVC codec (i.e., HEVC reference software, HM version 16.22).</p>
Test Setup	Non-real-time setup as shown in Figure 37.

Test Case ID	TC1.2
Test Content	<p>Test items common characteristics:</p> <ol style="list-style-type: none"> 1. Progressive scanning; 2. Aspect ratio 16:9; 3. Sampling YCbCr 4:2:0; 4. Bit depth 10 bit per component; 5. Colorimetry Wide Color Gamut Recommendation ITU-R BT.2100; 6. Dynamic range PQ HDR from PQ HDR test set; 7. Temporal resolution 59.94 frames per second.
Test Bitrate	<p>To determine the four target bitrates for each test content item, the item is to be encoded using HM 16.22 with fixed Quantization Parameter (QP) values of 22, 27, 32, and 37. The correspondent maximum bitrates (see bitrate spreadsheet) shall be used in fixed bitrate mode, with a tolerance of $\pm 10\%$, with HM 16.22 as the anchor. Specified spatial resolutions are:</p> <ol style="list-style-type: none"> 1. 1 280 x 720 pixels 2. 1 920 x 1 080 pixels 3. 2 560 x 1 440 pixels 4. 3 840 x 2 160 pixels 5. 5 120 x 2 880 pixels 6. 7 680 x 4 320 pixels
Test Procedure	<p>Codec configuration:</p> <ol style="list-style-type: none"> 1. RAP period: 64 frames; 2. RAP picture type: CRA; 3. All other parameters to be set shall be informed by the proponent and registered by Test Lab. <p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Take the Test Item presented as a YUV file, encode it at the desired QP or bitrate (see the Test Bitrate description) and store the output stream. 2. Decode the stored output stream and deliver the result, processed content, as a YUV file. 3. Analyze processed content and related Test Item form using video quality metrics. Register video quality metrics scores. <p>Summarize registered video quality metrics scores in spreadsheets and graphics. Provide Y, U, V PSNR-based, wPSNR-based and MS-SSIM-based rate distortion diagrams of codec under test compared to the HEVC anchor codec.</p>

4.4.3.2 Test 2 (Dynamic range)

Each proponent's system performance shall be evaluated for the following capabilities:

Test Case ID	TC2.1
Test Type	Feature
Test Description	<p>Requirements VC2.1, VC2.2.3 and VC2.3: SDR content</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to display the SDR test set with spatial resolution equal to 1 920 x 1 080 pixels. 2. The purpose of this test is to demonstrate the SDR feature. 3. The evaluator compares the image on Reference Monitor 1 and Reference Monitor 2.
Test Setup	Real-time setup as shown in Figure 38.
Test Content	<p>Test items common characteristics:</p> <ol style="list-style-type: none"> 1. Spatial resolution is 1 920 x 1 080 pixels; 2. Progressive scanning; 3. Aspect ratio 16:9; 4. Sampling YCbCr 4:2:0; 5. Bit depth 10 bit per component; 6. Colorimetry Wide Color Gamut Recommendation ITU-R BT.2020; 7. Dynamic range SDR from SDR test set; 8. Temporal resolution 59.94 frames per second. <p>The SDR test set consists of camera-generated content items.</p>
Test Bitrate	To determine the target bitrate, with a tolerance of $\pm 5\%$, for each test content item, the item is encoded using HM 16.22 with fixed Quantization Parameter (QP) value of 27 (see bitrate spreadsheet).

Test Case ID	TC2.1
Test Procedure	<p>Codec configuration:</p> <ol style="list-style-type: none"> 1. RAP period: 64 frames; 2. RAP picture type: CRA; 3. All other parameters to be set shall be informed by the proponent and registered by Test Lab. <p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. The evaluator selects and plays SDR test content items and compares adjacently the image quality on Reference Monitor 1 and Reference Monitor 2. <p>The test is passed if SDR content is displayed without video coding artifacts.</p>

Test Case ID	TC2.2
Test Type	Feature
Test Description	<p>Requirements VC2.1, VC2.2.2, and VC2.3: static HLG HDR content.</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to display static HLG HDR test set with spatial resolution equal to 1 920 x 1 080 pixels. 2. The purpose of this test is to demonstrate the static HLG HDR feature. 3. The evaluator compares the image on Reference Monitor 1 and Reference Monitor 2.
Test Setup	Real-time setup as shown in Figure 38.
Test Content	<p>Test items common characteristics:</p> <ol style="list-style-type: none"> 1. Spatial resolution is 1 920 x 1 080 pixels; 2. Progressive scanning; 3. Aspect ratio 16:9; 4. Sampling YCbCr 4:2:0; 5. Bit depth 10 bit per component; 6. Colorimetry Wide Color Gamut Recommendation ITU-R BT.2100; 7. Dynamic range HLG from static HLG HDR test set; 8. Temporal resolution 59.94 frames per second. <p>The static HLG HDR test set consists of camera-generated content items.</p>

Test Case ID	TC2.2
Test Bitrate	To determine the target bitrate for each test content item, with a tolerance of $\pm 5\%$, the item is encoded using HM 16.22 with fixed Quantization Parameter (QP) value of 27 (see bitrate spreadsheet).
Test Procedure	<p>Codec configuration:</p> <ol style="list-style-type: none"> 1. RAP period: 64 frames; 2. RAP picture type: CRA; 3. All other parameters to be set shall be informed by the proponent and registered by Test Lab. <p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. The evaluator selects and plays static HLG HDR test content items and compares adjacently the image quality on Reference Monitor 1 and Reference Monitor 2. <p>The test is passed if static HLG HDR content is displayed without video coding artifacts.</p>

Test Case ID	TC2.3
Test Type	Feature
Test Description	<p>Requirements VC2.1, VC2.2.1, and VC2.3: static PQ HDR content.</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to display static PQ HDR test set with spatial resolution equal to 1 920 x 1 080 pixels. 2. The purpose of this test is to demonstrate the static PQ HDR feature. 3. The evaluator compares the image on Reference Monitor 1 and Reference Monitor 2.
Test Setup	Real-time setup as shown in Figure 38.

Test Case ID	TC2.3
Test Content	<p>Test items common characteristics:</p> <ol style="list-style-type: none"> 1. Spatial resolution is 1 920 x 1 080 pixels; 2. Progressive scanning; 3. Aspect ratio 16:9; 4. Sampling YCbCr 4:2:0; 5. Bit depth 10 bit per component; 6. Colorimetry Wide Color Gamut Recommendation ITU-R BT.2100; 7. Dynamic range PQ from static PQ HDR test set; 8. Temporal resolution 59.94 frames per second. <p>The static PQ HDR test set consists of camera-generated content items.</p>
Test Bitrate	To determine the target bitrate for each test content item, with a tolerance of $\pm 5\%$, the item is encoded using HM 16.22 with fixed Quantization Parameter (QP) value of 27 (see bitrate spreadsheet).
Test Procedure	<p>Codec configuration:</p> <ol style="list-style-type: none"> 1. RAP period: 64 frames; 2. RAP picture type: CRA; 3. All other parameters to be set shall be informed by the proponent and registered by Test Lab. <p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. The evaluator selects and plays static PQ HDR test content items and compares adjacently the image quality on Reference Monitor 1 and Reference Monitor 2. <p>Evaluators should look at artifacts such as clipping, burnouts, and loss of details and document the observations as comments per content item and TV type. The test is passed if static PQ HDR content is displayed without video coding artifacts.</p>

Test Case ID	TC2.4
Test Type	Feature

Test Case ID	TC2.4
Test Description	<p>Requirements VC2.1, VC2.2.2, and VC2.3: HDR Dynamic Mapping camera content.</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to display HDR with Dynamic Mapping functionality with spatial resolution equal to 1 920 x 1 080 pixels. 2. The purpose of this test is to demonstrate the HDR Dynamic Mapping feature. 3. The evaluator compares the image on Reference Monitor 1 and Reference Monitor 2.
Test Setup	Real-time setup as shown in Figure 39 or non-real-time setup as shown in Figure 40.
Test Content	<p>Test items common characteristics:</p> <ol style="list-style-type: none"> 1. Spatial resolution is 1 920 x 1 080 pixels; 2. Progressive scanning; 3. Aspect ratio 16:9; 4. Sampling YCbCr 4:2:0; 5. Bit depth 10 bit per component; 6. Colorimetry Wide Color Gamut Recommendation ITU-R BT.2100; 7. Dynamic range PQ from HDR DM camera test set; 8. The temporal resolution depends on the test content item. <p>Test TC2.4 uses the camera-generated content items of the HDR Dynamic Mapping test set.</p>
Test Bitrate	The target bitrate for each test content item is HEVC with the Quantization Parameter (QP) value of 27 with a tolerance of $\pm 5\%$. The encoding shall be done with HM 16.22, HEVC Main 10 profile, and fixed bitrate mode.
Test Procedure	<p>All other parameters to be set shall be informed by the proponent and registered by Test Lab.</p> <p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. The HDR Dynamic Mapping shall be configured manually to make it compatible with two different peak luminance values: 700 cd/m² and 300 cd/m². 2. The evaluator selects and plays HDR Dynamic Mapping test content items and compares adjacently the image quality on Reference Monitor 1 and Reference Monitor 2. 3. The evaluator probes with the analyzer the level corresponding to the highest peak luminance in the sequence, and records the result per sequence. <p>Evaluators should look at dynamic mapping artifacts such as clipping, burnouts, and loss of details and document the observations as comments per content item. The test is passed if HDR Dynamic Mapping preserves details in the highlights compared to the Reference Monitor 1.</p>

Test Case ID	TC2.5
Test Type	Objective
Test Description	<p>Requirements VC2.1, VC2.2.2, and VC2.3: HDR Dynamic Mapping luminance test pattern content.</p> <ol style="list-style-type: none"> 1. Shall verify the behavior of the HDR Dynamic Mapping solution by using the luminance HDR test pattern. 2. Test bitstreams are generated with the HDR Dynamic Mapping solution and encoded with HEVC at a high bitrate to avoid video coding artifacts. The evaluator selects 10 peak luminances and produces bitstreams from 100 up to 4 000 cd/m². Example values are 4 000, 2 000, 1 000, 800, 700, 600, 500, 400, 300, 100 cd/m². To avoid fine-tuning by the proponent, the tested peak luminances should not be known in advance. 3. Measurements of the signal displayed on the reference monitor are collected using a waveform analyzer.
Test Setup	Real-time setup as shown in Figure 39 or non-real-time setup as shown in Figure 40.
Test Content	<p>Test items common characteristics:</p> <ol style="list-style-type: none"> 1. Spatial resolution is 1 920 x 1 080 pixels; 2. Progressive scanning; 3. Aspect ratio 16:9; 4. Sampling YCbCr 4:2:0; 5. Bit depth 10 bit per component; 6. Colorimetry Wide Color Gamut Recommendation ITU-R BT.2100; 7. Dynamic range PQ from HDR DM luminance test pattern; 8. Temporal resolution 59.94 frames per second. <p>Test TC2.5 uses the HDR luminance test patterns.</p>
Test Bitrate	The target bitrate for each test content item is HEVC with the Quantization Parameter (QP) value of 27 with a tolerance of $\pm 5\%$. The encoding shall be done with HM 16.22, HEVC Main 10 profile, and fixed bitrate mode.
Test Procedure	<p>All other parameters to be set shall be informed by the proponent and registered by Test Lab.</p> <p>For each Test Item conduct the following step:</p> <ol style="list-style-type: none"> 1. The HDR Dynamic Mapping shall be configured manually to the selected peak luminance. 2. The evaluator plays the sequence, probes with the analyzer the level corresponding to the highest peak luminance in the sequence, and records the result per sequence. <p>The evaluator produces one luminance record for each test pattern for each HDR-DM solution. The records allow him to judge how exact luminances are mapped.</p>

Test Case ID	TC2.6
Test Type	Objective
Test Description	<p>Requirements VC2.1, VC2.2.2, and VC2.3: HDR Dynamic Mapping chrominance test pattern content.</p> <ol style="list-style-type: none"> 1. Shall verify the behavior of the HDR DM solution by using the chrominance HDR test pattern(s). 2. Test bitstreams are generated with the HDR DM solution and encoded with HEVC at a high bitrate to avoid video coding artifacts. The evaluator selects 10 peak luminances and produces bitstreams from 100 up to 4 000 cd/m². Example values are 4 000, 2 000, 1 000, 800, 700, 600, 500, 400, 300, 100 cd/m². To avoid fine-tuning by the proponent, the tested peak luminances should not be known in advance. 3. Measurements of the signal displayed on the reference monitor are collected using a waveform analyzer.
Test Setup	Real-time setup as shown in Figure 39 or non-real-time setup as shown in Figure 40.
Test Content	<p>Test items common characteristics:</p> <ol style="list-style-type: none"> 1. Spatial resolution is 1 920 x 1 080 pixels; 2. Progressive scanning; 3. Aspect ratio 16:9; 4. Sampling YCbCr 4:2:0; 5. Bit depth 10 bit per component; 6. Colorimetry Wide Color Gamut Recommendation ITU-R BT.2100; 7. Dynamic range PQ from HDR DM chrominance test pattern; 8. Temporal resolution 59.94 frames per second.
Test Bitrate	The target bitrate for each test content item is HEVC with the Quantization Parameter (QP) value of 27 with a tolerance of ±5%. The encoding shall be done with HM 16.22, HEVC Main 10 profile, and fixed bitrate mode.
Test Procedure	<p>All other parameters to be set shall be informed by the proponent and registered by Test Lab.</p> <p>For each Test Item conduct the following step:</p> <ol style="list-style-type: none"> 1. The HDR-DM shall be configured manually to the selected peak luminance. 2. The evaluator plays the sequence, analyzes the chroma components with the waveform analyzer (vectorscope, CIE color chart, etc.), and records the result per test sequence. <p>The evaluator produces one chrominance record for each test pattern for each HDR-DM solution. The records allow him to judge how the display mapping solutions preserve the relative proportions of the color components for different display mapping settings.</p>

4.4.3.3 Test 3 (Temporal resolution)

Each proponent's system performance shall be evaluated for the following capabilities:

Test Case ID	TC3.1
Test Type	Objective
Test Description	<p>Requirements VC3.1.1, VC3.1.2, VC3.1.3, VC3.1.4, VC3.1.5, VC3.1.6, VC3.1.7 and VC3.1.8:</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to encode and decode the source video contents for each specific temporal resolution. 2. Each pair of source/processed video content in this test shall be evaluated by video quality metrics. The results shall be registered by Test Lab analysts.
Test Setup	Non-real-time setup as shown in Figure 37.
Test Content	<p>Test items common characteristics:</p> <ol style="list-style-type: none"> 1. Spatial resolution is 1 920 x 1 080 pixels; 2. Progressive scanning; 3. Aspect ratio 16:9; 4. Sampling YCbCr 4:2:0; 5. Bit depth 10 bit per component; 6. Colorimetry Wide Color Gamut Recommendation ITU-R BT.2020; 7. Dynamic range SDR from the SDR test set;
Test Bitrate	<p>To determine the four target bitrates for each test content item, the item is to be encoded using HM 16.22 with fixed Quantization Parameter (QP) values of 22, 27, 32, and 37. The correspondent maximum bitrates shall be used in fixed bitrate mode, with a tolerance of $\pm 10\%$, with HM 16.22 as the anchor (see bitrate spreadsheet). Specified frame rates are:</p> <ol style="list-style-type: none"> 1. 120 fps: RAP period: 128 frames; 2. (120/1.001) fps: RAP period: 128 frames; 3. 60 fps: RAP period: 64 frames; 4. (60/1.001) fps: RAP period: 64 frames; 5. 30 fps: RAP period: 32 frames; 6. (30/1.001) fps: RAP period: 32 frames; 7. 24 fps: RAP period: 32 frames; 8. (24/1.001) fps: RAP period: 32 frames.

Test Case ID	TC3.1
Test Procedure	<p>Codec configuration:</p> <ol style="list-style-type: none"> 1. RAP picture type: CRA; 2. All other parameters to be set shall be informed by the proponent and registered by Test Lab. <p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Take the Test Item presented as a YUV file, encode it at the desired bitrate and store the output stream. 2. Decode the stored output stream and deliver the result, processed content, as a YUV file. 3. Analyze processed content and related Test Item form using video quality metrics. Register video quality metrics scores. <p>Summarize registered video quality metrics scores in Tables and graphics. Provide Y, U, V PSNR-based, and MS-SSIM-based rate distortion diagrams of codec under test compared to the HEVC anchor codec.</p>

Specifications VC3.1.9 to VC3.1.11 are not required, therefore will not be verified.

4.4.3.4 Test 4 (Video coding quality)

Requirement VC4.1: This requirement is verified during the execution of Test Cases TC1.1 and TC1.2.

4.4.3.5 Test 5 (Video end to end latency)

Each proponent's system performance shall be evaluated for the following capabilities:

Test Case ID	TC5.1
Test Type	Objective
Test Description	<p>Requirements VC5.1 and VC5.2: Latency</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability for real-time encoding and decoding in a live broadcast environment. Video contents shall have a burn-in timecode counter in the active video area displaying values for hours, minutes, seconds, and frames.
Test Setup	Real-time setup as shown in Figure 38. For this setup, the Delay compensation element between content playout and reference monitor shall be removed.

Test Case ID	TC5.1
Test Content	<p>Test items common characteristics:</p> <ol style="list-style-type: none"> 1. Progressive scanning; 2. Aspect ratio 16:9; 3. Sampling YCbCr 4:2:0; 4. Bit depth 10 bit per component; 5. Colorimetry Wide Color Gamut Recommendation ITU-R BT.2100; 6. Dynamic range HLG HDR from HLG HDR test set; 7. Temporal resolution 59.94 frames per second; 8. Spatial resolution 1 920 x 1 080 pixels; <p>Test Contents to be used in this test shall be provided by proponents or SBTVD Forum members with a burn-in timecode counter in the active video area.</p>
Test Bitrate	To determine the target bitrate for each test content item, with a tolerance of $\pm 5\%$, the item is to be encoded using HM 16.22 with fixed Quantization Parameter (QP) value of 27 (see bitrate spreadsheet).
Test Procedure	<p>Codec configuration:</p> <ol style="list-style-type: none"> 1. RAP period: 64 frames; 2. RAP picture type: CRA; 3. All other parameters to be set shall be informed by the proponent and registered by Test Lab. <p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Take the Test Item presented as a YUV file and format it to the supported format by content playout. 2. Play the Test Item from the content playout system through the real-time test setup. 3. Take a photo framing Reference Monitor 1 and Reference Monitor 2. 4. Verify if both timecode counters are readable in the photo and register the values. If not, take another photo. <p>The measured end to end latency will be the timecode difference from the Reference Monitor 2 subtracted from the timecode from the Reference Monitor 1. The configuration parameters from the encoder / decoder must be registered.</p>

4.4.3.6 Test 6 (Sign language)

Requirements VC6.1.1, VC6.1.2, VC6.1.3, VC6.1.4, VC6.5, VC6.7.2, VC6.7.3, VC6.9.1, VC6.9.3, VC6.9.4, VC6.9.5, VC6.11, and VC6.12: These requirements will not be analyzed with feature or objective tests. The proponent's documentation provided in the Document Analysis phase may address these requirements.

Requirements VC6.1.5, VC6.1.6, VC6.2, VC6.3, VC6.4, VC6.6, VC6.7.1, VC6.8, VC6.9.2, and VC6.10: These requirements will be analyzed with objective tests (as described in TC6.1 and TC6.2). The proponent's documentation provided in the Document Analysis phase may also address these requirements.

Test Case ID	TC6.1
Test Type	Objective
Test Description	<p>Requirements VC6.1.5, VC6.1.6, VC6.2, VC6.3, VC6.4, VC6.6, VC6.7.1, VC6.8, VC6.9.2, and VC6.10:</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to encode and decode the source video contents for each specific spatial resolution and target bitrates. 2. Each pair of source/processed video content in this test shall be evaluated by video quality metrics. The results shall be registered by Test Lab analysts. <p>This test shall produce baseline data for comparison between HEVC performance and proposed video codecs. Test Lab shall execute TC6.1 using HEVC codec (i.e., HEVC reference software, HM version 16.22).</p>
Test Setup	Non-real-time setup as shown in Figure 37.
Test Content	<p>Test items common characteristics:</p> <ol style="list-style-type: none"> 1. Progressive scanning; 2. Aspect ratio 9:16; 3. Sampling YCbCr 4:2:0; 4. Bit depth 10 bit per component; 5. Colorimetry Wide Color Gamut Recommendation ITU-R BT.2100; 6. Dynamic range HLG HDR from HLG HDR test set; 7. Temporal resolution 29.97 frames per second.
Test Bitrate	<p>To determine the four target bitrates for each test content item, the item is to be encoded using HM 16.22 with fixed Quantization Parameter (QP) values of 22, 27, 32, and 37. The correspondent maximum bitrates (see bitrate spreadsheet) shall be used in fixed bitrate mode, with a tolerance of $\pm 10\%$, with HM 16.22 as the anchor. Specified spatial resolutions are:</p> <ol style="list-style-type: none"> 1. 540 x 960 pixels 2. 360 x 640 pixels

Test Case ID	TC6.1
Test Procedure	<p>Codec configuration:</p> <ol style="list-style-type: none"> 1. RAP period: 32 frames; 2. RAP picture type: CRA; 3. All other parameters to be set shall be informed by the proponent and registered by Test Lab. <p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Take the Test Item presented as a YUV file, encode it at the desired QP or bitrate (see the Test Bitrate description) and store the output stream. 2. Decode the stored output stream and deliver the result, processed content, as a YUV file. 3. Analyze processed content and related Test Item form using video quality metrics. Register video quality metrics scores. <p>Summarize registered video quality metrics scores in spreadsheets and graphics. Provide Y, U, V PSNR-based, wPSNR-based and MS-SSIM-based rate distortion diagrams of codec under test compared to the HEVC anchor codec.</p>

Test Case ID	TC6.2
Test Type	Objective
Test Description	<p>Requirements VC6.1.5, VC6.1.6, VC6.2, VC6.3, VC6.4, VC6.6, VC6.7.1, VC6.8, VC6.9.2, and VC6.10:</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to encode and decode the source video contents for each specific spatial resolution and target bitrates. 2. Each pair of source/processed video content in this test shall be evaluated by video quality metrics. The results shall be registered by Test Lab analysts. <p>This test shall produce baseline data for comparison between HEVC performance and proposed video codecs. Test Lab shall execute TC6.2 using HEVC codec (i.e., HEVC reference software, HM version 16.22).</p>
Test Setup	Non-real-time setup as shown in Figure 37.

Test Case ID	TC6.2
Test Content	<p>Test items common characteristics:</p> <ol style="list-style-type: none"> 1. Progressive scanning; 2. Aspect ratio 9:16; 3. Sampling YCbCr 4:2:0; 4. Bit depth 10 bit per component; 5. Colorimetry Wide Color Gamut Recommendation ITU-R BT.2100; 6. Dynamic range PQ HDR from PQ HDR test set; 7. Temporal resolution 29.97 frames per second.
Test Bitrate	<p>To determine the four target bitrates for each test content item, the item is to be encoded using HM 16.22 with fixed Quantization Parameter (QP) values of 22, 27, 32, and 37. The correspondent maximum bitrates (see bitrate spreadsheet) shall be used in fixed bitrate mode, with a tolerance of $\pm 10\%$, with HM 16.22 as the anchor. Specified spatial resolutions are:</p> <ol style="list-style-type: none"> 1. 540 x 960 pixels 2. 360 x 640 pixels
Test Procedure	<p>Codec configuration:</p> <ol style="list-style-type: none"> 1. RAP period: 32 frames; 2. RAP picture type: CRA; 3. All other parameters to be set shall be informed by the proponent and registered by Test Lab. <p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Take the Test Item presented as a YUV file, encode it at the desired QP or bitrate (see the Test Bitrate description) and store the output stream. 2. Decode the stored output stream and deliver the result, processed content, as a YUV file. 3. Analyze processed content and related Test Item form using video quality metrics. Register video quality metrics scores. <p>Summarize registered video quality metrics scores in spreadsheets and graphics. Provide Y, U, V PSNR-based, wPSNR-based and MS-SSIM-based rate distortion diagrams of codec under test compared to the HEVC anchor codec.</p>

4.4.3.7 Test 7 (Video emergency warning information)

Each proponent's system performance shall be evaluated for the following capabilities:

Test Case ID	TC7.1
Test Type	Feature
Test Description	Requirements VC7.1: 1. Shall perform a video application demonstrating emergency warning information sign language video.
Test Setup	Proponents can provide their own setup.
Test Content	Proponents can provide their own test content.
Test Bitrate	The bitrate for this test shall be chosen by the proponent's system.
Test Procedure	Perform a playback of a video application demonstrating how the video system can enable emergency warning information delivery using sign language video, particularly showing what metadata is carried in the video bitstream and how other applications could access or process this metadata to perform the same results (e.g. some sort of API specification). NOTE: This helps TV 3.0 application coding experts to incorporate this new feature into the future specification. Incorrect display of the available audio/video content, erroneous audio / video playback of the content leads to failure of the test.

4.4.3.8 Test 8 (New immersive video services)

Each proponent's system performance shall be evaluated for the following capabilities:

Test Case ID	TC8.1
Test Type	Feature and Objective
Test Description	Requirements VC8.1: 1. Shall perform playback of content demonstrating one or more of those applications: VR / AR / XR / 3DoF / 6DoF. If necessary, the audio codec to be used in this test shall be chosen by the proponent.
Test Setup	Proponents can provide their own setup.
Test Content	Proponents can provide their own test content.
Test Bitrate	The bitrate for this test shall be chosen by the proponent's system.

Test Case ID	TC8.1
Test Procedure	<p>Provide a comprehensive demonstration of the proposed format, allowing the evaluation of:</p> <ol style="list-style-type: none"> 1. features of the codec; 2. the quality of the codec; 3. the real-time decoding capability; 4. the readiness of delivery of the format over broadcast and broadband networks by relying in the IP protocol; 5. how the applications work in details; 6. how other applications could manipulate the content stream to perform the same results exhibited in the demonstration (e.g. some sort of API specification). NOTE: This helps TV 3.0 application coding experts to incorporate this new feature into the future specification. <p>Non-compliance with one or more of the above steps leads to failure of the test.</p>

4.4.3.9 Test 9 (Seamless decoding and A/V alignment)

Each proponent's system performance shall be evaluated for the following capabilities:

Test Case ID	TC9.1
Test Type	Feature
Test Description	<p>Requirements: VC9.1, VC10.1:</p> <ol style="list-style-type: none"> 1. Shall perform a video application demonstrating the desired capabilities. The audio codec and transport technology to be used in this test shall be chosen by the proponents.
Test Setup	Real-time setup as shown in Figure 38. The Streaming Server shall be connected to an Ethernet Layer 2 switch. The content to be provided by the Streaming Server can be encoded using the non-real-time setup as shown in Figure 37 Alternatively, the proponent can provide a special setup for this test.
Test Content	Proponents can provide their own test content.
Test Bitrate	The bitrate for this test shall be chosen by the proponent's system.

Test Case ID	TC9.1
Test Procedure	<p>Codec configuration:</p> <ol style="list-style-type: none"> 1. RAP period: 64 frames; 2. RAP picture type: CRA; 3. All other parameters to be set shall be informed by the proponent and registered by Test Lab. <p>Perform a playback of a video application demonstrating how the video system can switch (back and forth) between the live encoding and the Streaming Server content, seamlessly, and keeping the alignment between audio and video. Include an explanation of how the application works in detail and how other applications could manipulate the video system to achieve the same results (e.g. some sort of API specification). NOTE: This helps TV 3.0 application coding experts to incorporate this new feature into the future specification.</p> <p>Reproduction discontinuities and A/V sync (lip-sync) issues when switching (back and forth) between the live encoding and the Streaming Server content leads to failure of the test.</p>

4.4.3.10 Test 10 (Interoperability with different distribution platforms)

Requirement VC10.1: This requirement is verified during the execution of Test Case TC9.1.

4.4.3.11 Test 11 (Video scalability and extensibility)

Each proponent's system performance shall be evaluated for the following capabilities:

Test Case ID	TC11.1
Test Type	Feature (not applicable to single layer technologies)
Test Description	<p>Requirement VC11.1.1: Spatial scalability</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's spatial scalability capabilities by enhancing the video experience, increasing the video content spatial resolution.
Test Setup	Proponents can provide their own setup.

Test Case ID	TC11.1
Test Content	<p>Test item common characteristic:</p> <ol style="list-style-type: none"> 1. Progressive scanning; 2. Aspect ratio 16:9; 3. Sampling YCbCr 4:2:0; 4. Bit depth 10 bit per component; 5. Colorimetry Wide Color Gamut Recommendation ITU-R BT.2100; 6. Dynamic range HLG HDR from HLG HDR test set; 7. Temporal resolution 59.94 frames per second.
Test Bitrate	To determine the target bitrate for each test content item, with a tolerance of $\pm 10\%$, the item is to be encoded using HM 16.22 with fixed Quantization Parameter (QP) value of 27 (see bitrate spreadsheet).
Test Procedure	<p>Codec configuration:</p> <ol style="list-style-type: none"> 1. RAP period: 64 frames; 2. RAP picture type: CRA; 3. All other parameters to be set shall be informed by the proponent and registered by Test Lab. <p>For available Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Perform non-real-time scalable coding of a 2160p video content, with a 1080p base layer. 2. Perform non-real-time decoding of the scalable bitstream, switching on and off the enhancement layer every two seconds. The output YUV file should keep a constant 2160p resolution. When decoding only the base layer (1080p) every pixel should be duplicated vertically and horizontally (no interpolation or smoothing) 3. Encode the processed YUV file with HEVC reference software (HM 16.22) with fixed Quantization Parameter (QP) value of 22. 4. Evaluate, by monitoring the resulting HEVC decoding on the reference monitor, the capability of the system to continuously and seamlessly playback the content during all switching, back and forth, between the base layer and the enhancement layer. <p>Incorrect display of the available content or lack of continuous and seamless playback during all switching leads to failure of the test.</p>

Test Case ID	TC11.2
Test Type	Feature (not applicable to single layer technologies)

Test Case ID	TC11.2
Test Description	<p>Requirement VC11.1.2: Temporal scalability</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's temporal scalability capabilities by enhancing the video experience, increasing the video content temporal resolution.
Test Setup	Proponents can provide their own setup.
Test Content	<p>Test item common characteristic:</p> <ol style="list-style-type: none"> 1. Progressive scanning; 2. Aspect ratio 16:9; 3. Sampling YCbCr 4:2:0; 4. Bit depth 10 bit per component; 5. Colorimetry Wide Color Gamut Recommendation ITU-R BT.2100; 6. Dynamic range HLG HDR from HLG HDR test set; 7. Spatial resolution 1 920 x 1 080 pixels.
Test Bitrate	To determine the target bitrate for each test content item, with a tolerance of $\pm 10\%$, the item is to be encoded using HM 16.22 with fixed Quantization Parameter (QP) value of 27 (see bitrate spreadsheet).
Test Procedure	<p>Codec configuration:</p> <ol style="list-style-type: none"> 1. RAP period: 64 frames (for 59.94 fps) or 32 frames (for 29.97 fps); 2. RAP picture type: CRA; 3. All other parameters to be set shall be informed by the proponent and registered by Test Lab. <p>For available Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Perform non-real-time scalable coding of a 59.94 fps video content, with a 29.97 fps base layer. 2. Perform non-real-time decoding of the scalable bitstream, switching on and off the enhancement layer every two seconds. The output YUV file should keep a constant 59.94 fps temporal resolution. When decoding only the base layer (29.97 fps) every frame should be duplicated (no interpolation or smoothing). 3. Encode the processed YUV file with HEVC reference software (HM 16.22) with fixed Quantization Parameter (QP) value of 22. 4. Evaluate, by monitoring the resulting HEVC decoding on the reference monitor, the capability of the system to continuously and seamlessly playback the content during all switching, back and forth, between the base layer and the enhancement layer. <p>Incorrect display of the available content or lack of continuous and seamless playback during all switching leads to failure of the test.</p>

Test Case ID	TC11.3
Test Type	Feature (not applicable to single layer technologies)
Test Description	Requirement VC11.1.3: Quality scalability <ol style="list-style-type: none"> 1. Shall demonstrate the system's quality scalability capabilities by enhancing the video experience, increasing the video content quality bitrate.
Test Setup	Proponents can provide their own setup.
Test Content	Test item common characteristic: <ol style="list-style-type: none"> 1. Progressive scanning; 2. Aspect ratio 16:9; 3. Sampling YCbCr 4:2:0; 4. Bit depth 10 bit per component; 5. Colorimetry Wide Color Gamut Recommendation ITU-R BT.2100; 6. Dynamic range HLG HDR from HLG HDR test set; 7. Spatial resolution 1 920 x 1 080 pixels. 8. Temporal resolution 59.94 frames per second.
Test Bitrate	See Test Procedure.
Test Procedure	Codec configuration: <ol style="list-style-type: none"> 1. RAP period: 64 frames; 2. RAP picture type: CRA; 3. All other parameters to be set shall be informed by the proponent and registered by Test Lab. <p>For available Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Perform non-real-time scalable coding of a QP=37 base layer, enhancement layer QP=27 (both QP values of candidate codec). 2. Perform non-real-time decoding of the scalable bitstream, switching on and off the enhancement layer every two seconds. 3. Encode the processed YUV file with HEVC reference software (HM 16.22) with fixed Quantization Parameter (QP) value of 22. 4. Evaluate, by monitoring the resulting HEVC decoding on the reference monitor, the capability of the system to continuously and seamlessly playback the content during all switching, back and forth, between the base layer and the enhancement layer. <p>Incorrect display of the available content or lack of continuous and seamless playback during all switching leads to failure of the test.</p>

Test Case ID	TC11.4
Test Type	Objective
Test Description	Requirement VC11.1.1: Spatial scalability <ol style="list-style-type: none"> 1. Shall demonstrate the system's spatial scalability capabilities by enhancing the video experience, increasing the video content spatial resolution.
Test Setup	Non-real-time setup as shown in Figure 37.
Test Content	Test item common characteristic: <ol style="list-style-type: none"> 1. Progressive scanning; 2. Aspect ratio 16:9; 3. Sampling YCbCr 4:2:0; 4. Bit depth 10 bit per component; 5. Colorimetry Wide Color Gamut Recommendation ITU-R BT.2100; 6. Dynamic range HLG HDR from HLG HDR test set; 7. Temporal resolution 59.94 frames per second. <p>The test contents for this test case shall be the same 2160p resolution sequences used to perform TC1.1.</p>
Test Bitrate	To determine the target bitrate for each test content item, follow the below instructions: <ol style="list-style-type: none"> 1. The Base Layer (or single layer) target bitrates shall use the same values obtained when a 1080p resolution sequence from TC1.1 was encoded using HM 16.22 with a fixed Quantization Parameter (QP) values of 22, 27, 32, and 37. 2. For multilayer technologies, the Enhancement Layer Codec target bitrates shall be the values that resulted from the difference between the bitrate obtained when a 2160p resolution sequence from TC1.1 was encoded using HM 16.22 with fixed Quantization Parameter (QP) values of 22, 27, 32, and 37, and the respectively obtained bitrates in the previous step for Base Layer Codec using the same set of Quantization Parameters. Therefore: <ol style="list-style-type: none"> a. First Enhancement Layer Codec target bitrate = (2160p, HM 16.22 QP=22) – (1080p, HM 16.22 QP=22) b. Second Enhancement Layer Codec target bitrate = (2160p, HM 16.22 QP=27) – (1080p, HM 16.22 QP=27) c. Third Enhancement Layer Codec target bitrate = (2160p, HM 16.22 QP=32) – (1080p, HM 16.22 QP=32) d. Fourth Enhancement Layer Codec target bitrate = (2160p, HM 16.22 QP=37) – (1080p, HM 16.22 QP=37)

Test Case ID	TC11.4
Test Procedure	<p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Take the Test Item presented as a YUV file, perform non-real-time scalable encoding of a 2160p video content at the desired bitrates (see the Test Bitrate description), and store the output stream. For fixed resolution multilayer technologies, the base layer shall be encoded with 1080p resolution. 2. Perform non-real-time scalable decoding of the stored output stream and deliver the result, processed content, as an output YUV file with a constant 2160p resolution. Only for those Video Enhancement Codec technologies that are not able to provide an output YUV file with a constant 2160p resolution, an additional post-processing step shall be applied to the output stream to upscale all frames with a resolution less than 2160p to a 2160p resolution. The resulted output bitstream from the upscaling post-processing shall be a YUV file with a constant 2160p resolution and therefore used as processed content for the next step. 3. Analyze processed content and related Test Item form using video quality metrics. Register video quality metrics scores. <p>Summarize registered video quality metrics scores in spreadsheets and graphics. Provide Y, U, V PSNR-based, wPSNR-based and MS-SSIM-based rate distortion diagrams of codec under test compared to the single-layer 2160p HEVC anchor codec.</p>

Test Case ID	TC11.5
Test Type	Objective
Test Description	<p>Requirement VC11.1.1: Spatial scalability</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's spatial scalability capabilities by enhancing the video experience, increasing the video content spatial resolution.
Test Setup	Non-real-time setup as shown in Figure 37.

Test Case ID	TC11.5
Test Content	<p>Test item common characteristic:</p> <ol style="list-style-type: none"> 1. Progressive scanning; 2. Aspect ratio 16:9; 3. Sampling YCbCr 4:2:0; 4. Bit depth 10 bit per component; 5. Colorimetry Wide Color Gamut Recommendation ITU-R BT.2100; 6. Dynamic range PQ HDR from PQ HDR test set; 7. Temporal resolution 59.94 frames per second. <p>The test contents for this test case shall be the same 2160p resolution sequences used to perform TC1.2.</p>
Test Bitrate	<p>To determine the target bitrate for each test content item, follow the below instructions:</p> <ol style="list-style-type: none"> 1. The Base Layer (or single layer) target bitrates shall use the same values obtained when a 1080p resolution sequence from TC1.2 was encoded using HM 16.22 with a fixed Quantization Parameter (QP) values of 22, 27, 32, and 37. 2. For multilayer technologies, the Enhancement Layer Codec target bitrates shall be the values that resulted from the difference between the bitrate obtained when a 2160p resolution sequence from TC1.2 was encoded using HM 16.22 with fixed Quantization Parameter (QP) values of 22, 27, 32, and 37, and the respectively obtained bitrates in the previous step for Base Layer Codec using the same set of Quantization Parameters. Therefore: <ol style="list-style-type: none"> a. First Enhancement Layer Codec target bitrate = (2160p, HM 16.22 QP=22) – (1080p, HM 16.22 QP=22) b. Second Enhancement Layer Codec target bitrate = (2160p, HM 16.22 QP=27) – (1080p, HM 16.22 QP=27) c. Third Enhancement Layer Codec target bitrate = (2160p, HM 16.22 QP=32) – (1080p, HM 16.22 QP=32) d. Fourth Enhancement Layer Codec target bitrate = (2160p, HM 16.22 QP=37) – (1080p, HM 16.22 QP=37)
Test Procedure	<p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Take the Test Item presented as a YUV file, perform non-real-time scalable encoding of a 2160p video content at the desired bitrates (see the Test Bitrate description), and store the output stream. For fixed resolution multilayer technologies, the base layer shall be encoded with 1080p resolution. 2. Perform non-real-time scalable decoding of the stored output stream and deliver the result, processed content, as an output YUV file with a constant 2160p resolution. Only for those Video Enhancement Codec technologies that are not able to provide an output YUV file with a constant 2160p resolution, an additional post-processing step shall be applied to the output stream to upscale all frames with a resolution less than 2160p to a 2160p resolution. The resulted output bitstream from the upscaling post-processing shall be a YUV file with a constant 2160p resolution and therefore used as processed content for the next step. 3. Analyze processed content and related Test Item form using video quality metrics. Register video quality metrics scores. <p>Summarize registered video quality metrics scores in spreadsheets and graphics. Provide Y, U, V PSNR-based, wPSNR-based and MS-SSIM-based rate distortion diagrams of codec under test compared to the single-layer 2160p HEVC anchor codec.</p>

Requirement VC11.2: This requirement will not be analyzed with a feature test. The proponent's documentation provided in the Document Analysis phase shall address this requirement.

4.5 Audio Coding

The audio coding requirements set in the TV 3.0 Call for Proposals document, against which the proposals of candidate technologies will be tested and evaluated, are repeated here for the convenience of the reader. For further details, please refer to the TV 3.0 Call for Proposals document.

use case		minimum technical specification			over-the-air delivery	Internet delivery
AC1	Enable immersive (3D) audio.	AC1.1.1	channel-based	2.0	required	required
		AC1.1.2		5.1	required	required
		AC1.1.3		5.1 + 4H	required	required
		AC1.2	object-based		required	required
		AC1.3	scene-based (HOA)		desirable	desirable
AC2	Enable end-user interactivity/personalization when allowed by the broadcaster (e.g. switch among different languages, sports commentators, adjust the commentator loudness level and position).	AC2.1	switch components (audio objects and alternative full mix substreams)		required	required
		AC2.2	adjust object loudness		required	required
		AC2.3	adjust object position		required	required
		AC2.4	enable interactivity when using external sound reproduction devices		required	required
AC3	Enable audio description delivery in the same stream as the main audio, as an alternative full mix or as an additional audio object with associated metadata.	AC3.1	audio description delivery in the same stream as the main audio		required	required
		AC3.2	audio description delivery as an alternative full mix		required	required
		AC3.3	audio description delivery as an additional audio object with associated metadata		required	required
AC4	Enable emergency warning information delivery using audio description.	AC4.1	emergency warning information audio description		desirable	desirable
AC5	Enable a single delivery format for multiple audio playback configurations (TV loudspeakers, soundbars, home theaters, binaural).	AC5.1	flexible loudspeaker configuration render		required	required
		AC5.2	binaural render		required	required
AC6	Enable consistent loudness across programs and inside the same program.	AC6.1	consistent loudness across programs		required	required
		AC6.2	consistent loudness after user interaction		required	required

use case		minimum technical specification		over-the-air delivery	Internet delivery
AC7	Enable seamless configuration changes and A/V alignment.	AC7.1	seamless playback during configuration changes (e.g. from 5.1+4H to stereo)	required	required
		AC7.2	seamless playback during user interaction (e.g. enable/disable several audio elements)	required	required
		AC7.3	seamless playback during changes in production (e.g. broadcaster removes one object)	required	required
		AC7.4	seamless and sample-accurate stream splicing or ad-insertion at any time instance, even if some of the streams come from different distribution platforms (e.g. switch between over-the-air and Internet delivery)	required	required
AC8	Provide state-of-the-art coding efficiency, to allow better quality audio in limited capacity channels (over-the-air or Internet).	AC8.1	bit rate kbps @ MOS 4 / MUSHRA > 80 or equivalent objective metric	lower is better	lower is better
AC9	Provide live audio with minimum end-to-end latency.	AC9.1	real-time encoding	required	required
		AC9.2	latency ms	lower is better	lower is better
AC10	Provide audio/video synchronization.	AC10.1	A/V sync frame-accurate	required	required
AC11	Enable new immersive audio services.	AC11.1	VR / AR / XR / 3DoF / 6DoF support	desirable	desirable
AC12	Enable interoperability with different distribution platforms (e.g. DTT, cable, IPTV, DTH satellite, fixed broadband, 4G/5G mobile broadband, home network).	AC12.1	interoperability with different distribution platforms	required	required
AC13	Enable scalability (e.g. to enhance the over-the-air audio experience with additional Internet-delivered audio content, such as new sports commentator options) and extensibility (support new settings and/or features in the future, in a backward-compatible way).	AC13.1	scalability	required	required
		AC13.2	extensibility	required	required

AC-AR1. Provide free of charge test content (BW64 file with ADM metadata #1) with the required technical specification, strictly for technical evaluation of the SBTVD Forum (non-commercial usage). The content shall not make any reference to commercial brands.

AC-AR2. Provide free of charge reference encoder and decoder (software or hardware) with its corresponding documentation, strictly for temporary technical evaluation of the SBTVD Forum (non-commercial usage).

AC-AR3. Provide information about available implementations of the encoder and decoder, the latter both for professional (broadcast) and consumer electronic applications.

AC-AR4. Provide information about available implementations of production tools: authoring and monitoring for live and post-production.

AC-AR5. Provide some reference information about the decoder for TV sets manufacturing.

NOTE #1: The provided free of charge test content shall include, in addition to the BW64 (RF64 / linear PCM / 48 kHz / signed 24-bit little-endian) file with ADM metadata as informed in AC-AR1, its corresponding video content in QuickTime File Format (.mov) containing a ProRes 422 Proxy video (1080p59.94 / 10-bit / SDR / BT.2020).

Audio system proponents are also encouraged to submit an Application Coding proposal on an API to fulfill the minimum technical specification AP14.4 (3D object-based immersive audio interaction) with their proposed candidate technology. Please refer to 4.7 for further information on Application Coding.

The assessment methodology for audio systems is divided into three main evaluation steps: Documentation Analysis, Quality Assessment Reports, and Features Evaluation.

In the subsequent subsections, the following definitions are adopted:

- **real-time:** this phrase indicates that encoding and/or decoding is executed concurrently as audio/video content is being delivered to a system under test by a playout system and, after the decoding process, is displayed in an audio or video monitor.
- **non-real-time:** this phrase, or the phrase “file-based”, indicates that encoding and/or decoding is executed after audio/video content is received (normally as a file). Non-real-time encoding and/or decoding shall be done only with single-pass encoding and/or decoding.
- **source content:** this phrase indicates uncompressed audio or video content that is used to feed the system under test.
- **processed content:** this phrase indicates uncompressed audio or video content after being processed by the system under test.

4.5.1 Documentation analysis

Each received proposal for the audio system shall be analyzed in detail to map what the proponent's system can achieve in conformance with the TV 3.0 Call for Proposals requirements.

Proponents shall provide detailed documentation on how their system works and how it conforms with the specified requirements for the audio system. Proponents are encouraged to submit additional information about features from the proposed audio system that may enrich the overall audio quality of experience and are not a current requirement in the TV 3.0 Call for Proposals document.

At the end of the documentation analysis, the Test Lab shall produce a report consolidating all the analyzed requirements for the audio system classified as “*Fulfilled*”, “*Partially Fulfilled*” and “*Not Fulfilled*”. Test Lab analysts shall include in that report a detailed explanation of all requirements classified as “*Fulfilled*”, “*Partially Fulfilled*” and “*Not Fulfilled*”.

4.5.2 Subjective quality assessment reports

The SBTVD Forum does not intend to perform any subjective audio quality assessment. Each proponent shall send its own subjective quality assessment reports as described in this section.

Each proposal for audio systems shall provide qualitative and quantitative reports assessing the codec's performance results. Those reports shall include data from audio subjective test procedures in compliance with directives from the Recommendations ITU-R BS.1116 or ITU-R BS.1534, submitted to or produced by international standardization organizations for the evaluation of the proponent's audio system. Reports from independent test labs or proponent test labs can be submitted. In the latter case, SBTVD Forum members can request the description of the statistical tools used for the analysis and the content files used in the subjective test (both source and processed content) to allow cross-checking the results. The proponent shall grant, in a timely manner, a free of charge content license for its own content and provide information on how third-party content could be licensed (if applicable).

4.5.3 Features evaluation

Each proponent shall provide the required equipment and test content to allow the Test Lab to verify the compliance of the proponent's system regarding the requirements set in the TV 3.0 Call for Proposals document and its performance, through the test procedures described in this section.

At the end of this step, the appointed Test Lab shall produce a report consolidating all the results obtained from the analyzed requirements for the audio system classified as "*Fulfilled*", "*Partially Fulfilled*" and "*Not Fulfilled*". Test Lab analysts shall include in that report a detailed explanation of all requirements classified as "*Fulfilled*", "*Partially Fulfilled*" and "*Not Fulfilled*".

For the evaluation of proposed audio systems, a common set of test content shall be used by the Test Lab. The test content items shall be provided free of charge by the proponents as BW64/RF64 (linear PCM / 48 kHz / signed 24-bit little-endian) file with ADM metadata with its corresponding video content in QuickTime File Format (.mov) containing a ProRes 422 Proxy video (1080p59.94 / 10-bit / SDR / BT.2020). SBTVD Forum members are also encouraged to provide additional free of charge audio test content in the same format. Content licenses shall be free of charge but may describe usage conditions. The Test Lab and the SBTVD Forum will select the appropriate content from the submitted pool of content. The SBTVD Forum will select at least one element submitted by each proponent in assembling the common content set for each test case (to be used in testing all proponent systems)..

Audio test contents shall not make any reference to commercial brands and should contain a diverse set of ordinary broadcast program characteristics. It should contain pure speech, speech together with music or background noise, high dynamic orchestra music, and piano solo. The minimum length of the sequences shall be 15 seconds and the maximum length should not exceed 10 minutes. This test shall use twelve audio test contents, as described in Table .

Table 22: Audio test contents characteristics

File #	Audio test content characteristics	Ch 1	Ch 2	Ch 3	Ch 4	Ch 5	Ch 6	Ch 7	Ch 8	Ch 9	Ch 10	Ch 11	Ch 12	Ch 13	Ch 14	Ch 15	Ch 16
01	1: Stereo mix (Language 1)	1: L	1: R														
02	1: Stereo mix (Language 1) + 2: Stereo mix (Language 2) + 3: Stereo Audio Description (Language 1)	1: L	1: R	2: L	2: R	3: L	3: R										
03	1: Channel Bed 2.0 + 2: Mono Language 1 + 3: Mono Language 2 + 4: Mono Audio Description (Language 1) + 5: Mono Emergency Warning Information	1: L	1: R	2	3	4	5										
04	1: Channel Bed 5.1	1: L	1: R	1: C	1: LFE	1: Ls	1: Rs										
05	1: Channel Bed 5.1 + 2: Mono Language 1 + 3: Mono Language 2	1: L	1: R	1: C	1: LFE	1: Ls	1: Rs	2	3								
06	1: Channel Bed 5.1+4H	1: L	1: R	1: C	1: LFE	1: Ls	1: Rs	1: Ltf	1: Rtf	1: Ltr	1: Rtr						
07	1: Channel Bed 5.1+4H + 2: Mono Language 1 + 3: Mono Language 2	1: L	1: R	1: C	1: LFE	1: Ls	1: Rs	1: Ltf	1: Rtf	1: Ltr	1: Rtr	2	3				
08	1: Channel Bed 5.1+4H + 2: Mono Language 1 + 3: Mono Language 2 + 4: Mono Audio Description (Language 1) + 5: Mono Stadium Announcer	1: L	1: R	1: C	1: LFE	1: Ls	1: Rs	1: Ltf	1: Rtf	1: Ltr	1: Rtr	2	3	4	5		
09	1: Channel Bed 5.1+4H + 2: Mono Commentator 1 + 3: Mono Commentator 2	1: L	1: R	1: C	1: LFE	1: Ls	1: Rs	1: Ltf	1: Rtf	1: Ltr	1: Rtr	2	3				
10	1: Channel Bed 5.1+4H + 2: Mono Language 1 + 3: Mono Language 2 + 4: Mono Dynamic Object	1: L	1: R	1: C	1: LFE	1: Ls	1: Rs	1: Ltf	1: Rtf	1: Ltr	1: Rtr	2	3	4			
11	1: Channel Bed 5.1+4H + 2: Mono Language 1 + 3: Mono Language 2 + 4: Stereo mix (Language 1) + 5: Mono mix (Language 2)	1: L	1: R	1: C	1: LFE	1: Ls	1: Rs	1: Ltf	1: Rtf	1: Ltr	1: Rtr	2	3	4: L	4: R	5	

File #	Audio test content characteristics	Ch 1	Ch 2	Ch 3	Ch 4	Ch 5	Ch 6	Ch 7	Ch 8	Ch 9	Ch 10	Ch 11	Ch 12	Ch 13	Ch 14	Ch 15	Ch 16
12	1: Higher-Order Ambisonics (3 rd order, ACN channel ordering, SN3D gain normalization)	1: ACN 00	1: ACN 01	1: ACN 02	1: ACN 03	1: ACN 04	1: ACN 05	1: ACN 06	1: ACN 07	1: ACN 08	1: ACN 09	1: ACN 10	1: ACN 11	1: ACN 12	1: ACN 13	1: ACN 14	1: ACN 15

All proposed audio systems shall be evaluated by a common set of audio test content and shall use the same Test Lab room environment. This room shall have adequate audio listening and shall reproduce ordinary living room characteristics as much as possible (e.g., recommended dimensions for the room are width: 4 m to 6 m, height: 2.5 m to 3.5 m, length: 3.5 m to 5 m; and it should allow placement of the TV set and soundbar in the room 50 to 100 cm above the floor and 2 to 3 m away from the listening position).

For the audio feature evaluation, one of the two audio test setups (illustrated in Figure 41 and Figure 42 with their respective mandatory elements) shall be used, according to the test. Instructions about setup selection are provided in each audio test description. Additional monitoring elements may be added to those setups by the Test Lab or by the SBTVD Forum. Nevertheless, those additional elements shall be informed to all proponents before the test execution.

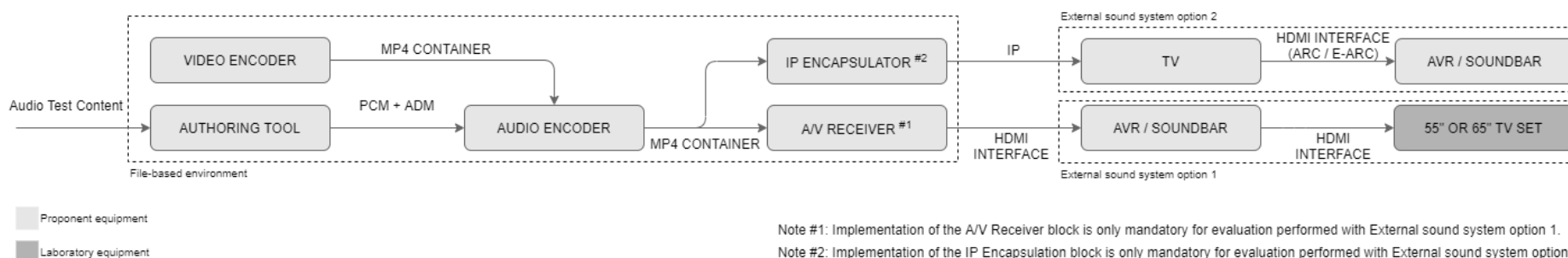


Figure 41: Audio test setup for non-real-time encoding / decoding

For evaluations using the non-real-time encoding / decoding setup, all elements (hardware and software) are the proponent's responsibility. The transport layer between the audio encoder and the A/V receiver shall use an MP4 container format. All MP4 files will be stored. A/V receiver shall use an HDMI interface to feed the external sound system and demonstrate the audio system capabilities. The video content, if necessary, shall be provided by the proponent and shall be encoded using ProRes 422 Proxy video codec, spatial resolution 1 920 x 1 080 pixels, 59.94 frames per second, progressive scanning, 10-bit per component, SDR Rec. ITU-R BT.2020 and aspect ratio 16:9.

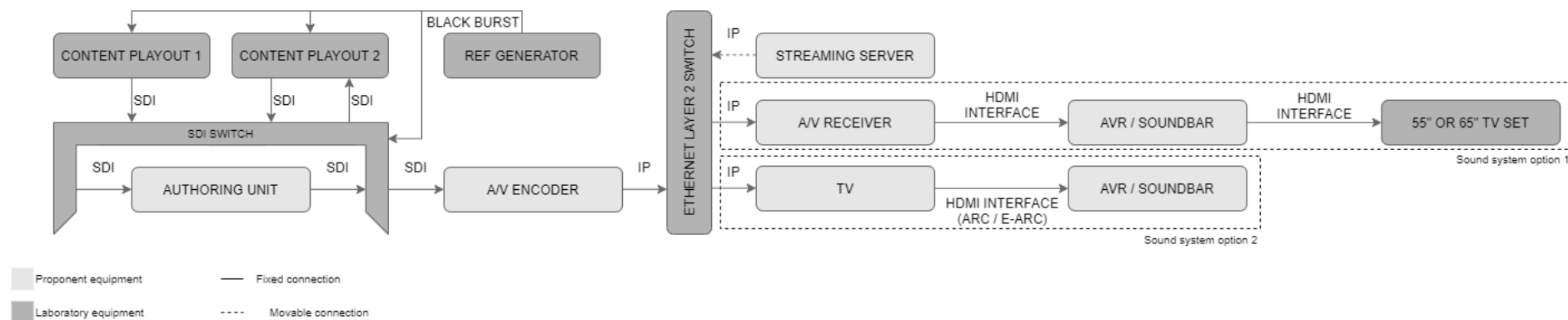


Figure 42: Audio test setup for real-time encoding / decoding

For evaluations using real-time encoding / decoding, the Authoring Unit block shall use the SDI interface for its input and output. The A/V encoder shall accept SDI interface input and, for the output interface, it shall use IP version 4 protocol over Ethernet (IEEE 802.3). The IP-based transport layer protocol shall be chosen by the proponent. The A/V receiver input interface shall accept IP version 4 over Ethernet (IEEE 802.3) and its A/V output interface shall use HDMI. Both content playouts in this setup shall be capable of playing uncompressed A/V content over the SDI interface. Any content authored by the Authoring Unit should be recorded by Content Playout 2 for later use in other audio tests. Content Playouts 1, 2, and SDI Switch shall be referenced to the genlock signal provided by the reference generator, to always obtain a clean switch operation with SDI Switch equipment. In the normal operation of this setup, the Streaming Server shall remain disconnected from Ethernet Layer 2 Switch. When necessary, particular Test Cases provide instructions about the Streaming Server connection.

4.5.3.1 Test 1 (Immersive audio)

Each proponent’s system performance shall be evaluated for the following capabilities:

Test Case ID	TC1.1
Test Description	Requirement AC1.1.1, AC1.1.2, AC1.1.3, and AC1.2: <ol style="list-style-type: none"> 1. Shall demonstrate the system’s ability to present audio in the specified channel mode and in accordance with the target bitrate for this Test Case. 2. Shall demonstrate the system’s ability to present audio in the specified channel mode and audio objects rendered together to various output setups (e.g., 2.0, 5.1, and 5.1+4H channels). The demonstration shall use the target bitrates for this Test Case.
Test Setup	Real-time setup as shown in Figure 42.

Test Case ID	TC1.1
Test Content	<p>Test items:</p> <ol style="list-style-type: none"> 1. Audio content 1; 2. Audio content 4; 3. Audio content 6; 4. Audio content 9.
Test Bitrate	<p>Specified bitrates are:</p> <ol style="list-style-type: none"> 1. Mono or Stereo (2.0) = 48 kbps; 2. Surround 5.1 = 144 kbps; 3. Immersive 5.1+4H = 256 kbps; 4. Audio object = 48 kbps per object. <p>The total bitrate to be used for each Test Item is computed by summing the specified bitrate for each component of the Test Item with a tolerance of $\pm 2\%$.</p>
Test Procedure	<p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Play the Test Item from the content playout system through the real-time test setup. 2. In the authoring system, author the metadata. 3. Playback the live test stream received over IP continuously and keep the volume of playback to a suitable level. 4. Evaluate the overall 3D experience when played back over the connected external sound device (AVR/Soundbar). Sound sources panned in production above the listener should be perceived during reproduction over the external sound system also above the listener. 5. Evaluate the overall spatial reproduction when the content is played back over a 5.1 setup and a stereo setup, up to the capabilities of the reproduction system. <p>Perceiving spatial sound events at wrong positions leads to failure of the test.</p>

Test Case ID	TC1.2
Test Description	<p>Requirement AC1.3:</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to present scene-based (HOA, Higher-Order Ambisonics) content in accordance with the target bitrate for this Test Case.
Test Setup	Non-real-time setup as shown in Figure 41.

Test Case ID	TC1.2
Test Content	Test item: 1. Audio content 12.
Test Bitrate	HOA content is characterized by a certain order, N. Shall be used the order N equal to 3, which gives the number of corresponding "HOA-channels" equal to 16 (as, per definition, $ch=(N+1)^2$). Shall be used 20 kbps per "HOA-channel", therefore the HOA bitrate shall be equal to 320 kbps.
Test Procedure	For each Test Item conduct the following steps: <ol style="list-style-type: none"> 1. Encode the HOA content with the video content to an MP4 file. 2. Playback the MP4 file on the proponent video player and keep the volume of playback to a suitable level. 3. Evaluate the overall 3D experience when played back over the connected external sound device (AVR/Soundbar). Sound events located left/right to or above the listener should be perceived during reproduction over the external sound system also left/right to or above the listener. 4. Evaluate the overall spatial reproduction when the content is played back over a 5.1 setup and a stereo setup, up to the capabilities of the reproduction system. <p>Perceiving spatial sound events at wrong positions leads to failure of the test.</p>

4.5.3.2 Test 2 (Interactivity and personalization)

Each proponent's performance shall be evaluated for the following capabilities:

Test Case ID	TC2.1
Test Description	Requirement AC2.1: Language Selection. 1. Shall demonstrate the system's ability to allow end-users to select between multiple audio languages based on user interaction or automatic language selection (e.g., the receiver's preferred audio settings).
Test Setup	Real-time setup as shown in Figure 42.
Test Content	Test items: <ol style="list-style-type: none"> 1. Audio content 3; 2. Audio content 5; 3. Audio content 8.

Test Case ID	TC2.1
Test Bitrate	<p>Specified bitrates are:</p> <ol style="list-style-type: none"> 1. Mono or Stereo (2.0) = 48 kbps; 2. Surround 5.1 = 144 kbps; 3. Immersive 5.1+4H = 256 kbps; 4. Audio object = 48 kbps per object. <p>The total bitrate to be used for each Test Item is computed by summing the specified bitrate for each component of the Test Item with a tolerance of $\pm 2\%$.</p>
Test Procedure	<p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Play the Test Item from the content playout system through the real-time test setup. 2. In the authoring system, author the metadata enabling the desired personalization options to be tested. The authored signal will be sent over SDI to the A/V encoder. 3. Playback the live test stream received over IP continuously and keep the volume of playback to a suitable level. 4. Evaluate the capability of the audio system to display on the receiver side all available languages authored in production. 5. Evaluate the capability of the audio system to enable the user to manually switch between different languages on the receiver side during live playback. 6. Set the preferred language of the receiving device to a different language and evaluate the capability of the audio system to: <ol style="list-style-type: none"> a. Start the playback at receiver tune-in with the preferred language active, given that the preferred language is available in the authored and received stream. b. Start the playback at receiver tune-in with the default language active, given that the preferred language is not available in the authored and received stream. <p>Incorrect display of the available languages, playback of the wrong audio language or lack of fallback to commentator available in the stream, disruption of the live playback (e.g., the audio stops during a user selection) leads to failure of the test.</p>

Test Case ID	TC2.2
Test Description	<p>Requirement AC2.1: Selection of different preselections.</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to allow end-users to select between different preselections created in production.
Test Setup	Real-time setup as shown in Figure 42.

Test Case ID	TC2.2
Test Content	<p>Test items:</p> <ol style="list-style-type: none"> 1. Audio content 8; 2. Audio content 11.
Test Bitrate	<p>Specified bitrates are:</p> <ol style="list-style-type: none"> 1. Mono or Stereo (2.0) = 48 kbps; 2. Surround 5.1 = 144 kbps; 3. Immersive 5.1+4H = 256 kbps; 4. Audio object = 48 kbps per object. <p>The total bitrate to be used for each Test Item is computed by summing the specified bitrate for each component of the Test Item with a tolerance of $\pm 2\%$.</p>
Test Procedure	<p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Play the Test Item from the content playout system through the real-time test setup. 2. In the authoring system, author the metadata enabling the desired personalization options to be tested. The authored signal will be sent over SDI to the A/V encoder. 3. Playback the live test stream received over IP continuously and keep the volume of playback to a suitable level. 4. Evaluate the capability of the audio system to display on the receiver side all preselections authored in production. 5. Evaluate the capability of the audio system to enable the end-user to manually switch between different preselections on the receiver side during live playback. 6. Evaluate the capability of the audio system to correctly render all the preselections on the receiver side. <p>Incorrect display of the available preselections, playback of the wrong preselection, playback of the wrong audio elements inside a preselection, or disruption of the live playback (e.g., the audio stops during a user selection) leads to failure of the test.</p>

Test Case ID	TC2.3
Test Description	<p>Requirement AC2.1: Switch between multiple commentators.</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to allow end-users to select between multiple commentators (e.g., during a sports event the user at home could switch between the usual commentator and the premium commentator or local team commentator).
Test Setup	Real-time setup as shown in Figure 42.

Test Case ID	TC2.3
Test Content	<p>Test items:</p> <ol style="list-style-type: none"> 1. Audio content 9.
Test Bitrate	<p>Specified bitrates are:</p> <ol style="list-style-type: none"> 1. Mono or Stereo (2.0) = 48 kbps; 2. Surround 5.1 = 144 kbps; 3. Immersive 5.1+4H = 256 kbps; 4. Audio object = 48 kbps per object. <p>The total bitrate to be used for each Test Item is computed by summing the specified bitrate for each component of the Test Item with a tolerance of $\pm 2\%$.</p>
Test Procedure	<p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Play the Test Item from the content playout system through the real-time test setup. 2. In the authoring system, author the metadata enabling the desired personalization options to be tested. The authored signal will be sent over SDI to the A/V encoder. 3. Playback the live test stream received over IP continuously and keep the volume of playback to a suitable level. 4. Evaluate the capability of the audio system to display on the receiver side all available commentators authored in the production. 5. Evaluate the capability of the audio system to enable the end-user to manually switch between different commentators on the receiver side during live playback. <p>Incorrect display of the available commentators, playback of the wrong commentators, or disruption of the live playback (e.g., the audio stops during a user selection) leads to failure of the test.</p>

Test Case ID	TC2.4
Test Description	<p>Requirement AC2.1: Display of textual labels.</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to display to the end-users correct textual labels for all audio objects that allow interactivity options and preselections as created in production.
Test Setup	Real-time setup as shown in Figure 42.

Test Case ID	TC2.4
Test Content	<p>Test items:</p> <ol style="list-style-type: none"> 1. Audio content 8; 2. Audio content 9; 3. Audio content 11.
Test Bitrate	<p>Specified bitrates are:</p> <ol style="list-style-type: none"> 1. Mono or Stereo (2.0) = 48 kbps; 2. Surround 5.1 = 144 kbps; 3. Immersive 5.1+4H = 256 kbps; 4. Audio object = 48 kbps per object. <p>The total bitrate to be used for each Test Item is computed by summing the specified bitrate for each component of the Test Item with a tolerance of $\pm 2\%$.</p>
Test Procedure	<p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Play the Test Item from the content playout system through the real-time test setup. 2. In the authoring system, author the metadata. Author personalized labels for several audio elements (e.g., Dialogs, Commentators, Stadium Announcers, etc.) and several preselections (e.g., Main mix, Dialog+, Stadium, etc.). The authored signal will be sent over SDI to the A/V encoder. 3. Playback the live test stream received over IP continuously and keep the volume of playback to a suitable level. 4. Evaluate the capability of the audio system to display on the receiver side the textual labels for all preselections and audio objects allowing user interactivity as authored in production. 5. Evaluate the capability of the audio system to correctly render all the preselections on the receiver side during live playback and modifications in production. <p>Incorrect display of the textual labels, playback of the wrong preselection, or disruption of the live playback leads to failure of the test.</p>

Test Case ID	TC2.5
Test Description	<p>Requirement AC2.2: Audio object loudness interactivity, changing the level relative to the background.</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to enable the end-users to interact with any audio object and adjust the object level at the end-user's device according to broadcaster settings in production. The user shall be able to increase or decrease the object level (relative to the background) only inside a range specified by the broadcaster (e.g., min/max gain interactivity values) and this range might differ for each object
Test Setup	Real-time setup as shown in Figure 42.
Test Content	<p>Test items:</p> <ol style="list-style-type: none"> 1. Audio content 8; 2. Audio content 9.
Test Bitrate	<p>Specified bitrates are:</p> <ol style="list-style-type: none"> 1. Mono or Stereo (2.0) = 48 kbps; 2. Surround 5.1 = 144 kbps; 3. Immersive 5.1+4H = 256 kbps; 4. Audio object = 48 kbps per object. <p>The total bitrate to be used for each Test Item is computed by summing the specified bitrate for each component of the Test Item with a tolerance of $\pm 2\%$.</p>
Test Procedure	<p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Play the Test Item from the content playout system through the real-time test setup. 2. In the authoring system, author the metadata enabling the desired personalization options to be tested (e.g., testing various gain interactivity ranges for each object). The authored signal will be sent over SDI to the A/V encoder. 3. Playback the live test stream received over IP continuously and keep the volume of playback to a suitable level. 4. Evaluate the capability of the audio system to display on the receiver side the object gain interactivity options within the limits authored in the production (e.g., some objects may allow interactivity while others do not allow it, as desired by the content). 5. Evaluate the capability of the audio system to enable the end-user to manually increase or decrease the level of the individual objects which allow interactivity on the receiver side during live playback. <p>Incorrect display of the available interactivity options within the limits, playback of the wrong audio objects, or disruption of the live playback (e.g., the audio stops during user interaction) leads to failure of the test.</p>

Test Case ID	TC2.6
Test Description	<p>Requirement AC2.3: Audio object interactivity, changing the object position.</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to enable the end-users to interact with any object and adjust the object position at the end-user's device according to broadcaster settings in production. The end-user shall be able to move audio elements at the end-user's device inside an area specified by the broadcaster (e.g., min/max position interactivity values) and this area might differ for each object.
Test Setup	Real-time setup as shown in Figure 42.
Test Content	<p>Test items:</p> <ol style="list-style-type: none"> 1. Audio content 8; 2. Audio content 10.
Test Bitrate	<p>Specified bitrates are:</p> <ol style="list-style-type: none"> 1. Mono or Stereo (2.0) = 48 kbps; 2. Surround 5.1 = 144 kbps; 3. Immersive 5.1+4H = 256 kbps; 4. Audio object = 48 kbps per object. <p>The total bitrate to be used for each Test Item is computed by summing the specified bitrate for each component of the Test Item with a tolerance of $\pm 2\%$.</p>
Test Procedure	<p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Play the Test Item from the content playout system through the real-time test setup. 2. In the authoring system, author the metadata enabling the desired personalization options to be tested (e.g., testing various position interactivity ranges for each object). The authored signal will be sent over SDI to the A/V encoder. 3. Playback the live test stream received over IP continuously and keep the volume of playback to a suitable level. 4. Evaluate the capability of the audio system to display on the receiver side the object position interactivity options within the limits authored in the production (e.g., some objects may allow position interactivity while others do not allow it, as desired by the content creator). 5. Evaluate the capability of the audio system to enable the end-user to manually adjust the position of individual objects which allow position interactivity on the receiver side during live playback. <p>Incorrect display of the available position interactivity options within the limits, playback of the wrong audio objects, or disruption of the live playback (e.g., the audio stops during user interaction, the audio/stream stops during a change in production) leads to failure of the test.</p>

Test Case ID	TC2.7
Test Description	<p>Requirement AC2.4: Enable Interactivity when using external sound reproduction systems.</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to enable interactivity when using external sound reproduction devices. All interactivity options described shall be demonstrated also using an external sound reproduction device (e.g., Soundbar/AVR). The tests shall demonstrate the system's ability to enable the interactivity options on the main receiving device (e.g., TV/STB) while the immersive sound is reproduced by the external sound reproduction device.
Test Setup	Real-time setup as shown in Figure 42.
Test Content	<p>Test items:</p> <ol style="list-style-type: none"> 1. Audio content 8; 2. Audio content 9; 3. Audio content 10.
Test Bitrate	<p>Specified bitrates are:</p> <ol style="list-style-type: none"> 1. Mono or Stereo (2.0) = 48 kbps; 2. Surround 5.1 = 144 kbps; 3. Immersive 5.1+4H = 256 kbps; 4. Audio object = 48 kbps per object. <p>The total bitrate to be used for each Test Item is computed by summing the specified bitrate for each component of the Test Item with a tolerance of $\pm 2\%$.</p>
Test Procedure	<p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Play the Test Item from the content playout system through the real-time test setup. 2. In the authoring system, author the metadata enabling the desired personalization options to be tested. The authored signal will be sent over SDI to the A/V encoder. 3. Playback the live test stream received over IP continuously and keep the volume of playback to a suitable level. 4. Evaluate the capability of the audio system to display on the receiver side a user interface with all interactivity options and limits as authored in the production (e.g., some objects may allow position or level interactivity while others do not allow it, as desired by the content creator). 5. Evaluate the capability of the audio system to enable the end-user to manually interact with the audio scene (e.g., change an object level or position, change the preset) on the receiver side during live playback and evaluate the immersive experience reproduced on the external sound device (e.g., objects moved in the 3D space should be perceived at specific positions according to the user interaction). <p>Incorrect display of the available position interactivity options and interactivity limits, playback of the wrong audio objects, or disruption of the live playback (e.g., the audio stops during user interaction, the audio/stream stops during a change in production) leads to failure of the test.</p>

4.5.3.3 Test 3 (Audio description)

Each proponent's performance shall be evaluated for the following capabilities:

Test Case ID	TC3.1
Test Description	Requirement AC3.1 and AC3.2: Audio description in the same stream as the main audio. <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to enable audio description delivered in the same stream as the main audio (e.g., a single stream containing the main audio mix and alternative mix with audio description).
Test Setup	Real-time setup as shown in Figure 42.
Test Content	Test items: <ol style="list-style-type: none"> 1. Audio content 2.
Test Bitrate	Specified bitrates are: <ol style="list-style-type: none"> 1. Mono or Stereo (2.0) = 48 kbps; 2. Surround 5.1 = 144 kbps; 3. Immersive 5.1+4H = 256 kbps; 4. Audio object = 48 kbps per object. <p>The total bitrate to be used for each Test Item is computed by summing the specified bitrate for each component of the Test Item with a tolerance of $\pm 2\%$.</p>

Test Case ID	TC3.1
Test Procedure	<p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Play the Test Item from the content playout system through the real-time test setup. 2. In the authoring system, author the metadata enabling the desired personalization options to be tested. The authored signal will be sent over SDI to the A/V encoder. 3. Playback the live test stream received over IP continuously and keep the volume of playback to a suitable level. 4. Evaluate the capability of the audio system to display on the receiver the available Audio Description options in multiple languages as authored in production. 5. Evaluate the capability of the audio system to enable the end-user to manually switch between different Audio Description elements on the receiver side during live playback. 6. On the receive enable Audio Description and set the preferred language in the preferred settings of the device and evaluate the capability of the audio system to start the playback at receiver tune-in with Audio Description in the preferred language, given that the Audio Description in the preferred language is in the authored stream. <p>Incorrect display of the available Audio Description, playback of the Audio Description in the wrong language, or disruption of the live playback (e.g., the audio stops during a user change) leads to failure of the test.</p>

Test Case ID	TC3.2
Test Description	<p>Requirement AC3.3 Part 1: Audio description delivered as an additional audio object.</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to enable audio description delivered as an additional audio object with associated metadata.
Test Setup	Real-time setup as shown in Figure 42.
Test Content	<p>Test items:</p> <ol style="list-style-type: none"> 1. Audio content 3; 2. Audio content 8.

Test Case ID	TC3.2
Test Bitrate	<p>Specified bitrates are:</p> <ol style="list-style-type: none"> 1. Mono or Stereo (2.0) = 48 kbps; 2. Surround 5.1 = 144 kbps; 3. Immersive 5.1+4H = 256 kbps; 4. Audio object = 48 kbps per object. <p>The total bitrate to be used for each Test Item is computed by summing the specified bitrate for each component of the Test Item with a tolerance of $\pm 2\%$.</p>
Test Procedure	<p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Play the Test Item from the content playout system through the real-time test setup. 2. In the authoring system, author the metadata enabling the desired personalization options to be tested. The authored signal will be sent over SDI to the A/V encoder. 3. Playback the live test stream received over IP continuously and keep the volume of playback to a suitable level. 4. Evaluate the capability of the audio system to display on the receiver the available Audio Description options as authored in production. 5. Evaluate the capability of the audio system to enable the end-user to manually enable and disable Audio Description on the receiver side during live playback. <p>Incorrect display of the available Audio Description options, playback without Audio Description after user selection of Audio Description, or disruption of the live playback (e.g., the audio stops during a user change) leads to failure of the test.</p>

Test Case ID	TC3.3
Test Description	<p>Requirement AC3.3 Part 2: Audio description delivered as additional audio objects and language selection.</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to enable/disable audio description in multiple languages, delivered as an additional audio object with associated metadata.
Test Setup	Real-time setup as shown in Figure 42.
Test Content	<p>Test items:</p> <ol style="list-style-type: none"> 1. Audio content 3; 2. Audio content 8.

Test Case ID	TC3.3
Test Bitrate	<p>Specified bitrates are:</p> <ol style="list-style-type: none"> 1. Mono or Stereo (2.0) = 48 kbps; 2. Surround 5.1 = 144 kbps; 3. Immersive 5.1+4H = 256 kbps; 4. Audio object = 48 kbps per object. <p>The total bitrate to be used for each Test Item is computed by summing the specified bitrate for each component of the Test Item with a tolerance of $\pm 2\%$.</p>
Test Procedure	<p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Play the Test Item from the content playout system through the real-time test setup. 2. In the authoring system, author the metadata enabling the desired personalization options to be tested. The authored signal will be sent over SDI to the A/V encoder. 3. Playback the live test stream received over IP continuously and keep the volume of playback to a suitable level. 4. Evaluate the capability of the audio system to display on the receiver the available Audio Description options and available languages as authored in production. 5. On the receiving device enable Audio Description and set the preferred language in the preferred settings of the device and evaluate the capability of the audio system to start the playback at receiver tune-in with active Audio Description in the preferred language, given that the Audio Description in the preferred language is in the authored stream. <p>Incorrect display of the available Audio Description options, playback of the content without Audio Description when Audio Description is enabled or disruption of the live playback (e.g., the audio stops during a user change) lead to failure of the test.</p>

Test Case ID	TC3.4
Test Description	<p>Requirement AC3.3 Part 3: Audio description delivered as additional audio objects and spatial separation of main dialog and audio description.</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to enable/disable audio description and spatially separate the main dialog and the audio description for better speech intelligibility.
Test Setup	Real-time setup as shown in Figure 42.

Test Case ID	TC3.4
Test Content	<p>Test items:</p> <ol style="list-style-type: none"> 1. Audio content 3; 2. Audio content 8.
Test Bitrate	<p>Specified bitrates are:</p> <ol style="list-style-type: none"> 1. Mono or Stereo (2.0) = 48 kbps; 2. Surround 5.1 = 144 kbps; 3. Immersive 5.1+4H = 256 kbps; 4. Audio object = 48 kbps per object. <p>The total bitrate to be used for each Test Item is computed by summing the specified bitrate for each component of the Test Item with a tolerance of $\pm 2\%$.</p>
Test Procedure	<p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Play the Test Item from the content playout system through the real-time test setup. 2. In the authoring system, author the metadata enabling the desired personalization options to be tested. A dedicated preselection for the Audio Description shall be created where the main dialog is placed at one specific position (e.g., front left speaker) and the Audio Description object is placed at a different position (e.g., front right speaker). The authored signal will be sent over SDI to the A/V encoder. 3. Playback the live test stream received over IP continuously and keep the volume of playback to a suitable level. 4. Evaluate the capability of the audio system to enable the end-user to manually switch between different preselections on the receiver side during live playback. 5. Evaluate the capability of the audio system to correctly reproduce at the receiver side the main dialog and the Audio Description at the desired locations in each preselection during live playback according to the metadata authored in production. <p>Reproduction of the main dialog and Audio Description at different locations than set in production leads to failure of the test.</p>

4.5.3.4 Test 4 (Audio emergency warning information)

Each proponent's performance shall be evaluated for the following capabilities:

Test Case ID	TC4.1
Test Description	<p>Requirement AC4.1:</p> <ol style="list-style-type: none"> 1. Shall demonstrate how the audio system can deliver emergency warning information audio description, particularly showing what metadata is carried in the audio bitstream and how other applications could access or process this metadata to achieve the same result (e.g. some sort of API specification). NOTE: This helps TV 3.0 application coding experts to incorporate this new feature into the future specification.
Test Setup	Real-time setup as shown in Figure 42.
Test Content	<p>Test items:</p> <ol style="list-style-type: none"> 1. Audio content 3 including the Emergency Warning Information (EWI) audio object.
Test Bitrate	<p>Specified bitrates are:</p> <ol style="list-style-type: none"> 1. Mono or Stereo (2.0) = 48 kbps; 2. Surround 5.1 = 144 kbps; 3. Immersive 5.1+4H = 256 kbps; 4. Audio object = 48 kbps per object. <p>The total bitrate to be used for each Test Item is computed by summing the specified bitrate for each component of the Test Item with a tolerance of $\pm 2\%$.</p>

Test Case ID	TC4.1
Test Procedure	<p>The EWI audio object shall be active only for a limited period during the playback of the normal Test Item and could be active at any moment in time.</p> <p>With the Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Play the Test Item from the content playout system through the real-time test setup. 2. In the authoring system, author the metadata enabling the desired personalization options to be tested, with the Emergency Warning Information audio object disabled. The authored signal will be sent over SDI to the A/V encoder. 3. Playback the live test stream received over IP continuously and keep the volume of playback to a suitable level. 4. In the authoring system. Enable Emergency Warning Information (EWI) audio object. 5. Evaluate the overall experience of playing emergency warning information audio description during reproduction over the external sound system: <ol style="list-style-type: none"> a. Before the Emergency Warning Information is triggered; b. During the Emergency Warning Information; c. After the emergency Warning Information has finished. 6. Evaluate the continuous playback of the content before, during, and after the Emergency Warning Information. 7. Evaluate the capability of the audio system to signal the Emergency Warning Information in the authoring system and the flexibility to control the Emergency Warning Information (i.e., if the audio object should be active in all preselections or a dedicated preselection, should mute the main dialog or playback over the main dialog, etc.). <p>Incorrect display of the Emergency Warning Information Audio Description, playback without Emergency Warning Information Audio Description, or disruption of the live playback (e.g., the audio stops during the presentation) leads to failure of the test.</p>

4.5.3.5 Test 5 (Flexible audio playback configuration)

Each proponent's performance shall be evaluated for the following capabilities:

Test Case ID	TC5.1
Test Description	<p>Requirement AC5.1 and AC5.2:</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to decode and render the same content to multiple audio playback configurations including TV loudspeakers, soundbars, home theaters (immersive and 5.1 AVRs), and binaural
Test Setup	Real-time setup as shown in Figure 42.

Test Case ID	TC5.1
Test Content	<p>Test items:</p> <ol style="list-style-type: none"> 1. Audio content 8; 2. Audio content 11.
Test Bitrate	<p>Specified bitrates are:</p> <ol style="list-style-type: none"> 1. Mono or Stereo (2.0) = 48 kbps; 2. Surround 5.1 = 144 kbps; 3. Immersive 5.1+4H = 256 kbps; 4. Audio object = 48 kbps per object. <p>The total bitrate to be used for each Test Item is computed by summing the specified bitrate for each component of the Test Item with a tolerance of $\pm 2\%$.</p>
Test Procedure	<p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Play the Test Item from the content playout system through the real-time test setup. 2. In the authoring system monitor the metadata. The authored signal will be sent over SDI to the A/V encoder. 3. Playback the live test stream received over IP continuously and keep the volume of playback to a suitable level. 4. Evaluate the capability of the audio system to playback the test item on TV loudspeakers with the correct spatial impression (within the limits of the TV loudspeakers). 5. Evaluate the capability of the audio system to playback the identical test item on a soundbar with the correct spatial impression (within the limits of the soundbar). 6. Evaluate the capability of the audio system to playback the identical test item (same encoded version) on an AVR connected to a 5.1 loudspeaker setup with the correct spatial impression (within the limits of the 5.1 loudspeaker setup). 7. Evaluate the capability of the audio system to playback the identical test item (same encoded version) on an AVR connected to a 5.1+4H loudspeaker setup with the correct spatial impression (within the limits of the 5.1+4H loudspeaker setup). 8. Evaluate the capability of the audio system to playback the identical test item (same encoded version) as binaural rendering over headphones with the correct spatial impression (within the limits of headphone reproduction). <p>Failure to render the correct spatial sound image within the limits of the reproduction device/setup (e.g. sound directions swapped left/right or collapse of the spatial image) leads to failure of the test. Other obvious rendering deficiencies (e.g., drop-outs, distortion) also lead to failure of the test.</p>

4.5.3.6 Test 6 (Consistent loudness)

Each proponent's performance shall be evaluated for the following capabilities:

Test Case ID	TC6.1
Test Description	Requirement AC6.1: Loudness Normalization Test - Programs. 1. Shall demonstrate the system's ability to achieve the target loudness level across multiple programs.
Test Setup	Non-real-time setup as shown in Figure 41.
Test Content	Test items: 1. Audio content 8; 2. Audio content 11.
Test Bitrate	Specified bitrates are: 1. Mono or Stereo (2.0) = 48 kbps; 2. Surround 5.1 = 144 kbps; 3. Immersive 5.1+4H = 256 kbps; 4. Audio object = 48 kbps per object. The total bitrate to be used for each Test Item is computed by summing the specified bitrate for each component of the Test Item with a tolerance of $\pm 2\%$.
Test Procedure	For each Test Item conduct the following steps: 1. Verify the ADM metadata correctness in the proponent authoring tool. 2. Encode the audio content using the proponent software audio encoder. 3. Decode the audio content using the proponent software audio decoder to three different target loudness levels: -31, -24, and -16 LKFS. 4. Evaluate the loudness consistency across multiple Test Items. The program loudness shall be measured according to ITU-R BS.1770-4 with a tolerance of ± 3 dB, using the FFMPEG tool. 5. From the FFMPEG tool output results, the loudness measurement is the value of the parameter labeled as " <i>Integrated Loudness</i> " (I), which unit is " <i>LUFS</i> " (LUFS is equal to LKFS as defined in Rec. ITU-R BS.1770). Detection of a loudness jump leads to failure of the test.

Test Case ID	TC6.2
Test Description	Requirement AC6.2: Loudness Normalization Test - Preselections. <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to preserve the target loudness level across multiple preselections inside the same program.
Test Setup	Non-real-time setup as shown in Figure 41.
Test Content	Test items: <ol style="list-style-type: none"> 1. Audio content 8; 2. Audio content 11.
Test Bitrate	Specified bitrates are: <ol style="list-style-type: none"> 1. Mono or Stereo (2.0) = 48 kbps; 2. Surround 5.1 = 144 kbps; 3. Immersive 5.1+4H = 256 kbps; 4. Audio object = 48 kbps per object. <p>The total bitrate to be used for each Test Item is computed by summing the specified bitrate for each component of the Test Item with a tolerance of $\pm 2\%$.</p>
Test Procedure	For each Test Item conduct the following steps: <ol style="list-style-type: none"> 1. Verify the ADM metadata correctness in the proponent authoring tool. 2. Re-author the content using the proponent authoring tool and add more preselections. 3. Encode the audio content using the proponent software audio encoder. 4. Decode the audio content using the proponent software audio decoder to the target loudness levels: -31, -24, and -16 LKFS. Enable one by one all available audio preselections. 5. Evaluate the loudness consistency across all available preselections. The program loudness shall be measured according to ITU-R BS.1770-4 with a tolerance of ± 3 dB, using FFMPEG tool. 6. From the FFMPEG tool output results, the loudness measurement is the value of the parameter labeled as "<i>Integrated Loudness</i>" (I), which unit is "<i>LUFS</i>" (LUFS is equal to LKFS as defined in Rec. ITU-R BS.1770). <p>Detection of a loudness jump leads to failure of the test. Preselections with intentionally low loudness may be skipped.</p>

Test Case ID	TC6.3
Test Description	Requirement AC6.2: Loudness Compensation Test. 1. Shall demonstrate the system's ability to preserve the target loudness level after user interaction, e.g., if the user increases the level of the dialog the overall loudness shall not increase.
Test Setup	Non-real-time setup as shown in Figure 41.
Test Content	Test items: 1. Audio content 8; 2. Audio content 11.
Test Bitrate	Specified bitrates are: 1. Mono or Stereo (2.0) = 48 kbps; 2. Surround 5.1 = 144 kbps; 3. Immersive 5.1+4H = 256 kbps; 4. Audio object = 48 kbps per object. The total bitrate to be used for each Test Item is computed by summing the specified bitrate for each component of the Test Item with a tolerance of $\pm 2\%$.
Test Procedure	For each Test Item conduct the following steps: 1. Verify the ADM metadata correctness in the proponent authoring tool. 2. Re-author the content using the proponent authoring tool and change the minimum and maximum gain interactivity options for several dialog objects to at least ± 10 dB. 3. Encode the audio content using the proponent software audio encoder and create an MP4 file muxing encoded audio and video streams together. 4. Playback the MP4 file using the proponent video player and interact with the content by manually increasing the level of dialog objects. 5. Evaluate the overall perceived loudness before and after the user interaction. Detection of an overall loudness level increase leads to failure of the test.

4.5.3.7 Test 7 (Seamless configuration changes and A/V alignment)

Shall include a detailed description of the alignment of audio and video streams that can be achieved for enabling seamless stream splicing and the impacts on the bitrate of the solution used for alignment of the audio and video streams.

Each proponent's performance shall be evaluated for the following capabilities:

Test Case ID	TC7.1
Test Description	<p>Requirement AC7.1: Seamless configuration changes</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to seamless playback content during configuration changes. Configuration changes between any of the available configurations available in the test content shall be tested (e.g., combinations between 2.0, 5.1, and 5.1+4H).
Test Setup	Real-time setup as shown in Figure 42.
Test Content	<p>Test items:</p> <ol style="list-style-type: none"> 1. Audio content 1; 2. Audio content 4; 3. Audio content 6; 4. Audio content 8.
Test Bitrate	The total bitrate to be used for the concatenated Test Item shall be set to a maximum bitrate of 448 kbps.
Test Procedure	<p>For this test, a test item can be created containing a concatenation of many different Test Items with different configurations (previously recorded after the authoring step, containing the authored metadata). For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Play the Test Item from the content playout system through the real-time test setup. 2. In the authoring system monitor the metadata. The authored signal will be sent over SDI to the A/V encoder. 3. In the authoring system monitor the correctness of the metadata. The test item contains a concatenation of many different Test Items with different configurations and the metadata shall be correctly displayed in the authoring system after each configuration change. The authored signal will be sent over SDI to the A/V encoder. 4. Playback the live test stream received over IP continuously and keep the volume of playback to a suitable level. 5. Evaluate the capability of the audio system to: <ol style="list-style-type: none"> a. Display on the receiver side the various interactivity options corresponding to each configuration and seamlessly update the user interface at each configuration. b. Continuously and seamlessly playback the content during all configuration changes. <p>Incorrect display of the available interactivity options, an erroneous audio playback, or disruption of the live playback during a configuration change leads to failure of the test.</p>

Test Case ID	TC7.2
Test Description	<p>Requirement AC7.2: Seamless content playback during user interaction.</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to seamless playback content during user interaction. Shall include changes between different audio languages or preselections, increasing or decreasing the level of various audio objects, without any audio drop-outs or glitches.
Test Setup	Real-time setup as shown in Figure 42.
Test Content	<p>Test items:</p> <ol style="list-style-type: none"> 1. Audio content 8; 2. Audio content 11.
Test Bitrate	<p>Specified bitrates are:</p> <ol style="list-style-type: none"> 1. Mono or Stereo (2.0) = 48 kbps; 2. Surround 5.1 = 144 kbps; 3. Immersive 5.1+4H = 256 kbps; 4. Audio object = 48 kbps per object. <p>The total bitrate to be used for each Test Item is computed by summing the specified bitrate for each component of the Test Item with a tolerance of $\pm 2\%$.</p>
Test Procedure	<p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Play the Test Item from the content playout system through the real-time test setup. 2. In the authoring system, author the metadata enabling the desired personalization options to be tested. The authored signal will be sent over SDI to the A/V encoder. 3. Playback the live test stream received over IP continuously and keep the volume of playback to a suitable level. 4. Evaluate the capability of the audio system to display on the receiver side a user interface indicating all interactivity options within the limits authored in production. 5. Evaluate the capability of the audio system to enable the end-user to manually and seamlessly interact with the audio content on the receiver side during live playback (e.g., change preselection, increase dialog level, enable audio description, move objects to left/right or up/down, etc.). <p>Incorrect display of the available interactivity options within the limits or disruption of the live playback during user interaction (e.g., the audio stops during user interaction, the audio/stream stops during a change in production) leads to failure of the test.</p>

Test Case ID	TC7.3
Test Description	<p>Requirement AC7.3 Part 1: Seamless content playback during changes in production.</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to seamless playback content during changes in production during a live broadcast. All typical changes in a live broadcast shall be tested, including: <ol style="list-style-type: none"> a. Change the audio scene (objects, preselections, etc.); b. Enable/disable dialogs in multiple languages; c. Enable/disable Audio Description in multiple languages; d. Enable/disable interactivity options for one or more preselections; e. Change the interactivity options (min/max gain and position values) for one or more objects; f. Change the textual labels for one or more objects or preselections.
Test Setup	Real-time setup as shown in Figure 42.
Test Content	<p>Test items:</p> <ol style="list-style-type: none"> 1. Audio content 8; 2. Audio content 9; 3. Audio content 11.
Test Bitrate	<p>Specified bitrates are:</p> <ol style="list-style-type: none"> 1. Mono or Stereo (2.0) = 48 kbps; 2. Surround 5.1 = 144 kbps; 3. Immersive 5.1+4H = 256 kbps; 4. Audio object = 48 kbps per object. <p>The total bitrate to be used for each Test Item is computed by summing the specified bitrate for each component of the Test Item with a tolerance of $\pm 2\%$.</p>

Test Case ID	TC7.3
Test Procedure	<p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Play the Test Item from the content payout system through the real-time test setup. 2. In the authoring system, author the metadata enabling the desired personalization options to be tested. The authored signal will be sent over SDI to the A/V encoder. 3. Playback the live test stream received over IP continuously and keep the volume of playback to a suitable level. 4. Evaluate the capability of the audio system to display seamlessly playback the content and correctly display the user interaction options while making the following changes in the live production: <ol style="list-style-type: none"> a. Change the audio scene (objects, preselections, etc.): <ol style="list-style-type: none"> i. Remove the last audio object on the production side and evaluate the capability of the audio system to correctly adapt, display, and reproduce the audio objects on the receiver side (e.g., if the stadium announcer audio object is removed from a preselection in production, the audio object shall not be audible any longer in that preselection and not available for user selection/interactivity); ii. Add or remove several preselections on the production side and evaluate the capability of the audio system to correctly adapt and display the available preselections on the receiver side; b. Enable/disable dialogs in multiple languages; c. Enable/disable Audio Description in multiple languages; d. Enable/disable interactivity options for one or more preselections and one or more audio objects: <ol style="list-style-type: none"> i. Enable or disable gain interactivity options for individual objects in the authoring system and evaluate the capability of the audio system to correctly adapt and display the available interactivity options on the receiver side; ii. Enable or disable position interactivity options for individual objects in the authoring system and evaluate the capability of the audio system to correctly adapt and display the available interactivity options on the receiver side; e. Change the interactivity options (min/max gain and position values) for one or more objects: <ol style="list-style-type: none"> i. Change the gain interactivity options limits for individual objects in the authoring system and evaluate the capability of the audio system to correctly adapt and display the available interactivity options on the receiver side; ii. Change the position interactivity options limits for individual objects in the authoring system and evaluate the capability of the audio system to correctly adapt and display the available interactivity options on the receiver side; f. Change the textual labels for one or more objects or preselections: <ol style="list-style-type: none"> i. Modify any of the labels available in production and evaluate the capability of the audio system to correctly adapt and display the updated textual labels on the receiver side during live playback without interruption of audio playback. <p>Audio drop out during production configuration changes, incorrect display of the available interactivity options within the limits and textual labels, playback of the wrong preselection, playback of the wrong audio elements inside a preselection, or disruption of the live playback (e.g., the audio stops during a user selection, the audio/stream stops during a change in production) lead to failure of the test.</p>

Test Case ID	TC7.4
Test Description	<p>Requirement AC7.3 Part 2: Seamless content playback during changes in production using a contribution feed.</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to seamlessly playback during changes in production in a live broadcast scenario. <p>This test case emulates the typical broadcast scenario where the broadcast feed is authored in one location (e.g., event location) and provided over a contribution link to the broadcast center where it is monitored and re-authored if needed.</p>
Test Setup	Real-time setup as shown in Figure 42.
Test Content	<p>Test items:</p> <ol style="list-style-type: none"> 1. Audio content 8; 2. Audio content 11.
Test Bitrate	<p>Specified bitrates are:</p> <ol style="list-style-type: none"> 1. Mono or Stereo (2.0) = 48 kbps; 2. Surround 5.1 = 144 kbps; 3. Immersive 5.1+4H = 256 kbps; 4. Audio object = 48 kbps per object. <p>The total bitrate to be used for each Test Item is computed by summing the specified bitrate for each component of the Test Item with a tolerance of $\pm 2\%$.</p>
Test Procedure	<p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. The pre-recorded output of the proponent authoring system for the test item will be used as the remote location production content. 2. Play the pre-recorded output of the proponent authoring system for the test item from the content playout system through the live chain. 3. Playback the live test stream received over IP continuously and keep the volume of playback to a suitable level. 4. In the authoring system, re-author the metadata and correct potential errors in the original authoring as the last quality control check in the broadcast center: <ol style="list-style-type: none"> a. Enable/disable interactivity options for one or more preselections and one or more audio objects; b. Change the interactivity options (min/max gain and position values) for one or more objects; c. Change the textual labels for one or more objects or preselections; 5. Evaluate the capability of the audio system to display seamlessly playback the content and correctly display the user interaction options while making the following changes in live production. <p>Audio drop out during production configuration changes leads to failure of the test.</p>

Test Case ID	TC7.5
Test Description	<p>Requirement AC7.4 Part 1: Seamless Ad-Insertion.</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to enable seamless ad-insertion at any time instance, e.g., switch between the main feed authored live (Content playout 1) and an additional feed containing the pre-authored advertisement break (Content playout 2).
Test Setup	Real-time setup as shown in Figure 42.
Test Content	<p>Test items:</p> <ol style="list-style-type: none"> 1. Audio content 1; 2. Audio content 11.
Test Bitrate	The total bitrate to be used for the Test Item shall be set to a maximum bitrate of 448 kbps.
Test Procedure	<p>This test is aiming at evaluation the audio system capabilities to handle ad-insertion in live broadcast, therefore two types of test items are used:</p> <ol style="list-style-type: none"> I. Test Items emulating the live broadcast with typical immersive and interactive options available. For these test items, the metadata is authored live in the authoring system. II. Test Items emulating the ad-breaks which are pre-authored and contain limited capabilities (e.g., only stereo and 5.1 content). <p>For evaluation conduct the following steps:</p> <ol style="list-style-type: none"> 1. Play the Test Items emulating the live broadcast from the Content Playout 1 through the real-time test setup. 2. In the authoring system, author the metadata enabling the desired personalization options to be tested. The authored signal will be sent over SDI to the A/V encoder. 3. From the Content Playout 2 play any of the Test Items emulating the ad-breaks. 4. Playback the live test stream received over IP continuously and keep the volume of playback to a suitable level. 5. Using a clean SDI switch, switch between the content authored live and the pre-authored ad-breaks. 6. Evaluate the capability of the audio system to: <ol style="list-style-type: none"> a. Display on the receiver side the various interactivity options corresponding to each configuration and seamlessly update the user interface at each ad-insertion. b. Continuously and seamlessly playback the content during the ad-insertion. <p>The seamless playout shall be achieved based on the capability of the clean switch to sample accurately switch between the different feeds.</p> <p>Incorrect display of the available interactivity options, an erroneous audio playback of the or disruption of the live playback during ad-insertion leads to failure of the test.</p>

Test Case ID	TC7.6
Test Description	<p>Requirement AC7.4 Part 2: User selection persistency after the Ad-break.</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to preserve the user interaction settings after the ad-break, e.g., if the user selects, before the ad-break, the English language (EN) and increases the dialog level with 7 dB, after the ad-break the content will start with the exact same settings.
Test Setup	Real-time setup as shown in Figure 42.
Test Content	<p>Test items:</p> <ol style="list-style-type: none"> 1. Audio content 1; 2. Audio content 11.
Test Bitrate	The total bitrate to be used for the Test Item shall be set to a maximum bitrate of 448 kbps.
Test Procedure	<p>This test is aiming at evaluation the audio system capabilities to handle ad-insertion in live broadcast, therefore two types of test items are used:</p> <ol style="list-style-type: none"> I. Test Items emulating the live broadcast with typical immersive and interactive options available. For these test items, the metadata is authored live in the authoring system. II. Test Items emulating the ad-breaks which are pre-authored and contain limited capabilities (e.g., only stereo and 5.1 content). <p>For evaluation conduct the following steps:</p> <ol style="list-style-type: none"> 1. Play the Test Items emulating the live broadcast from the Content Playout 1 through the real-time test setup. The authored signal will be sent over SDI to the A/V encoder. 2. In the authoring system, author the metadata enabling the desired personalization options to be tested. 3. From the Content Playout 2 play any of the Test Items emulating the ad-breaks. 4. Playback the live test stream received over IP continuously and keep the volume of playback to a suitable level. 5. On the receiver side, interact with the audio scene by selecting a different preselection, changing the language, and changing the dialog level. 6. Using a clean SDI switch, switch from the content authored live to the pre-authored ad-breaks. After 1 minute, switch from the pre-authored ad-breaks back to the content authored live. 7. Evaluate the capability of the audio system to preserve the user selections on the receiver side after the ad-break. <p>Starting playback after the ad-break with different settings than the changes done by the user on the receiver side before the ad-break leads to failure of the test.</p>

Test Case ID	TC7.7
Test Description	<p>Requirement AC7.4 Part 3: Hybrid Delivery.</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to synchronize and replace the main soundtrack delivered via broadcast for an alternative audio signal delivered via broadband.
Test Setup	Real-time setup as shown in Figure 42.
Test Content	<p>Test items:</p> <ol style="list-style-type: none"> 1. Audio content 3.
Test Bitrate	<p>Specified bitrates are:</p> <ol style="list-style-type: none"> 1. Mono or Stereo (2.0) = 48 kbps; 2. Surround 5.1 = 144 kbps; 3. Immersive 5.1+4H = 256 kbps; 4. Audio object = 48 kbps per object. <p>The total bitrate to be used for each Test Item is computed by summing the specified bitrate for each component of the Test Item with a tolerance of $\pm 2\%$.</p>
Test Procedure	<p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Encode offline the content, using a real-time encoder (which might run in the real-time setup or offline), and prepare it as multiple ISOBMFF streams ready for DASH streaming from the Streaming Server: <ol style="list-style-type: none"> a. stream 1 (main broadcast stream) containing Channel Bed 2.0 + 1 Object containing language 1; b. stream 2 containing Channel Bed 2.0 + 1 Object containing language 2; c. stream 3 containing Channel Bed 2.0 + 1 Object containing language 1 + Object containing Audio description in language 1. 2. Make the Streaming Server ready to provide all 3 streams over IP connection (using different ports for the main broadcast stream and the additional streams). 3. Playback the live test Stream 1 received over IP continuously and keep the volume of playback to a suitable level. 4. On the receiver side, evaluate: <ol style="list-style-type: none"> a. the ability to synchronize the multiple streams received live; b. the ability to display the options available, the playing starts always with stream 1 but options from stream 2 and 3 shall be displayed as available; c. the ability to switch to additional languages coming from IP chain 2 (Streaming Server); d. the ability to switch back to the main language if the IP chain 2 is disconnected (e.g., stopped from the Streaming Server). <p>Incorrect handling of the audio elements delivered on OTT leads to failure of the test.</p>

4.5.3.8 Test 8 (Audio coding efficiency)

The proponent's documentation provided on the Quality Assessment Reports shall provide the data to analyze the audio coding efficiency.

4.5.3.9 Test 9 (Audio End to end latency)Requirement AC9.1:

This requirement is tested during the execution of Test Case TC1.1. The classification for requirement AC9.1 shall be equal to:

- “*Fulfilled*”, if the proponent's system was able to encode and decode requirements AC1.1.1, AC1.1.2, and AC1.1.3;
- “*Partially Fulfilled*”, if the proponent's system fails to encode and decode at least one of requirements AC1.1.1, AC1.1.2, and AC1.1.3;
- “*Not Fulfilled*”, if the proponent's system fails to encode and decoding two or more of requirements AC1.1.1, AC1.1.2, and AC1.1.3;

Requirement AC9.2:

This requirement will not be analyzed with a feature test. The proponent's documentation provided in the Document Analysis phase shall address this requirement. The delay of each module of the real-time test setup shall be documented, including the audio and video encoding delay, additional video buffering (if any) before the video encoder, audio decoding and rendering delay, transcoding to a different format delay, and final decoding delay in the external sound reproduction system.

4.5.3.10 Test 10 (A/V synchronization)

Each proponent's system shall be tested using the real-time setup and the performance shall be evaluated for the following capability:

Test Case ID	TC10.1
Test Description	Requirements AC10.1: 1. Shall demonstrate the system's ability to perform adequate A/V synchronization
Test Setup	Real-time setup as shown in Figure 42.

Test Case ID	TC10.1
Test Content	<p>Test items:</p> <ol style="list-style-type: none"> 1. Audio content 3; 2. Audio content 5; 3. Audio content 7; 4. Audio content 9.
Test Bitrate	<p>Specified bitrates are:</p> <ol style="list-style-type: none"> 1. Mono or Stereo (2.0) = 48 kbps; 2. Surround 5.1 = 144 kbps; 3. Immersive 5.1+4H = 256 kbps; 4. Audio object = 48 kbps per object. <p>The total bitrate to be used for each Test Item is computed by summing the specified bitrate for each component of the Test Item with a tolerance of $\pm 2\%$.</p>
Test Procedure	<p>For video codec, proponents shall use HEVC, 10 bit per component, 1 920 x 1 080 pixels, SDR, 59.94 frames per second, WCG Rec ITU-R BT.2020, aspect ratio 16:9, progressive scanning, and video bitrate equal to 30 000 kbps.</p> <p>For each Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Play the Test Item from the content playout system through the real-time test setup. 2. In the authoring system, author the metadata. 3. Playback the live test stream received over IP continuously and keep the volume of playback to a suitable level. 4. Evaluate the downmix and rendering when the content is played back over a 5.1 setup and a stereo setup. 5. Evaluate the overall 3D experience when the content is played back over an external sound system. <p>Perceiving lip-sync anomalies during the presentation with and without an external sound system leads to failure of the test.</p>

4.5.3.11 Test 11 (New immersive audio services)

Each proponent's system performance shall be evaluated for the following capabilities:

Test Case ID	TC11.1
Test Description	Requirements AC11.1: <ol style="list-style-type: none"> 1. Shall perform playback of audio demonstrating one or more of those applications: VR / AR / XR / 3DoF / 6DoF. If necessary, a video codec to be used in this test shall be chosen by the proponent.
Test Setup	Proponents can provide their own setup.
Test Content	Proponents can provide their own test content.
Test Bitrate	The bitrate for this test shall be chosen by the proponent's system.
Test Procedure	Provide a comprehensive demonstration of the proposed format, allowing to evaluate: <ol style="list-style-type: none"> 1. features of the codec; 2. the readiness for real-time coding/decoding; 3. the readiness of delivery of the format over broadcast and broadband networks; 4. how the application works in detail; 5. how other applications could manipulate the audio codec stream to perform the same results exhibited in the demonstration (e.g. some sort of API specification). NOTE: This helps TV 3.0 application coding experts to incorporate this new feature into the future specification. <p>Non-compliance with one or more of the above steps leads to failure of the test.</p>

4.5.3.12 Test 12 (Interoperability with different distribution platforms)

Each proponent's system performance shall be evaluated for the following capabilities:

Test Case ID	TC12.1
Test Description	Requirements AC12.1 and AC13.1: <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to send multiple audio contents over two or more communications channels.
Test Setup	Real-time setup as shown in Figure 42. The Streaming Server shall be connected to an Ethernet Layer 2 switch.
Test Content	Test items: <ol style="list-style-type: none"> 1. Audio content 8.

Test Case ID	TC12.1
Test Bitrate	<p>Specified bitrates, with a tolerance of $\pm 2\%$, are:</p> <ol style="list-style-type: none"> 1. Mono or Stereo (2.0) = 48 kbps; 2. Surround 5.1 = 144 kbps; 3. Immersive 5.1+4H = 256 kbps; 4. Audio object = 48 kbps per object.
Test Procedure	<p>For available Test Item conduct the following steps:</p> <ol style="list-style-type: none"> 1. Play the Test Item from the content playout system through the real-time test setup. 2. In the authoring system, author the metadata and record the output of the authoring system. 3. Encode offline the content, using a real-time encoder (which might run in the real-time setup or offline), and prepare it as multiple ISOBMFF streams ready for DASH streaming from the Streaming Server: <ol style="list-style-type: none"> a. stream 1 (main broadcast stream) containing Channel Bed 5.1+4H + 1 Object containing language 1; b. stream 2 (1 Object containing language 2); c. stream 3 (1 Object containing language Audio Description in language 1). 4. Make the Streaming Server ready to provide all 3 streams over IP connection (using different ports for the main broadcast stream and the additional streams). 5. Playback the live test Stream 1 received over IP continuously and keep the volume of playback to a suitable level. 6. On the receiver side, verify: <ol style="list-style-type: none"> a. the ability to synchronize the multiple streams received live; b. the ability to display the options available, the playing starts always with stream 1 but options from stream 2 and 3 shall be displayed as available; c. the ability to switch to additional languages coming from IP chain 2 (Streaming Server); d. the ability to switch back to the main language if the IP chain 2 is disconnected (e.g., stopped from the Streaming Server). <p>Incorrect display of the available languages, playback of the wrong audio language or lack of fallback to language available in the stream 1, disruption of the live playback (e.g., the audio stops during a user selection, the audio/stream stops during a change of the available languages in production) leads to failure of the test.</p>

4.5.3.13 Test 13 (Audio scalability and extensibility)

Requirement AC13.1:

This requirement is verified during the execution of Test Case TC12.1.

Requirement AC13.2:

This requirement will not be analyzed with a feature test. The proponent's documentation provided in the Document Analysis phase shall address this requirement.

4.6 Captions

The captions requirements set in the TV 3.0 Call for Proposals document, against which the proposals of candidate technologies will be tested and evaluated, are repeated here for the convenience of the reader. For further details, please refer to the TV 3.0 Call for Proposals document.

use case		minimum technical specification		over-the-air delivery	Internet delivery
CC1	Enable frame-accurate synchronization with video.	CC1.1	video/caption sync frame-accurate	required	required
CC2	Support the complete character set currently used for closed captioning in Brazil.	CC2.1	support the complete character set currently used for closed captioning in Brazil (as specified in ABNT NBR 15610-1)	required	required
		CC2.2	support other languages character sets (Latin and non-Latin)	not required for Brazil, but may be useful for other countries that may wish to adopt the same DTTB system	
CC3	Enable live and offline closed-captioning.	CC3.1	live closed-captioning	required	required
		CC3.2	offline closed-captioning	required	required
CC4	Enable text styling control.	CC4.1	control text horizontal and vertical position	required	required
		CC4.2	control text horizontal and vertical alignment	required	required
		CC4.3	select text font	required	required
		CC4.4	control text size	required	required
		CC4.5	select font style (normal, bold, italic and underline)	required	required
		CC4.6	select text color	required	required
CC4.7	select background-color	required	required		
CC5	Support images (e.g. PNG) to enable displaying non-textual information.	CC5.1	support images (e.g. PNG) to enable displaying non-textual information	desirable	desirable
CC6	Enable sending sign language gloss as a separate caption stream to be synthesized as sign language video by an appropriate app.	CC6.1	enable sending sign language gloss as a separate caption stream	required	required

use case		minimum technical specification		over-the-air delivery	Internet delivery	
CC7	Enable emergency warning information delivery using captions.	CC7.1.1	emergency information media format	captions (text)	required	required
		CC7.1.2		captions (image)	desirable	desirable
		CC7.1.3		sign language (gloss)	desirable	desirable
CC8	Enable interoperability with different distribution platforms (e.g. DTT, cable, IPTV, DTH satellite, fixed broadband, 4G/5G mobile broadband, home network).	CC8.1	interoperability with different distribution platforms	required	required	
		CC8.2	convertibility between the new caption format and the format specified in ABNT NBR 15610-1	required	required	

CC-AR1. Provide free of charge reference caption encoder and decoder/renderer (hardware or software) with its corresponding documentation, strictly for temporary technical evaluation of the SBTVD Forum (non-commercial usage).

CC-AR2. Provide information about available implementations of the encoder and decoder/renderer, the latter both for professional (broadcast) and consumer electronic applications.

CC-AR3. Provide some reference information about the decoder/renderer for TV sets manufacturing.

The assessment methodology for captions systems is divided into two main evaluation steps: Documentation Analysis, and Features and Subjective Performance Evaluation.

4.6.1 Documentation analysis

Each received proposal for the captions system shall be analyzed in detail to map what the proponent's system can achieve in conformance with the TV 3.0 Call for Proposals requirements.

Proponents shall provide detailed documentation on how their system works and how it conforms with the specified requirements for the captions system. Proponents are encouraged to submit additional information about features from the proposed captions system that may enrich the overall captioning quality of experience and are not a current requirement in the TV 3.0 Call for Proposals document.

At the end of the documentation analysis, the Test Lab shall produce a report consolidating all the analyzed requirements for the captions system classified as “Fulfilled”, “Partially Fulfilled” and “Not Fulfilled”. Test Lab analysts shall include in that report a detailed explanation of all requirements classified as “Fulfilled”, “Partially Fulfilled” and “Not Fulfilled”.

4.6.2 Features and subjective performance evaluation

Each proponent shall provide the required equipment and test content to allow the Test Lab to verify the compliance of the proponent's system regarding the requirements set in the TV 3.0 Call for Proposals and its performance, through the test procedures described in this section.

At the end of this step, the appointed Test Lab shall produce a report consolidating all the results obtained from the analyzed requirements for the captions system classified as “*Fulfilled*”, “*Partially Fulfilled*” and “*Not Fulfilled*”. Test Lab analysts shall include in that report a detailed explanation of all requirements classified as “*Fulfilled*”, “*Partially Fulfilled*” and “*Not Fulfilled*”.

For the evaluation of proposed captions systems, a common definition for the test contents shall be used by all proponents. The character set to be used in the test is based on Tables 11 and 12 from ABNT NBR 15610-1. Test content shall be composed by:

1. A video content encoded using HEVC codec (H.265), profile Main 10, spatial resolution 1 920 x 1 080 pixels, 59.94 frames per second, progressive scanning, 10-bit per component, WCG SDR (Rec. ITU-R BT.2020), aspect ratio 16:9, at the bitrate of 15 Mbps, containing a timecode counter (SS:FF, starting at 00:00) burnt-in, aligned with the top left graphics safe margin (5%, as defined in the Rec. ITU-R BT.1848), with a monospaced serif font, white color, black outline, using 10% of the screen height, and encapsulated in an MP4 container. Video content duration shall be equal to 60 seconds.
2. An audio content related to video content, encoded using MPEG-4 AAC (Advanced Audio Codec) LC (Low Complexity) at the bitrate of 192 kbps, stereo, encapsulated in the same MP4 container as the video container. The audio content duration shall be equal to 60 seconds.
3. Closed caption contents are described in detail in each test description section for each Test Case.

For the captions' feature evaluation, the test setup illustrated in Figure 43 with its respective mandatory elements shall be used. Additional monitoring elements may be added to this setup by the Test Lab or by the SBTVD Forum. Nevertheless, those additional elements information shall be informed to all proponents before the test execution.

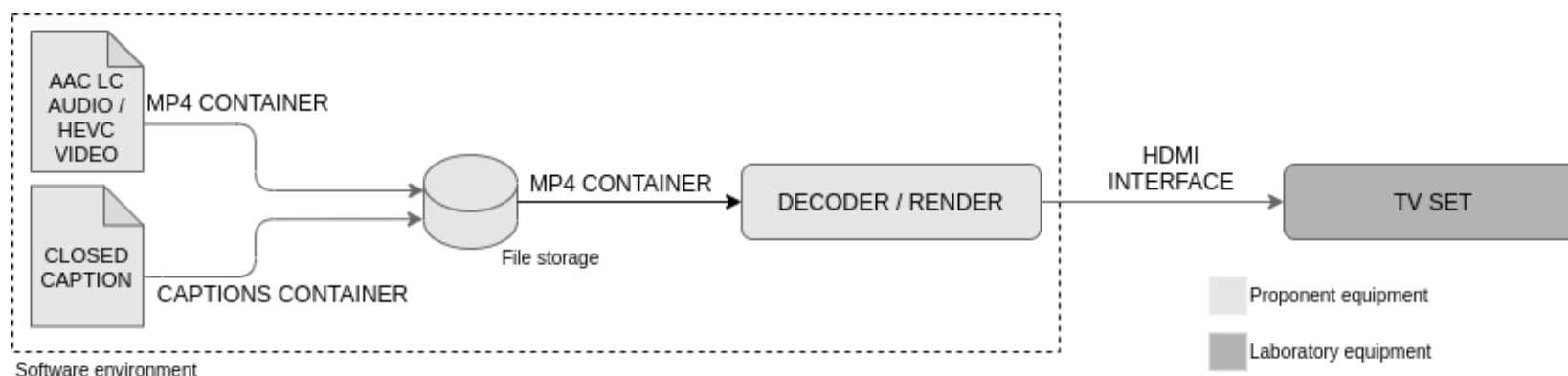


Figure 43: Captions test setup for decoding and rendering

For evaluations using the captions test setup, the elements in Figure 43 labeled as Software environment (hardware and software) are the proponent’s responsibility. The proponent’s decoder/renderer shall decode audio content and video content encapsulated in an MP4 container format. Proponent’s decoder/renderer shall use an HDMI interface to feed the TV set and demonstrate the captions system capabilities. The proponent software environment shall contain a mouse and a keyboard. It shall allow Test Lab analysts to switch captions on or off, toggle between multiple captions, and capture screenshots from what is being displayed on the TV set screen. Those screenshots shall be analyzed and saved by Test Lab analysts to verify the conformance of proponent technology in accordance with instructions to be provided in each Test Case.

4.6.2.1 Test 1 (Frame-accurate synchronization)

Each proponent’s system performance shall be evaluated for the following capability:

Test Case ID	TC1.1
Test Status	Mandatory
Test Description	Requirements CC1.1 and CC3.2: <ol style="list-style-type: none"> 1. Shall demonstrate the system’s ability to present captions synchronized with the video content. 2. Shall demonstrate the system’s ability to perform offline closed-captioning.
Test Setup	Setup as shown in Figure 43.

Test Case ID	TC1.1
Test Content	<p>Test items:</p> <ol style="list-style-type: none"> 1. Video content as specified in 4.6.2. 2. Closed caption content containing text information that represents the timecode counter value (SS:FF) for each video frame. Closed caption rendering shall be aligned with the top right graphics safe margin, with a monospaced serif font, white color, black outline, using 10% of the screen height.
Test Procedure	<p>For this test, conduct the following steps:</p> <ol style="list-style-type: none"> 1. Decode audio, video, and captions contents using the decoder/render. Present the result in the TV set. 2. Evaluate if the closed caption content, containing the timecode values for seconds and frames, is correctly displayed on the TV set. 3. Evaluate if the closed caption content, containing the timecode values for seconds and frames, presents those timecode values synchronized with the timecode counter burnt-in in the active video (aligned with the top left graphics safe margin). To verify the frame-accuracy in this step, take three screenshots from the content being exhibited on the TV set screen. Save the screenshots and register the frame difference between the timecode embedded in the active video and the timecode values exhibited as captioning. <p>Perceiving a difference greater than one frame during step 3 execution of this test procedure leads to failure of the test.</p>

4.6.2.2 Test 2 (Character set)

Each proponent's performance shall be evaluated for the following capabilities:

Test Case ID	TC2.1
Test Status	Mandatory
Test Description	<p>Requirements CC2.1 and CC2.2:</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to present the correct complete character set currently used for closed captioning in Brazil (as specified in ABNT NBR 15610-1) and support to other languages character sets (Latin and non-Latin).
Test Setup	Setup as shown in Figure 43.

Test Case ID	TC2.1
Test Content	<p>Test items:</p> <ol style="list-style-type: none"> 1. Video content as specified in 4.6.2. 2. Closed caption rendering shall be center-aligned with the bottom graphics safe margin, with a proportional sans-serif font, white color, black outline, using 5% of the screen height. Closed caption content shall be the following: <ol style="list-style-type: none"> a. From timecode 05:00 to 10:00 exhibit the caption “abcdefghijklmnopqrstuvwxyz”; b. From timecode 10:00 to 15:00 exhibit the caption “ABCDEFGHIJKLMNOPQRSTUVWXYZ”; c. From timecode 15:00 to 20:00 exhibit the caption “0123456789@!#\$%&':()*+,-./< >=?[.] {^}~”; d. From timecode 20:00 to 25:00 exhibit the caption “áéíóúÁÉÍÓÚâêîôûÂÊÎÔÛãõÃÕäèìòùÄËÏÒÛçÇ”; e. It is optional for the proponent to use the remaining video time to demonstrate the support of other languages' character sets (Latin and non-Latin).
Test Procedure	<p>For this test, conduct the following steps:</p> <ol style="list-style-type: none"> 1. Decode audio, video, and captions contents using the decoder/render. Present the result in the TV set. 2. Evaluate if the closed caption content is displayed correctly and matches the desired text sequence. To verify the match in this step, take screenshots of each character sequence exhibited on the TV set screen. Save the screenshots and compare the characters sequence registered in each of these screenshots with the desired characters sequence described in Test Content. <p>Perceiving any error or mismatch on step 2 of this test procedure leads to failure of the test.</p>

4.6.2.3 Test 3 (Live and offline closed-captioning)

Each proponent's performance shall be evaluated for the following capabilities:

Test Case ID	TC3.1
Test Status	Mandatory
Test Description	<p>Requirement CC3.1:</p> <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to perform live closed-captioning.
Test Setup	Proponents can provide their own setup.

Test Case ID	TC3.1
Test Content	Proponents can provide their own test content. Test items shall contain: <ol style="list-style-type: none"> 1. Video content; 2. Audio content related to the video content.
Test Procedure	For this test, conduct the following steps: <ol style="list-style-type: none"> 1. Prepare the systems to perform live captioning for the audio dialog content. 2. Decode audio, video, and captions contents using the decoder/render. Present the result in the TV set. 3. Evaluate if the closed caption content is correctly displayed on the TV set. Observe the system latency and look for anomalies in the captioning being displayed. <p>Perceiving any of those undesirable events during step 3 execution of this test procedure leads to failure of the test.</p>

Requirement CC3.2: This requirement is verified during the execution of Test Case TC1.1.

4.6.2.4 Test 4 (Text styling control)

Each proponent's performance shall be evaluated for the following capabilities:

Test Case ID	TC4.1
Test Status	Mandatory
Test Description	Requirement CC4.1, CC4.2, CC4.3, CC4.4, CC4.5, CC4.6, and CC4.7: <ol style="list-style-type: none"> 1. Shall demonstrate how the captions system can manipulate text styling.
Test Setup	Setup as shown in Figure 43.
Test Content	Test items: <ol style="list-style-type: none"> 1. Video content as specified in 4.6.2. 2. Unless otherwise indicated, closed caption rendering shall be center-aligned with the bottom graphics safe margin, with a proportional sans-serif font, white color, black outline, using 5% of the screen height. Closed caption content shall be the following:

Test Case ID	TC4.1
	<p>a. From timecode 01:00 to 03:00 exhibit the caption “top line, right alignment, from 1s to 3s” aligned with the top right graphics safe margin;</p> <p>b. From timecode 03:00 to 05:00 exhibit the caption “middle line, left alignment, from 3s to 5s” middle aligned with the left graphics safe margin;</p> <p>c. From timecode 05:00 to 07:00 exhibit the caption “bottom line, center alignment, from 5s to 7s”;</p> <p>d. From timecode 07:00 to 09:00 exhibit the caption: “two simultaneous lines” (first line), and “from 7s to 9s” (second line).</p> <p>e. From timecode 09:00 to 11:00 exhibit the caption: “three” (first line), “simultaneous lines” (second line), and “from 9s to 11s” (third line).</p> <p>f. From timecode 11:00 to 13:00 exhibit the caption “bottom left, first line, from 11s to 20s” aligned with the bottom left graphics safe margin.</p> <p>g. At the timecode 13:00, the caption from step “f” shall be moved one line up to add the caption “add a second line from 13s” as a second caption line.</p> <p>h. At the timecode 15:00 the captions from steps “f” and “g” shall be moved one line up to add the caption “add a third line from 15s” as a third caption line.</p> <p>i. At the timecode 20:00 the first caption line, containing the caption “bottom left, first line, from 11s to 20s” shall be removed, the second caption line, containing the caption “add a second line from 13s” shall be moved to the first line, third caption line, containing caption the first “add a third line from 15s” shall be moved to the second line, and the third caption line shall display the caption “first line disappears as last line appears from 20s to 25s”.</p> <p>j. At the timecode 25:00 all three captions from step “i” shall disappear from the active video.</p> <p>k. From timecode 26:00 to 30:00 the caption “progressive: five words per second from 26s to 30s” shall be displayed progressively and with a speed of five words per second.</p> <p>l. From timecode 30:00 to 35:00 exhibit the caption: “text style” (first line), “normal, bold, italics, underline” (second line), and “from 30s to 35s” (third line). The caption on the second line shall be formatted as normal style for the word “normal”, as bold style for the word “bold”, as italics style for the word “italics”, and as underline style for the word “underline”.</p> <p>m. From timecode 35:00 to 40:00 exhibit the caption: “text and background color” (first line), “white, green, cyan, red, yellow, magenta, blue, black” (second line), and “from 35s to 40s” (third line). The caption on the second line shall be formatted with font color white and background color black for the word “white”, font color green and background color blue for the word “green”, font color cyan and background color magenta for the word “cyan”, font color red and background color yellow for the word “red”, font color yellow and background color red for the word “yellow”, font color magenta and background color cyan for the word “magenta”, font color blue and background color green for the word “blue” and font color black and background color white for the word “black”.</p> <p>n. From timecode 40:00 to 45:00 exhibit the caption: “text size” (first line), “size 3%, size 5%, size 7%, size 10%” (second line), and “from 40s to 45s” (third line). Caption on the second line shall use 3% of the screen height for the expression “size 3%,”, 5% of the screen height for the expression “size 5%,”, 7% of the screen height for the expression “size 7%,”, and 10% of the screen height for the expression “size 10%”.</p> <p>o. From timecode 45:00 to 50:00 exhibit the caption: “text font family” (first line), “monospaceSerif proportionalSansSerif” (second line), and “from 45s to 50s” (third line). Caption on the second line shall be formatted with font family monospaceSerif for the word “monospaceSerif” and with font family proportionalSansSerif for the word “proportionalSansSerif”.</p> <p>Figure 44 illustrates the captions content to be used in this test procedure.</p>

Test Case ID	TC4.1
Test Procedure	<p>For this test, conduct the following steps:</p> <ol style="list-style-type: none">1. Decode video and captions contents using the decoder/render. Present the result in the TV set.2. Evaluate if the closed captions are correctly exhibited on the active video screen in accordance with the conditions described from steps "a" to "o" for caption content in Test Content description of this test. To verify the match in this step, take screenshots of each step exhibited on the TV set screen. Save the screenshots and compare them with the description in Test Content and with Figure 44. <p>Incorrect display of the captions regarding one or more conditions from step 2, leads to failure of the test.</p>



Figure 44: Captions content description for Test Case 4.1

4.6.2.5 Test 5 (Displaying non-textual information)

Each proponent's performance shall be evaluated for the following capabilities:

Test Case ID	TC5.1
Test Status	Optional
Test Description	Requirement CC5.1: <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to display non-textual information, e.g., images.
Test Setup	Setup as shown in Figure 43.
Test Content	Proponents can provide their own test content. Test items shall contain: <ol style="list-style-type: none"> 1. Video content; 2. Audio content related to the video content; 3. Image-based caption; 4. Description of the caption content.
Test Procedure	For this test, conduct the following steps: <ol style="list-style-type: none"> 1. Decode audio, video, and captions contents using the decoder/render. Present the result in the TV set. 2. Evaluate the experience when each image sequence is displayed on the TV set, switching the captions on and off, and looking for anomalies in the image being displayed. <p>Perceiving any of those undesirable events specified in step 2 of this test procedure leads to failure of the test.</p>

4.6.2.6 Test 6 (Multiple caption streams)

Each proponent's performance shall be evaluated for the following capabilities:

Test Case ID	TC6.1
Test Status	Mandatory for Test items 1, 2, 3, 4, and 5. Optional for Test items 6 and 7.

Test Case ID	TC6.1
Test Description	Requirements CC6.1, CC7.1.1, CC7.1.2 and CC7.1.3: <ol style="list-style-type: none"> 1. Shall demonstrate the system's ability to send multiple caption streams.
Test Setup	Setup as shown in Figure 43.
Test Content	Test items: <ol style="list-style-type: none"> 1. Video content as specified in 4.6.2. 2. Audio content as specified in 4.6.2; 3. Closed caption 1 (CC-1) containing text information that represents the transcription of the audio content in one language (e.g., Portuguese). Closed caption 1 shall be formatted to use font color white on a black background color. 4. Closed caption 2 (CC-2) containing text information that represents the transcription of the audio content in one language different from the chosen language on step 3 (e.g., English). Closed caption 2 shall be formatted to use font color green on a blue background color. 5. Closed caption 3 (CC-3) containing text information that represents the transcription of the audio content in one language different from the chosen languages on steps 3 and 4 (e.g., Spanish). Closed caption 3 shall be formatted to use font color cyan on a magenta background color. 6. Optional content. Proponents may choose not to use this. Closed caption 4 (CC-4) containing text information that represents the transcription of the audio content in one language different from the chosen languages on steps 3 to 5 (e.g., French). Closed caption 4 shall be formatted to use font color red on a yellow background color. 7. Optional content. Proponents may choose not to use this. Closed caption 5 (CC-5) containing an image-based caption (description to be provided by the proponent). 8. Optional content. Proponents may choose not to use this. Closed caption content 6 (CC-6) containing another image-based caption (description to be provided by the proponent).
Test Procedure	For this test, conduct the following steps: <ol style="list-style-type: none"> 1. Decode audio, video, and captions contents using the decoder/render. Present the result in the TV set. 2. Toggle between the available closed caption contents. 3. Evaluate if each caption exhibition occurs in accordance with the content description. Look for anomalies in the captioning being displayed before and after switching. <p>Incorrect display of CC-1, CC-2, or CC-3 and/or inability to toggle between CC-1, CC-2, and CC-3, leads to failure of the test. The performance on displaying CC-4, CC-5, and CC-6 (and toggling among them) shall be registered for information but does not lead to failure of the test.</p>

4.6.2.7 Test 7 (Emergency warning information)

Requirements CC7.1.1, CC7.1.2, and CC7.1.3: These requirements are verified during the execution of Test Case TC6.1.

4.6.2.8 Test 8 (Interoperability with different platforms)

Requirements CC8.1 and CC8.2: These requirements will not be analyzed with a feature test. The proponent's documentation provided in the Documentation Analysis phase shall address these requirements.

4.7 Application Coding

The application coding requirements set in the TV 3.0 Call for Proposals document, against which the proposals of candidate technologies will be tested and evaluated, are repeated here for the convenience of the reader. For further details, please refer to the TV 3.0 Call for Proposals document.

use case		minimum technical specification		over-the-air delivery	Internet delivery
AP1	Enable application re-use/interoperability with FSD_09 Ginga receiver profile (as defined in ABNT NBR 15606-1).	AP1.1	FSD_09 Ginga receiver profile application re-use/interoperability	required	required
AP2	Re-use, as much as possible, the implementation of the middleware components and subsystems used in FSD_09 Ginga receiver profile (as defined in ABNT NBR 15606-1).	AP2.1	FSD_09 Ginga receiver profile middleware components and subsystems implementation re-use	required	required
AP3	Support all the use cases supported in FSD_09 Ginga receiver profile (as defined in ABNT NBR 15606-1).	AP3.1	FSD_09 Ginga receiver profile use cases support	required	required
AP4	Support the new technologies to be adopted in the TV 3.0 project.	AP4.1	support TV 3.0 transport layer	required	required
		AP4.2	support TV 3.0 video coding	required	required
		AP4.3	support TV 3.0 audio coding	required	required
		AP4.4	support TV 3.0 captions	required	required
AP5	Enable accessing lower-level (physical-layer/transport-layer/operating-system) information.	AP5.1	access the identification of the TV network, the originating station, and the transmission station	required	N/A
		AP5.2	access the receiver front-end parameters (RF channel, reception power in dBm and C/N in dB)	required	N/A
		AP5.3	geolocation API with multiple sources of data such as transmission station, GPS, and assisted GPS (using Wi-Fi networks)	required	required
AP6	Enable application-oriented TV.	AP6.1	application-oriented user experience with TV	required	required
		AP6.2	handling the presentation of all audiovisual content	required	required
		AP6.3	application switching delay	lower is better	lower is better

use case		minimum technical specification		over-the-air delivery	Internet delivery
AP7	Support for Enhanced User Interface.	AP7.1	voice interaction, pre-defined commands, and natural language	desirable	desirable
		AP7.2	gesture interaction, at least with pre-defined gestures	desirable	desirable
		AP7.3	multi-touch interaction, at least with pre-defined gestures	desirable	desirable
		AP7.4	multimodal interaction, free input compositions	desirable	desirable
		AP7.5	multi-device support, synchronous and asynchronous modes	required	required
		AP7.6	multi-user identification support	required	required
		AP7.7	multi-user interaction support	desirable	desirable
AP8	Provide audience measurement common interface.	AP8.1	standardized audience measurement API (taking multi-user identification support into account)	required	required
AP9	Machine-learning support for context-awareness.	AP9.1	machine-learning APIs	desirable	desirable
AP10	Protect user privacy.	AP10.1	API-based user privacy	required	required
		AP10.2	compliance with Brazilian General Personal Data Protection Act (Law nº 13.709/2018)	required	required
AP11	Enable IP convergence.	AP11.1	full IP convergence, both in broadcast and broadband channels	required	required
		AP11.2	Internet of Things protocols and mechanisms	desirable	desirable
		AP11.3	IP-based application push delivery	required	required
		AP11.4	low-latency content forwarding	required	required
AP12	Enable the streaming of accessibility services to a Smart TV or companion device app.	AP12.1	audio description streaming to a Smart TV or companion device app	required	required
		AP12.2	closed caption streaming to a Smart TV or companion device app (for it to display the closed caption or to perform automatic translation and adaptation from the closed caption to sign language)	required	required
		AP12.3	sign language gloss streaming for a client-side application (in the Smart TV or companion device) to perform the synthesis of the sign language video	required	required
		AP12.4	sign language video streaming to a Smart TV or companion device app	required	required
AP13	Enable emergency warning information delivery using an interactive application.	AP13.1	emergency warning information interactive application	desirable	desirable

use case		minimum technical specification		over-the-air delivery	Internet delivery
AP14	Support for Immersive TV.	AP14.1	sensory effects (lighting, temperature, wind, scents, vibration)	desirable	desirable
		AP14.2	3DoF video interaction	desirable	desirable
		AP14.3	6DoF video interaction	desirable	desirable
		AP14.4	3D object-based immersive audio interaction	required	required
		AP14.5	3D media positioning and interaction	desirable	desirable
		AP14.6	VR / AR / XR support	desirable	desirable
AP15	Support optimized application transport.	AP15.1	inherent compression support	required	required
		AP15.2	multi-sourced application delivery	required	required
AP16	Support multi-sourced scalable content.	AP16.1	multi-sourced scalable content API	required	required
AP17	Enable future extensions to the middleware (e.g. to support new features in future receiver profiles).	AP17.1	extensibility	required	required

AP-AR1. Provide interoperability test suite with its corresponding documentation.

AP-AR2. Provide information about available prototypes of the proposed middleware components.

AP-AR3. Provide some reference information about the middleware for TV sets manufacturing.

SBTVD Forum will define the application coding specification for TV 3.0 as a collection of selected proposals, no matter if they were submitted by different proponents. This approach focuses on delivering the best specification as a whole, for a layer that SBTVD Forum historically holds control and high expertise. Therefore, it is expected that after the evaluation phase SBTVD Technical Module members will start a joint work to select, adjust, harmonize, and improve the proposed solutions.

Selected solutions will proceed to the next phase if their respective proponents commit to contributing with SBTVD Forum on drafting the normative specifications and implementing its test suite.

In the subsequent subsections, the following definitions are adopted:

- **solution:** term that identifies the set of documentation and software components needed for a use case application to be executed and thus demonstrate how a specific requirement (or some of its aspects) is addressed.
- **use case application:** a digital TV application pushed from a server to a presentation environment that implements a demonstration of a given requirement (or some of its aspects) being addressed.

4.7.1 Expected deliverables

Proposals targeted at any AP requirement, given its software nature, are expected to include the needed documentation, prototypes, additional software, and hardware for a complete and independent demonstration on how the proposal is designed, how it works internally, and how it behaves under execution.

A single proposal may address just a subset of AP requirements, where AP1.1 and AP2.1 are always mandatory to be included in the subset. Proponents are not required to submit proposals for the whole AP requirement list. For fairness on the testing and evaluation procedures, proponents that wish to present their solutions targeting multiple requirements are allowed and recommended to submit different proposals, each one specifically targeted at a requirement or a small subset of requirements.

Except where otherwise noted, **the expected deliverables** for each submission are:

1. **Specification Document:** Describes the proposed solution, including an architectural overview, design principles, API specifications (syntax and semantics), protocols, and any other relevant information. Proponents are expected to identify how the solution is implemented in the FSD_09 Ginga receiver profile (e.g.: extending Ginga-NCL, Ginga CC WebServices, as an application, etc.). **Format: PDF file.**
2. **Software Prototypes:**
 - 2.1. **Runtime Prototype:** Implementation of the presentation environment needed to receive a use case application and run it. **Format: LXC 3.0 container** (ready to run, includes all binaries and dependencies; source code if possible).
 - 2.2. **Push-server Prototype:** Implementation of the broadcaster environment needed to transmit the use case application. **Format: LXC 3.0 container** (ready to run, includes all binaries and dependencies; source code if possible).
 - 2.3. **Prototype Specification Document:** Describes the implementation of both Runtime and Push-server prototypes, including design and architecture, dependencies, programming languages, and user instructions. **Format: PDF file.**
3. **Use-case applications:** applications that implement demonstrations of the addressed aspects of a given requirement. **Format: Files included in the Broadcaster Container** (ready to be transmitted; source code required).
 - 3.1. **Companion apps/servers:** any other software component that shall run in a companion environment, if needed, different from the presentation and broadcaster environments. **Format: LXC 3.0 container** (ready to run, includes all binaries and dependencies; source code if possible).
 - 3.2. **End-user documentation:** User instructions for all included use case applications and companion apps/servers. **Format: PDF file.**
4. **Additional hardware:** any other hardware that shall be used by the apps at runtime. The hardware will be connected to one of the ports or network interfaces available in the common testing environment; the power supply must be AC 100 V to 240 V, 50/60 Hz.

4.1. **End-user documentation:** User instructions for the additional hardware. **Format: PDF file.**

5. **Proponent's testing report:** describes methodology and results for test procedures carried out by the proponent on its premises (optional). The proponent's testing methodology must be in accordance with the procedures defined in this document. **Format: PDF File.**

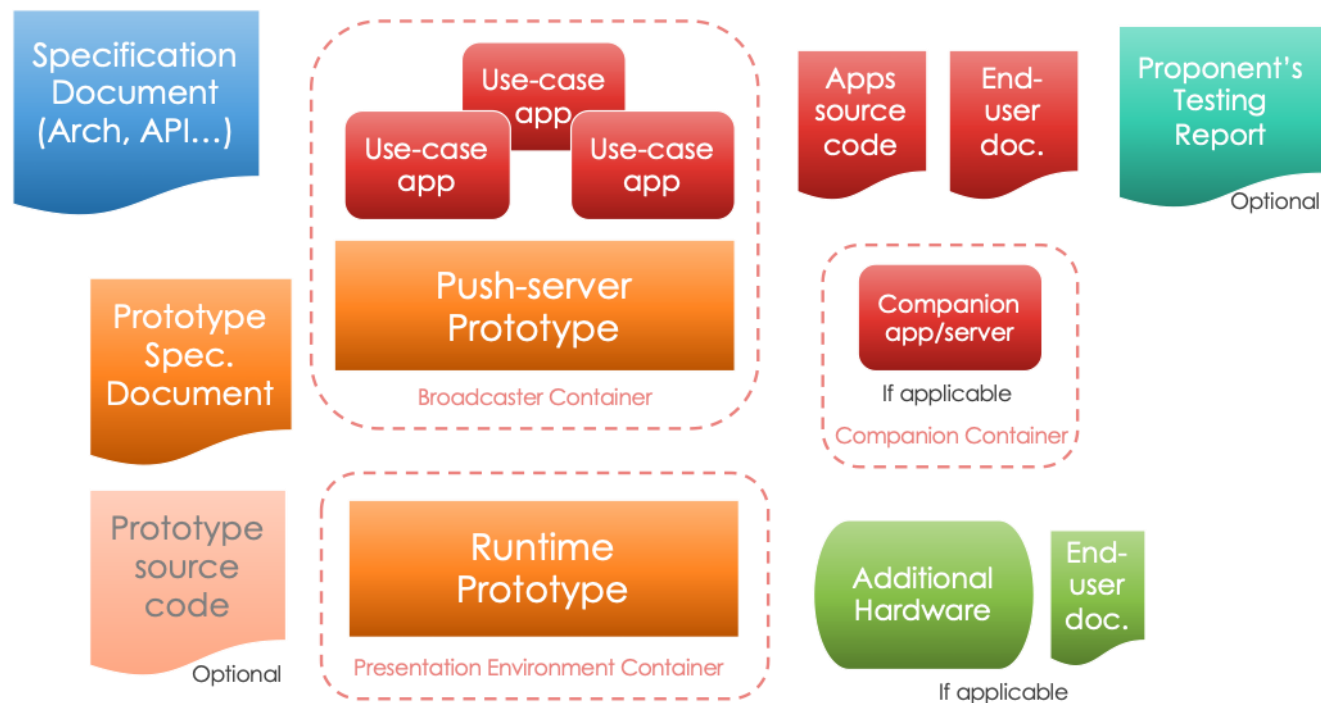


Figure 45: AP Expected Deliverables

4.7.2 Common testing environment specification

Envisaging a fair and reproducible process, SBTVD Forum appointed Test Labs will have a common testbed setup. This common testing environment is also advised to be mounted at proponents' premises for local validations of their prototypes and apps before submission.

The common testing environment includes equipment based on commercial hardware and software platforms. It can be divided into three subsystems as follows:

1. Network subsystem: specifies the network equipment, links, and protocols that interconnect the presentation subsystem, the companion subsystem, and the Internet;

2. Presentation subsystem: specifies hardware and software platforms dedicated to run the runtime prototype (Presentation Environment Container);
3. Companion subsystem: specifies hardware and software platforms dedicated to run the push server prototype (Broadcaster Container) as well as the companion apps/servers (Companion Container).

Figure 46 illustrates the common testing environment.

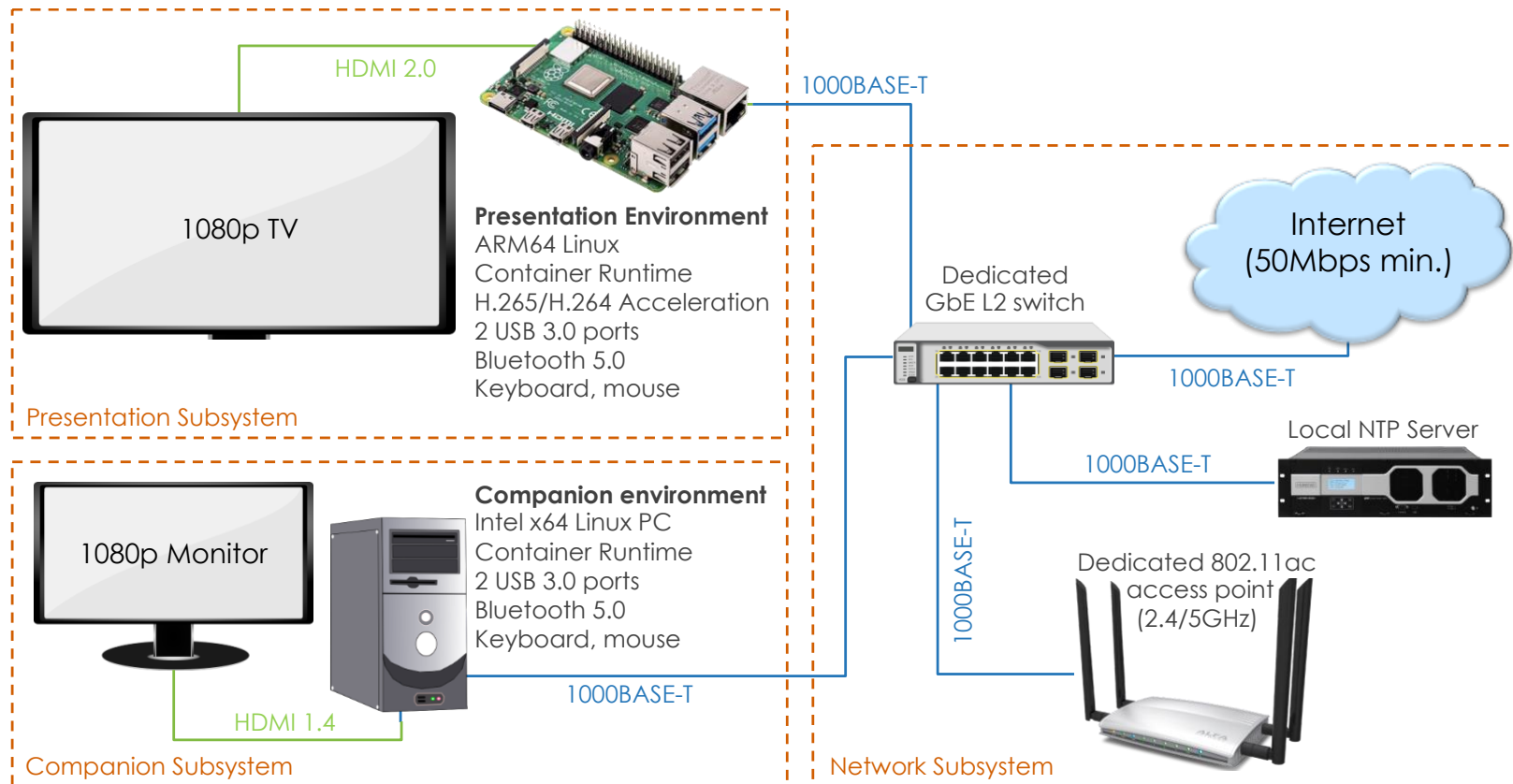


Figure 46: Common testing environment

4.7.2.1 Network subsystem

A wired network interconnects all subsystems and connects them to the Internet. A wireless network is also included only for connecting additional hardware if needed. The following equipment and specifications define the network subsystem:

Dedicated GbE L2 switch: Gigabit Ethernet switch, 24 ports (1000BASE-T), L2, 176 Gbps switching fabric. Interconnects the presentation subsystem, the companion subsystem, the wireless hotspot, and the Internet.

Dedicated 802.11ac access point: Dual-band IEEE802.11ac access point, L2, 450 Mbps bandwidth. Can be used for connecting additional hardware only.

Local NTP Server: Server PC running NTP daemon providing synchronization accuracy lower than 2 ms, 1000BASE-T interface.

Internet connection: Connection supporting at least 50 Mbps. Can be used only for media/data delivery (no application logic, except where otherwise noted).

4.7.2.2 Presentation subsystem

The presentation subsystem runs the runtime prototype included in the Presentation Environment Container. The following equipment and specifications define the presentation subsystem:

Presentation environment: ARM-based system-on-a-chip device:

Hardware specs:

Cortex-A72 (ARM v8), 64-bit, Quad-core 1.5GHz

4 GB LPDDR4-3200 SDRAM

SD Card 64GB

H.265 (4kp60 decode), H264 (1080p60 decode, 1080p30 encode)

1080p TV HDMI 2.0

Connectivity: 1000BASE-T interface, Bluetooth 5.0, 2 USB 3.0 ports. May be used for connecting additional hardware.

USB keyboard and mouse

Software specs:

Ubuntu Server Linux 20.04.1 LTS
(ubuntu-20.04.1-preinstalled-server-arm64+raspi.img.xz)

Container hypervisor LXC/LXD 3.0

Presentation Environment Container will be limited to: 2 GB RAM, 2 CPUs

4.7.2.3 Companion subsystem

The companion subsystem runs the push-server prototype included in the Broadcaster Container, as well as any companion app/server included in the Companion Container if needed. The following equipment and specifications define the companion subsystem:

Companion environment: Business-grade Desktop PC:

Hardware specs:

Intel Core i5-6500 3.2 GHz 4-core 6 MB cache

8 GB DDR4 RAM 2133 MHz

HDD SATA 7200RPM 500 GB

Intel HD Graphics 530 (1080p@60 Hz) HDMI 1.4

H.264 hardware acceleration

1080p Monitor HDMI 1.4

Connectivity: 1000BASE-T interface, Bluetooth 5.0, 2 USB 3.0 ports. May be used for connecting additional hardware.

USB keyboard and mouse

Software specs:

Ubuntu Linux 20.04.1 LTS (ubuntu-20.04.1-server-amd64.iso)

Container hypervisor LXC/LXD 3.0

Containers' resources will not be limited

4.7.3 Common testing steps

The following testing steps are commonly applied to submitted solutions, except where otherwise noted. The steps shall be executed by a group of two lab analysts.

- A. Start procedural recording
- B. Container instantiation and bootstrap tests
 - a. Instantiation of Presentation Environment Container in the Presentation Environment
 - b. Instantiation of Broadcaster Container in the Companion Environment
 - c. Instantiation of Companion Container in the Companion Environment (if applicable)
 - d. Bootstrap tests, from a container point of view: liveness, connectivity, resources
 - e. Clock synchronization using NTP local server, accuracy better than 2 ms
- C. t0: Launch push-server instance
- D. t1: Launch use-case app transmission
- E. t2: Launch companion app/server instance(s) (if applicable)
- F. t3: Launch prototype instance
- G. t4: Interact with and observe use case app and companion app (if applicable)
- H. Stop use-case app transmission
- I. Repeat Steps D to H for each use-case app included in the Broadcaster Container
- J. Stop procedural recording
- K. Fill in the evaluation form

NOTE Each instant (t1...t4) depends on the time needed to launch the previous component and will be limited to 30 s.

4.7.4 Evaluation methodology

Considering that the evaluation will aim at both the proposed Specification (API/Architecture, interface, framework, library) and the proposed Prototypes, together with the use case apps, the methodology will follow ISO/IEC 25010 (2011) Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — System and software quality models. The methodology includes qualitative and quantitative evaluation criteria, organized by categories.

The following template applies to each requirement and since some categories or questions may not apply to all requirements, the template is adapted on a case-by-case basis (see 4.7.5). Qualitative questions shall be answered with "Yes", "No" or "Partially", accompanied by justification in any case. Quantitative questions shall be answered with a number in their respective unit of measurement.

Evaluation Form for Requirement AP x.y
<p>Test procedure identification</p> <p>Requirement description:</p> <p>Evaluator identification data:</p> <p>Proponent identification data: (<i>anonymized</i>)</p> <p>Evaluated artifacts (identifies spec. documents, prototypes/use case apps):</p>
<p>Category 1: Functional Suitability</p> <p>Q1.1 Does the proposed specification completely address the requirement? (Functional Completeness)</p> <p>Q1.2 Does the proposed prototype and use case apps run as expected? (Functional Correctness)</p> <p>Q1.3 Does the proposed use case apps demonstrate the required feature? (Functional Appropriateness)</p>

Evaluation Form for Requirement AP x.y**Category 2: Performance Efficiency**

Focuses on runtime environment: **prototype running a use case app**

Q2.1 Average CPU Load (%);

Q2.2 Peak CPU Load (%);

Q2.3 Peak Volatile memory usage (RAM in MiB);

Q2.4 Peak Persistent memory usage (HD in MiB);

Q2.5 Average network bandwidth (in/out in Mbps);

Q2.6 Peak network bandwidth (in/out in Mbps);

Q2.7 Overall latency – environment loading + app delivery + app start + data presentation (ms)

Category 3: Compatibility

Q3.1 Is the proposed **specification** in line with the backward compatibility with interactive receiver profiles (see ABNT NBR 15606-1)? (Co-existence)

Q3.2 Does the proposed **specification** use standardized/open protocols and data formats? (Interoperability)

Category 4: Usability

Q4.1 Is the proposed **specification** appropriate to developers' needs? (Appropriateness)

Q4.2 Is the proposed **specification** easy to be learned by developers? (Learnability)

Q4.3 How prone to errors is the use of the proposed **specification**? (User error protection)

Category 5: Reliability

Q5.1 How far the proposed **specification** has been validated and adopted? (Maturity)

Q5.2 Is the proposed **specification** based on mature technologies? (Maturity)

Q5.3 Do the **specification/prototype** employ fault-tolerance methods? (Fault tolerance)

Q5.4 Do the **specification/prototype** employ data/system recovery methods? (Recoverability)

Evaluation Form for Requirement AP x.y**Category 6: Security**

Q6.1 Do the **specification/prototype** employ user data protection? (Confidentiality)

Q6.2 Do the **specification/prototype** prevent unauthorized use of user data? (Integrity)

Q6.3 Do the **specification/prototype** ensure the identity of users? (Authenticity)

Category 7: Maintainability

Q7.1 Is the proposed **specification** self-contained and attachable to other software components? (Modularity and reusability)

Q7.2 Is the proposed **specification** easy to be modified and extended? (Modifiability)

Q7.3 Does the proposed **specification** provide the elements needed for a test suite specification? (Testability)

Category 8: Portability

Q8.1 Can the **specification** be adapted to different software environments? (Adaptability)

Q8.2 Do the **specification and/or prototype** depend on specific hw/sw platforms? (Installability)

4.7.5 Requirement-specific notes**Use case:**

AP1 Enable application re-use/interoperability with FSD_09 Ginga receiver profile (as defined in ABNT NBR 15606-1).

Requirement:

AP1.1 FSD_09 Ginga receiver profile application re-use/interoperability

Minimum set of deliverables: Specification Document

Applicable evaluation categories: 1, 3, 4, 5, 7, 8

Applicable evaluation questions: Q1.1, Q3.All, Q4.1, Q4.2, Q4.3, Q5.1, Q5.2, Q7.All, Q8.All

Use case:

AP2 Re-use, as much as possible, the implementation of the middleware components and subsystems used in FSD_09 Ginga receiver profile (as defined in ABNT NBR 15606-1).

Requirement:

AP2.1 FSD_09 Ginga receiver profile middleware components and subsystems implementation re-use

Minimum set of deliverables: Specification Document

Applicable evaluation categories: 1, 3, 4, 5, 7, 8

Applicable evaluation questions: Q1.1, Q3.All, Q4.1, Q4.2, Q4.3, Q5.1, Q5.2, Q7.All, Q8.All

Use case:

AP3 Support all the use cases supported in FSD_09 Ginga receiver profile (as defined in ABNT NBR 15606-1).

Requirement:

AP3.1 FSD_09 Ginga receiver profile use cases support

Minimum set of deliverables: Specification Document

Applicable evaluation categories: 1, 3, 4, 5, 7, 8

Applicable evaluation questions: Q1.1, Q3.All, Q4.1, Q4.2, Q4.3, Q5.1, Q5.2, Q7.All, Q8.All

Use case:

AP4 Support the new technologies to be adopted in the TV 3.0 project.

Requirement:

AP4.1 support TV 3.0 transport layer

<p>Use case: AP4 Support the new technologies to be adopted in the TV 3.0 project.</p>
<p>Minimum set of deliverables: Specification Document Applicable evaluation categories: 1, 3, 4, 5, 7, 8 Applicable evaluation questions: Q1.1, Q3.All, Q4.1, Q4.2, Q4.3, Q5.1, Q5.2, Q7.All, Q8.All</p>
<p>Requirement: AP4.2 support TV 3.0 video coding</p>
<p>Minimum set of deliverables: Specification Document Applicable evaluation categories: 1, 3, 4, 5, 7, 8 Applicable evaluation questions: Q1.1, Q3.All, Q4.1, Q4.2, Q4.3, Q5.1, Q5.2, Q7.All, Q8.All</p>
<p>Requirement: AP4.3 support TV 3.0 audio coding</p>
<p>Minimum set of deliverables: Specification Document Applicable evaluation categories: 1, 3, 4, 5, 7, 8 Applicable evaluation questions: Q1.1, Q3.All, Q4.1, Q4.2, Q4.3, Q5.1, Q5.2, Q7.All, Q8.All</p>
<p>Requirement: AP4.4 support TV 3.0 captions</p>
<p>Minimum set of deliverables: Specification Document Applicable evaluation categories: 1, 3, 4, 5, 7, 8 Applicable evaluation questions: Q1.1, Q3.All, Q4.1, Q4.2, Q4.3, Q5.1, Q5.2, Q7.All, Q8.All</p>

Use case:**AP5 Enable accessing lower-level (physical-layer/transport- layer/operating-system) information.**

NOTE Since some lower-level technologies are also targeted at this CfP, while others are out of the scope of TV 3.0 specification, proponents may adopt any IP-based transport and/or other simulated information for prototyping (e.g. static parameters in local files).

Requirement:

AP5.1 access the identification of the TV network, the originating station, and the transmission station

Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation

Applicable evaluation categories: All

Applicable evaluation questions: All

Requirement:

AP5.2 access the receiver front-end parameters (RF channel, reception power in dBm and C/N in dB)

Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation

Applicable evaluation categories: All

Applicable evaluation questions: All

Requirement:

AP5.3 geolocation API with multiple sources of data such as transmission station, GPS, and assisted GPS (using Wi-Fi networks)

Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation

Applicable evaluation categories: All

Applicable evaluation questions: All

<p>Use case:</p> <p>AP6 Enable application-oriented TV.</p>
<p>Requirement: AP6.1 application-oriented user experience with TV</p>
<p>Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation</p> <p>Applicable evaluation categories: All</p> <p>Applicable evaluation questions: All</p>
<p>Requirement: AP6.2 handling the presentation of all audiovisual content</p>
<p>Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation</p> <p>Applicable evaluation categories: All</p> <p>Applicable evaluation questions: All</p>
<p>Requirement: AP6.3 application switching delay</p>
<p>Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation</p> <p>Applicable evaluation categories: All</p> <p>Applicable evaluation questions: All</p>

<p>Use case: AP7 Support for Enhanced User Interface.</p>
<p>Requirement: AP7.1 voice interaction, pre-defined commands, and natural language</p>
<p>Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation, additional hardware, and its end-user documentation</p> <p>Applicable evaluation categories: All</p> <p>Applicable evaluation questions: All</p>
<p>Requirement: AP7.2 gesture interaction, at least with pre-defined gestures</p>
<p>Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation, additional hardware, and its end-user documentation</p> <p>Applicable evaluation categories: All</p> <p>Applicable evaluation questions: All</p>
<p>Requirement: AP7.3 multi-touch interaction, at least with pre-defined gestures</p>
<p>Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation, additional hardware, and its end-user documentation</p> <p>Applicable evaluation categories: All</p> <p>Applicable evaluation questions: All</p>
<p>Requirement: AP7.4 multimodal interaction, free input compositions</p>

Use case:**AP7 Support for Enhanced User Interface.**

Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation, additional hardware, and its end-user documentation

Applicable evaluation categories: All

Applicable evaluation questions: All

Requirement:

AP7.5 multi-device support, synchronous and asynchronous modes

Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, Companion apps, End-user documentation

Applicable evaluation categories: All

Applicable evaluation questions: All

Requirement:

AP7.6 multi-user identification support

Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation

Applicable evaluation categories: All

Applicable evaluation questions: All

Requirement:

AP7.7 multi-user interaction support

Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation

Applicable evaluation categories: All

Applicable evaluation questions: All

Use case:**AP8 Provide audience measurement common interface.**

Requirement:

AP8.1 standardized audience measurement API (taking multi-user identification support into account)

Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation

Applicable evaluation categories: All

Applicable evaluation questions: All

Use case:**AP9 Machine-learning support for context-awareness.**

Requirement:

AP9.1 machine-learning APIs

Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation

Applicable evaluation categories: All

Applicable evaluation questions: All

Use case:**AP10 Protect user privacy.**

Requirement:

AP10.1 API-based user privacy

Use case:**AP10 Protect user privacy.**

Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation

Applicable evaluation categories: All

Applicable evaluation questions: All

Requirement:

AP10.2 compliance with Brazilian General Personal Data Protection Act (Law no 13.709/2018)

Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation

Applicable evaluation categories: All

Applicable evaluation questions: All

Use case:**AP11 Enable IP convergence.****Requirement:**

AP11.1 full IP convergence, both in broadcast and broadband channels

Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation

Applicable evaluation categories: All

Applicable evaluation questions: All

Requirement:

AP11.2 Internet of Things protocols and mechanisms

<p>Use case: AP11 Enable IP convergence.</p>
<p>Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation Applicable evaluation categories: All Applicable evaluation questions: All</p>
<p>Requirement: AP11.3 IP-based application push delivery</p>
<p>Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation Applicable evaluation categories: All Applicable evaluation questions: All</p>
<p>Requirement: AP11.4 low-latency content forwarding</p>
<p>Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, Companion apps, End-user documentation Applicable evaluation categories: All Applicable evaluation questions: All</p>

<p>Use case: AP12 Enable the streaming of accessibility services to a Smart TV or companion device app.</p>
<p>Requirement: AP12.1 audio description streaming to a Smart TV or companion device app</p>

Use case:**AP12 Enable the streaming of accessibility services to a Smart TV or companion device app.**

Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, Companion apps, End-user documentation

Applicable evaluation categories: All

Applicable evaluation questions: All

Requirement:

AP12.2 closed caption streaming to a Smart TV or companion device app (for it to display the closed caption or to perform automatic translation and adaptation from the closed caption to sign language)

Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, Companion apps, End-user documentation

Applicable evaluation categories: All

Applicable evaluation questions: All

Requirement:

AP12.3 sign language gloss streaming for a client-side application (in the Smart TV or companion device) to perform the synthesis of the sign language video

Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, Companion apps, End-user documentation

Applicable evaluation categories: All

Applicable evaluation questions: All

Requirement:

AP12.4 sign language video streaming to a Smart TV or companion device app

Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, Companion apps, End-user documentation

Applicable evaluation categories: All

Applicable evaluation questions: All

Use case: AP13 Enable emergency warning information delivery using an interactive application.
Requirement: AP13.1 emergency warning information interactive application
Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation Applicable evaluation categories: All Applicable evaluation questions: All

Use case: AP14 Support for Immersive TV.
Requirement: AP14.1 sensory effects (lighting, temperature, wind, scents, vibration)
Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation, Additional hardware, and its end-user documentation Applicable evaluation categories: All Applicable evaluation questions: All
Requirement: AP14.2 3DoF video interaction

<p>Use case:</p> <p>AP14 Support for Immersive TV.</p>
<p>Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation</p> <p>Applicable evaluation categories: All</p> <p>Applicable evaluation questions: All</p>
<p>Requirement:</p> <p>AP14.3 6DoF video interaction</p>
<p>Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation</p> <p>Applicable evaluation categories: All</p> <p>Applicable evaluation questions: All</p>
<p>Requirement:</p> <p>AP14.4 3D object-based immersive audio interaction</p>
<p>Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation, Additional hardware, and its end-user documentation</p> <p>Applicable evaluation categories: All</p> <p>Applicable evaluation questions: All</p>
<p>Requirement:</p> <p>AP14.5 3D media positioning and interaction</p>
<p>Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation</p> <p>Applicable evaluation categories: All</p> <p>Applicable evaluation questions: All</p>

Use case: AP14 Support for Immersive TV.
Requirement: AP14.6 VR / AR / XR support
Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation, Additional hardware, and its end-user documentation Applicable evaluation categories: All Applicable evaluation questions: All

Use case: AP15 Support optimized application transport.
Requirement: AP15.1 inherent compression support
Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation Applicable evaluation categories: All Applicable evaluation questions: All
Requirement: AP15.2 multi-sourced application delivery
Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation Applicable evaluation categories: All Applicable evaluation questions: All

<p>Use case: AP16 Support multi-sourced scalable content.</p>
<p>Requirement: AP16.1 multi-sourced scalable content API</p>
<p>Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation</p> <p>Applicable evaluation categories: All</p> <p>Applicable evaluation questions: All</p>

<p>Use case: AP17 Enable future extensions to the middleware (e.g. to support new features in future receiver profiles).</p>
<p>Requirement: AP17.1 extensibility</p>
<p>Minimum set of deliverables: Specification Document, Runtime Prototype, Push-server Prototype, Prototype Specification Document, Use-case applications, End-user documentation</p> <p>Applicable evaluation categories: 1, 3, 4, 5, 6, 7, 8</p> <p>Applicable evaluation questions: Q1.All, Q3.All, Q4.1, Q4.2, Q5.All, Q6.All, Q7.All, Q8.All</p>

5 Schedule

The overall schedule for TV 3.0 standardization involves receiving proposals of candidate technologies between the end of 2020 and the beginning of 2021, evaluating and comparing the proposals along 2021, selecting the appropriate technologies for each system component by the end of 2021, and developing the standards in 2022. The TV 3.0 Call for Proposals document (available at <https://forumsbtvd.org.br/wp-content/uploads/2020/07/SBTVDTV-3-0-CfP.pdf>) already provided the information on how to provide Phase 1 responses. Subsection 5.1 presents the deadlines and procedures for responding the Phase 2 of this Call for Proposals.

5.1 Responding to Phase 2 of the TV 3.0 Call for Proposals

The TV 3.0 Call for Proposals is open for any interested organization to submit its proposed candidate technologies for any of the system components or sub-components. One proponent can provide multiple responses, either to address multiple components or sub-components, or to provide alternative technology options for the same component or sub-component. Joint contributions from multiple organizations are also allowed and encouraged (as they indicate broader support for the proposed candidate technologies).

To respond to Phase 2 of the TV 3.0, it's necessary to provide the Phase 1 response first. Please refer to the TV 3.0 Call for Proposals document for further details. Phase 1 responses for each system component and sub-component will be analyzed by the SBTVD Forum prior to the beginning of Phase 2. If the requirements established in the TV 3.0 Call for Proposals document are not completely met, the SBTVD Forum may relax some of the requirements, extend the process deadlines, and/or release a second Call for Proposals (not necessarily encompassing all the system components or sub-components). Assuming Phase 1 responses are considered satisfactory by the SBTVD Forum, the following schedule applies to Phase 2 responses.

By 25 June 2021, the following documentation shall be provided by e-mail to the SBTVD Forum:

- The full specification of the technical proposal, preferably in technical standards of internationally recognized SDOs;
- Commitment to fair, reasonable, and non-discriminatory licensing (or any other form of commercialization) of the technical proposal, as specified in the SBTVD Forum Intellectual Property Rights Policy (see the TV 3.0 Call for Proposals document, Annex A);
- All the information requested in the "Additional Requirements" subsections of the TV 3.0 component corresponding to the technical proposal, e.g., about the available implementations of the proposed technology (see the TV 3.0 Call for Proposals document);
- Commitment to contribute with SBTVD Forum on drafting the TV 3.0 normative specifications and implementing its conformity assessment tests (reference implementations, reference streams, test suites, etc.) if their proposed candidate technologies are fully or partially adopted.

This documentation shall be directed to:

Mauricio Kakassu, Superintendent, SBTVD Forum: superintendencia@forumsbtvd.org.br

Doris Guardia, Secretary, SBTVD Forum: secretaria@forumsbtvd.org.br

NOTE This documentation deadline does not apply to the delivery of hardware, software, or test content requested in the "Additional Requirements" subsections of the TV 3.0 Call for Proposals document and further specified in this document, or to the proponent's test results reports. The deadlines for those deliverables are specified as follows.

All the equipment required for testing as specified in this document, shall be delivered between 24 May 2021 and 25 June 2021 in the SBTVD Forum office, at the following address:

Rua Manoel da Nóbrega, 211 – Paraíso – São Paulo – SP – Brazil – 04001-081

The Test Labs will be responsible for picking up this equipment in the SBTVD Forum office between 28 June 2021 and 02 July 2021 and returning it after the tests, between 06 and 10 December 2021.

The proponent shall collect the equipment in the SBTVD Forum office between 13 and 17 December 2021.

The following responsibilities shall be borne by the proponent, regarding the logistics of the equipment required for testing:

- The proponent is responsible for all its inbound and outbound logistic costs, including, but not limited to, customs clearance, fees, taxes, charges, duties, international and/or local freight, as well as hiring cargo agents, customs brokers, local and qualified importers, if applicable.
- The proponent is responsible for the proper packaging for the equipment. The packaging shall be adequate and sufficient to protect the goods, according to their nature, against impact and handling, during the entire way from proponent premises to the SBTVD Forum and on its return (for local or international shipments).
- In the case of equipment coming from abroad, it is recommended to have a local and qualified importer in Brazil to fill all the customs and fiscal procedures in Brazil. The SBTVD Forum shall not be named as the importer.
- The proponent shall deliver the equipment completely free and released and with all applicable Brazilian tax rules and with local documentation for evaluation covering the whole period of tests. The SBTVD Forum will not accept any equipment delivered without the Brazilian local documentation (named as “Nota Fiscal”).
- Any extra costs or taxes due to incorrect filling of this local documentation will be the responsibility of the proponent and/or its intermediaries named as the sender mentioned on the document. Therefore, we strongly recommend that the proponent uses qualified companies to fill that in case the proponent is unable to comply with Brazilian tax rules.
- The proponent is responsible for the transport insurance (local and/or international) as well as the equipment permanence insurance throughout the testing period from delivery to the moment of return. Such insurance must cover any risks of losses and material damages resulting from external causes, as well as, but not limited to, fire, flooding, theft, falls, breaks, dents, and electrical damage.
- All equipment will be repacked in their original cases or crates, but it shall be the responsibility of the proponent to check and attest to the safety of the packaging at the time of collection. The SBTVD Forum shall have no responsibility in case of poorly packed equipment.
- The SBTVD Forum will provide, according to the Brazilian tax rules, the local documentation for returning the equipment, naming on the document the proponent and/or its intermediaries as the new recipients.
- After the collection of the equipment, the proponent attests to the “proof of receipt” of the equipment and local documentation.

The Test Lab shall inform the proponent (through SBTVD Forum intermediation) if any equipment does not work properly, to enable arranging its replacement, if necessary.

All audio and video test content items required for testing as specified in 4.4.3 and 4.5.3 shall be delivered by 02 April 2021. All the other test content and software files required for testing as specified in this document, as well as the proponent's test results reports (including the objective test results as specified in 4.4.3 and draft subjective quality assessment reports as specified in 4.4.2 and 4.5.2), shall be delivered by 25 June 2021. The final subjective quality assessment reports as specified in 4.4.2 and 4.5.2 shall be delivered by 29 October 2021. For instructions on how to submit the appropriate files, please contact the SBTVD Forum by e-mail.

All the deadlines refer to 23:59 UTC-3 time zone.

Figure 47 illustrates the Phase 2 schedule.

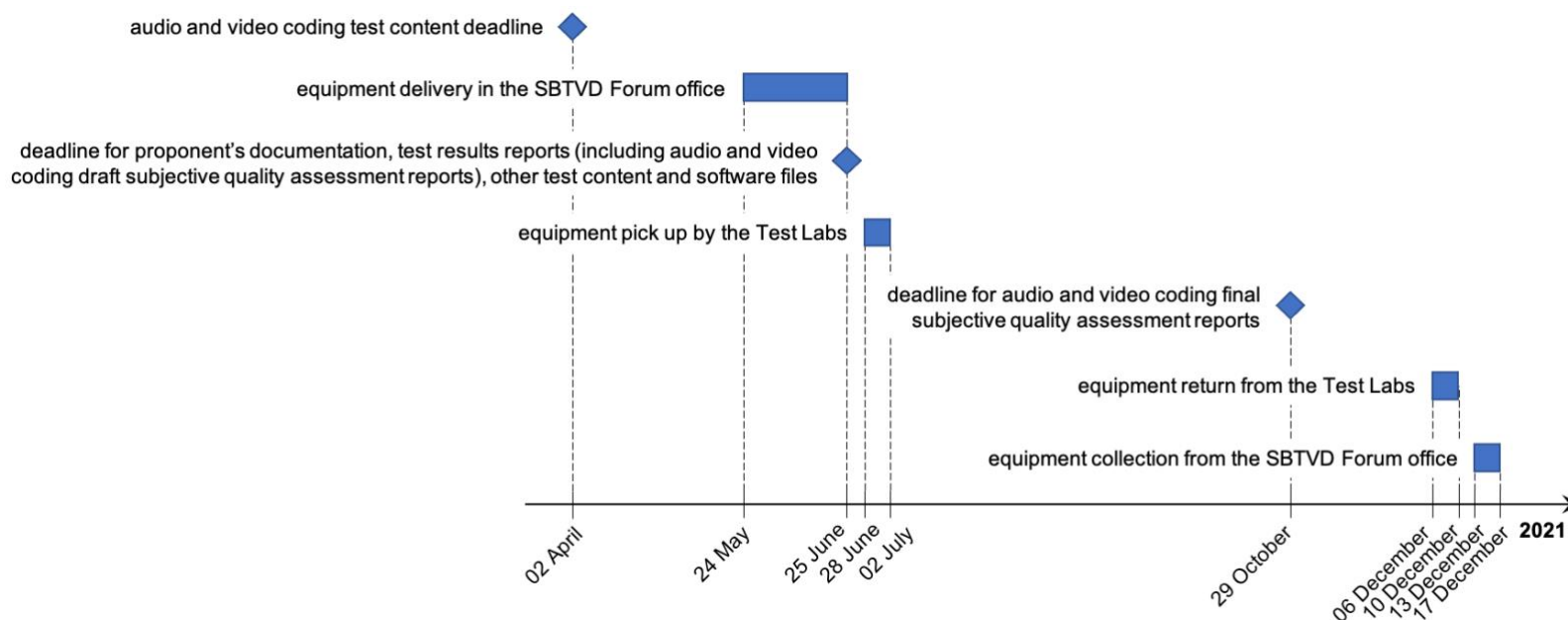


Figure 47: Phase 2 schedule

SBTVD Forum will notify the proponents upon the receiving of TV 3.0 Call for Proposals responses (Phase 1 and 2) and all related deliverables.

Proponents may be required to provide clarifications deemed necessary by the SBTVD Forum regarding their Call for Proposals responses (in Phase 1 and Phase 2), their documentation, their equipment, their software, their test content files, or unexpected test results involving their proposed candidate technologies.

Proponents may be invited to participate remotely in specific SBTVD Forum meetings, on mutually agreed dates and times, to present and discuss their proposed candidate technologies.

Questions related to this document should be directed to:

Luiz Fausto, Chair, Technical Module, SBTVD Forum: luiz.fausto@forumsbtvd.org.br

Doris Guardia, Secretary, SBTVD Forum: secretaria@forumsbtvd.org.br

6 SBTVD Forum Disclaimer

SBTVD Forum reserves the right to modify or withdraw this document without notice.