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Network Operations Subcommittee

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ANSI/SCTE 168-4 2019

**Recommended Practice for
Transport Stream Verification Metrics**

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1.0 SCOPE

This document is identical to SCTE 168-4 2010 except for informative components which may have been updated such as the title page, NOTICE text, headers and footers. No normative changes have been made to this document.

This Recommended Practice provides a common methodology for defining the measurement points and metrics of interest in digital cable networks that impair the compressed multimedia (video/audio/data) quality end to end. Uncompressed content and those metrics not related to “quality” are not included in this Recommended Practice,

Issues related to the IP network are addressed in SCTE 168-7.

2.0 INFORMATIVE REFERENCES

The following documents contain provisions, which, through reference in this text, constitute provisions of this standard. At the time of subcommittee approval, the editions indicated were valid. All standards are subject to revision, and parties to agreement based on this standard are encouraged to investigate the possibility of applying the most recent editions of the documents listed below.

2.1 SCTE References

- [1] SCTE: ANSI/SCTE 18-2007, Emergency Alert Messaging for Cable
- [2] SCTE: ANSI/SCTE 35-2007, Digital Program Insertion Cueing Message for Cable
- [3] SCTE: ANSI/SCTE 54-2009, Digital Video Service Multiplex and Transport System Standard for Cable Television
- [4] SCTE: ANSI/SCTE 65-2008, Service Information Delivered Out-Of-Band for Digital Cable Television
- [5] SCTE: SCTE-142-2009, Recommended Practice for Transport Stream Verification

2.2 Standards from other Organizations

- [6] ATSC: “ATSC Digital Television Standard: Part 3 - Service Multiplex and Transport Subsystem Characteristics,” Document A/53 Part 3:2009, 7 August 2009
- [7] ATSC: “ATSC Standard: Program and System Information Protocol for Terrestrial Broadcast and Cable (PSIP)”, Document A/65:2009, 14 April 2009”.
- [8] ATSC: “ATSC Recommended Practice: Transport Stream Verification” Document ATSC A/78A, 9 May 2007
- [9] ISO: “ISO/IEC IS 13818-1:2007 (E), International Standard, Information technology – Generic coding of moving pictures and associated audio information: systems”.

3.0 COMPLIANCE NOTATION

“SHOULD”	This word or the adjective “RECOMMENDED” means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications should be understood and the case carefully
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	weighted before choosing a different course.
“SHOULD NOT”	This phrase means that there may exist valid reasons in particular circumstances when the listed behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
“MAY”	This word or the adjective “OPTIONAL” means that this item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because it enhances the product, for example; another vendor may omit the same item.

4.0 DEFINITIONS AND ACRONYMS

8-VSB – Acronym for 8-Level Vestigial Sideband (Digital TV RF modulation format)

AEIT - Acronym for Aggregate Event Information Table, defined in SCTE-65 [4].

AETT - Acronym for Aggregate Extended Text Table, defined in SCTE-65 [4].

CM - Acronym for Component Missing, defined in SCTE-142 [8].

CRC - Acronym for Cyclic Redundancy Check, defined in ISO/IEC 13818-1 [9].

CVCT - Acronym for Cable Virtual Channel Table, defined in ATSC A/65 [7].

DPI - Acronym for Digital Program Insertion, defined in SCTE 35[2].

DTS - Acronym for Decoding Timestamp, defined in ISO/IEC 13818-1 [9].

DTV - Acronym for Digital Television.

EAS - Acronym for Emergency Alert System, defined in SCTE 18[1].

EIT - Acronym for Event Information Table, defined in ATSC A/65 [7].

EPG - Acronym for Electronic Program Guide.

ES - Acronym for Elementary Stream, defined in ISO/IEC 13818-1 [9].

ETT - Acronym for Extended Text Table, defined in ATSC A/65 [7].

GPS - Acronym for Global Positioning System.

L-VCT - Acronym for Long-form Virtual Channel Table, defined in SCTE-65 [4].

MPEG - Acronym for Moving Picture Experts Group.

MGT - Acronym for Master Guide Table, defined in ATSC A/65 [7].

MRD – Acronym for MPEG-2 Registration Descriptor, defined in ISO/IEC 13818-1 [9].

Mux – Multiplexer.

OOB-SI - Acronym for Out of Band - SI, defined in SCTE-65 [4].

PAT - Acronym for Program Association Table, defined in ISO/IEC 13818-1 [9].

PCR - Acronym for Program Clock Reference, defined in ISO/IEC 13818-1 [9].

PES - Acronym for Packetized Elementary Streams, defined in ISO/IEC 13818-1 [9].

PID - Acronym for Packet ID, defined in ISO/IEC 13818-1 [9].

PMT - Acronym for Program Map Table, defined in ISO/IEC 13818-1 [9].

POA - Acronym for Program Off Air, defined in SCTE-142 [8].

PSI - Acronym for Program Specific Information, defined in ISO/IEC 13818-1 [9].

PSIP - Acronym for Program and System Information Protocol, defined in ATSC A/65 [7].

PTS - Acronym for Presentation Time-Stamp, defined in ISO/IEC 13818-1 [9].

PVR - Acronym for Personal Video Recorder.

QAM - Acronym for Quadrature Amplitude Modulation.

QoS - Acronym for Quality of Service, defined in SCTE-142 [8].

RF - Acronym for Radio Frequency.

RP - Acronym for Recommended Practice.

RRT - Acronym for Rating Region Table, defined in ATSC A/65 [7].

SCTE - Acronym for Society of Cable Telecommunications Engineers.

SI - Acronym for Service Information, defined in SCTE 54 [3].

SLD - Acronym for Service Location Descriptor, defined in ATSC A/65 [7].

STT - Acronym for System Time Table, defined in ATSC A/65 [7].

S-VCT - Acronym for Short-form Virtual Channel Table, defined in SCTE-65 [4].

TNC - Acronym for Technically Non-Conformant, defined in SCTE-142 [8].

TOA - Acronym for Transport Stream Off Air, defined in SCTE-142 [8].

TVCT - Acronym for Terrestrial Virtual Channel Table, defined in ATSC A/65 [7].

TS - Acronym for Transport Stream, defined in SCTE 54 [3].

TSID – Transport Stream ID, defined in ISO/IEC 13818-1 [9].

T-STD - Acronym for Transport Stream System Target Decoder, defined in ISO/IEC 13818-1 [9].

TVCT- Acronym for Cable Virtual Channel Table, defined in ATSC A/65 [7].

VCT - Acronym for Virtual Channel Table, defined in ATSC A/65 [7].

5.0 INTRODUCTION

This Recommended Practice provides a common methodology for associating transport stream verification metrics with functional subsystems in cable architectures. Appropriate metrics are grouped into sets specific to functional areas within the cable network.

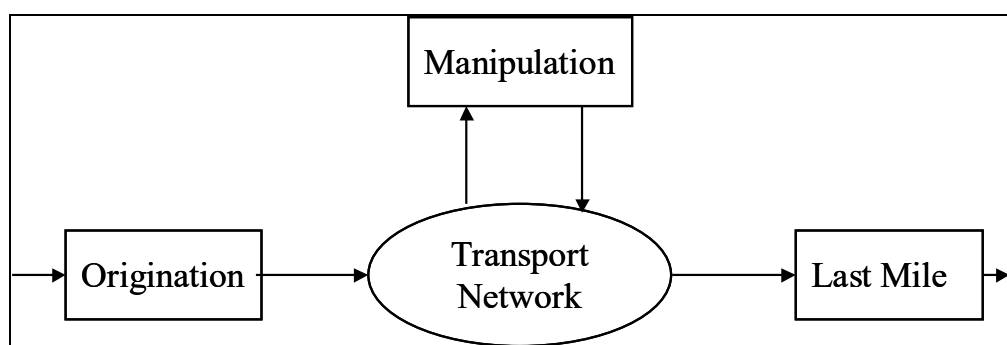


Figure 5-1 : Topology View of Metric Categories

Metrics are measurements aimed at determining the presence of impairments (errors in the transport streams carrying compressed content that can affect the perceived quality of the delivered content). The location of these metrics can be used to determine the source of the impairment, which is a key step in troubleshooting and resolving problems. As shown in Figure 5.2, below, a cable architecture is quite complex. However, it is composed of a number of functional blocks – each performing a specific function in the flow of content through the system. These blocks may be organized into common functional categories of operations which can be further organized into groups which perform similar operations from the viewpoint of metrics (by nature of the operations performed by the components of the category, the impairments that can be created are in common). Section 6.0 explains the categories used in this RP.

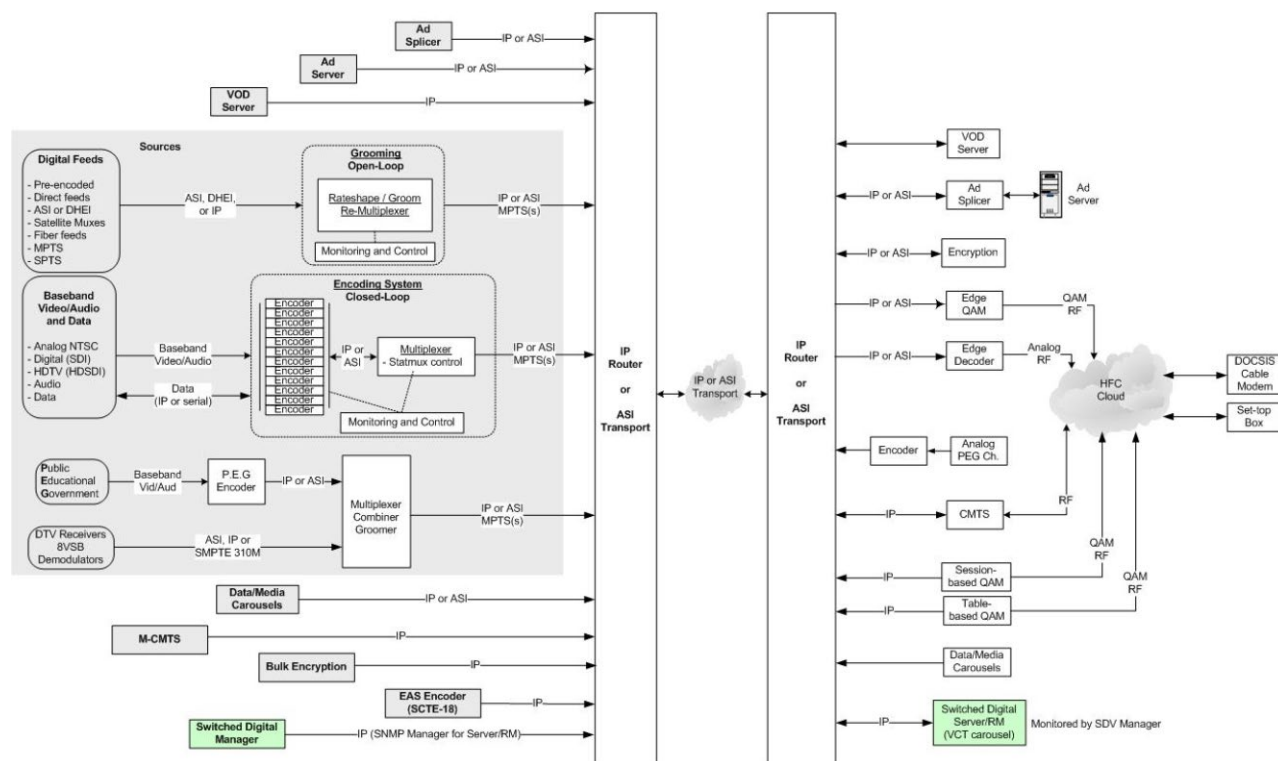


Figure 5-2 : Representative Cable Architecture

The metrics are used to provide insight to video/audio impairments while the categories help to define the location of the impairment and ultimately the root cause based on the type of equipment introducing the impairment. SCTE 142 [5] provides a methodology for transport stream conformance criteria, describing the elements and parameters that should be verified in an SCTE Transport Stream for it to be considered a proper emission. SCTE 142 also establishes severity ranges for deviations from the standardized limits found in SCTE 54 [3], ATSC A/53-3 [6] and ATSC A/65 [7]. SCTE 142, however, does not provide recommendations about where in a cable plant particular metrics would be useful, especially in the determination that impairments exist and the ability to localize them.

The target audience for this RP is the members of the cable community responsible for quality control for the compressed content flowing through the cable plant, as well as those who determine the strategy and approach for deploying monitoring equipment aimed at ensuring things run smoothly. As is usual with recommended practices, the recommendations in this document do not represent the only way to achieve this goal, but one that, if followed, will work. Other approaches may be used.

Since this recommended practice draws from SCTE-142, a brief summary of the major aspects of the methodology established therein follows:

SCTE-142 identifies transport stream issues by type, dividing errors into the following categories:

- PSI tables (PAT and PMT): An SCTE transport stream is also required to be MPEG-2 conformant. Therefore, an SCTE transport stream must include the two mandatory Program Specific Information (PSI) tables. These two tables are known as the Program Association Table (PAT) and the Program Map Table (PMT). The syntax is defined within ISO/IEC 13818-1 [9].
- Out-Of-Band Tables: ANSI/SCTE 65 [4] defines out-of-band service information for cable. The service information is designed to support “navigation devices” on cable. There are two main categories of information in the ANSI/SCTE 65 Standard, system information and schedule data. System information allows navigation among and access to the channels currently within the DTV transport stream. It is similar to the PSI data discussed elsewhere in this document. The schedule data provides necessary information for efficient browsing and selection of current and future events.
- In-Band Tables: In band tables include EAS messages (SCTE-18 [1]) and DPI messages (SCTE-35 [2]).
- PSIP tables (MGT, VCT, etc.): PSIP (ATSC A/65) [7] is the glue that holds the digital television (DTV) signal together. PSIP is a voluntary standard of ATSC and the SCTE and it has been fully and completely adopted into the regulations of the Federal Communications Commission (FCC), so it is, in fact, a requirement in terms of actual real-world operation¹. In most locations, multiple DTV stations can be received, and in some cases, from multiple markets. The purpose of PSIP is to describe the information at the system and event levels and to enable an abstract of the collection of programs called a virtual channel. There are two main categories of information in the ATSC PSIP Standard, system information and schedule data. System information allows navigation among and access to the channels currently within the DTV transport stream. It is similar to the PSI data discussed elsewhere in this document. The schedule data provides necessary information for efficient browsing and selection of current and future events.
- Timing Model and Buffering: Timing is the key to the MPEG-2 encoding and decoding processes. MPEG-2 Systems (ISO/IEC 13818-1) [9] defines a model for the system timing, adherence to which allows independent design of encoders and decoders that can interoperate. An MPEG-2 decoder’s 27 MHz reference clock needs to be synchronized with the equipment that is creating the encoded stream. In order to achieve this synchronization, PCR (Program Clock Reference) 27 MHz clock timestamps are sent within the stream at a rate frequent enough to re-synchronize the decoder with the encoder clock. The incorporation and use of Presentation and Decoding Time Stamps (PTS & DTS) enables synchronization between elements of a program (lip synch). The buffer model ensures that sufficient storage will be available in the receiver to hold the frames of audio and video until they need to be decoded.
- Consistency: Before a receiver can decode a transport stream, it must identify the relationship between components in the stream. Some components contain audio and video (Elementary Streams), and other components contain information describing the relationship between them (Metadata). The receiver uses metadata to identify each component, determine its function and select an appropriate set of components when the

¹ The current version of ATSC A/65 contains additional features and capabilities that are not covered by this RP.

user selects a virtual channel for decoding. Conflicts and problems within the structure of metadata are called ‘consistency errors.’ Consistency errors can result in broken decoding, missing system components (such as closed captioning), and/or missing program guide information. This section covers the types of errors that can cause these problems.

- **General Errors:** General errors cover a variety of types of problems (typically transport-related). For those listed in only the QOS and TNC columns, a single occurrence should be treated merely as a minor problem, which, unless periodically re-occurring, is not of concern. A repeated occurrence should warrant investigation, as it might be indicative of a device approaching total failure.

5.1 Discussion of Error Severity Classification

In addition to categorizing types of errors, SCTE-142 established a classification of error severities. While all variations from values established in the appropriate standards should be avoided (impairments), the impact of a particular impairment varies depending upon how large the variation is. Minor excursions from a standardized limit may produce no viewer perceived quality issue (for example, a PAT cycle time of 102ms). Major excursions typically represent serious quality issues. From an operational viewpoint, placing equal emphasis on all errors, no matter the severity will lead to operator fatigue (i.e. ignore red lights on the alarm screen, because there are always some lit). The error severity classification established in SCTE-142 is described below and offers a means to alleviate the problem just described:

- **Transport Stream Off Air (TOA):** The transport is effectively off-air as the Transport Stream errors are severe enough that transport level logical constructs are damaged beyond utility. Receivers will not be able to tune and decode anything within the transport. The complete or repeated absence of sync bytes would be an example of this level of error.
- **Program Off Air (POA):** A main service (virtual channel) is flawed to the point that that service is effectively off air for conformant/reasonable receiver designs. This could involve all of the program elements being improperly constructed or incorrect/missing signaling about elements. The absence of a PMT instance for a service would be an example of this type of error.
- **Component missing (CM):** One of the program components that is signaled by PSIP or PSI as present is either not present or cannot be found and decoded. One example would be a mismatch between the video PID signaled in the PMT and the actual PID used for the video elementary stream.
- **Quality of Service (QOS):** Parameters are out of specification by such a margin that a significant fraction of the receivers can be expected to produce flawed outputs. In many cases, the broadcast is viewable, but may exhibit some form of degradation to the viewer. An example might be the PAT cycle time being somewhat longer than the specification, which would cause slower than normal tuning.
- **Technically Non-Conformant (TNC):** Violates the letter of the standard, but in practice will have little effect on the viewing experience. Errors of this type may need to be corrected, but do not have the urgency of higher severity errors, while others are due to

“shall statement” collisions. An example might be a single instance of a 102 ms PAT cycle time (with the remainder of the PATs coming at less than 100 ms intervals).

In most cases the error threshold for what may appear to be escalating categorization is based on: 1) the official metric to twice the metric, 2) twice the official metric to 5 times the metric, and 3) over five times the metric. The nominal mathematical expression of this is shown below, where T_c is the metric for the cycle time and t is the time since the last arrival (note that for clarity of expression of the time intervals, this document ignores time advances during each millisecond increment):

1. $T_c < t \leq 2T_c$
2. $2T_c < t \leq 5T_c$
3. $5T_c < t$

This scale can prevent “shall-statement collisions” from producing meaningless error alarms, yet provides guidance to equipment makers and users regarding severities.

6.0 METRICS ORGANIZATION

For practicality, this document has decomposed the system in figure 5.2 above into a small number of major functional categories; each consisting of a number of functional blocks (devices) with characteristics and types of compressed streams in common. The presence of common characteristics allows a grouping of impairments (metrics) that would be appropriate to capture for different devices in order to allow localization to take place. In all cases, the measurement point for these metrics for each device is the output of the device.

Table 6.1 lists the major functional categories, classifies each functional block (along with a brief explanation of the function of that block) and then groups each functional block by characteristics of the manipulations and transport streams.

The major functional categories are:

- ☐ Origination – Sources of compressed content distributed by the cable system, including encoders, video servers and external sources of compressed content coming from outside of the digital cable plant. (Example: video/audio encoding from analog.)
- ☐ Manipulation – Receives streams of compressed content, processes it and outputs the modified form. (example: remultiplexing to change the markup of transport streams).
- ☐ Last Mile – Transforms compressed content to a form that can be distributed to the receiver. (example: QAM modulation onto HFC).

Table 6-1 : Category/Functional Block/Metrics Mapping

Functional Category	Functional Block	Description	Metrics Set * Naming convention is to group functions.
Origination	8-VSB Demod	Receiver for ATSC DTV broadcast taking in 8-VSB RF signals and outputting digital MPEG-2 Transport Streams.	Metrics A
Origination	Ad Server	Video Server that plays out Advertising clips for insertion.	Metrics B
Origination	VOD Server	Video Server for Video on Demand payout.	Metrics B
Origination	Encoder	MPEG compression of video and audio sources that make up a program	Metrics B
Manipulation	Encryptor	Encryption of subscription services	Metrics C
Manipulation	Groomer/ Rateshaper	Device that allows selection of programs from an existing MPTS sources, as well as modification of the bit rate for each program.	Metrics C
Origination	Mux	Device that combines a number of SPTS streams into an MPTS stream	Metrics C
Last Mile	QAM Modulator	Device that modulates and upconverts digital transports for carriage over an HFC distribution system using QAM	Metrics C
Origination	Satellite Receiver	Receiver for digital satellite broadcast signals (typically using QPSK or xPSK modulation), which outputs digital MPEG-2 Transport Streams	Metrics C

Manipulation	Remux	Device that combines one or more MPTS streams into a single MPTS output, allowing the selection of which programs are included	Metrics C
Manipulation	Ad Splicer	Device that inserts ad clips directly into a compressed transport stream (refer to SCTE 35 [2])	Metrics C
Last Mile	CPE/STB	Consumer Premises Equipment/Set-Top Box (receiving device)	Metrics C
Origination	Digital Feeds	Compressed Mpeg-2 Transport Streams from external sources entering the cable system.	Metrics C
Origination	DPI Encoder	Device (typically an MPEG encoder) that creates/inserts Digital Program Insertion (SCTE 35) messages, usually in response to SCTE104 trigger messages	Metrics D ²
Origination	EAS Generator	Device that creates/inserts Emergency Alert Messages (SCTE 18)	Metrics E

² Note: The DPI Encoder is not show in Figure 5-2 or Figure 6-1