ATSC Recommended Practice:
Program and System Information Protocol
Implementation Guidelines for Broadcasters

The Advanced Television Systems Committee, Inc., is an international, non-profit organization developing voluntary standards for digital television. The ATSC member organizations represent the broadcast, broadcast equipment, motion picture, consumer electronics, computer, cable, satellite, and semiconductor industries.

Specifically, ATSC is working to coordinate television standards among different communications media focusing on digital television, interactive systems, and broadband multimedia communications. ATSC is also developing digital television implementation strategies and presenting educational seminars on the ATSC standards.

ATSC was formed in 1982 by the member organizations of the Joint Committee on InterSociety Coordination (JCIC): the Electronic Industries Association (EIA), the Institute of Electrical and Electronic Engineers (IEEE), the National Association of Broadcasters (NAB), the National Cable Telecommunications Association (NCTA), and the Society of Motion Picture and Television Engineers (SMPTE). Currently, there are approximately 140 members representing the broadcast, broadcast equipment, motion picture, consumer electronics, computer, cable, satellite, and semiconductor industries.

ATSC Digital TV Standards include digital high definition television (HDTV), standard definition television (SDTV), data broadcasting, multichannel surround-sound audio, and satellite direct-to-home broadcasting. Contact information is given below.

Mailing address	Advanced Television Systems Commmittee, Inc. 1776 K Street, N.W., Suite 200 Washington, D.C. 20006
Telephone	202-872-9160 (voice), 202-872-9161 (fax)
Web site	http://www.atsc.org, E-mail: standard@atsc.org

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The revision history of this document is given below.

A/69 Revision History

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1. SCOPE

This document provides a set of guidelines for the use and implementation of the Advanced Television Systems Committee (ATSC) Program and System Information Protocol (PSIP). These guidelines are intended to be recommendations for the usage of the ATSC PSIP Standard as described in document A/65:2009, "Program and System Information Protocol for Terrestrial Broadcast and Cable" [1]. The information contained herein applies to broadcasters, network operators, infrastructure manufacturers, and receiver manufacturers.

The recommendations for PSIP functions as described in this document in no way prohibit consumer device manufacturers from including additional features, and this document should not be interpreted as stipulating any form of upper limit to system performance.

This document uses the terminology defined in the ATSC PSIP Standard [1] and should be read in conjunction with [1]. It is important to point out that PSIP documentation is—in effect—spread among several ATSC documents, depending on the application. For example, the Data Broadcast Standard (A/90) [2] builds upon A/65 [1] to add a new functionality. Likewise, the Conditional Access System Standard (A/70) [3] builds upon the PSIP foundation to provide content management functions.

The ramifications of data broadcast-related PSIP are not addressed to a significant degree in this Recommended Practice.

This document establishes no normative provisions; it discusses normative provisions of standards it references.

1.1 The Need for this Document

Although proper implementation of PSIP at the television station level is not particularly complex, neither is it straightforward. The intent of this Recommended Practice is to explain the operator-oriented elements of PSIP and to provide practical examples of typical station operation, as well as to provide guidelines for designers of PSIP-related hardware and software to optimize user interface information for such equipment.

PSIP is the glue that holds the digital television (DTV) signal together. In the U.S., FCC regulations require broadcasters to comply with PSIP. U.S. 47 Code of Federal Regulations 73.682 (d) requires digital broadcast television signals to comply with A/65. In other countries, similar regulations may apply.

PSIP is a companion standard to ATSC A/53 [4] that consists of a small collection of tables designed to reside within every Transport Stream (TS) for terrestrial broadcast of digital television. Its purpose is to describe the information at the system and event levels for all *virtual channels* carried in a particular TS. Additionally, information for analog channels as well as digital channels from other Transport Streams may be incorporated.

There are two main functions and therefore two main categories of information in the ATSC PSIP Standard, *system information* and *program data*:

- System information allows navigation and access of the channels within the DTV transport stream.
- Program data provides information to facilitate efficient browsing and event selection.

Some tables announce future events and some are used to locate the digital streams than make up an event. The PSIP data are carried via a collection of hierarchically arranged tables.

1.2 Other System Considerations

The ATSC television system relies upon digital video, audio, and related data, along with PSIP transmitted to viewers in an MPEG-2 Transport Stream (TS). This TS is a complex construct, and station operators need reliable tools to monitor its health. The ATSC has provided a Recommended Practice on this topic, A/78 [5]. Readers should ensure their broadcast stations are equipped with monitoring devices following the A/78 paradigm[1]. SCTE produced a TS verification Recommended Practice with extensions for cable-only aspects. The SCTE document is ANSI/SCTE 142 [6].

1.3 Organization

The sections of this document are organized as follows:
- **Section 1**. Provides this general introduction.
- **Section 2**. Lists references and applicable documents.
- **Section 3**. Provides a definition of terms and a list of acronyms and abbreviations used in this document.
- **Section 4**. Describes the overall PSIP structure.
- **Section 5**. Describes the basic PSIP requirements for broadcasters.
- **Section 6**. Describes format and structure of the PSIP tables.
- **Section 7**. Describes the interrelation of the PSIP tables.
- **Annex A**. Explains the need for PSIP, the history of the standard, and the fundamental structure of the system.
- **Annex B**. Provides an example of a typical PSIP implementation.
- **Annex C**. Briefly explains the differences between PSIP for terrestrial broadcast and cable applications.
- **Annex D**. Provides an overview of the syntax and format of the tables used in the PSIP Standard.
- **Annex E**. Describes the concepts behind and the use of GPS time, a key element in PSIP operation.
- **Annex F**. Provides examples of near-video on demand.
- **Annex G** Provides additional explanation of the PSIP Master Guide Table.
- **Annex H**. Summarizes the use of analog transmission signal ID information.
- **Annex I.** Expands upon the use of the component name descriptor.
- **Annex J**. Explains the sources of PSIP information for the DTV station.
- **Annex K**. Explains specific coding issues related to the Rating Region Table.

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1. Many older Transport Stream analyzers assess noncompliance with A/65 strictly, without regard for the severity of the non-compliance. A/78, in contrast, is oriented towards emphasizing important deviations based on the severity of each error in a real-world manner.

- **Annex L**. Explains the operation of Directed Channel Change.

1.4 Use of This Document

The authors of this document recommended that it be studied in its entirety. The subject of PSIP is complex and a full understanding is facilitated by following the logical progression of topics provided in this Recommended Practice. However, in recognition of the practical time limitations faced by engineers today, the following sections are identified as "must-read":

- **For television station engineers**: Section 5, Section 6, Annex A, and Annex B.
- **For PSIP generator manufacturers**: Section 5, Section 6, Section 7, Annex C, Annex D, Annex E, Annex F, Annex G, Annex H, and Annex I. In addition, manufacturers are referred to ATSC Standard A/65 [1].

For those readers who are unfamiliar with the genesis of the PSIP Standard and why it is important to broadcasters, the authors recommend that Annex A be read first as it provides valuable background information on the subject.

As an additional aid to readers, specific recommendations in this document are noted by the graphic: ☑.

2. REFERENCES

At the time of publication, the editions indicated below were valid. All standards are subject to revision, and parties to agreement based on this document are encouraged to investigate the possibility of applying the most recent editions of the documents listed below.

[1]   ATSC: "Program and System Information Protocol for Terrestrial Broadcast and Cable," Doc. A/65:2009, Advanced Television Systems Committee, Washington, D.C., 14 April 2009.

[2]   ATSC: "ATSC Data Broadcast Standard," including Amendment 1 and Corrigendum 1 and Corrigendum 2," Advanced Television Systems Committee, Washington, D.C., 26 July 2000 (Amendment 1 dated 14 May 2002; Corrigendum 1 and 2 dated 1 April 2002).

[3]   ATSC: "Conditional Access System for Terrestrial Broadcast, Revision A, with Amendment No. 1," Doc. A/70A, Advanced Television Systems Committee, Washington, D.C., 22 July 2004 (Amendment No. 1 dated 11 September 2006).

[4]   ATSC: "ATSC Digital Television Standard, Parts 1–6," Doc A/53:2007/2009, Advanced Television Systems Committee, Washington, D.C., 3 January 2007 and 7 August 2009.

[5]   ATSC: "Recommended Practice, Transport Stream Verification," Doc. A/78A, Advanced Television Systems Committee, Washington, D.C., 9 May 2007.

[6]   SCTE: "Recommended Practice for Transport Stream Verification," Doc. ANSI/SCTE 142-2009, Society of Cable Telecommunications Engineers, Exton, PA, 2009.

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

[8]   ISO: ISO 639.2, "Code for the Representation of Names of Languages — Part 2: alpha-3 code," as maintained by the ISO 639/Joint Advisory Committee (ISO 639/JAC), http://www.loc.gov/standards/iso639-2/iso639jac.html. JAC home page: http://www.loc.gov/

standards/iso639-2/iso639jac.html; ISO 639.2 standard online: http://www.loc.gov/standards/iso639-2/langhome.html.

[9] CEA: "PSIP Recommended Practice," Doc. CEA-CEB12-B, Consumer Electronics Association, Arlington, VA, 2009.

[10] ATSC: "Programming Metadata Communication Protocol Standard, Revision B," Doc. A/76B, Advanced Television Systems Committee, Washington, D.C., 14 January 2008.

[11] CEA: "Line 21 Data Services," Doc. CEA-608-E, Consumer Electronics Association, Arlington, VA, April 2008.

[12] SMPTE: "Broadcast Exchange Format (BXF)," Doc. SMPTE 2021M-2008, Society of Motion Picture and Television Engineers, White Plains, NY, 2008.

[13] CEA: "U.S. and Canadian Rating Region Tables (RRT) and Content Advisory Descriptors for Transport of Content Advisory Information Using ATSC Program and System Information Protocol (PSIP)," Doc. ANSI/CEA-766-C, American National Standards Institute and Consumer Electronics Association, April 2008.

[14] ISO: ISO/IEC 13818-1:2007, "Information Technology—Generic coding of moving pictures and associated audio; Part 1: Systems."

2.1 Acquiring Reference Documents

2.1.1 ATSC Standards

Advanced Television Systems Committee (ATSC), 1776 K Street N.W., Suite 200 Washington, D.C. 20006 USA; Phone 202-872-9160; Fax 202-872-9161.
Internet: http://www.atsc.org/standards/.

2.1.2 CEA Standards and Bulletins

Consumer Electronics Association (CEA) 1919 S. Eads St., Arlington, VA 22202; Standards: Phone 703-907-7634, Fax 703-907-7693.
Internet: http://www.ce.org.

CEA documents are available from Global Engineering Documents, World Headquarters, 15 Inverness Way East, Englewood, CO 80112-5776; Phone 800-854-7179; Fax 303-397-2750; Internet: http://global.ihs.com.

2.1.3 ISO Standards

ISO Central Secretariat, 1, rud de Varembe, Case postale 56, CH-1211 Geneve 20, Switzerland; Phone +41 22 749 01 11; Fax + 41 22 733 34 30;
Internet: http://www.iso.ch ; Email central@iso.ch.

ISO documents are available from Global Engineering Documents, World Headquarters, 15 Inverness Way East, Englewood, CO 80112-5776; Phone 800-854-7179; Fax 303-397-2750; Internet: http://global.ihs.com.

3 DEFINITION OF TERMS

With respect to definition of terms, abbreviations, and units, the practice of the Institute of Electrical and Electronics Engineers (IEEE) as outlined in the Institute's published standards [7]

are used. Where an abbreviation is not covered by IEEE practice or industry practice differs from IEEE practice, the abbreviation in question will be described in Section 3.2 of this document.

3.1 Treatment of Syntactic Elements

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

3.2 Acronyms and Abbreviation

The following acronyms and abbreviations are used within the ATSC PSIP Standard [1] or this document and are repeated here for quick reference.

ATSC – Advanced Television Systems Committee

BMP – basic multilingual plane

bslbf – bit serial, leftmost bit first

CAT – conditional access table

CEA – Consumer Electronics Association

CRC – cyclic redundancy check

CVCT – cable virtual channel table

DCC – directed channel change

DCCSCT – directed channel change selection code table

DET – data event table

DTV – digital television

EIT – event information table

EMM – entitlement management message

EPG – electronic program guide

ETM – extended text message

ETT – extended text table

GPS – Global Positioning System

IEC – International Electrotechnical Commission

IPG – interactive program guide

ISO – International Standards Organization

kbps – kilo (1000) bits per second

MGT – master guide table

MHz – megahertz

MPAA – Motion Picture Association of America

MPEG – Moving Picture Experts Group

NTSC – National Television Systems Committee

NVOD – near video on demand

OOB – out of band

PAT – program association table

PCR – program clock reference

PES – packetized elementary stream

PID – packet identifier

PMT – program map table

PSI – program specific information

PSIP – program and system information protocol

PTC – physical transmission channel

QAM – quadrature amplitude modulation

RCU – remote control unit

rpchof – remainder polynomial coefficients, highest order first

RRT – rating region table

RTT – ratings text table

SCTE – Society of Cable Telecommunications Engineers

SD – standard definition

SDTV – standard definition television

SI – system or service information

SLD – Service Location Descriptor

SMPTE – Society of Motion Picture and Television Engineers

STD – system target decoder

STT – system time table

TS – transport stream

TSID – transport stream ID or transmission signal ID

TVCT – terrestrial virtual channel table

TVPG – Television Parental Guidelines

uimsbf – unsigned integer, most significant bit first

unicode – Unicode™

UTC – Coordinated Universal Time

VBI – vertical blanking interval

VC – virtual channel

VCT – virtual channel table; used in reference to either TVCT or CVCT

VSB – vestigial sideband

3.3   Definition of Terms

The following key terms that are used in the ATSC PSIP standard [1] are repeated here for ease of reference:

base PID – A packet identifier of fixed value 0x1FFB.

descriptor – A data structure of the format: descriptor_tag, descriptor_length, and a variable amount of data. The tag and length fields are each 8 bits in length. The length specifies the length of data that begins immediately following the descriptor_length field itself. A descriptor whose descriptor_tag identifies a type not recognized by a particular decoder is expected to be ignored by that decoder. Descriptors can be included in certain specified places within PSIP tables, subject to certain restrictions. Descriptors may be used to extend data represented as fixed fields within the tables. They make the protocol very flexible because they can be included only as needed. New descriptor types can be standardized and included without affecting receivers that have not been designed to recognize and process the new types.

digital channel – A set of one or more digital elementary streams. See *virtual channel*.

event – A collection of elementary streams with a common time base, an associated start time, and an associated end time. An event is equivalent to the common industry usage of "television program."

instance – See *table instance*.

logical channel – See *virtual channel*.

major channel – The first number in a two-part number used to identify a virtual channel. Each virtual channel carries one service, such as a television program.

minor channel – The second number in a two-part number used to identify a virtual channel. The minor number changes for each different service that is or will be present in a DTV transport stream.

packet identifier – Also known as PID. A unique integer value used to identify packets in a Transport Stream.

physical channel – A generic term to refer to the each of the 6 MHz frequency bands where television signals are embedded for transmission. Also known as the physical transmission channel (PTC). One analog virtual channel fits in one PTC but multiple digital virtual channels typically coexist in one PTC.

physical transmission channel – See *physical channel*.

program element – A generic term for one of the elementary streams or other data streams that may be included in a program. For example: audio, video, data, and so on.

program – In MPEG terminology, a collection of program elements. Program elements may be streams of data such as video, data, and audio. Program elements need not have any defined time base; those that do have a common time base are intended for synchronized presentation. The term *program* is also commonly used in the context of a "television program" such as a scheduled daily news broadcast. In ATSC standards, the term "event" is used to refer to a "television program" to avoid confusion with the MPEG technical definition.

region – As used in the PSIP document, a region is a geographical area consisting of one or more countries.

section – A data structure comprising a portion of an ISO/IEC 13818-1 (MPEG Systems) defined table, such as the Program Association Table (PAT), Conditional Access Table (CAT), or Program Map Table (PMT). All sections begin with the table_id and end with the CRC_32 field, and their starting points within a packet payload are indicated by the pointer_field mechanism defined in the ISO/IEC 13818-1 International Standard.

stream – An ordered series of bytes. The usual context for the term stream is the series of bytes extracted from transport stream packet payloads which have a common unique PID value (e.g., video PES packets or Program Map Table sections).

table, PSIP – A collection of tables describing virtual channel attributes, event features, and other elements. PSIP tables are compliant with the private section syntax of ISO/IEC 13818-1.

table, instance – Tables are identified by the table_id field. However, in cases such as the RRT and EIT, several tables with different content can be defined simultaneously; each of these is a table instance. All instances have the same PID and table_id but a different table_id_extension.

version number – A number that increments each time there is a change in a referenced table.

virtual channel – A virtual channel (VC) is the numeric designation that is recognizable by the user as the single entity that will provide access to a TV program. It is called "virtual" because its identification (name and number) may be defined independently from its physical (RF) location. Examples of virtual channels include: digital radio (audio only), a typical cable analog TV channel, a typical digital TV channel (composed of one audio and one video stream), multi-visual digital channels (composed of several video streams and one or more audio tracks), or a data broadcast channel (composed of one or more data streams). In the case of an analog TV channel, the virtual channel designation will link to a specific physical transmission channel. In the case of a digital TV channel, the virtual channel designation will link both to the physical transmission channel and to the particular video and audio streams within that physical transmission channel that make up the event currently on that VC.

4. PSIP STRUCTURE

PSIP is a collection of tables, each of which describes elements of typical digital television services [1]. Figure 4.1 shows the primary components and the notation used to describe them. The packets of the base tables are all labeled with a base *packet identifier* (PID) (base_PID). The base tables are:

- System Time Table (STT)
- Rating Region Table (RRT)
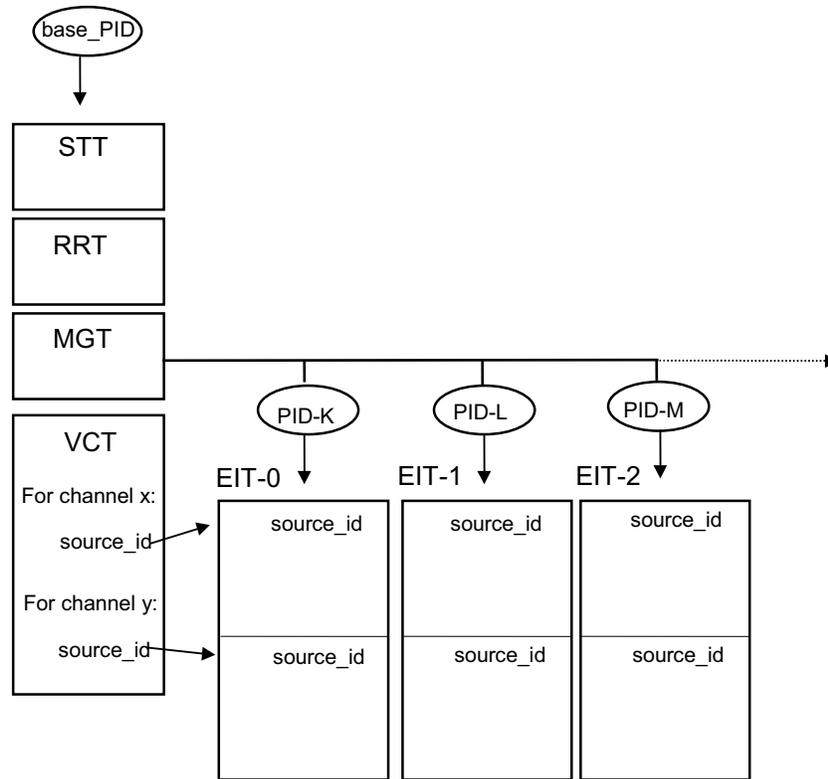
Figure 4.1 Overall structure of the PSIP tables.

- Master Guide Table (MGT)
- Virtual Channel Table (VCT)

The Event Information Tables (EIT) are a second set of tables, whose packet identifiers are defined in the MGT. The Extended Text Tables (ETT) are a third set of tables, and similarly, their PIDs are defined in the MGT.

The System Time Table is a small data structure that fits in one Transport Stream packet and serves as a reference for time-of-day functions. Receivers can use this table to manage various operations and scheduled events, as well as display time-of-day.

The Rating Region Table has been designed to transmit the rating system in use for each country using the ratings. In the U.S., this is incorrectly but frequently referred to as the "V-chip" system; the proper title is Television Parental Guidelines (TVPG). Provisions have been made in the PSIP Standard [1] for multi-country systems.

The Master Guide Table provides indexing information for the other tables that comprise the PSIP Standard. It also defines table sizes necessary for memory allocation during decoding, defines version numbers to identify those tables that need to be updated, and generates the packet identifiers that label the tables.

The Virtual Channel Table, also referred to as the Terrestrial VCT (TVCT), contains a list of all the channels that are or will be on-line, plus their attributes. Among the attributes given are the channel name and channel number.
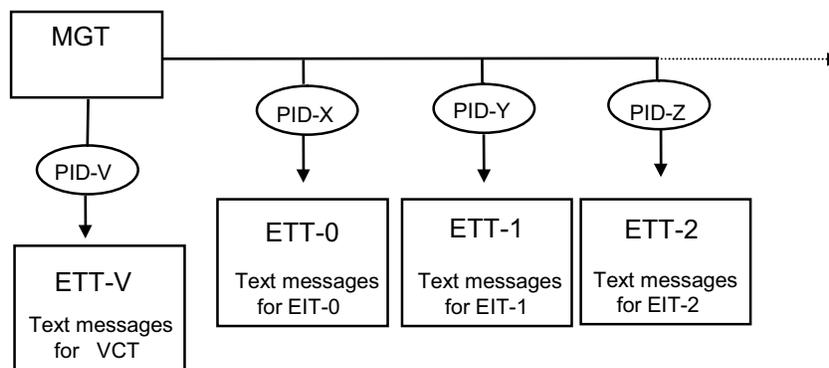
Figure 4.2 Extended text tables in the PSIP hierarchy.

There are up to 128 Event Information Tables, EIT-0 through EIT-127, each of which describes the events or television programs for a time interval of three hours. Because the maximum number of EITs is 128, up to 16 days of programming may be advertised in advance. At minimum, the first four EITs are required to always be present in every transport stream, and 24 are recommended. Each EIT-k may have multiple instances, one for each virtual channel in the VCT.

As illustrated in Figure 4.2, there may be multiple Extended Text Tables, one or more channel ETT sections describing the virtual channels in the VCT, and an ETT-k for each EIT-k, describing the events in the EIT-k. These are all listed in the MGT. An ETT-k contains a table instance for each event in the associated EIT-k. As the name implies, the purpose of the ETT is to carry text messages. For example, for channels in the VCT, the messages can describe channel information, cost, coming attractions, and other related data. Similarly, for an event such as a movie listed in the EIT, the typical message would be a short paragraph that describes the movie itself. Extended Text Tables are optional in the ATSC system.

5. BASIC PSIP REQUIREMENTS FOR BROADCASTERS

The three main tables (VCT, EIT, and STT) contain information to facilitate suitably equipped receivers to find the components needed to present a program (event). Although receivers are expected to use stored information to speed channel acquisition, sometimes parameters change and the MGT, VCT, and EIT-0 are the tables that are most critical each and every instant as they provide the actual connection path and critical information that can affect the display of the events. If nothing has changed since an EIT was sent for an event, then the anticipatory use of the data is expected to proceed, and when there is a change the new parts would be used. Additional tables provide TV parental advisory information and extended text messages about certain events. These relationships—and the tables that carry them—are designed to be kept with the DTV signal when it is carried by a cable system.

5.1 The Basics

There are certain PSIP elements that are required, and there are certain rules to be followed. If these PSIP elements are missing or wrong, there may be severe consequences, which vary

depending on the design of receiver. The following are key elements that are required to be set and/or checked by each station:

- **Transport Stream Identification** (TSID). The pre-assigned TSIDs are required to be set correctly in all three locations (PAT, VCT common information, and virtual channel-specific information). See Section 6.3.1 for more information.

- **System Time Table** (SST). The System Time is required to be accurate to within plus or minus one second. It should be checked daily and, ideally, locked to GPS time. See Section 6.6. A/65 recommends that the STT be inserted into the TS a few milliseconds before each seconds-count increment of the house time with the to-be-valid value.

- **Short Channel Name**. This is a seven-character name that can be set to any desired name indicating the virtual channel name. For example, a station's call letters followed by SD1, SD2, SD3, and SD4 to indicated various SDTV virtual channels or anything else to represent the station's identity (e.g., WNABSD1, KNABSD2, WNAB-HD, KIDS, etc.). See Section 6.3.1.

- **Major Channel**. A number from 1 – 99[2]. For the U.S., the major channel number is the FCC-assigned RF channel number (2 – 69) for each NTSC broadcast licensee. See Section 6.3.1 for more detail and exceptions.

- **Service Type**. The service type selects DTV, NTSC, audio only, data, etc., and is required to be set as operating modes require. See Section 6.3.1.

- **Source ID**. The Source ID is a number that associates virtual channels to events on those channels. It typically is automatically updated by PSIP equipment or updated from an outside vendor. See Section 6.3.4.

- **Service Location Descriptor** (SLD). Contains the MPEG references to the contents of each component of the programs plus a language code for audio (ISO 639-2 [8]). See Section 6.3.3. The PID values for the components identified here are required to be the same for the elements of an event/program that appear in the PMT. PID values assigned to a VC should not be changed as it is recommended that receivers be designed to rely upon their constancy to speed average channel change time.

The maximum cycle time/repetition rate of the tables should be set or confirmed to conform to the suggested guidelines given in Table 5.1 for mandatory PSIP tables and Table 5.2 for optional PSIP tables.

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2.   The major channel number used in the CVCT has a larger range, 0 – 999. See Annex C.

☑   **Table 5.1** Suggested Repetition Intervals for Mandatory PSIP Table

PSIP Table	Suggested Repetition Interval	Required Repetition Interval
MGT	150 ms	> = 150 ms
TVCT	400 ms	> = 400 ms
EIT-0	Once every 0.5 seconds	n/a
EIT-1	Once every three seconds	n/a
EIT-2 and EIT-3	Once every minute	n/a
STT	Once every second	> = 1000 ms
RRT (not required in some areas[a])	Once every minute	> = 1 minute
[a] The U.S. is one such area.		

☑   **Table 5.2** Suggested Repetition Intervals for Optional PSIP Tables

PSIP Table		Transmission Interval
ETT		Once every minute
EIT-4 and higher		Once every minute
DCCSCT		Once per hour
DCCT	A/65 [1] specifies the following repetition rates for DCC per specified conditions.	
	DCC request in progress	150 msec
	2 seconds prior to DCC request	400 msec
	No DCC	n/a

It is recommended that broadcasters send populated EITs covering at least three days (see Section 6.4 for more detail). The primary cycle time guidelines are illustrated in Figure 5.1.

The recommended table transmission times given in this section result in a minimal demand on overall system bandwidth. Considering the importance of the information that these PSIP tables provide to the receiver, the bandwidth penalty is trivial. (Additional details on the impact of table transmission times on DTV system bandwidth can be found in Section 7.6.)

5.2 Accuracy of Contents

The PSIP standard applies to the construction of the media and metadata contents of the Transport Stream and the requirement to avoid inconsistencies amongst that data. PSIP metadata consists of information intended for use within the receiving device (for example, tuning) and information meant to be displayed to the user (for example the contents of the ETTs—event descriptions). The actual contents for user readable fields are under the control of the broadcaster and therefore out of scope of a technical standard. However, the system is required to be able to accurately and consistently transport whatever media data and metadata is provided. The standard also attempts to describe the system concepts and how the data should be used for maximum benefit to both the consumer and the broadcaster.

To amplify and explain the balance between technical precision and operational flexibility text, let us examine the text from Section 6.5 of A/65 [1] which says:
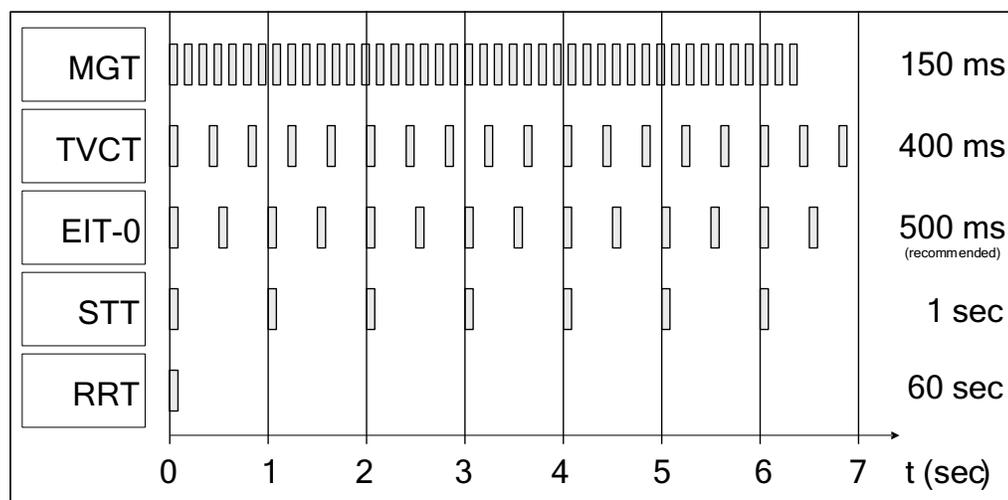
Figure 5.1 Recommended PSIP table transmissions.

> "The contents of the fields and the descriptors in each events descriptor loop shall be accurate representations of the known information about each event at the time the event instance is created and shall be updated if more accurate information becomes available."

The key to understanding this provision is the meaning of the word "known" in the technical context. The word "known" was inserted during the drafting to address the practical reality of the variation in capability of broadcast station infrastructure. In this usage, "known" by definition cannot be ambiguous, it must be certain. In precise technical terms the scope of the standard is only the PSIP data stream as transmitted, and the standard does not establish how human knowledge gets into the facility equipment in general. It also does not address the use of PMCP or BXF protocols (or others) as tools to facilitate getting accurate information from one piece of equipment to another, but certainly use of such protocols can greatly facilitate matters. Additionally, the "known information" technically must be electronically communicated using the defined PSIP protocol as receivers rely upon the data conveyed.

So it is the broadcast stream generation equipment that must "know" this information. As information can be created in multiple locations, and the standard just covers the end result, it is that piece of equipment which creates the particular data structure that must have the certain "knowledge", so that the data can be made consistent (within the transport). The standard describes the equipment's required capability and not what or when an input was provided to the equipment. So these provisions require standards-compliant equipment to make the correct association and send the correct information.

The PSIP data is contained in multiple table structures. As the stream is serial, not parallel, these tables are transmitted at different points in time. If a change is made, there will be brief moments where the information sent will, by necessity, differ from the last transmission of the associated tables. At the point where the information is changed there can be an interval (usually

much less than a second) where the data differs. However, once all of the updated tables are transmitted, the information is then in synch again.

5.2.1 Practical Considerations

Requirements on the PSIP generator and the roles of the human or the equipment that sends commands to that generator are important to keep separate. The PSIP standard only covers the data that must be able to be emitted, when it is emitted, and exactly how it is structured. There is no requirement for when a human must enter data, or for when commands are to be sent from any control system. Accordingly the time accuracy for changes is not normatively asserted in the PSIP standard. The standard just requires construction of accurate data structures from the input data. Not stated, but expected in practical implementations, that as soon as the PSIP generator can generate corrected data, it will be emitted at the next time slot for each impacted table section. The key point is that PSIP equipment that meets the current version of the PSIP standard enables sending updated event titles, start times and durations (along with other event related metadata). The practical issue is management and control of the data. When an event (program) runs over, there is a ripple impact to later programs. Should the next program be shortened or should it be shifted in time and some later program shortened (or the broadcast day extended)? This is usually considered a traffic system issue and usually requires human intervention. The standard is silent on this aspect of operation and only covers the construction of relevant parts of the data steam based on the information it is provided. Please refer to the discussion in ATSC A/78 [5] "Consistency Errors" for additional background on this topic.

Also please note the footnote 10 at the beginning of Section 6.5 of A/65 [1], which is important notwithstanding its placement as a note. It documents the intent of the change to require equipment to be more accurate. It says in relevant part "These EITs should be populated with the correct information, so that the user knows what programs are on for this [9 to] 12 hour period." The word "should" here applies to the entire set of information in the EIT.

5.2.2 Unanticipated and Emergency Situations

When a response to an unanticipated occurrence, such as an emergency situation, results in modification of program audio and/or video content, adjustment of PSIP metadata to reflect transient (short-duration) conditions need not be made. This may result, for example, in all virtual channels carrying the announcement in the same language and the language tags for some audio tracks being temporarily incorrect. Other examples of temporarily inconsistent data include program name and caption service descriptions.

5.3 Program Guide

Support for an Electronic Program Guide (EPG) or Interactive Program Guide (IPG) is another important function enabled by the PSIP Standard. The concept is to provide a way for viewers to find out "what's on" directly from their television sets, similar to the programming guides that are typically available for cable and satellite broadcast services. In a terrestrial broadcast environment, each broadcaster needs to include this type of information within the broadcast stream. Viewers' receivers that follow the CEA recommendations in CEA-CEB-12 [9] are able to scan all the available channels can create a program guide channel from the consolidated information[3]. Viewers will have the ability not only to choose what channel to watch but also be able to select from multiple options within a broadcast. Examples include selecting from a set of

alternative audio tracks in different languages, or choosing one of several SDTV programs shown at the same time on different virtual channels.

5.4 Most Common Mistakes

Experience in the U.S. has shown that certain errors in configuration of PSIP generation equipment can occur if proper care is not given to their setup or maintenance. These problems may include the following:

- Missing tables, particularly the STT and EIT.
- Major channel number set to the DTV RF channel number, rather than the associated (legacy) NTSC channel number.
- TSID set to 0 or 1, the NTSC TSID, or another station's TSID; or not correctly set in the three required places.
- System time inaccuracy.
- Not populating all required PSIP fields.
- Not providing accurate and up-to-date information in the fields, such as meaningful event titles, as contrasted with such titles as "TV Program," or "TBA".
- Inconsistent table data, either between PSIP tables or between PSIP and the PAT/PMT. See Section 7.6 for more details.

6. THE PSIP TABLES

The following sections describe the basic functions of the PSIP tables and indicate where the data in the tables originates, as well as generic information about the data itself. In general, the data comes from the following sources[4]:

- Provided by the broadcast station as input to the PSIP system user software; this is station-specific information (for example, the major and minor channel numbers).
- Set as default in PSIP software; this information is usually MPEG-2 data that is ATSC-specific (for example, all table IDs).
- Calculated by the PSIP generator (for example, the descriptor length).
- Provided from or to the audio or video encoder (for example the elementary PID for the video or audio).
- Provided from or to the Closed Captioning system (for example the language of the captions).

The user software supplied with the PSIP encoder system will typically guide the user in inputting the needed information, so it is not normally necessary for users to be concerned about the formal details of the PSIP table structure as presented in ATSC Standard A/65 [1] (see Annex B for specific examples). More importantly, users should first understand what data they are required to provide to the user software and second what the correct data is.

It should be noted that the PSIP tables are constructed using a form of "C Code" syntax and format. Annex D explains this construction scheme.

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3. Note: Receivers built prior to the publication of CEA-CEB12 [9] may not have implemented its recommendations.
4. See also Annex J.

6.1 General Considerations

Not all of the tables are required for all terrestrial and cable applications, as summarized in Table 6.1.

Table 6.1 PSIP Tables Required for Transmission in the Broadcast and Cable Modes

Table	Required for Broadcast?	Required for Cable?
STT	Yes	Yes
MGT	Yes	Yes
VCT	Yes (TVCT) (CVCT is optional)	Yes (CVCT)
RRT	Conditional [a]	Conditional [a]
EIT	Yes (EIT-0, -1, -2, -3); all others optional	Conditional [b]
ETT	Optional	Optional

[a] If a content advisory descriptor is transmitted, the associated RRT—except for RRT 01—is required to be transmitted.

[b] On 18 January 2001, the FCC issued its first Report and Order on Cable Carriage of DTV (Docket 98-120), which in paragraph #83, required carriage of PSIP data related to the primary video service when present, but does not require generation of such data for channels that do not have PSIP data.

The VCT comes in two flavors, one specifically for terrestrial broadcast—the Terrestrial Virtual Channel Table (TVCT)—and the other for cable—the Cable VCT (CVCT).

All PSIP tables are extensible via the *descriptor* method. In PSIP, some descriptors are mandatory, while others are optional. A receiver that does not recognize a descriptor of a certain type is required to simply ignore it, so addition of new features via new descriptor definitions is a powerful way to add new features to the protocol while maintaining backwards compatibility.

One hard-coded PID value has been chosen for the transport packets that carry all PSIP data except the program guide data and extended text. PID 0x1FFB was chosen so as not to collide with other known fixed-assigned PID values.

☑ As detailed in Section 5, all ATSC-compatible digital broadcast television multiplexes are required to carry at least the following PSIP tables:

- Master Guide Table, repeated at a required minimum rate of once every 150 msec.
- System Time Table, repeated at a required minimum rate of once per second.
- Rating Region Table, repeated at a required minimum rate of once per minute if present.
- Terrestrial Virtual Channel Table, repeated at a required minimum rate of once each 400 msec.
- The first four Event Information Tables, representing up to twelve hours of program schedules (see Tables 5.1 and 5.2 for recommended repetition rates).

☑ Further EITs may be transmitted if a broadcaster wishes to provide program schedules beyond half a day; it is recommended that at least 24 be sent. (See Section 6.4 for more information.)

A receiver is required to handle data rates of PSIP data in PID 0x1FFB (base_PID) of up to 250 kbps. Each EIT and event text PID can also be sent at a rate of up to 250 kbps.

The A/65 Standard [1] defers to SCTE for specification of data rates on cable systems in North America, but does state that the MGT, STT, and cable VCT are required, as detailed in Table 6.1. Cable systems may elect to supply program guide data in a format other than PSIP's

MGT			
table_type	**PID**	**version_num.**	**table size**
VCT	0x1FFB (base_PID)	4	391 bytes
RRT – USA	0x1FFB (base_PID)	1	959 bytes
EIT-0	0x1FD0	6	970 bytes
EIT-1	0x1FD1	4	970 bytes
EIT-2	0x1DD1	2	970 bytes
EIT-3	0x1DB3	7	970 bytes
ETT for VCT	0x1AA0	21	312 bytes
ETT-0	0x1BA0	10	2543 bytes
ETT-1	0x1BA1	2	2543 bytes

Figure 6.1 Example content of the Master Guide Table.

EIT/ETT (this is the typical case in the U.S. and Canada) and U.S. cable system operators are allowed to constrain the total data rate of the PSIP data by removing optional table instances (or contents therein) and adjusting the MGT to so reflect when large amounts of PSIP data are being sent by a broadcaster.

6.2   Master Guide Table

The purpose of the MGT is to describe everything about the other tables, listing features such as version numbers, table sizes, and packet identifiers (PIDs). Figure 6.1 shows a typical Master Guide Table indicating, in this case, the existence in the Transport Stream of a Virtual Channel Table, the Rating Region Table, four EITs, one Extended Text Table for channels, and two Extended Text Tables for events.

The first entry of the MGT describes the version number and size of the Virtual Channel Table. The second entry corresponds to an instance of the Rating Region Table. Notice that the base_PID (0x1FFB) are required to be used for the VCT and the RRT instances as specified in PSIP.

The next entries shown in the MGT example above (no ordering of elements is required) correspond to the first four EITs that are required to be supplied in the transport stream. The broadcaster is free to choose the PID values (subject to the constraints in A/53 Part 3, Section 6.9) as long as they are unique in the Transport Stream. After the EITs, the MGT example indicates the

existence of a channel Extended Text Table using PID 0x1AA0. Similarly, the last two entries in the MGT signal the existence of two Extended Text Tables, one for EIT-0 and the other for EIT-1.

Descriptors can be added for each entry as well as for the entire MGT. By using descriptors, future improvements can be incorporated without modifying the basic structure of the MGT. The MGT is like a flag table that continuously informs the decoder about the status of all the other tables (except the STT, which has an independent function). The MGT is continuously monitored at the receiver to prepare and anticipate changes in the channel/event structure. When tables are changed at the broadcast side, their version numbers are incremented and the new version numbers are listed in the MGT. Based on the version updates and on the memory requirements, the decoder can reload the newly defined tables for proper operation.

6.3 Virtual Channel Table

This table contains the set of data that enables a receiver to tune and locate the service being broadcast. The Virtual Channel Table is essentially a list containing information about each service that a broadcaster creates or has announced that it will create within the DTV transport stream, as well as information about the broadcaster's associated analog channel[5]. See Figure 6.2 for an example VCT. The VCT consists of one or more virtual channel definitions. The major elements of these definitions are:

- The two-part (major/minor) channel number the user will use to access the service.
- Its short name (up to seven characters).[6]
- How the service is physically delivered (carrier frequency[7] and modulation mode).
- The service channel_TSID[8].
- Its MPEG-2 program_number.
- The type of service (analog TV, digital TV, audio only, data).
- Its "source ID" [9].
- Descriptors indicating what PIDs are being used to identify packets transporting parts of the service and descriptors for extended channel name information.

Other data specific to each terrestrial virtual channel includes a flag that tells whether the service requires one of several special handling conditions, and an indication as to whether "extended text" is available to provide a textual description of the service.

6.3.1 VCT Structure

The field number_of_channels_in_section indicates the number of channels described in this section of the VCT. In normal applications, as in the example being considered here, all channel information will fit into one section.[10] In the example (Figure 6.2) the number_channels_insection is 5.

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5. The PSIP Standard also supports sending information about Virtual Channels that are transmitted in another broadcaster's transport streams, but this is not the typical case.

6. PSIP provides a descriptor mechanism to define longer channel names as needed.

7. Use of the carrier frequency field caused implementation issues in cases where the DTV signal was shifted in frequency. Its use was deprecated in an amendment to the original Standard to avoid the hardware complexity that otherwise would have been required when each such frequency shift was made.

8. This is required to be the same as the TSID of the stream where the DTV service is being transmitted.

9. This is the key link to the announcements in the EITs.

major num.	minor num.	short name	carrier freq. (MHz)	channel TSID	progr. num.	flags type	service id	source	descriptors
12	0	NBZ	0	0x0AA0	0xFFFF	--	analog	12	ch_name
12	1	NBZD	0	0x0AA1	0x0001	--	digital	1	ch_name serv_locat.
12	2	NBZ-S	0	0x0AA1	0x0002	--	digital	2	ch_name serv_locat.
12	3	NBZ-M	0	0x0AA1	0x0003	--	digital	3	ch_name serv_locat.
12	4	NBZ-H	0	0x0AA1	0x0004	--	digital	4	ch_name serv_locat.

VCT

current_next_indicator = 1
number_channels_in_section = 5

Figure 6.2 Selected typical content of a Virtual Channel Table.

The fields major_channel_number and minor_channel_number are used for identification of the service on a virtual channel. The major channel number is used to group all channels that are to be identified as belonging to a particular broadcaster (or particular identifying number such as 12 in this case). In the U.S., the original NTSC RF channel is required to be used as a major channel number. Refer to A/65 [1] Annex B for complete details on the channel number assignment rules for U.S. broadcasting. In the example, channel 12 was originally assigned as an NTSC channel and the associated digital channel assigned by the FCC also used the channel 12 "brand;" so that all the programming for broadcaster "NBZ" can be accessed together through surfing or in a paper or electronic program guide. Services that are unrelated to the NTSC brand may have another major channel number. The minor channel number specifies a particular channel within the group with each major number.

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10. However, there may be rare times when most of the physical channel is used to convey dozens of low-bandwidth services such as audio-only and data channels in addition to one video program. In those cases, the channel information may be larger than the VCT section limit of 1 kbyte and therefore VCT segmentation will be required. Information about a channel cannot be split across two sections. For example, assuming that a physical channel conveys 20 low-bandwidth services in addition to a TV program, and assuming that their VCT information exceeds 1 kbyte, then two or more sections may be defined. The first section may describe 12 virtual channels and the second 9 if such a partition leads to VCT sections with less than 1 kbyte.

Note: When the hidden flag is set to '1' and the hide_guide flag is set to '0' (inactive channel), the program number for the inactive channel is set to 0x00 and the SLD is not present in the VCT, per A/65. This enables a receiving device to determine that the channel status is inactive.

The field short_name is a seven-character name for the channel that allows receivers to use text-assisted access and navigation.

The field modulation_mode gives information to the receiver that may help it configure to demodulate a service.

In the U.S. the FCC assigns a TSID for each digital station upon authorization of digital transmission. The TSID for the digital station is an odd hex number in the range of 0x0001 to 0xFFFE. The FCC has assigned the next lowest even hex number to the paired analog station. In the example (Figure 6.2), channel 12 digital is assigned 0x0AA1. The range for TSID values for Canada and Mexico have been allocated. The range for Canada is in two parts: 0x4000 to 0x5FFF will be made available for immediate use and 0x6000 to 0x7FFF is assigned for future use. The range for Mexico is 0x8000 to 0xBFFF.

The channel_TSIDs listed in the VCT are required to match the TSID listed in the MPEG Program Association Table (PAT) where the digital service is transmitted. This may be done automatically by the PSIP encoder, but should be verified by the broadcaster or changed in the special cases of cross announcement agreements or other special circumstances.

☑ The program_number is included to associate the VCT with the MPEG PAT and Program Map Table. This is an arbitrary number between 1 and 65,534. When an analog channel is referenced, the number is required to be 65,535. The communication path between encoder/multiplexer equipment and PSIP encoder is outside the scope of this recommendation. Private and PMCP [10] implementations exist which facilitate consistency in the program_number values used. If there is no electronic communication, the broadcaster is required to insure that the corresponding values match.

☑ The link between the VCT and the SLD is via the program_number. If values for the transport stream_id, program_number, and SLD information are specified by the broadcaster in setting up the VCT, the PAT/PMT combination can be automatically generated by some PSIP encoders. Other equipment configurations require direct settings of the video encoder and/or the emission multiplexer. It is recommended that all PSIP encoders automatically control these relationships.

The hidden and hide_guide fields provide information to the receiver on how to offer access to virtual channels to the receiver user. Table 6.2 shows expected DTV receiver behavior for the various combinations of the hidden and hide_guide attributes.

Table 6.2 Receiver Behavior with hidden and hide_guide Attributes

hidden	hide_guide	Receiver Behavior		Description
		Surf	Guide	
0	X	ü	ü	Normal channel
1	1			Special access only
1	0		ü	Inactive channel

A channel that is currently active should be available by surfing (sequential channel display via repeated activation of a single control by the receiver user) as well as through the receiver's

program guide user interface or by direct entry of the two part channel number in a remote control. The broadcaster indicates this by setting hidden to '0'. When hidden is '0' the value of hide_guide is meaningless and should be ignored. When a channel is currently inactive, the receiver should skip over that channel while the user is surfing, but future program listings should be viewable in the program guide. The broadcaster should assign '1' to hidden and '0' to hide_guide to these channels in the current VCT. This combination may be used by broadcasters that change the number of services during each day. Both hidden and hide_guide may be set to '1' when transmitting test signals, for example.

The field service_type is a description of the type of service offered, and is included to help the receiving device configure properly where:

- 1 denotes an NTSC analog service
- 2 denotes an ATSC full digital TV service including video, audio (if present) and data (if present)
- 3 denotes an ATSC audio and data (if present) service
- 4 denotes a ATSC data service

The source_id is a critical internal index for representing the particular logical channel. Broadcasters can assign arbitrary source_id numbers from 1 to 4095.

The source IDs are used in each Event Information Table to identify which minor channel will carry its programming for each 3 hour period. In the example, if channel 12.1 is or will be active during any part of a specific EITs time slot, that EIT will reference source_id 1 when listing that channel's programs. The PSIP encoder interface software will provide the source_id cross reference for each EIT once the decision about which virtual channel should carry the program is made by the broadcaster.

The Extended Text Tables also use the source_id for each minor channel (along with an event_id from the Event Information Table) to associate the extended text messages with the appropriate minor channel and event. (See Sections 6.4 and 6.5 for details.)

Two descriptors are associated with the logical channels in the example. The first one is extended_channel_name and—as its name indicates—it gives the full name of the channel. An example for channel NBZ-S could be: "NBZ Sports and Fitness." The broadcaster simply enters this information for each minor channel.

The other one, the service_location descriptor, is used to list the available bit streams and their PIDs necessary to locate their packets at the receiver. Assuming that NBZ-M offers bilingual transmission, then the following attributes are tabulated within its service_location descriptor:

PID_audio_1	AC-3 audio	English
PID_audio_2	AC-3 audio	Spanish
PID_video	MPEG-2 video	No language

When the VCT refers[11] to an analog service type, the channel_TSID does not refer to the identifier of a "Transport Stream" in the MPEG-2 sense. Analog NTSC broadcast signals can, however, carry a 16-bit unique identifier called a "Transmission Signal Identifier." For the example VCT in Figure 6.2, the Transmission Signal Identifier for channel 12.0 was 0x0AA0. A

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11. In the U.S., use of this referencing capability will decline to zero over time, as NTSC services are being shut down.

receiver can use the Transmission Signal ID given in the analog channel's channel_TSID field to verify that the received NTSC signal is actually the desired signal.

When a broadcaster adds EIT data for a virtual channel, that channel is required to be included in the VCT, even if it is currently off-air. This means if no current program was using 7.7, and if a program 16 days from now was being announced for 7.7, that 7.7 would be in the VCT. This would enable receivers to include the channel number in a program guide presented to the consumer. Any channels in the VCT that are not currently active are required to have the hidden attribute set to '1' and the hide_guide attribute set to '0'. So, if a program is announced in the EIT, the receiver can determine from the values of the hidden and hide_guide bits that the channel is currently inactive. Receiver behavior is undefined, with the presumption that if a consumer directly enters a major-minor combination that is inactive, the receiver will gracefully handle the situation.

6.3.2   Station-Specific Data

There is *essential* station-specific VCT information that the broadcaster is required to input for viewers to be able to properly tune programs. This information is given in Table 6.3.

☑   **Table 6.3** Station-Specific PSIP Data

Data	Action by Broadcaster	Example
major channel number	Entered once. (Use the same channel number as the NTSC channel number assignment. If no paired NTSC channel, use the assigned DTV channel number. For special cases, see text.)	2
minor channel numbers	Entered once per virtual channel. (See text.)	1
TSID	Entered once. (See text.)	0x0D4B
service location descriptor	Pointers to each video, audio, and data stream.	
source id	Entered once for each virtual channel or automatically generated. (See text.)	0x17E9
service type	Entered once. (Tells the receiver whether the associated minor channel is providing digital or analog service.)	2
short name	Input once.	"NAB-DT"
modulation mode	Entered once for each virtual-minor number	0x04
carrier frequency	Recommend zero.	0
MPEG program number	Entered once for each virtual channel. (See text.) The MPEG program number is required to be unique within the transport stream and not be zero.	1
ETM location	None	N/A
access controlled	yes/no	0
Hidden	yes/no	0
hide guide	yes/no	1

☑   The PIDs for each component in a minor channel should not be changed without cause as any changes are expected to increase the time it takes for the receiver to tune the station.

It is recognized that PID changes might be required if, for example, consecutive programs on a minor channel have differing numbers of audio tracks or the source of pre-compressed content for a virtual channel changes unexpectedly.

6.3.2.1   VCT Standard and Calculated Data

A station is required to provide the data described previously in this section to allow station- and program-specific VCTs to be constructed by the PSIP encoder system; however, much of the VCT data is *standard* to the ATSC system in general so it need only be supplied once to the PSIP encoder. This data may come preloaded in the PSIP software. Also, some of the VCT entries are *calculated* by the PSIP encoder. Examples are given in Table 6.4. (Also see Annex B.)

Table 6.4 VCT Example Entries

Examples of Default or Fixed VCT Entries	
table_id	0xC8
section_syntax_indicator	one bit set to '1'
private_indicator	one bit set to '1'
protocol_version	0x00
last_section_number	Default to 0x00 as seldom need more than one section
Examples of Automatically Calculated VCT Entries	
section_length	Number of bytes of this section of the VCT starting immediately after this field
section_number	If more than one section is used, which section is currently being filled is determined
version_number	Incremented when contents of table section changed
CRC_32	Based on the contents of the table section

6.3.3   Descriptors

☑ Any VCT definition can include descriptors to further describe a service. The Service Location Descriptor was designed to reduce the time it takes to change virtual channels when tuning via PSIP tables. This descriptor contains the video PID that is currently used (and should always be used) for that VC.

Use of the stored PID values also avoids the sequential decoding of the PAT and PMT to locate the PID values. The PID values in the VCT are required to be the same as the corresponding ones in the PMT.

PSIP also defines an Extended Channel Name descriptor that allows a broadcaster or cable system operator to give any channel a name exceeding the seven characters offered by the basic VCT record. The seven-character limit for the basic name label was chosen to support on-screen program guides in which a limited amount of screen real estate is available for the name text.

A third type of descriptor can be used to indicate that the channel carries programming identical to another channel, except time-shifted by a given amount.

6.3.4   Source ID

A source ID is defined as a number that uniquely identifies a source of scheduled programming. PSIP introduced a new level of flexibility into the definition of source ID by stating that the scope of uniqueness is local to the transport stream for values in the range zero to 0x0FFF, and the scope is network-wide for values 0x1000 or above. This means each station can freely assign unique

numbers below 0x1000. A system to enable use of higher numbers by terrestrial broadcasters has not been defined, but numbers above 0x1000 are not prohibited and may occur in some cable systems associated with non-broadcast sources.

6.3.4.1   NTSC TSID

For analog broadcasting, it is necessary that the NTSC TSID be added to line 21, field 2 in order for the receiver to locate any programs referenced in PSIP. Some receivers may not be able to associate the NTSC channel with the major channel number when it is received if this TSID is not present.

To permit the digital receiver to correctly associate the analog signal, the XDS capability of the closed captioning system, which is documented in CEA-608 [11] is used. To announce NTSC programming in the DTV signal, the NTSC TSID is required to be present in the NTSC signal to be in compliance with the PSIP standard.

6.3.4.2   Tuning Functions

The DTV receiver is expected to use the information in the channel's VCT together with the information contained in other channels' VCTs to build a navigation aid for the viewer so that both analog and DTV programs can be selected.

☑ During set-up, the DTV receiver is expected to scan the broadcast band and store the location of each active major channel per its physical channel number (i.e., the RF channel number assigned for that specific 6 MHz channel, or some internal key representing that frequency band). Unlike analog television, the DTV receiver does not use the physical channel number to identify the source of digital programming. Instead, the receiver looks at the major channel assignment in the channel's VCT and utilizes that number as the major channel number for navigation via the virtual channel number. This way, the viewer uses a channel number, labeled by the station itself and stored in the receiver's memory along with the station frequency information, to identify and tune the RF emission from the station. The receiver also looks at and stores the minor channel information carried in the VCT and uses it in conjunction with major channel number for navigation. The stored information for each virtual channel allows the receiver to select the desired video and audio information from among all the other video and audio streams that may be in the DTV station's emission stream. Because some of the VCT information may change over time, the Consumer Electronics Association has recommended in CEA-CEB12 [9] that receivers rescan the broadcast band when convenient (typically when "off") to get updates on VCT and future program information from all the stations. Maintaining these relationships is key to enabling the shortest possible channel change time by the receiver. To improve receiver performance when acquiring digital channels, once assigned, the same PID should be used for video or audio packets for a given virtual channel.

Note that selecting a DTV program by attempting to input the physical channel number to the receiver may result in acquisition of an undesired channel or other unexpected behavior. The virtual channel number is the number the receiver looks for, and the DTV channel seldom will coincide with the number of the physical channel that the station occupies. Newspaper and magazine program guides are expected to list programs by their virtual major and minor channel numbers.

6.3.4.3   Updating the VCT

☑ Even though the TSID and other parameters for each virtual channel can be a permanent assignment, the minor channels that the station is using may change over time. When a new virtual channel is created, it is recommended that the VCT be updated first to reflect a change in the channel lineup and then to use the appropriate source_id in constructing the EITs.

☑   A new VCT containing updated information can be transmitted at any time with the version_number increased by one. It is required that the virtual channel be in the VCT as soon as an EIT that will use that virtual channel is sent. This gives receivers the opportunity to scan the frequencies and detect the channel presence. This is an additional benefit from recommending three days of EITs be programmed for transmission. It is recommended to send three days worth of EITs to reduce the risk of the receiver not having information at the time of tuning.

☑   Delivery of the "next" VCT (value 0 in the field current_next_indicator) should be avoided.

6.4 Event Information Table

The Event Information Table (EIT) is the PSIP table that carries program schedule information for each virtual channel. In ATSC standards, TV programs are called *events*. Each instance of an EIT covers a three-hour time span, and provides the following information for each programming source:

- Event start time
- Event duration
- Event title
- A pointer to optional descriptive text for the event
- Program content advisory data (optional, but if present it is required to be placed here)
- Caption service data service signaling (sometimes optional, but when present is required to be placed here)
- AC-3 Audio Stream Descriptor (required if audio is present)

Most of this data may be provided from other systems[12] to the PSIP generator. Regardless of the source, the broadcaster needs to ensure the information is provided to describe what programs are on and when.

Each EIT covers a period of three hours. The PSIP generator should automatically convert from local time to the universal time used inside the system. (The receiver converts back to that receiver's local time.) EIT-0 represents the "current" three hours of programming. For terrestrial PSIP, the first four EITs (EIT-0, EIT-1, EIT-2, and EIT-3) are required by A/65 [1]. The maximum number of EITs is 128, permitting up to 16 days of program information to be delivered to receivers.

☑   It is strongly recommended that at least 24 EITs be sent at all times (three days).

Daily updates of the EITs can be done for all programming, but the current EIT has some additional needs (see below). The EITs should be updated as often as it is practical to do so. It is strongly recommended that at the minimum, a daily update be done and that this update contain at least three days worth of station-correct programming announcements (24 EITs). As receivers are expected to acquire future EITs while "off," a broadcaster following this recommendation will enable their virtual channels to be offered among the choices available in the program guide. It is

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12. Other standards, for example ATSC A/76 (PMCP) [10] and SMPTE 2021M (BXF) [12], have been developed for metadata communication within a broadcast facility.

desirable to send all 16 days worth of EITs to enable consumers' pre-setting of recorders further in advance.

EIT-0 plays an additional role, as it provides signaling information pertaining to the current program and therefore is particularly important with respect to the carriage of closed caption information, ratings information, language information and other essential data. The connection from broadcast station equipment to the PSIP generator should enable direct updates of current program parameters in EIT-0. By contrast, the EITs for the future are primarily informational and less critical to system performance as long as the station virtual channel line-up is not changed.

EITs should not be sent describing test signal occurrences in a virtual channel.

Each EIT has space for event titles. The receiver recommendation is to display the first 30 characters of the title, and it is recommended that the first 30 characters be chosen carefully to maximize the chance of meaningful display by receivers. If it is desired to send additional information about the entire event, this is sent in another structure—the Extended Text Table (ETT). Such information would optionally be presented to consumers, usually after an action. Receivers may have limited support for descriptive text so there may be a trade-off between covering more events and more data about each event. Also, the rate this information is sent can be adjusted by setting the time interval between ETTs to make more efficient use of bandwidth. If however, these were set longer than one minute apart, receiver "off" search time would be increased.

6.4.1   EIT Structure

PSIP tables can have a multitude of *instances*. The different instances of a table share the same table_id value and PID but use different table_id_extension values. An instance of EIT-*k* contains the list of events for a single virtual channel with a unique source_id. For this reason, the table_id_extension has been renamed as source_id in the EIT syntax. Figure 6.3 shows, for example, the NBZ-S instance for EIT-0. Following similar procedures, the NBZ-D, NBZ-M, and NBZ-H instances of EIT-0 can be constructed. The process can be extended and repeated to obtain all of the instances for the other tables in the time sequence: EIT-1, EIT-2, and so on.

The three events programmed for the 3-hour period for NBZ-S are listed in the Figure. The field event_id is a number used to identify each event. If an event time period extends over more than one EIT, the same event_id has to be used. The event_id is used to link events with their messages defined in the ETT, and therefore it has to be unique only within a virtual channel and a 3-hour interval defined by EITs. The event_id is followed by the start_time and then the length_in_seconds. Notice that events can have start times before the activation time (14:00 EDT in this example) of the table. The ETM_location specifies the existence and the location of an Extended Text Message (ETM) for this event. ETMs are simply long textual descriptions. The collection of ETMs constitutes an Extended Text Table (ETT).

An example of an ETM for the car racing event might be:

> "Live coverage from Indianapolis. This car race has become the largest single-day sporting event in the world. Two hundred laps of full action and speed."

Several descriptors can be associated with each event. One is the Content Advisory Descriptor, which assigns a rating value according to one or more systems. Recall that the actual rating system definitions are tabulated within the RRT. Another is a Closed Caption Descriptor, which signals the existence of closed captioning and lists the necessary parameters for decoding.

event ID	local start time	Length (sec)	ETM location	title	descriptors
51	12:30	7200	01	Soccer Live	content_advisory
52	14:30	3600	00	Golf Report	closed_caption
53	15:30	9000	01	Car Racing	content_advisory

EIT-0
source_id = 22 (NBZ-S instance)

num_events_in_section = 3
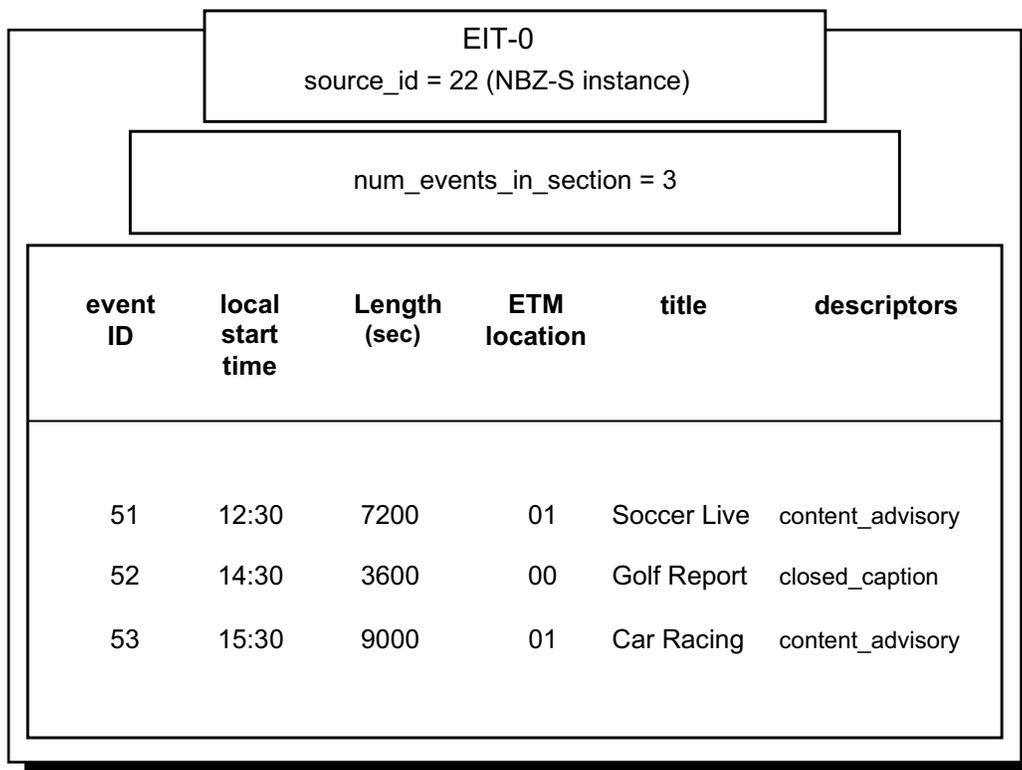
Figure 6.3 Content of EIT-0 for NBZ-S.

6.5 Extended Text Table

☑ The ETT is an optional component used to provide detailed descriptions of virtual channels or events. While optional, ETTs should be sent as they are a powerful promotional tool and many consumer receivers display ETT data when it is available.

These descriptions are called Extended Text Messages (ETMs). The format of the 32-bit ETM identification element tells the receiver whether the ETM describes a channel or an event within the EIT. This format allows the receiver to search for a single description quickly without having to parse the payload of a large table.

Each instance of an Extended Text Table carries one text block enabling the receiver to uniquely identify each instance in a time slot by using the ETT_id_extention value. Fields in the EIT and VCT link a program event or virtual channel to an ETT instance. As with all text delivered with PSIP, multiple languages are supported.

6.6 System Time Table

The System Time Table is the simplest and smallest of the PSIP tables. Its function is to provide a reference for time of day to receivers. In addition, the STT provides daylight saving time information.

The STT bases its reference for time of day on Global Positioning Satellite (GPS) time, which is measured in terms of seconds since 12:00 a.m. January 6, 1980. This count increments monotonically and hence can be used as a reliable and predictable time base for specification of future times of action.

A receiver needs one other piece of information to derive Coordinated Universal Time (UTC): the current count of the number of leap seconds that have occurred since the beginning of GPS time. The STT delivers this data as well. Leap seconds account for the difference between time based on atomic clocks (as is GPS time) and time based on astronomical events such as the earth's rotation.

The STT also provides daylight saving time status (whether or not daylight saving time is in effect), and indicates the day of the month and the hour that the next transition will occur.

A receiver needs two pieces of additional information before it can use the STT data to track local time of day: 1) the offset in hours from UTC (the time zone), and 2) whether or not daylight saving time is observed locally. For a digital television, this information may be entered directly by the consumer via a unit setup function. For a cable set-top box, this information may be delivered by the system operator.

The System Time data is required to be no less accurate than plus or minus one second with reference to GPS time; by locking it to the station master clock, the DTV receiver could be one of the most accurate timepieces in the household. The STT seconds count should be set to the next second and sent approximately 2T milliseconds before the seconds count is due to increment, where T represents the average number of milliseconds between TS packets identified with the SI base_PID (0x1FFB). Note that use of an adjusted insertion point typically can mitigate the effects of small contributors to timing errors due to factors such as propagation delay from station to station and normal passage through the processing of a translator may result in small excursions beyond the plus or minus one second tolerance. The exact interval before the seconds transition is station configuration dependent.

Where a translator station demodulates the relayed signal to baseband and reconstructs the TS for transmission, the STT should be re-established within plus or minus one second accuracy.

Most PSIP generators convert local time to GPS time internally (for the STT and all other tables with time).

6.7 The Rating Region Table

The function of the RRT is to define a rating system for a given region, where the rating system is characterized by a number of *rating dimensions*, each of which is composed of two or more *rating levels*. An example of a typical rating dimension used on cable is the Motion Picture Association of America (MPAA) system. The levels within the MPAA dimension include "G," "PG," "PG-13," and so on.

Once a receiver learns the dimensions and levels of a rating system it can do two things:
- Provide a user interface to allow the user to set limits on program content
- Interpret content advisory data on individual program events

Based on a user's preference for certain program content, the receiver can block programming that exceeds a desired threshold.

PSIP does not define the actual dimensions and levels of any rating region; rather, it provides the transport mechanism to deliver the table. The table structure in PSIP allows one or more instances of the RRT to be sent, as needed, where each instance defines one region. For terrestrial broadcast, for many parts of the U.S., only the U.S. Rating Region will be applicable. For areas close to national borders, however, a Canadian[13] or Mexican rating table may be sent in addition.

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13. See ANSI/CEA-766 [13]
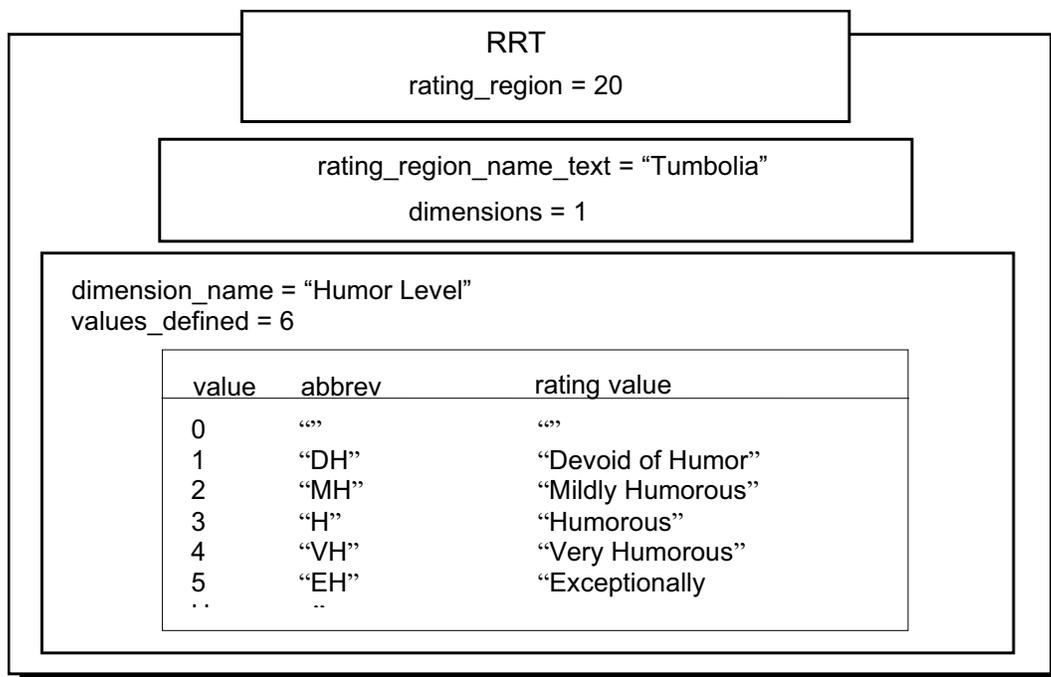
Figure 6.4 An Instance of a Rating Region Table (RRT).

Note: Inclusion of the RRT corresponding to rating_region value 0x01 (U.S. plus possessions) is not required in transmissions in the U.S.

6.7.1 RRT Structure

The Rating Region Table is a fixed data structure in the sense that its content remains mostly unchanged. It defines the rating standard that is applicable for each region and/or country. Several instances of the RRT can be constructed and carried in the transport stream simultaneously. Each instance is identified by a different table_id_extension value (which becomes the rating_region in the RRT syntax) and corresponds to one and only one particular region. Each instance has a different version number that is also carried in the MGT. This feature allows updating each instance separately.

Figure 6.4 shows an example of one instance of an RRT for a region called "Tumbolia," assigned by the ATSC as rating_region 20. Each event listed in any of the EITs may carry a content advisory descriptor. This descriptor is an index or pointer to one or more instances of the RRT.

6.8 Directed Channel Change

Directed Channel Change is a technology intended to allow broadcasters to tailor programming or advertising based upon viewer demographics. For example, viewers who enter location information such as their zip code into a DCC-equipped receiver could receive commercials that provide specific information about retail stores in their neighborhood. Segments of newscasts, such as weather alerts that are relevant to certain areas could also be targeted based upon this location information.

A channel change may also be based upon the subject matter of the content of the program. Nearly 140 categories of subject matter have been tabulated that can be assigned to select the program content. A broadcaster can use this category of DCC request switching to direct a viewer to a program based upon the viewer's desire to receive that subject matter. For additional information on Directed Channel Change, see Annex L.

Note that all information in the Directed Channel Change Selection Code Table (DCCSCT) is for comparison and redirection decision purposes only, and is not an alternative method to communicate information about the programs.

6.9 Service Descriptors

Digital television receivers are required to decode closed captioning and to support blocking of programming based on content advisory information. They may also offer the option to decode alternate audio services (similar to NTSC SAP). In order to inform the viewer that closed captioning and alternate audio are available from the broadcast station and to provide easy access to these services, receivers depend on data that can be sent by the broadcaster via PSIP. Content advisory information, also sent in PSIP, is directly acted on by the receiver to block programs.

☑   This information is carried in PSIP data structures called *descriptors*. Descriptors are a general purpose, extensible tool provided by the MPEG-2 Systems standard (ISO/IEC 13818-1). All descriptors have a format that begins with an 8-bit tag value followed by an 8-bit descriptor length and data fields. The tag value tells the receiver what type of descriptor it is. The length field permits devices which do not understand the descriptor to easily bypass it. Delivery of the following three descriptors is mandatory when the element described is part of a program:

- The Content Advisory Descriptor (EIT)
- AC-3 Audio Descriptor (EIT and PMT)
- Caption Service Descriptor (EIT)

Table 6.4 lists most of the core descriptors and their descriptor tags for terrestrial broadcast applications. (See Standard A/65 [1] for a complete list.) The Service Location Descriptor is required to always be present in the Terrestrial VCT (shown with an "S"). When present, some descriptors are required to be (and only are allowed to be) in certain locations (shown with an "M"). Some descriptors also may be present in a second location within either the terrestrial or the cable case (shown with an "O"). Asterisks mark the tables where the descriptors may appear without restrictions.

Table 6.5a List and Location of PSIP Descriptors – Terrestrial Broadcast

Descriptor Name	Descriptor Tag	Terrestrial Broadcast					
		PMT	MGT	VCT	EIT	DCCT	DCC SCT
stuffing descriptor	0x80	*	*	*	*	*	*
AC-3 audio descriptor	0x81	M			M		
caption service descriptor	0x86	O			M		
content advisory descriptor	0x87	O			M		
extended channel name descriptor	0xA0			M			
service location descriptor	0xA1			S			
time-shifted service descriptor	0xA2			M			
component name descriptor	0xA3	M					
DCC departing request descriptor	0xA8					M	
DCC arriving request descriptor	0xA9					M	
redistribution control descriptor	0xAA	M			M		
ATSC private information descriptor	0xAD	*	*	*	*	*	*
ISO 639 descriptor	0x0A	O*					
genre descriptor	0xAB				M		

Table 6.5b List and Location of PSIP Descriptors – Cable

Descriptor Name	Descriptor Tag	Cable					
		PMT	MGT	VCT	EIT	DCCT	DCCS CT
stuffing descriptor	0x80	*	*	*	*	*	*
AC-3 audio descriptor	0x81	M			M		
caption service descriptor	0x86	M			M		
content advisory descriptor	0x87	M			M		
extended channel name descriptor	0xA0			M			
service location descriptor	0xA1			M			
time-shifted service descriptor	0xA2			M			
component name descriptor	0xA3	M					
DCC departing request descriptor	0xA8					M	
DCC arriving request descriptor	0xA9					M	
redistribution control descriptor	0xAA	M			M[a]		
ATSC private information descriptor	0xAD	*	*	*	*	*	*
ISO 639 descriptor	0x0A	M*					
genre descriptor	0xAB				M		
Notes: [a] When the EIT is present.							

☑   SCTE 54 requires this descriptor when there is more than one audio track. It is strongly recommended that it be provided in such cases where the content is expected to be distributed in a SCTE 54 compliant system.

6.9.1   Content Advisory Descriptor

Parental advisory (so-called "V-chip" information) is carried in the Content Advisory Descriptor. The receiver uses this information directly to block programs that exceed the ratings selected in a user set up procedure, and may be used by the receiver to provide on screen information about a programs rating for objectionable material.

6.9.2   AC-3 Audio Descriptor

The receiver looks for and uses the AC-3 Audio Descriptor to create viewer information about the audio services that are available. In addition to describing possible alternate audio services that a broadcaster might send, this descriptor provides the receiver with audio set up information such as whether the program is in stereo or surround sound.

☑   Digital television can carry audio streams in different languages. Analog television allowed a clear distinction between primary and secondary audio. A flag has been introduced into the AC-3 Audio Descriptor structure to replicate this function, allowing a broadcaster to indicate which audio stream is to be considered primary. Additionally, as of 1 March 2008, inclusion of ISO-639 language code bytes in the AC-3 descriptor provides signaling and announcement of the language used for the audio service. While the previous mechanism (the ISO-639 Language Descriptor) is now deprecated, it is strongly recommended to include this descriptor in the emission to support older receivers that may not understand the newer method.

6.9.3   Caption Service Descriptor

Captioning text itself, which is carried in an area of the video data set aside for captioning, does not carry a description of the type of captioning that it is (such as English or Spanish), so receivers are expected to rely on the Captioning Service Descriptor to provide the data needed to create on-screen captioning information.

The intention of the caption service announcement in PSIP data is to indicate to the viewers whether the main programming (described by the program name and description in EIT/ETT) is scheduled to be captioned, and if so, in what language(s). During an advertising insert within the program, caption data is not required [1] to match the description in the Caption Service Descriptor.

More importantly, the receiver is expected to rely on the Caption Service Descriptor to tell it that the program is captioned in the first place; the presence of captioning text is not used by most receivers to indicate to the viewer that the program is captioned. In addition to viewer information, the Caption Service Descriptor contains important control information needed by the receiver for proper display of captioning.

7.   CONSTRUCTION OF THE PSIP TABLES

The tables described in Section 6 are interrelated to form a seamless structure for conveying program and system information. The PSIP generator should manage these internal relationships, which generally should not be exposed to the operations personnel. For clarification, however,

Base PID = 0x1FFB

Master Guide Table (MGT)

List of tables:

type = EIT-0
PID = 0x3E00 version = 1

type = EIT-1
PID = 0x3E01 version = 1

type = RRT
PID = 0x1FFB version = 0

type = TVCT or CVCT
PID = 0x1FFB version = 0

Rating Region Table (RRT)

Virtual Channel Table (VCT)

List of channels:
name = KVGN-S
channel no. = 10.1
MPEG p.n. = 0x746E
source_ID = 5000
...
name = KVGN-M
channel no. = 10.2
MPEG p.n. = 0xE9A7
source_ID = 5010

System Time Table (STT)

PID = 0x3E00

Event Information Table (EIT) 0
00:00 - 03:00 UTC
(7-10pm local)

source_ID = 5000
List of events (local time):
7-8 pm: Tennis news
8-9 pm: Basketball today
9-10 pm: Hockey report

source_ID = 5010
List of events (local time):
7-7:30 pm: "Happy Days"
7:30-8pm: "Cosby"
8-11 pm: Movie: "Popeye"

PID = 0x3E01

Event Information Table (EIT) 1
03:00 - 06:00 UTC
(10pm-1am local)

source_ID = 5000
List of events (local time):
10-12 pm: Hockey game

source_ID = 5010
List of events (local time):
8-11 pm: Movie: "Popeye"
11pm-1am: Movie: "Hi-5"

Figure 7.1 Example of the relationship among PSIP tables.

Figure 7.1 provides a simplified view of the relationship among the PSIP tables (the ETT is not shown).

As indicated in the figure, the MGT, Terrestrial or Cable VCT, RRT, and STT are transported in the "base PID," 0x1FFB. The MGT provides location (PID), version, and length (not shown) of all tables except STT. In the example, the two EITs are transported in PIDs 0x3E00 and 0x3E01.

The Virtual Channel Table defines a set of services available, including (at minimum) those on the Transport Stream carrying the VCT itself. In this case, two channels named KVGN-S and KVGN-M are shown. The VCT gives the channel numbers associated with the channels (10.1 and 10.2), the MPEG-2 program numbers the receiver would use to extract the elementary streams from the multiplex, and the source ID values for each.

As indicated in the figure, source ID is used to link the VCT with the EPG data delivered in the EITs. Each PSIP EIT describes program events for a three-hour time slot, and lists, for each

Base PID = 0x1FFB

Master Guide Table (MGT)

List of tables:
type = RRT
PID = 0x1FFB
version = 0

type = CVCT
PID = 0x1FFB
version = 0

Rating Region Table (RRT)

System Time Table (STT)

Cable Virtual Channel Table (CVCT)

List of channels:
 name = KVGN-S
 channel no. = 10.1
 MPEG p.n. = 0x746E
 source_ID = 5000
 ...
 name = KVGN-M
 channel no. = 10.2
 MPEG p.n. = 0xE9A7
 source_ID = 5010
 ...

PID = X

EPG Database (any vendor)

source_ID = 5000
List of events:
 7-8 pm: Tennis news
 8-9 pm: Basketball today
 9-10 pm: Hockey report

source_ID = 5010
List of events:
 7-7:30 pm: "Happy Days"
 7:30-8pm: "Cosby"
 8-11 pm: Movie: "Popeye"

Figure 7.2 Relationship among PSIP tables for a cable application.

source ID, start times, durations, and program titles. Pointers are provided to Extended Text Tables which can provide further descriptive text.

Figure 7.2 shows PSIP used on cable in a case in which the VCT links to a proprietary EPG database. A cable operator may want to offer users a program guide function that provides extended features not available with PSIP.

7.1 Text Representation

PSIP uses Unicode character coding and offers a method of Unicode character code page selection, and includes methods for text compression. Two Huffman encode/decode tables for English text are included in the A/65 Standard [1]. One is optimized for title text, where the first characters of words are often capitalized, and the other is optimized for the event description text. A compression efficiency approaching 2:1 is typical.

7.2   Transport Stream and Transmission Signal IDs

PSIP, like all current System/Service Information standards for digital television, is based on the MPEG-2 Systems Standard, ISO/IEC 13818-1. Most digital television delivered over cable or terrestrial broadcast today uses a transport protocol defined by the MPEG-2 standard. Digital data is divided into a sequence of 188-byte transport packets. Each packet is associated with a data stream such as an audio or video service by means of a tag called the Packet Identifier (PID). Special PIDs identify packets carrying the SI and program guide data in the multiplex. The combination of service streams comprising the services and control data (SI and PSI) is called the MPEG-2 Transport Stream.

The MPEG-2 Standard defines a way to identify the multiplex itself so that it can be referenced within a larger network of digital multiplexes: each transport stream is identified by a 16-bit number called the Transport Stream ID (TSID). In the U.S., the FCC assigned values of TSID to the broadcasters to ensure uniqueness. Canada, Mexico and U.S. have formally agreed to allocate ranges of TSID values distinct from one another. North America can be considered a "network" in the sense that TSID values are required to be unique within a network.

Either analog or digital TSID values can appear in Virtual Channel Tables. In the normal case for terrestrial broadcast, the VCT will contain channel definitions for digital channels carried on the same multiplex that carries the VCT. The analog TSID is important for PSIP and digital receivers because it allows the receiver to verify that a received analog signal is actually the one referenced by the PSIP data.

In most cases, a receiver will not be able to receive more than one broadcaster's signal on any physical channel. Receivers on the fringe areas or those with directional or movable antennas, however, may be able to pick up more than one signal on a given frequency. A check of TSID data will allow the receiver to correctly identify and display channel name and/or program guide data.

Use of TSID data in the receiver actually makes it possible for the receiver to correctly display channel data and perform navigation without the frequency data being signaled. PSIP data does not include frequency information because a broadcast translator may shift the frequency of a transmitted signal without modifying the PSIP data. A receiver will find the signal when it "learns" the channel lineup, however, and it can take note of the frequency at which this particular TSID was found.

7.3   Event Information Functions

The Event Information Tables contain information or announcements of events on defined channels. Each EIT covers a time interval of three hours. The maximum time span covered by the EITs is 16 days (128 three-hour EITs). The rate of transmission is not defined, and some experts have suggested that EITs further in the future be transmitted with longer intervals. EITs are typically a few tens of bytes per event therein.

Start times for EITs are constrained to be one of the following UTC times: 0:00 (midnight), 3:00, 6:00, 9:00, 12:00 (noon), 15:00, 18:00, and 21:00. Imposing constraints on the start times as well as the interval duration is necessary for the purpose of re-multiplexing. During re-multiplexing, EIT tables coming from several distinct transport streams may end up grouped together or *vice versa*. If no constraints were imposed, re-multiplexing equipment would have to parse EITs by content in real time, which is a difficult task.

For example, consider a broadcast corporation operating in the Eastern time zone of the U.S. This corporation decides to carry 6 EITs (18 hours of TV program information). If at present, the

Eastern Time is 15:30 EDT (19:30 UTC), then the coverage times for the EIT tables are as shown in Table 7.1.

Table 7.1 An Example of EIT Coverage Times

EIT Number	Version Number	Assigned PID	Coverage (UTC)	Coverage (EDT)
0	6	123	18:00 - 21:00	14:00 - 17:00
1	4	190	21:00 - 24:00	17:00 - 20:00
2	2	237	0:00 - 3:00 (nd)	20:00 - 23:00
3	7	177	3:00 - 6:00 (nd)	23:00 - 2:00 (nd)
4	8	295	6:00 - 9:00 (nd)	2:00 (nd) - 5:00 (nd)
5	15	221	9:00 - 12:00 (nd)	5:00 (nd) - 8:00 (nd)

The abbreviation "nd" denotes *next day* (from EIT-0). Before 17:00 EDT, the MGT will list the currently valid PIDs as: 123, 190, 237, 177, 295, and 221. At 17:00 EDT, table EIT-0 will become obsolete while the other ones will remain valid. At that time, the PID list can be changed to 190, 237, 177, 295, 221, maintaining the version number list as 4, 2, 7, 8, 15. Therefore, by simply shifting the listed PID values in the MGT, table EIT-1 can become EIT-0, table EIT-2 can become EIT-1, and so on. Typically, a new EIT-5 would be generated at that time with programming information for the time period 12:00 – 15:00 (UTC). This could go in PID 123, replacing the obsolete data there, or could go in a new PID.

However, it is also possible to regenerate one or several EITs at any time for correcting and/or updating the content (e.g., in cases where "to be assigned" events become known). Regeneration of EITs is flagged by updating version fields in the MGT. For example, if table EIT-2 needs to be updated at 16:17 EDT, then the new table is required to be transmitted with a version number equal to 3. Whenever the decoder monitoring the MGT detects a change in the version number of a table, it assumes that the table has changed and needs to be reloaded.

7.3.1   Example Case

For the purpose of example, we assume that a broadcaster, here denominated NBZ, manages the frequency bands for RF channels 12 and 39. In this example, Channel 12 is (or *was*, after analog shut-off) its analog channel whereas Channel 39 is used or will be used for digital broadcast. NBZ is required to carry the PSIP tables in the digital transport stream of RF channel 39. The tables are required to describe TV programs and other services provided on RF channel 39 but can also describe information for the analog RF channel 12.

Assume that NBZ operates in the Eastern Time zone of the U.S., and that the current time is 15:30 EDT (19:30 UTC). NBZ decides to operate in minimal configuration, therefore only the first four EITs need to be transmitted. As explained previously, EIT-0 is required to carry event information for the *current* time window, which is between 14:00 and 17:00 EDT, whereas EIT-1 to EIT-3 will cover the subsequent 9 hours. For the first 6 hours, the following scenario applies (see Table 7.2 and Table 7.3).

Table 7.2 First Three Hour Segment Described in VCT and EIT-0

CH		14:00–14:30	14:30–15:00	15:00–15:30	15:30–16:00	16:00–16:30	16:30–17:00
12.0	NBZ	City Life	City Life	Travel Show	Travel Show	News	News
12.1	NBZ -D1	City Life	City Life	Travel Show	Travel Show	News	News
12.2	NBZ -D2	Soccer	Golf Report	Golf Report	Car Racing	Car Racing	Car Racing
12.3	NBZ -D3	Secret Agent	Secret Agent	Lost Worlds	Lost Worlds	Lost Worlds	Lost Worlds
12.4	NBZ -D4	Headlines	Headlines	Headlines	Headlines	Headlines	Headlines

Table 7.3 Second Three Hour Segment Described in VCT and EIT-1

CH		17:00–17:30	17:30–18:00	18:00–18:30	18:30–19:00	19:00–19:30	19:30–20:00
12.0	NBZ	Music Today	NY Comedy	World View	World View	News	News
12.1	NBZ -D1	Music Today	NY Comedy	World View	World View	News	News
12.2	NBZ -D2	Car Racing	Car Racing	Sports News	Tennis Playoffs	Tennis Playoffs	Tennis Playoffs
12.3	NBZ -D3	Preview	The Bandit	The Bandit	The Bandit	The Bandit	Preview
12.4	NBZ -D4	Headlines	Headlines	Headlines	Headlines	Headlines	Headlines

Similar tables can be built for the next 6 hours (for EIT-2 and EIT-3). According to this scenario, NBZ broadcasts four regular digital channels (also called virtual channels and denoted as VC), one matching the analog transmission (simulcast), another for sports, and a third one for movies. The fourth one supports a service displaying headlines with text and images.

7.4 Packetization and Transport

Typically, the MGT, STT, VCT, and each instance of the RRT and EIT will have one or at most a few sections. For each table, the sections are appended one after the other, and then segmented into 184-byte packets. After adding the 4-byte MPEG-2 transport stream header, the packets are multiplexed with the others carrying audio, video, data, and any other components of the service. Figure 7.3 illustrates this process.

7.4.1 Tuning Operations and Table Access

As described by the PSIP protocol, each transport stream will carry a set of tables describing system information and event description. For channel tuning, the first step is to collect the VCT from the transport stream that contains the current list of services available. Figure 7.4 shows this process.

Once the VCT has been collected, a user can tune to any virtual channel present in the transport stream by referring to the major and minor channel numbers. Assuming that in this case,
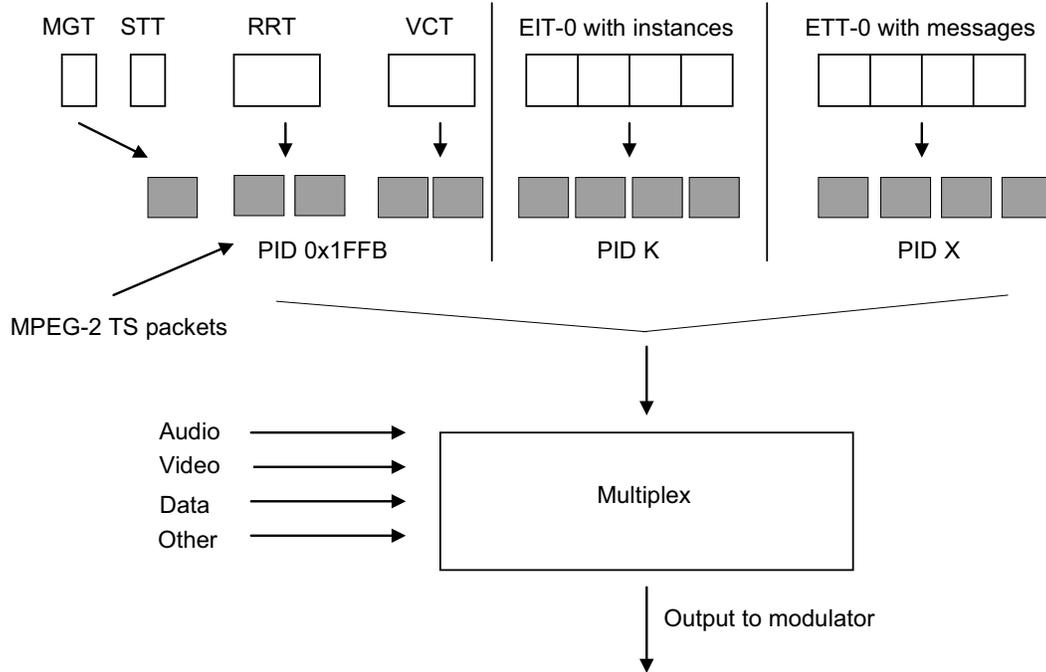
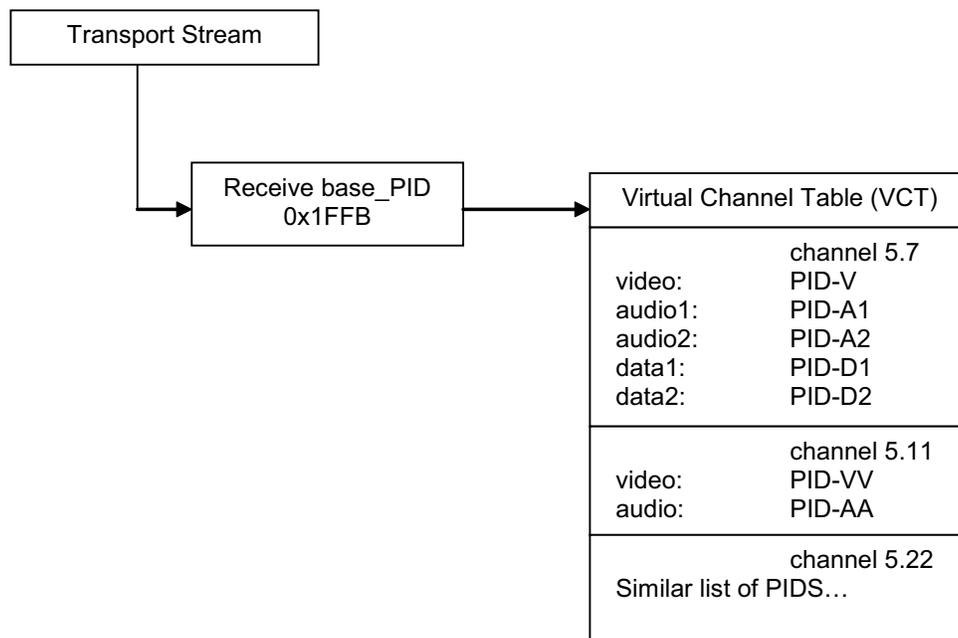**Figure 7.3** Packetization and transport of the PSIP tables.

Figure 7.4 Extraction of the VCT from the transport stream.

the user selects channel 5.11, then the process for decoding the audio and video components is shown in Figure 7.5.
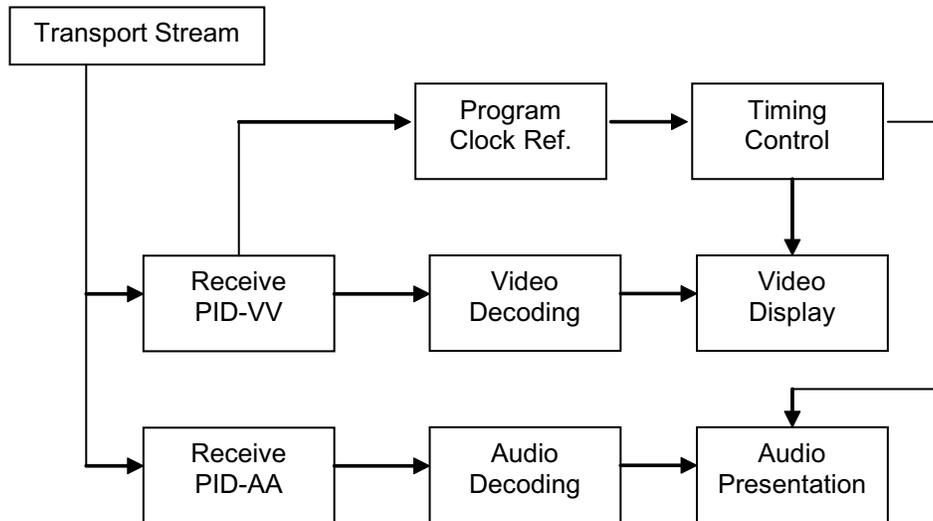
Figure 7.5 Acquisition of audio/visual components.

For terrestrial broadcast, the existence of a service_location_descriptor() in the TVCT is mandatory for each active channel. The PID values needed for acquisition of audio and video elementary streams are to be found in either a service_location_descriptor() within the TVCT, or in the PMT. The PID values have been included in the PSIP TVCT to minimize the time required for changing and tuning to channels, and to enable simple virtual channels to be tuned without referring to the PMT. However, PAT and PMT information is required to be present in the Transport Stream to provide MPEG-2 compliance. Access to data or other supplemental services may require access to the PAT or PMT.

The service_location_descriptor() is required to be updated when the PMT is updated to ensure that they are as consistent. Normally the contents are the same, but there is a special case. The special case is when there are multiple audio tracks with the same language offered. There are two ways to construct such services. The PMT supports a means to directly associate textual name for each of the tracks with the PID of the packets for each audio stream. However, using the PMT provides no means to inform the receiver of the options available for future programs. To handle this case and the case where multiple languages are available, the AC-3 descriptor was extended so that direct association of language was possible for future programs announced in the EIT. Creating separate virtual channels to associate each such audio option with the (same) video is another method to provide a persistent signaling of a channel of program services that are in a particular language. Announcing and navigation among data enhancements can be significantly more complex and is not addressed.

7.5   MPEG Transport Stream Considerations

It should be noted that, except for the MGT, PSIP table sections may start in any byte position within an MPEG-2 transport stream packet. The Master Guide Table is special in that the first byte always is aligned with the first byte of the packet payload. The A/65 Standard [1] states this restriction as the pointer_field of the transport stream packet carrying the table_id field of the MGT section is required to have the value 0x00 (section starts immediately after the pointer_field).

In general, table sections may span packet boundaries. Also, if the table sections are small enough, more than one PSIP table section may be present within a single transport stream packet. The MPEG-2 pointer_field mechanism is used to indicate the first byte of a table within a packet payload. The starting byte of subsequent tables that might be in the same payload is determined by processing successive section_length fields. The location of the section_length field is guaranteed to be consistent for any type of PSIP table section, as the format conforms to MPEG-2 defined Program Specific Information (PSI) tables.

If a packet payload does not include the start of a table section, the payload_unit_start_indicator bit in the packet header is set to '0' and the pointer_field is not present.

7.6 Consistency Errors in PSIP Tables and MPEG PSI

ATSC A/78 [5] Section 8 says:

> "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 user selects a virtual channel for decoding. Conflicts and problems within the structure of metadata are called "consistency errors.""

This summary lays out the potential pitfalls of an emission with inconsistent tables. Different receivers will react in different ways to the inconsistent data. Since various parts of the emission system may generate different parts of the tables, care must be taken to ensure they are always consistent. A Transport Stream analyzer supporting the A/78 analysis paradigm should be used. See A/78 [5] for additional methodology regarding classification of errors as to their level of severity.

7.7 Considerations Regarding Large PSIP Tables in the Base PID

The PSIP Base PID carries a mixture of short tables with short repeat cycles and larger tables with long cycle times. Transmission of one table section is required to be completed before the next section can be sent: time-interleaving of parts of sections carried by one PID is not allowed. Thus, transmission of large table sections (even with long cycle times) are required to be completed within a short period in order to allow fast cycling tables to achieve specified time interval. The result is a PID stream that has a bursty characteristic, which may lead to bandwidth inefficiency if upstream multiplexers reserve bandwidth for the peak PSIP requirement.

Table 7.4 lists typical characteristics for various table types.

Table 7.4 Bandwidth Considerations for Some PSIP Tables

Table Type	Section Size (bytes)	Number of Packets	Repeat Interval	Average BW (kbps)	Peak BW (kbps)
MGT (24 EITs)	589	4	150 msec	40.1	40.1
VCT (5 VCs)	356	2	400 msec	7.5	20
STT	20	<usually in spare space>	1000 msec	0.2	0.2

Annex A:
Fundamental PSIP Structure

A.1 INTRODUCTION

The primary purpose of PSIP is to facilitate acquisition and navigation among analog and digital services available to a particular receiver or set-top box, but it also serves as a support platform for applications such as data broadcasting.

In analog broadcast or cable television, if a user selects channel "4," the receiver knows to tune the frequency of channel 4 as standardized by the FCC—the 66–72 MHz band. The situation changes, however, with advent of digital transmission—digital broadcasters have the freedom to define channel numbers independently of the radio frequency (RF) band used to carry the signal. PSIP is built around the concept of *virtual channels*. A virtual channel is called "virtual" because its definition is given by indirect reference through a data structure called a virtual channel table. So, when an end-user selects "channel 4" the receiver is actually selecting the channel record associated with user channel number 4. The definition of the channel as given in the VCT includes:

- The frequency and method of modulation
- Textual name
- Channel type (analog audio/video, digital audio/video, audio only, or data)
- Channel number the user may use to access it

The A/65 protocol [1] introduced a powerful navigational concept, the "two-part" channel number. Broadcasters declared the need, as new digital services are introduced, to retain the brand-identity they currently have as a result of years of marketing and advertising. For broadcasters, the first part of the two-part number (called the *major* channel number) is required to be the same as the FCC channel number already in use for the analog service. The second part of the number (called the *minor* channel number) identifies one service within the group of services defined by the major number. From the point of view of the user, where before there was just "Channel 4," now there may also be Channels 4.1, 4.2, 4.3, and so on.

Broadcasters may deliver a Rating Region Table that defines the structure of a multi-dimensional content advisory system for a specific region (e.g., country), and a content advisory descriptor that can be used to associate specific program events with rating levels defined in the RRT.

A.1.1 System Functional Requirements

The following list comprises the basic set of system functional requirements that ATSC adopted as their starting point:

- Provide direct access to any channel. The navigational model is required to support the ability to access any analog or digital channel by direct entry of its channel number or call letters.
- Support grouping of selected digital services with an existing analog service, or with digital services on other multiplexes. There will be a period of time in which broadcasters operate an analog channel in addition to a digital multiplex. The navigation model is

required to include a grouping concept to support channel surfing within a set of related analog and digital channels.

- Preserve channel branding. When a broadcaster begins a digital service, the system is required to allow association of the new programming with the channel label used in past years of advertising.

- Harmonized with cable standards. The chosen solution for broadcast is required to recognize that cable set-tops and cable-ready receivers will also employ navigational and channel naming methods. These are required to work in harmony with methods defined for terrestrial broadcast.

- Accommodate the flexibility of digital transport. The MPEG-2 standard provides a great deal of latitude in defining a "service" on the multiplex. The approach is required to accommodate the wide variety of service structures possible via digital transport.

- Allow a broadcaster to "package" or "market" some services separately from others on the multiplex. For example, as a public service, the owner of a digital broadcasting license may offer a couple of spare megabits/sec of SDTV bandwidth to a college or community access channel, or to a government affairs (city politics) channel. It is required to be possible for the operator to label that channel separately from the other services offered on the multiplex.

In addition to these general requirements, an important consideration was identified specific to cable transmission media: the cable system operator must be able to label digital services independently of the RF channel number used to transmit them. In other words, cable would use a "virtual channel" scheme. Each cable operator is free to use whatever frequency slot the company chooses to deliver the digital signal and still be able to label it for the user in a meaningful way. Practically speaking, when the cable operator takes an off-air digital broadcast signal and re-modulates for cable, the operator should be able to label it the same as the broadcaster does for televisions that receive the signal directly off-air.

Lastly, two requirements were identified specific to terrestrial broadcasting. First, the system is required to accommodate terrestrial broadcast translators. Broadcasters do not want to have to re-process PSI or the program guide data if they transmit the same MPEG-2 transport stream on an alternate frequency. Second, the receiver should be able to deal with a movable antenna, either steerable by the user or because the receiver itself is movable.

A.1.1.1 The PSIP Solution

The ATSC A/65 PSIP Standard [1] addresses all these system concerns for both terrestrial broadcasting and cable. Specifically:

- **Direct access**. The user can access any service, whether it is an audio/video service, an audio only service, or a data broadcast service, by specifying either its channel number or its service name. The channel number method is compatible with numeric-keypad remote control units (RCUs).

- **Channel grouping**. Channel numbers are assigned through the Virtual Channel Table. The two-part channel number scheme provides a grouping function in that the major channel number identifies the group and the minor number the member of the group. Broadcasters are required to use the RF channel for the current analog NTSC broadcast channel as the major channel numbers for all the new digital services.

- **Channel branding**. As described, the broadcasters keep the "brand identity" associated with their analog channels because the new digital channels use that same number for their major channel number.

- **Harmonized with cable**. PSIP was designed with the needs of cable in mind. The overall design of System Information tables in PSIP achieves nearly complete parallelism between the methods used for cable and terrestrial broadcast. There are only a few places where the specification differentiates cable and terrestrial broadcast. One example is that major channel numbers on cable can range from 1 to 999 for video services, where on terrestrial broadcast the range is limited to 2 to 99.

- **Accommodates flexibility of digital transport**. PSIP builds upon the MPEG-2 Systems standard [14] without imposing constraints on its use. Any service that can be represented by the MPEG-2 standard method can be referenced by the PSIP VCT. Note that this is in contrast to the original A/53 ATSC Digital Television Standard [4] which mandated the use of the so-called "program paradigm" for broadcast television.

- **Separate packaging of services**. PSIP states that for the U.S., in addition to using the major channel number that matches the analog broadcasting license for some services, a broadcaster may label one or more virtual channels on the multiplex with major channel numbers in the 70 – 99 range. Certain conditions are required to be met, however: assignment of major channel numbers are required to be coordinated such that they are unique within a region. Otherwise, one receiver could access two different digital services labeled with the same channel number, and that would cause user confusion.

- **Cable virtual channels**. This requirement is met because PSIP is based on the virtual channel concept. The more significant aspect is that digital terrestrial broadcasting is also based on virtual channels.

- **Broadcast translators**. If a digital broadcast is shifted in frequency at a translator, all SI and EPG information that it carries remains correct except for frequency references. As it happens, even though carrier frequency information is included in the SI tables, a receiver is expected to correctly operate without it (or, more likely, ignore frequency discrepancies it might find).

- **Movable broadcast receivers and antennas**. PSIP tables are delivered repetitively. Broadcast virtual channel tables, for example, are repeated no less often than once each 400 msec. A receiver may therefore quickly learn the labels to use for navigation. If a receiver itself is moving, even as one signal fades out and another is acquired, navigational and channel label data will always be readily accessible.

A.1.1.1.1 Channel Mapping

Within the broadcaster community, the initial view was that channel mapping was not needed, and the extra complexity was not worth the effort. When considering a 6 MHz channel carrying a digital multiplex with just one HDTV program, the channel numbering paradigm in use for analog TV seemed to work just fine. When the ATSC recognized that standard definition formats were possible and desirable, they acknowledged that a method was needed for selection of just one program in the multiplex. The MPEG-2 Systems specification provides data called *program specific information* (PSI) that included a parameter called a "program number," which seemed to fit this purpose. It was assumed that the user could specify or enter the MPEG-2 program number directly.
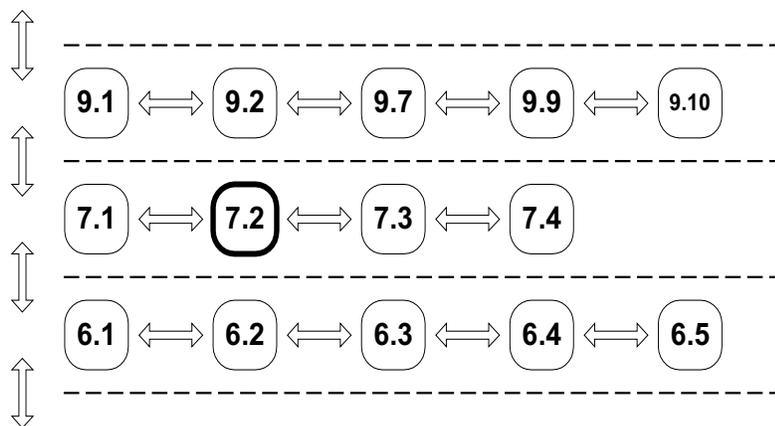
Figure A.1 Example of two-dimensional channel navigation.

Those in the committees representing the cable community objected to this use of the MPEG program number as a user "sub-channel number" because of considerations related to the re-multiplexing that is routinely done at cable headends. Cable operators need to be able to decouple the physical channel used to deliver a programming service from the user's method of access (the channel number). With this kind of decoupling, the operators are free to move a service to a new carrier frequency, or rearrange the delivery method of a group of services by remultiplexing, without causing user confusion.

The argument for virtual channels that held the most sway with broadcasters, though, was primarily related to the branding issue. Broadcasters were asked to consider the investment they had in brand recognition—nearly all TV channel logos in media and print advertising feature the local broadcast channel number. The channel number is recognized by the public as the way to access the service (where to get it). Now consider what would happen when a local broadcaster is given a high-numbered UHF channel to use for the new digital broadcasts. For example, the broadcaster is known locally as "Channel 8," but now would have to use "Channel 41" for the added digital services. A virtual channel numbering scheme solves this problem by allowing the channels which are broadcast on UHF channel 41 to be labeled so they appear to the consumer as "parts of" Channel 8. Figure A.1 illustrates the concept of two-dimensional channel navigation.

The major channel number is thus used to group all services associated with a broadcaster's NTSC brand, for example Channel 6. The minor channel number specifies a particular channel within that group. Zero (0) is reserved for the NTSC channel; all other values (1 – 999) are allowed for digital services. One common approach is to start with 1 and to continue numerically for different programs. Video services are required to use the range of 1 – 99 and data services are required to use 100 or greater (100 – 999). If there is a video component of the data service, however, that service is required to use a minor channel number between 1 and 99.

For example, the NTSC channel would be 6.0, the first digital channel signal would be 6.1, the second 6.2, and the first data service 6.100. ATSC Standard A/65 [1] assigns major channel numbers for existing NTSC broadcasters for the U.S. based upon their NTSC RF channel number (2 – 69). Refer to Annex B of [1] for detailed channel assignment rules for the U.S. Higher major channel number values are possible. Values from 70 to 99 may be used to identify groups of digital services carried in an ATSC multiplex that the broadcaster wishes to be identified by a
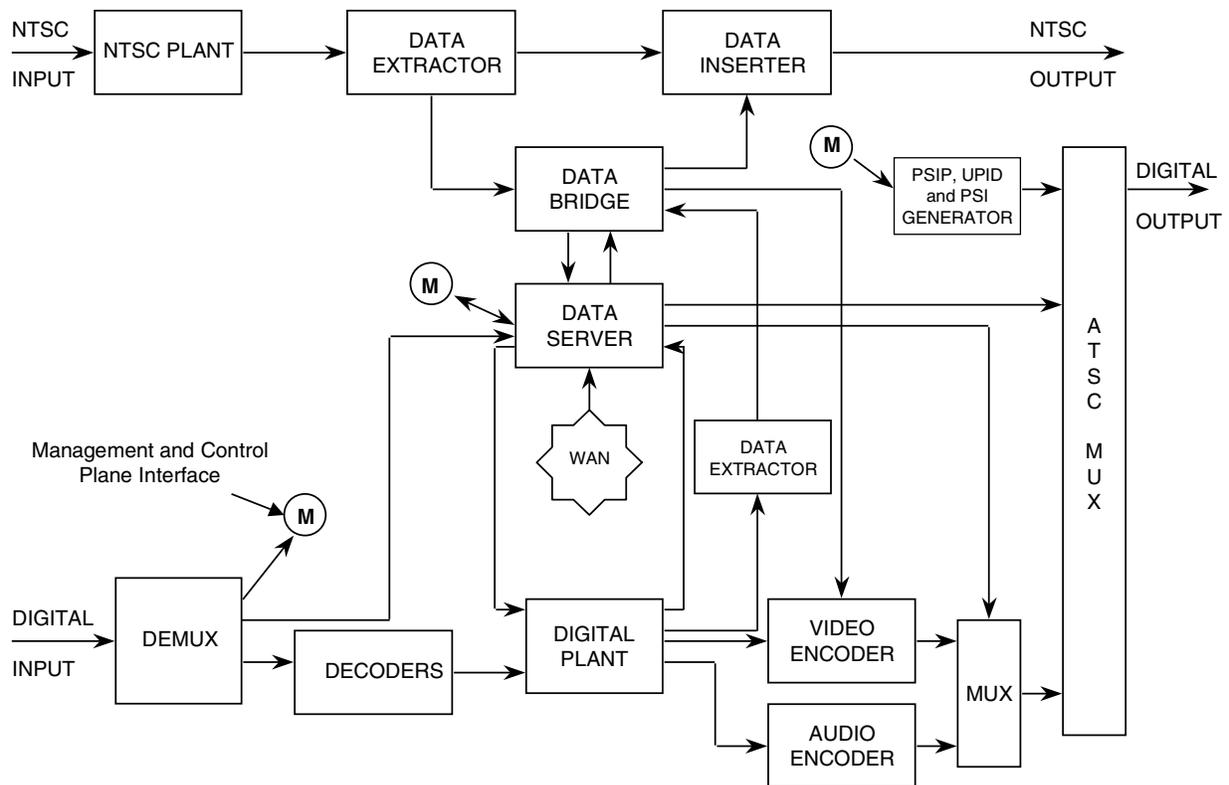
Figure A.2 Block diagram of the PSIP generation and insertion process.

different major channel number. For example, a local broadcaster transmitting community college lectures in its bit stream may want to use a major channel number different from its own major channel number for the virtual channel carrying the lectures.

A.1.1.1.2 The "Program Paradigm"

The "program paradigm" was an early method for assigning PID values for audio and video elementary streams, with an algorithmic relationship between PID values and the value of the program_number. The "program paradigm" was removed from the ATSC A/53 Standard in 2000. This method could lead to PID values out of the permitted range. Whatever method is used to assign PID values should ensure the resulting values lie in the permitted range.

A.1.2 PSIP Information Flow

PSIP information is generated through a process illustrated in Figure A.2 for the general case. Figure A.3 places the PSIP generator in perspective relative to the ATSC transmission system, and Figure A.4 describes the reception and decoding process.
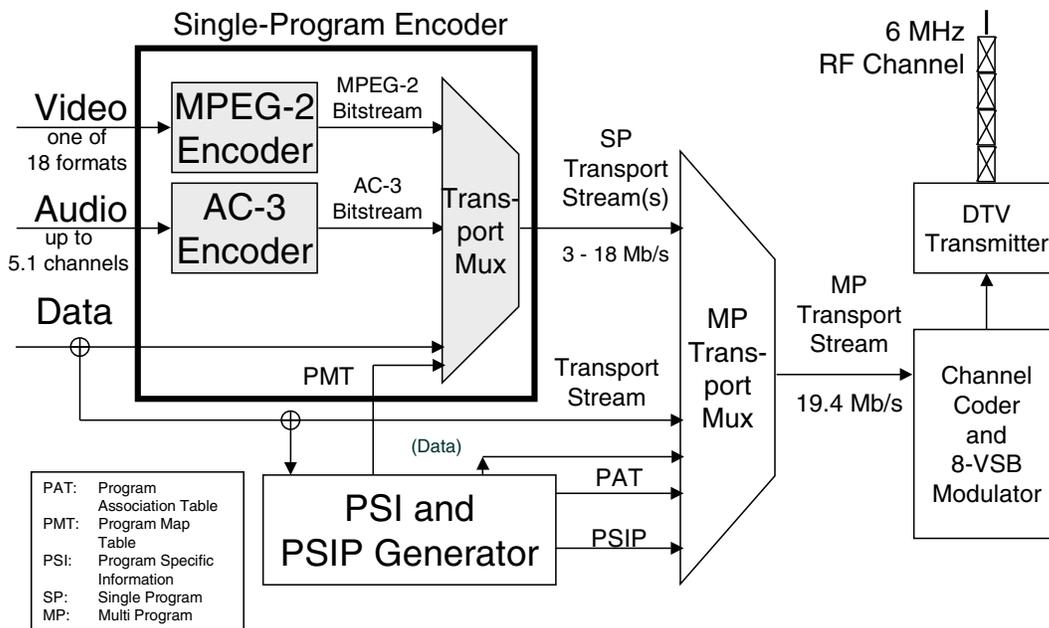
Figure A.3 Block diagram of the ATSC transmission system, including PSIP generation and insertion.
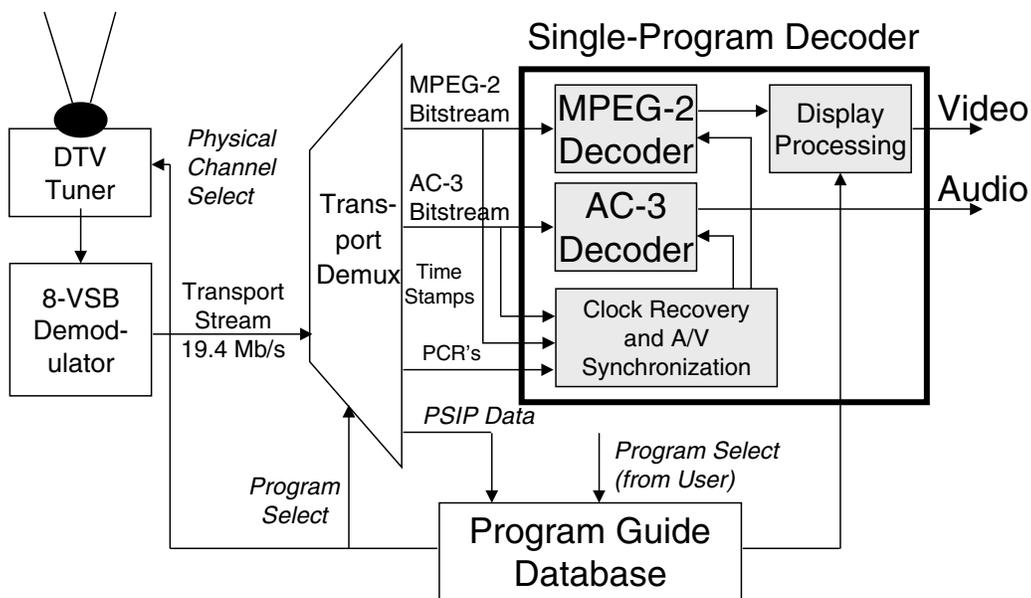
Figure A.4 Bock diagram of an ATSC decoder, including PSIP extraction and program guide generation.

Example Settings for PSIP Parameters

B.1 INTRODUCTION

This example applies to an RF (DTV) channel operated in the Alaska time zone by a station licensed to broadcast on NTSC channel 2. The DTV service has a single channel of programming. The system parameters for the broadcast at 9:00:01 p.m. Alaska Standard Time on 1 January 2001 should be set as given in the following tables.

B.1.1 Terrestrial Virtual Channel Table Settings

Table B.1 lists example settings for the T-VCT.

Table B.1 Example Settings for the T-VCT

| Parameter	Value	Comments
table_id	0xC8	Value created by PSIP generator.
transport_stream_id	0x0003	FCC assigned value, preferably the default setting by the PSIP generator when shipped to the customer.
num_channels_in_section	0x01	This broadcaster is not announcing the NTSC programming.
short_name	NEW2	User entry of up to 7 alpha-numeric characters; value created by PSIP generator.
major_channel_number	0x002	Preferably the default setting by the PSIP generator when shipped to this customer; if not, user entry of 2 converted to 10 bits.
minor_channel_number	0x001	Preferably the default setting by the PSIP generator when shipped to this customer; if not, user entry converted to 10 bits.
modulation_mode	0x04	Default value created by PSIP generator, with user capability to change.
carrier_frequency	0x00000000	Default value created by PSIP generator, with user capability to change.
channel_TSID	0x0002	Automatically generated value created by PSIP generator, with user capability to change only if other services not carried in this transport are described.
program_number	0x01	Value created by PSIP generator and communicated to the device creating the PMT.
ETM_location	0x00	Value created by PSIP generator.
access_controlled	0	Value created by PSIP generator based on user input (in this example 0).
hidden	0	Value created by PSIP generator based on user input (in this example 0).
hide_guide	0	Value created by PSIP generator based on user input (in this example 0).
service_type	0x02	Value created by PSIP generator based on user input.
source_id	0x0001	Value created by PSIP generator
descriptors_length	0x12	Value calculated by PSIP generator (this example has one service_location_descriptor).

Table B.1 Example Settings for the T-VCT

descriptor_tag	0xA1	Value created by PSIP generator alone.
descriptor_length	0x11	Value calculated by the PSIP generator.
PCR_PID	0x09FF	Value created by PSIP generator; normally the same as the PID used for the video.
number_elements	0x02	Value calculated by the PSIP generator.
first stream_type	0x02	Video. Value created by PSIP generator based on user input.
elementary_PID	0x09FF	Value created by PSIP generator; is required to be the same as the elementary_PID in the PMT (in this case 0x09FF).
ISO_639_language_code	0x000000	Value created by PSIP generator based on language of the associated elementary stream.
second stream_type	0x81	Audio. Value created by PSIP generator based on user input that audio is present.
elementary_PID	0x09FE	Arbitrary value created by PSIP generator; is required to be the same as the elementary_PID in the PMT (in this case 0x09FE).
ISO_639_language_code	0x737061	Value created by PSIP generator based on language selection (in this case Spanish).
additional_descriptors_length	0	Value calculated by the PSIP generator.
additional_descriptor		In this example not sent.
CRC_32 (not shown)		Value calculated by the PSIP generator.

B.1.2 Event Information Table

For simplicity, one three-hour program in EIT-0 is assumed; it has a caption service descriptor and a content advisory descriptor.

Table B.2 Example Settings for Event Information Table

Parameter	Value
event_information_table_section() {	
table_id	0xCB
section_length	12
source_id	0x0001
version_number	0x00
num_events_in_section	0x01
event_id	0x0041
start_time	0x27 7E 7F 7F
ETM_location	0x0
length_in_seconds	0x2A30
title_length	8
title_text()	STARTREK

B.1.3 Caption Service Descriptor

The caption service in this program is assumed to have standard and wide aspect ratio captions.

Table B.3 Example Settings for Caption Service Descriptor

Parameter	Value
descriptor_tag	0x86
number_of_services	0x02
language	0x656E67
cc_type	1
reserved	1
reserved	11111
line21_field	1
first caption_service_number	0x01
first service easy_reader	0
first service wide_aspect_ratio	0
language	0x737061
cc_type	1
reserved	1
reserved	11111
line21_field	1
second caption_service_number	0x02
second service easy_reader	0
second service wide_aspect_ratio	1

B.1.4 Content Advisory Descriptor

This program is assumed to have a rating of TV-Y.

Table B.4 Example Settings for Content Advisory Descriptor

Parameter	Value
descriptor_tag	0x87
descriptor_length	0x05
rating_region_count	0x01
rating_region	0x01
rated_dimensions	0x01
first rating_dimension_j	0x01
rating_value	0x1
rating_description_length	0x00
rating_description_text()	not present

B.1.5 I. PSIP Generator Calculated Tables

B.1.5.1 System Time Table

It is expected that the following values would be calculated by the PSIP generator from user inputs of:
- The local time zone
- Whether or not DST was observed at that station
- The current GPS_UTC_offset (15 seconds as of midnight 31 December 2008)

For this example, the values for the variable fields in the STT are given in Table B.5.

Table B.5 Example System Time Table Parameters

Parameter	Value	Comments
system_time	0x27 7E 7F 80	Value created by PSIP generator.
GPS_UTC_offset	0x0D (13)	Value created by PSIP generator.
daylight_saving	0x6000	Value created by PSIP generator.

B.1.5.2 Master Guide Table

There are 25 tables in this example, so:

tables_defined	0x19	Value calculated by PSIP generator.

The first table in the list is the VCT:

table_type	0x0000	Value created by PSIP generator.
table_type_PID	0x1FFB	Value created by PSIP generator.
table_type_version_number	00000	Value created and maintained by PSIP generator.

There are no table type descriptors for the VCT:

number_bytes	0x0002	Value calculated by the PSIP generator.

The table_type_descriptors_length is zero as there are none for the VCT:

table_type_descriptors_length	0x000	Value calculated by the PSIP generator.

The next table in the list is the EIT-0 for the sole virtual channel:

table_type	0x0100	Value created by PSIP generator.
table_type_PID	0x0FF0	Value created by PSIP generator.
table_type_version_number	0x00	Value created and maintained by PSIP generator.
number_bytes	0x00000002	Value calculated by the PSIP generator.

There are no descriptors for this EIT-0 in this example:

table_type_descriptors_length	0x0	Value created by PSIP generator.

The next tables in the MGT list are EIT-1 through EIT-23 (the descriptors_length field for the MGT is zero as there are none):

descriptors_length	0	Value calculated by PSIP generator.
CRC_32 value	Not shown here.	Value calculated by PSIP generator.

B.1.5.3 PSIP Driven MPEG System Tables (selected critical fields)

Example settings for the PAT and PMT are given below.

Table B.6 Example PAT Settings

Parameter	Value	Comments
transport_stream_id	0x0C33	FCC assigned value, preferably the default setting by the PSIP generator when shipped to the customer. (Example is KOMO-DT, Seattle)
program_number	0x0010	Value assigned by PSIP generator.
program_map_PID	0x0FFA	Arbitrary value assigned by PAT generator.

Table B.7 Example PMT (TS_program_map_section)

Parameter	Value	Comments
program_number	0x0010	Arbitrary value assigned by PSIP generator.
PCR_PID	0x09FF	Arbitrary value assigned by PSIP generator; is required to be the same as the PCR_PID in the VCT's SLD (usually the same as video packets).
first stream_type	0x02	Value created by PSIP generator based on user input.
elementary_PID	0x09FF	Arbitrary value created by PSIP generator; is required to be the same as the elementary_PID in the VCT's SLD.
second stream_type	0x81	Value created by PSIP generator based on user input that audio is present.
elementary_PID	0x09FE	Arbitrary value created by PSIP generator; is required to be the same as the elementary_PID in the VCT's SLD.

C.1 INTRODUCTION

Typical cable systems use an *out of band* (OOB) control channel for addressable control and to carry much of the same information that is defined in PSIP. The cable operator is thus afforded guaranteed access at all times to control or to update data tables in each cable-system-owned box and potential access to each cable-ready receiver. SI or EPG data delivered on the OOB channel can flow at low data rates because each cable terminal will store the received data in RAM for instant access. In-band PSIP data, on the other hand, is repeated at a higher rate on the assumption that the conditions may have changed since the last time a receiver accessed the data and, thus, needs to be verified as soon as possible.

Digital cable-ready receivers and VCRs will typically include an interface for a replaceable POD security module that handles conditional access descrambling. The POD module also receives the cable OOB data and delivers appropriate parts of it to the receiver or VCR, using a standardized format. When such a POD is present, the cable operator's potential access to control and/or update data tables becomes guaranteed access. In addition, the receiver or VCR can receive and process in-band PSIP data from those multiplexes that include it.

PSIP was designed to allow the owner of a single digital terrestrial multiplex to include SI and EPG data describing services on that same multiplex (plus EPG data for an associated analog NTSC service). A cable-ready receiver can use PSIP on cable in just the same way—it can collect SI data from each multiplex that incorporates PSIP data as it is acquired and aggregate that data into a larger channel map and EPG database.

C.1.1 PSIP Tables for Cable

PSIP was designed, as much as possible, to be independent of the physical system used to deliver the MPEG-2 multiplex. Therefore, the System Time Table, Master Guide Table, Virtual Channel Table, Event Information Table, and Extended Text Table are generally applicable equally as well to cable as to terrestrial broadcast delivery methods.

The differences can be summarized as follows:

- For cable, the Cable Virtual Channel Table provides the VCT function, while the Terrestrial Virtual Channel Table applies for terrestrial broadcast. The cable VCT includes two parameters not applicable to the terrestrial broadcast case, and the syntax of several parameters in the table is slightly different for cable compared with the terrestrial broadcast case.

- Under applicable SCTE standards, use of the program guide portion of PSIP (future EITs and ETTs) is considered optional on a cable system, while it is mandatory on a terrestrial broadcast signal. Note that per FCC rules cable operators are required to pass through PSIP data delivered on broadcast channels but are not required to add PSIP to cable programming channels or to broadcast channels.

- While the syntax of the cable and terrestrial VCTs are nearly identical, the cable VCT has two parameters not present in the terrestrial VCT: a *path select* bit, and a bit that can indicate that a given virtual channel is transported out of band (OOB). Also, the semantics

of the major and minor channel number fields and the source ID differ for the cable VCT compared with its terrestrial broadcast counterpart.

C.1.1.1 Channel Numbers

When PSIP is used for terrestrial broadcast, stations are required to take care in the assignment of major and minor channel numbers to avoid conflicts. For example, the PSIP standard requires that for the U.S. and its possessions, a terrestrial broadcaster with an existing NTSC license are required to use a major channel number for digital services that corresponds to the NTSC RF channel number in present use for the analog signal. For cable, these restrictions are technically unnecessary as the cable operator can insure that no duplicate numbers exist. For terrestrial broadcast, the major channel number is limited to the range 2 to 99 for ATSC digital television or audio services. For cable, major channel numbers can range from 0 to 999. The technical capability exists to communicate the two-part number to a cable-ready digital TV.

Cable operators often placed analog versions of each local broadcast channel at the same frequency and physical channel number that the broadcaster used for the analog terrestrial broadcast. But for digital cable, several different broadcast channels may be multiplexed together by the cable operator and carried on the same cable physical channel. Any one-part or two-part channel number may be displayed to the user for any broadcast channel, independent of the physical channel it is carried on. Broadcast channels delivered on cable and displayed on cable-ready DTV receivers typically use the same two-part channel numbers as the off-air signal, but cable set top boxes typically display only a one-part number. That one-part channel number for each digital station might be negotiated so that all of the DTV stations in the market are clustered around the same group of numbers.

Digital cable-ready receivers with a POD security module use the channel numbering scheme defined by the cable operator.

C.1.1.2 PSIP Data on Cable

PSIP data carried on cable in-band is analogous to PSIP included in the terrestrial digital broadcast multiplex: a receiver can discover the structure of digital services carried on that multiplex by collecting the current VCT from it. A cable-ready digital TV can visit each digital signal on the cable, in sequence, and record from each a portion of the full cable VCT. This is exactly the same process a terrestrial digital broadcast receiver performs to build the terrestrial channel map.

C.1.1.3 Re-Multiplexing Issues

A cable operator may wish to take incoming digital transport streams from various sources (terrestrial broadcast, satellite, or locally generated), add or delete services or elementary streams, and then re-combine them into output transport streams. If the incoming transport streams carry PSIP data, cable operators are required to process this data in the re-multiplexer such that the resultant multiplex conforms to A/65. Specifically, the re-multiplexer needs to account for any MPEG or PSIP fields or variables that are scoped to be unique within the transport stream. Such fields include PID values, MPEG program numbers, certain source ID tags, and event ID fields. Additionally, PSIP utilizes PIDs that are not announced in the PAT/PMT, so cable remultiplexers need to be aware of the PSIP PID allocation mechanisms. The timing of the updates of sequential table sections and the packet substitutions are implementation issues.

The ATSC A/53 Standard requires language signaling to be placed in the extended AC-3 descriptor, and does not require the ISO 639 language descriptor to be placed in the PMT. However, SCTE 54 requires the presence of the ISO 639 language descriptor in the PMT for language identification in order to support legacy equipment in cable systems.

☑   Broadcasters are encouraged to continue to include the ISO 639 language descriptor in the PMT in addition to the extended AC-3 descriptor to signal the language of each audio service for programs carried over cable.

Annex D:
Understanding PSIP Table Syntax

D.1 CONVENTIONS

ATSC and MPEG-2 standards use a common convention for specifying how to construct the data structures defined in the standards. This convention consists of a table specifying the syntax (the in-order concatenation of the fields), following by a section specifying the semantics (the detailed definitions of the syntax fields). The syntax is specified using C-language "like" constructs, meaning statements that take the form of the computer language, but would not necessarily be expected to produce reasonable results if run through a compiler.

The tables typically have three columns, as shown in the fragment in Table D.1.

- *Syntax*: The name of the field or a "C-like" construct
- *Bits*: The size of the field in bits.
- *Format*: Either how to order the bits in the field (an acronym or mnemonic is used, which is defined earlier in the standard—in this example, uimsbf means unsigned integer, most significant bit first)—or, when the field has a pre-defined value, the value itself (typically in either binary or hex notation).

Table D.1 Table Format

Syntax	No. of Bits	Format
typical_PSI_table() {		
table_id	8	uimsbf
section_syntax_indicator	1	'1'
….	…	…
}		

It should be noted that when the data structures are constructed, the fields are concatenated using *big-endian* byte-ordering. This means that for a multi-byte field, the most significant byte is encountered first. A common practice for implementation is to step through the syntax structure and copying the values for the fields to a memory buffer. The end result of this type of operation may vary for multi-byte fields, depending upon the computer architecture (especially for "Intel processors", which are *little-endian* [least significant byte encountered first]). It is therefore recommended that implementations use byte oriented instructions to construct the data (i.e., mask and shift operations).

D.1.1 Formatting

The curly-bracket characters ('{' and '}') are used to group a series of fields together. In the sample shown in Table D.1, the curly-bracket characters are used to indicate that all of the fields between the paired curly-brackets belong to the "typical_PSI_table()". For the conditional and loop statements that follow below, curly-bracket pairs are used to indicate the fields affected by either the conditional or loop statements.

The syntax column uses indentation as an aid to the reader (in a similar fashion to a common convention when writing C-code). When a series of fields is grouped, then the convention is to indent them.

D.1.2 Conditional Statements

In many of the constructs, a series of fields is included only if certain conditions are met. This situation is indicated using an "if (condition) { }" statement as shown in Table D.2. When this type of statement is encountered, the fields grouped by brackets are included only if the condition is true.

Table D.2 If Statement

Syntax	No. of Bits	Format
typical_PSI_table() {		
field_1	8	uimsbf
if (condition) {		
field_2	8	uimsbf
field_3	8	uimsbf
}		
…	…	…
}		

As with C-code, an alternate path may be indicated by an "else" statement, as illustrated below:

```
if (condition) {
    fields_1
} else {
    fields_2
}
```

If the condition is true, then fields_1 are used; otherwise, fields_2 are used.

D.1.3 Loop Statements

For-loop statements are commonly used in the syntax tables and have the widest variation in style and interpretation[14]. The for-loop takes the following form:

```
for ( i=0; i<N; i++ ) {
    fields
}
```

This type of statement indicates that the fields between curly-brackets should be included a number of times, but can't necessarily be interpreted the way a C compiler would (due to variations in the meaning of the end-point (N in the example above) and nesting of for-loops with

---

14. The for-loop statement represents the biggest divergence from actual C-code usage.

re-use of the counter variables). The syntax tables always provide enough information to understand the meaning of the for-loop (unfortunately, in many cases, common-sense and insight need to be used). The following example, fragments (taken from the syntax tables in A/65), illustrate how to interpret the for-loop for different types of usage:

Table D.3 For-loop Example 1

Syntax	No. of Bits	Format
…		
field_1	8	uimsbf
private_data_length	8	uimsbf
for (I=0; I<private_data_length; I++) {		
private_data_bytes	8	uimsbf
}		
….	…	…

In the example shown in Table D.3, the interpretation is quite straightforward: the end-point variable (private_data_length, which is given a value in the field immediately above the for-loop) simply indicates the number of private_data_bytes that follow.

Table D.4 For-loop Example 2

Syntax	No. of Bits	Format
…	8	uimsbf
num_channels_in_section	8	uimsbf
for(i=0; i<num_channels_in_section; i++) {		
field_1	8	uimsbf
…		
descriptors_length	10	uimsbf
for (i=0;i<N;i++) {		
descriptor()		
}		
}		
…	…	…

Upon examination of Table D.4, it is evident that there are two nested for-loops, both using the same counter variable (i). As opposed to the interpretation in a real C-program where a change in the value held by the variable in the inner loop will be reflected in the outer, these counter variables do not affect each other. In practice, the actual variable name chosen should be ignored—simply view the for-loop construct as a loop that should be traversed some number of times.

Furthermore, the inner and outer loops of this example represent different ways of interpreting how many times to traverse the loop. The outer loop represents a fairly conventional interpretation—the loop is to be traversed "num_channels_in_section" times; each traversal includes

all of the fields between this level of paired curly-brackets. As in the example in Table D.3, the value for "num_channels_in_section" is set by the field preceding the loop.

The inner loop has a different interpretation. In this case, contents of the loop are descriptors. Different descriptors have different lengths, but as shown in Table D.5, the second byte of each descriptor always specifies the length (in bytes) of the remaining descriptor. The end-point variable "N" is not explicitly set, but may be inferred from knowledge of how descriptors are constructed. For the inner loop example, the "descriptors_length" field specifies how many bytes make up the fields included in all traversals of this particular loop. In practice, one would follow the steps listed below when parsing this portion of the syntax:

1) Read descriptors_length field

2) Read the descriptor_tag and descriptor_length fields that follow

3) If the descriptor_tag is understood, interpret the following descriptor_length bytes according to the syntax of the particular descriptor, otherwise skip over these bytes

4) Increment the number of bytes traversed by the descriptor_length field + 2 bytes (to include the descriptor_tag and descriptor_length fields)

5) If the number of bytes traversed is less than the value in the descriptors_length field, go to step 2; otherwise, the loop has been fully traversed.

Table D.5 General Descriptor Format

Syntax	No. of Bits	Format
descriptor() {		
descriptor_tag	8	uimsbf
descriptor_length	8	uimsbf
fields		
...		
}		

Upon examining Table D.6, we encounter a particularly odd usage of the for-loop. In this case, the end-point variable is listed simply as N, with no indication of what N might be[15]. In some cases, the for-loop is immediately preceded by a length field. For this type of situation, N would take the value of the length field and be interpreted as in one of the cases above.

---

15.   Note: This type of usage is more common in the MPEG-2 standards than in the ATSC standards.

Table D.6 For-loop Example 3

Syntax	No. of Bits	Format
system_time_table_section() {		
table_id	8	0xCD
…		
section_length	12	uimsbf
…		
daylight_saving	16	uimsbf
for (i= 0;i< N;i++) {		
descriptor()		
}		
CRC_32	32	rpchof
}		

The particular case illustrated in Table D.6 (taken from the System Time Table) requires a little more insight to understand. The field immediately above the for-loop provides no information as to what value to use for N. If we examine the entire table, we find that the only portion of the syntax with variable length is the for-loop. In addition, one of the earlier fields in the table is the section_length field, which specifies the size of the overall table. These two observations provide enough information to allow the calculation of how many bytes would be included in the for-loop carrying the descriptors.

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E.1 INTRODUCTION

The System Time Table provides time of day information to receivers. In PSIP, time of day is represented as the number of seconds that have elapsed since the beginning of "GPS time," 00:00:00 UTC 6 January 1980. GPS time is referenced to the Master Clock at the U.S. Naval Observatory and steered to Coordinated Universal Time (UTC).

The cycle of the seasons, technically known as the *tropical year*, is approximately 365.2422 days. Using the Gregorian calendar we adjust for the fractional day by occasionally adding an extra day to the year. Every fourth year is a leap year, except that three leap years in every 400 are skipped (the centennial years not divisible by 400). With this scheme there are 97 leap years in each 400-year span, yielding an average year that is 365.2425 days long.

UTC is occasionally adjusted by one-second increments to ensure that the difference between a uniform time scale defined by atomic clocks does not differ from the Earth's rotational time by more than 0.9 seconds. The timing of occurrence of these "leap seconds" is determined by careful observations of the Earth's rotation; each is announced months in advance. On the days it is scheduled to occur, the leap second is inserted just following 12:59:59 p.m. UTC.

UTC can be directly computed from the count of GPS seconds since 6 January 1980 by subtracting from it the count of leap seconds that have occurred since the beginning of GPS time.

E.2 PSIP AND GPS TIME

In the A/65 protocol [1], times of future events (such as event start times in the EIT) are specified the same as time of day—as the count of seconds since 6 January 1980. Converting an event start time to UTC and local time involves the same calculation as the conversion of system time to local time. In both cases, the leap seconds count is subtracted from the count of GPS seconds to derive UTC.

GPS time is used to represent future times because it allows the receiver to compute the time interval to the future event without regard for the possible leap second that may occur in the meantime. Also, if UTC were to be used instead, it would not be possible to specify an event time that occurred right at the point in time where a leap second was added. UTC is discontinuous at those points.

Around the time a leap second event occurs, program start times represented in local time (UTC adjusted by local time zone and [as needed] daylight saving time) may appear to be off by plus or minus one second. PSIP generating equipment may use one of two methods to handle leap seconds.

In method *A*, PSIP generating equipment does not anticipate the future occurrence of a leap second. In this case, prior to the leap second, program start times will appear correct. An event starting at exactly 10:00 a.m. will be computed as starting at 10:00:00. But just following the leap second, that same event time will be computed as 9:59:59. The PSIP generating equipment should re-compute the start times in all the EITs and introduce the leap second correction. Once that

happens, and receivers have updated their EIT data, the computed time will again show as 10:00:00. In this way the disruption can be limited to a matter of seconds.

In method *B*, PSIP generating equipment does anticipate the occurrence of a leap second, and adjusts program start times for events happening after the new leap second is added. If the leap second event is to occur at midnight tonight, an event starting at 10:00 a.m. tomorrow will be computed by receiving equipment as starting at 10:00:01.

For certain types of events, the precision of method *B* is necessary. By specifying events using a time system that involves no discontinuities, difficulties involving leap seconds are avoided. Events such as program start times do not require that level of precision. Therefore, method *A* works well.

E.2.1 An Example

Consider the following example. Times are given relative to UTC, and would be corrected to local time zone and daylight saving time as necessary.
- Time of day (UTC): 1:00 p.m., 30 December 1998
- Event start time (UTC): 2:00 p.m., 2 January 1999
- A leap second event will occur just after 12:59:59 p.m. on 31 December 1998
- Leap seconds count on 30 December is 12

The data in the System Time message is:
- GPS seconds = 599,058,012 = 0x23B4E65C
- GPS to UTC offset = 12

Using method *A* (upcoming leap second event is not accounted for):
- Event start time in EIT: 599,320,812 = 0x23B8E8EC
- Converted to UTC: 2:00:00 p.m., 2 January 1999
- Number of seconds to event: 262,800 = 73 hours, 0 minutes, 0 seconds

Using method *B* (upcoming leap second event is anticipated):
- Event start time in EIT: 599,320,813 = 0x23B8E8ED
- Converted to UTC: 2:00:01 p.m., 2 January 1999
- Number of seconds to event: 262,801 = 73 hours, 0 minutes, 1 second

Note that when using method *B*, the number of seconds to event is correct, and did not need to be recomputed when the leap seconds count moved from 12 to 13 at year-end.

Note: The leap second count became 15 at the end of 2008.

The current leap second count can be found at http://tf.nist.gov/pubs/bulletin/leapsecond.htm. Further information may be found at http://tycho.usno.navy.mil/leapsec.html.

F.1   INTRODUCTION

The examples within this annex describe an NVOD Base channel with four Child channels. The most delayed Child channel runs four hours after its Base channel.
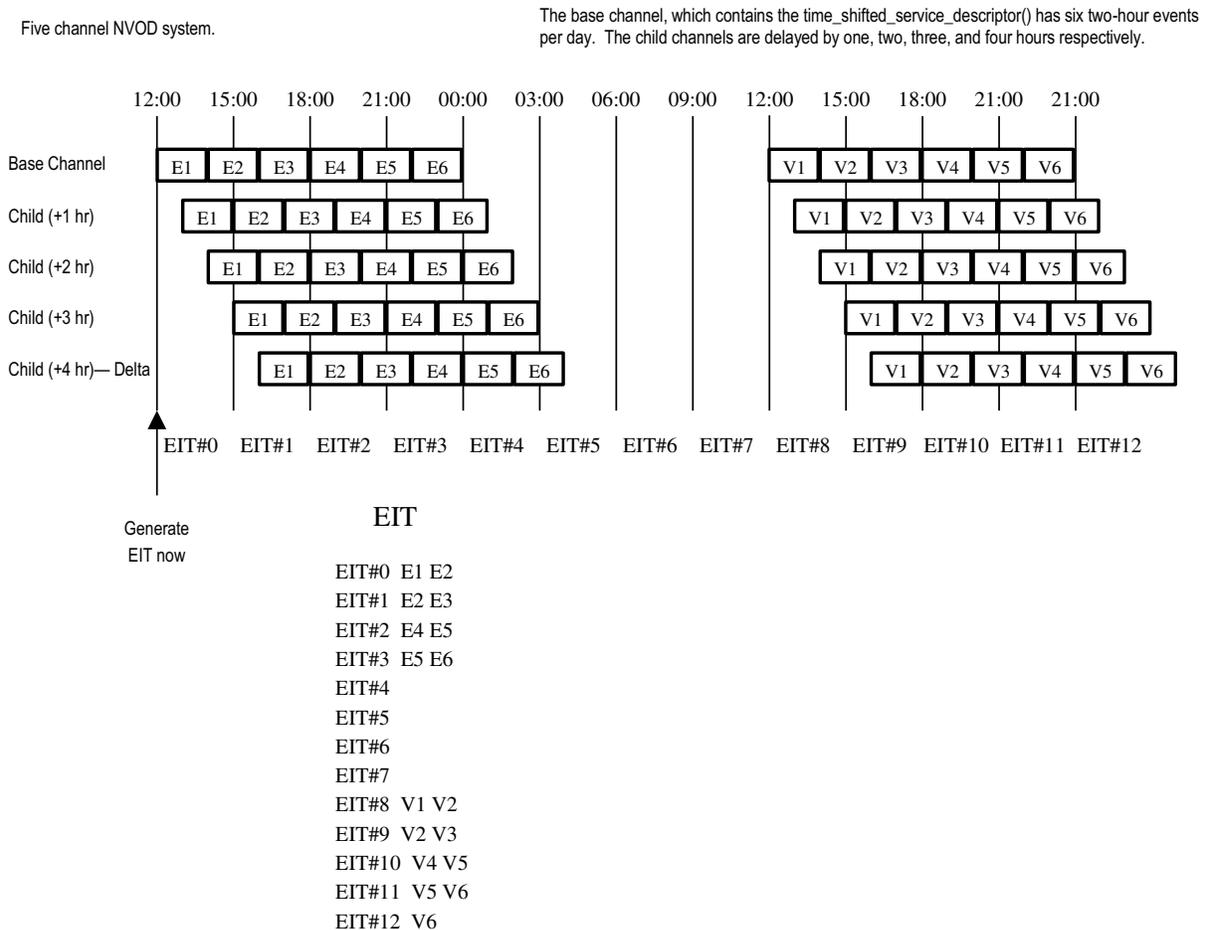
Five channel NVOD system.

The base channel, which contains the time_shifted_service_descriptor() has six two-hour events per day. The child channels are delayed by one, two, three, and four hours respectively.

| 12:00 | 15:00 | 18:00 | 21:00 | 00:00 | 03:00 | 06:00 | 09:00 | 12:00 | 15:00 | 18:00 | 21:00 | 21:00 |

Base Channel | E1 | E2 | E3 | E4 | E5 | E6 ... V1 | V2 | V3 | V4 | V5 | V6

Child (+1 hr) | E1 | E2 | E3 | E4 | E5 | E6 ... V1 | V2 | V3 | V4 | V5 | V6

Child (+2 hr) | E1 | E2 | E3 | E4 | E5 | E6 ... V1 | V2 | V3 | V4 | V5 | V6

Child (+3 hr) | E1 | E2 | E3 | E4 | E5 | E6 ... V1 | V2 | V3 | V4 | V5 | V6

Child (+4 hr)— Delta | E1 | E2 | E3 | E4 | E5 | E6 ... V1 | V2 | V3 | V4 | V5 | V6

EIT#0   EIT#1   EIT#2   EIT#3   EIT#4   EIT#5   EIT#6   EIT#7   EIT#8   EIT#9   EIT#10   EIT#11   EIT#12

Generate EIT now

EIT

EIT#0 E1 E2
EIT#1 E2 E3
EIT#2 E4 E5
EIT#3 E5 E6
EIT#4
EIT#5
EIT#6
EIT#7
EIT#8 V1 V2
EIT#9 V2 V3
EIT#10 V4 V5
EIT#11 V5 V6
EIT#12 V6

Figure F.1 NVOD Example #1.

F.1.1   NVOD Example #1 Notes

As there are no events that have expired in the base channel, all EIT and ETT entries are the same as those for an ordinary channel. To find what event starts on channel Delta at 18:00 the steps are:

1) Subtract the channel's time offset (4 hours) from 18:00, giving 14:00.

2) Calculate which EIT window covers 14:00, giving EIT#0.

3) Look in EIT#0 of the base channel for the event at 14:00, giving event E2.

Five channel NVOD system.

The base channel, which contains the time_shifted_service_descriptor() has six two-hour events per day. The child channels are delayed by one, two, three, and four hours
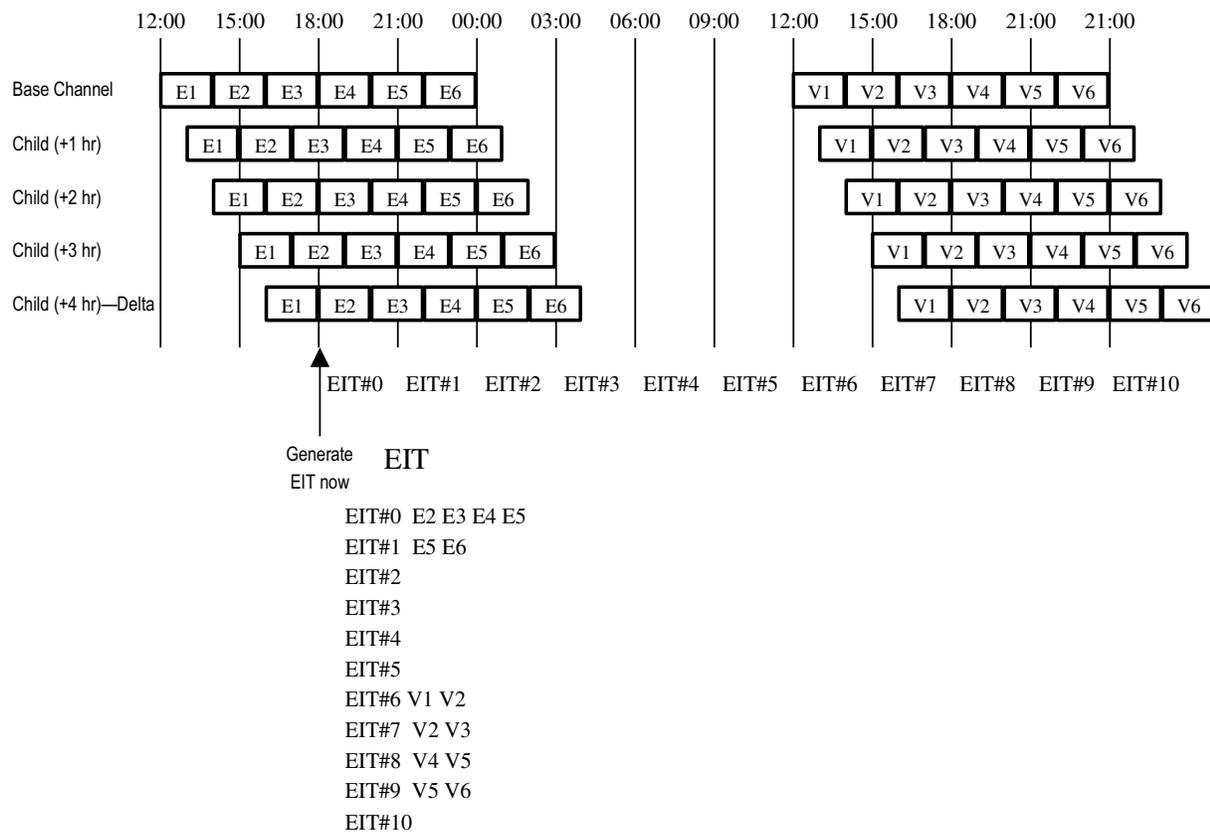

Figure F.2 NVOD Example #2.

F.1.2   NVOD Example #2 Notes

1) E1 has expired on channel Delta (the most delayed child); it is no longer listed in the EIT.

2) E2 and E3 have not expired on channel Delta (although they have expired on the base channel); they have to be listed in EIT#0.

3) EIT#1 and above are still the same as for a normal channel.

4) To find what event starts on channel Delta at 18:00 the steps are:

   • Subtract the channel's time offset (4 hours) from 18:00, giving 14:00.
   • Calculate which EIT window covers 14:00, giving EIT#-2 (i.e. minus two). A negative number is not legal for a window => We must use EIT#0.
   • Look in EIT#0 of the base channel for the event at 14:00, giving event E2.

Annex G:
Interpretation of MGT Table Version Numbers

G.1 INTRODUCTION

At first glance, it may appear that the Master Guide Table (MGT) simply provides the version numbers for the table sections that make up the EIT/ETT tables for each timeslot. For example, the MGT may indicate a table_type_version_number of 5 for a table_type value of 0x0100 (EIT-0), which could lead one to say "EIT-0 is at version 5." In fact, the MGT does give table version information for all transmitted tables, but a careful and correct interpretation of the data provided, including table_type_PID, is required to be made to avoid errors in processing.

The proper interpretation of table_type_version_number is to consider it to reflect the version_number field in the referenced table. In accordance with MPEG-2 Systems, the scope of table version_number is limited to table sections delivered in transport packets with a common PID value. For example, among table sections with a given value of table_ID, a table section delivered in transport packets with PID value 0x1E00 and version_number 6 is required to be interpreted as a separate and distinct table from a table section delivered in transport packets with PID value 0x1E01 and version_number 6.

The following example is designed to illustrate the distinction between the simple (incorrect) interpretation and the correct one. In the illustration, the incorrect interpretation leads to processing errors, which involve re-loading tables that have not in fact changed, or (more seriously) not updating tables that have changed.

G.1.1 Examples

For the following example, the time zone offset is 0. Each EIT table instance is associated with a separate PID (as per A/65 [1] rules):

1) Assume that it is noon. From noon to 3:00 p.m. the following is true:

    a) The EIT describing noon to 3:00 p.m. is in PID[16] 0x1000; version number is 0

    b) The EIT describing 3:00 p.m. to 6:00 p.m. is in PID 0x1001; version number is 1

    c) The EIT describing 6:00 p.m. to 9:00 p.m. is in PID 0x1002; version number is 0

    d) The EIT describing 9:00 p.m. to midnight is in PID 0x1003; version number is 0

    e) The MGT is at version 7 and indicates:

    - EIT-0, PID 0x1000, version number 0
    - EIT-1, PID 0x1001, version number 1
    - EIT-2, PID 0x1002, version number 0
    - EIT-3, PID 0x1003, version number 0

---

16. The expression "in PID" as used here is a shorthand way of saying that the indicated table section is "carried in transport packets with a PID value equal to" the indicated value.

2) The time moves to 3:00 p.m., crossing a timeslot boundary. Assume that the EIT describing 6:00 p.m. to 9:00 p.m. is changed now too.

   a) The EIT for noon to 3:00 p.m. is no longer sent, since its time has passed

   b) The EIT for 3:00 p.m. to 6:00 p.m. is still in PID 0x1001; version number is still 1

   c) The EIT for 6:00 p.m. to 9:00 p.m. is still in PID 0x1002; version number is moved to 1

   d) The EIT for 9:00 p.m. to midnight is still in PID 0x1003; version number is still 0

   e) MGT moves to version 8 and indicates:

   - EIT-0, PID 0x1001, version number 1
   - EIT-1, PID 0x1002, version number 1
   - EIT-2, PID 0x1003, version number 0

   f) What is now EIT-0 did not change. What is now EIT-1 *did* change.

For this case, if the MGT is interpreted to give the version numbers of EIT-*n* for each value of *n*, the receiver will see the version of EIT-0 change from 0 to one and refresh it. It will decide the version of EIT-1 has not changed, and not refresh it. But both inferences are incorrect: in this example, EIT-0 has not changed, and EIT-1 has changed.

The correct interpretation involves processing version numbers with respect to the associated PID values. Looking at the same example, the MGT indicates that the table associated with PID 0x1001 did not change versions. Likewise, the table associated with PID value 0x1002 changed from version 0 to 1 and should be refreshed.

Annex H:
Use of Analog Transmission Signal ID

H.1 INTRODUCTION

The Virtual Channel Table in PSIP associates a user-friendly definition of a service (a channel name and number) with the physical location of that service. Both digital and analog services are accommodated. For digital services, the Transport Stream ID (TSID) parameter defined in ISO/IEC 13818-1 (MPEG-2 Systems) is used as a unique identifier at the TS level. For analog services, an identifier called the Transmission Signal ID (the acronym is also TSID) may be used.

The analog TSID, like its digital counterpart, is a 16-bit number that uniquely identifies the NTSC signal within which it is carried. CEA-608 [11] Section 9.5.3.4 defines the data format for carriage of the Transmission Signal ID within eXtended Data Service (XDS) packets in the NTSC Vertical Blanking Interval.

In the U.S., the system is designed with the expectation that the analog TSID will be included in any NTSC broadcast signal referenced by PSIP data. Whenever PSIP data provides a reference to an analog service, the receiver is expected to use that service's analog TSID to make a positive identification. The receiver is expected to not associate any channel or program information data with an NTSC service that does not broadcast its analog TSID. As NTSC is being phased out in the U.S., the use of this capability will diminish toward zero over time.

Annex I:
Use of Component Name Descriptor

I.1 OVERVIEW

The component_name_descriptor() provides a mechanism to associate a multilingual textual label with an Elementary Stream component of any MPEG-2 program. If the program consists of one video stream and one audio track, such a label would not add much value. A program may be offered multilingually, for example with separate French and English tracks. In that case, a receiving device may choose, without need for user intervention, the track corresponding to the language set up as the user's preferred language.

It may be, however, that the service happens to have two English-language audio tracks. In another case, one or more of the audio tracks may not be associated with a spoken language. An example of such a track, sometimes called "clean effects," is ambient sound such as crowd noise from a sporting event. In both of these cases, use of the component_name_descriptor() is mandatory by the rules established in the PSIP Standard. The net result is that a display device will always have sufficient information to either choose an audio track by its language, or will have text describing each track that can be used to create an on-screen user dialog to facilitate the user's choice.

Annex J:
Sources of PSIP Information for the DTV Station

J.1 PREFACE

It is important to note that this is not the only possible scenario for introduction of PSIP information into a PSIP generator and that there may be sources of PSIP information not detailed here.

J.2 OVERVIEW

Just as there are many possible sources of programming for a DTV station, there are many possible methods of supplying PSIP information to the DTV station PSIP generator. There are however two simple paths. Data may be entered into the PSIP generator manually via a keyboard. This keyboard may be attached to the PSIP generator directly or to a PC-like device that is—in turn—connected to the PSIP generator.

In a similar fashion the PSIP generator may be connected in some fashion to one of the many systems that contain schedule information relevant to the station: listing services, traffic systems, program management systems, and/or automation systems. Each of these systems can be characterized as having different depths of information about the current scheduling, as well as different degrees of accuracy concerning event details (such as start time, duration, ratings, etc.). The PSIP generator may accept schedule information from one or more of these sources. In the case where there are multiple sources, it is recommended to prioritize the information sources. Information may be obtained by polling the source at periodic intervals (pull) or by having the information source send updates when available (push).

If the programming is part of a continuous DTV stream from a network or syndication source, then this source may include in the stream properly formatted PSIP tables at reasonable intervals. The PSIP generator (or some ancillary input device to it) should then extract from this stream the PSIP data that is relevant for the current emission. Note that a station may be fed by more than one of these DTV sources, which might not be an MPEG-2 Transport Stream.

Standardized protocols have been developed for exchange of PSIP information:

- Programming Metadata Communication Protocol (PMCP), defined in ATSC A/76 [10]
- BXF, as defined in SMPTE 2021 [12]

Note that the SMPTE BXF standard references PMCP for some of its functionality. There are also proprietary interfaces and protocols in use.

Annex K:
Coding of the Rating Region Table

K.1 INTRODUCTION

There may be some confusion caused by the semantics for abbrev_rating_value_text and rating_value_text, whether an explicit (verbose) coding of the null string is required or if a shorter representation is acceptable.

The verbose method requires 20 bytes to describe abbrev_rating_value and rating_value text strings "". The short method requires 2 bytes. These two strings with "" value are repeated for each of the 8 defined dimensions of rating region 1. Using the short method can save over 100 bytes over the verbose method.

The ANSI/CEA-766 [13] constraint of compression_type = 0 was placed to reduce the complexity of receiver implementations.

K.1.1 Excerpt of RRT Section

Tables K.1 and K.2 compare the verbose and the simplified methods.

Table K.1 Verbose Coding Method

Syntax	No. of Bits	Value
…		
values_defined	4	
for (j=0; j<values_defined; j++) {		
abbrev_rating_value_length	8	0x08
abbrev_rating_value_text() {		
number_strings	8	0x01
for (i= 0; i< number_strings; i++) {		
ISO_639_language_code	8*3	'eng'
number_segments	8	0x01
for (j=0; j<number_segments; j++){		
compression_type	8	0x00
mode	8	0x00
number_bytes	8	0x01
for (k= 0; k<number_bytes; k++)		
compressed_string_byte [k]	8	0x00
}		
}		
}		
rating_value_length	8	0x08
rating_value_text() {		

Table K.1 Verbose Coding Method

number_strings	8	0x01
for (i= 0; i< number_strings; i++) {		
ISO_639_language_code	8*3	'eng'
number_segments	8	0x01
for (j=0; j<number_segments; j++){		
compression_type	8	0x00
mode	8	0x00
number_bytes	8	0x01
for (k= 0; k<number_bytes; k++)		
compressed_string_byte [k]	8	0x00
}		
}		
}		
}		

Table K.2 Simplified Coding Method

Syntax	No. of Bits	Value
…		
values_defined	4	
for (j=0; j<values_defined; j++) {		
abbrev_rating_value_length	8	0x00
rating_value_length	8	0x00
}		

Annex L:
An Overview of Directed Channel Change

L.1 INTRODUCTION

The PSIP Standard established a forward-looking capability to dynamically allocate content at the receiver. Deployment requires access to alternative program stream, and receiver support. This advanced synergistic capability requires resource allocations by both broadcasters and receiver manufacturers, and while some broadcast products support the capability, only limited experimentation has occurred as of this update.

A Directed Channel Change request is a trigger event sent within the PSIP stream of the DTV multiplex that will cause a "DCC-capable DTV reference receiver" (DCCRR) to select a different virtual channel from that to which it is already tuned. Depending upon the kind of DCC request, the change to a different virtual channel can occur without intervention by the viewer, if the viewer has enabled the capability by providing required information during a setup process or during operation of the display. Alternatively, the change can take place under direct control of the viewer, for instance using a remote control device.

To enable the automatic carrying out of a DCC request within a DCCRR, the DTV viewer will be required to provide information to the display system. This may be accomplished through an interactive setup session or may be done during operation of the receiver, as different viewing options become available. The information provided by the viewer to the DCCRR will permit the unit to determine which, if any, alternate virtual channel the DCCRR should display upon receipt of a DCC request. This selection will take place through the DCCRR matching the viewer information with categorization information or other selection criteria sent by the broadcaster or system operator. There are also forms of DCC request that enable real time viewer selections among alternate program streams, such as, for example, alternate camera views of a sporting event.

L.2 DCC SWITCH CRITERIA

A switch from a currently viewed virtual channel to another virtual channel may be accomplished upon occurrence of any of the following selection criteria, some of which may be used in combination:

- Unconditional switch[17]
- Postal code, zip code[17], or location code
- Program Identifier[17]
- Demographic category
- Content subject category
- Authorization level
- Content advisory value

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17. Items required within a DTV device providing minimal support for Directed Channel Change as defined by the "reference receiver" (DCCRR) specification in A/65.

- One of eight user categories[17]

In addition to the criteria listed above that serve to include groups of viewers into a DCC request, several of the criteria may also be used to exclude viewers from inclusion in a request. For example, instead of listing many zip codes for inclusion of viewers in a DCC request, the inverse logic may be used to specify the group of all viewers not included within a group of zip codes.

Two other DCC request actions have also been defined: an action to be taken upon a viewer switching away from a channel, and an action to be taken upon a viewer switching into a channel.

The broadcaster may specify more than one type of selection criteria within a single DCC request. For example, it is possible to specify several individual zip codes by employing the loop structure within the DCC Table.

L.2.1 Unconditional Switch

An unconditional switch would cause all viewers' channel, regardless of any other DCC selection criteria selected within the DCCRR, to switch to a specified virtual channel. A potential use of this criterion would be to aggregate viewers on different virtual channels to a single channel.

L.2.2 Postal Code, Zip Code, or Location Code

A channel change based upon the viewer's location may be accomplished by using one or more of these location-based criteria. Broadcasters may use these capabilities to provide targeted programming based upon a viewer's location within the viewing area. Note that the location_code field currently is defined only for U.S. geographic entities.

L.2.3 Program Identifier

A channel change based upon a program's episode and version number may be accomplished with this criteria. Use of this function would permit a broadcaster to direct a viewer's attention to a broadcast of a particular program having a certain episode and version number. If the viewer had previously enabled a function within the DCCRR that would "remember" a particular program's episode/version number, the viewer could be directed to that program again upon detection of this criteria within the multiplex.

L.2.4 Demographic Category

A Directed Channel Change may be accomplished using demographic categories as a switching criterion. Demographics such as age group and gender can be selected.

L.2.5 Content Subject Category

A channel change based upon the subject matter of the content of the program can be accomplished. Nearly 140 categories of subject matter have been tabulated that can be assigned to describe the content of a program. A broadcaster may use this category of DCC request switching to direct a viewer to a program based upon the viewer's desire to receive content of that subject matter. Although nearly 140 subject categories have been identified for inclusion in the current version of the specification, additional categories may be determined in the future and may be transmitted to the DCCRR through a table revision mechanism (the Directed Channel Change Selection Code Table).

L.2.6 Authorization Level

A channel change may be accomplished using this mechanism in the event that the viewer attempts to switch to a virtual channel that he or she is not authorized to view. This category of DCC would permit the DCCRR to be directed to an alternative channel (such as a "barker" channel informing the viewer of ineligibility to view the channel) instead of the channel the viewer attempted to tune.

L.2.7 Content Advisory Level

This category of DCC is similar to that described in the preceding section (Authorization Level) but would redirect the viewer to another channel based on the content advisory level in the DCCRR.

L.2.8 User Specified Category

This category of DCC would allow a broadcaster to specify one of eight classifications of a program so that if a viewer pressed one of eight "viewer-direct-select" buttons on a remote control, he or she would be directed to a virtual channel airing a program having that classification. This function would permit a broadcaster to define classifications not anticipated by this standard and then permit the viewer to be directed to programs or segments having those classifications.
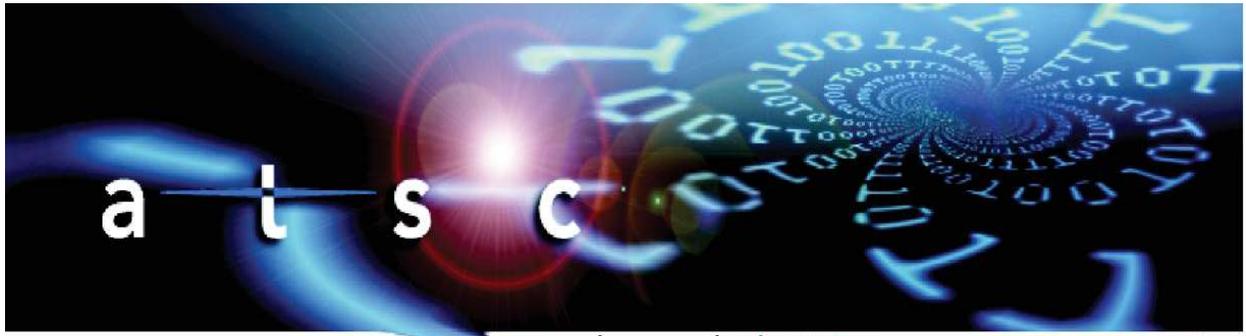
L.2.9 Arriving/Departing Request

Two additional Directed Channel Change request actions are specified:
- A Departing Request descriptor may be used within a DCC signal the occurrence of a departing request or to cause a text box to appear for a definable amount of time prior to performing a channel change requested by the viewer. The text box may be used by the broadcaster to present information to the viewer, such as plot elements remaining in the program or upcoming segment schedule information.
- An Arriving Request descriptor may be used to signal the occurrences of an arriving request or cause a text box to appear for a definable amount of time upon arrival at a newly tuned virtual channel. For example, the text box may be used by the broadcaster to convey story line information up to this point in time, or even program schedule change or preemption information such as a program delayed announcement due to the previous or current program running long.

L.3 DOWNLOADABLE SELECTION CODE TABLE

Through an optional downloadable table mechanism called the Directed Channel Change Selection Code Table, updated information may be delivered to DCC-capable DTV reference receivers over the broadcast link.