

A Broadcasters' Guide to PSIP

1. INTRODUCTION

Although proper implementation of the DTV *Program and System Information Protocol* (better known as PSIP) at the television station level is not particularly complex, neither is it straightforward. It has come to the attention of the ATSC that implementation concerns at the station level need to be addressed in a simplified form relative to PSIP Standard A/65A. To this end, the ATSC is developing a draft Recommended Practice to explain the operator-oriented elements of PSIP and to provide practical examples of typical station operation. The draft document is also intended to provide guidelines for designers of PSIP-related hardware and software to optimize user interface information for such equipment.

The draft PSIP Recommended Practice was being balloted at the Technology Group level as this issue of *BE* went to print. Final approval of the document as an ATSC Recommended Practice could come as early as April. This article is based on the findings of the specialist group responsible for PSIP development. Please keep in mind that some substantive changes could be made before the Recommended Practice is finalized.

1.1 Inside PSIP

PSIP is the glue that holds the digital television signal together. Although PSIP is a voluntary standard of the ATSC and only parts of the standard are required¹ by the Federal Communications Commission (FCC), it is—in fact—a requirement in terms of actual real-world operation. In most locations, multiple DTV stations can be received—and in some cases, from multiple markets. The PSIP protocol was developed with these real-world situations in mind.

PSIP is a small collection of tables designed to operate 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 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, and the program data provides necessary information for efficient browsing and event selection. Some tables announce future events and some are used to locate the digital streams that make up an event. The PSIP data are carried via a collection of hierarchically arranged tables. Figure 1 shows the primary components and the notation used to describe them. The base tables are:

- System Time Table (STT)
- Rating Region Table (RRT)
- 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.

¹ On January 18, 2001, the FCC issued its first Report and Order on Cable Carriage of DTV (Docket 98-120) which in paragraph #83 requires carriage of PSIP data related to the primary video service if present. On the same day the R&O in Docket 00-39 (DTV review) of January 18, 2001, (paragraph #61) the FCC said the TSID must be unique and that the FCC will assign those numbers as a part of the licensing process at some future date.

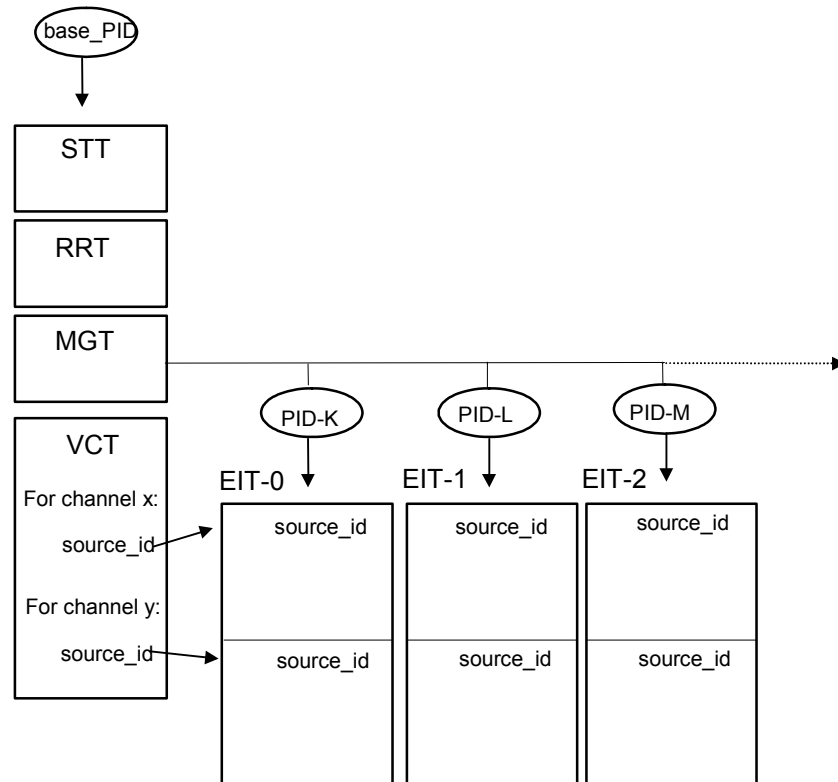


Figure 1 Overall structure of the PSIP tables.

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 United States, this is incorrectly but frequently referred to as the “V-chip” system; the proper title is Television Parental Guidelines (TVPG). Provisions have been made 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. This table is critically important as it contains the set of data that enables a receiver to tune and locate the service being broadcast. The VCT is essentially a list containing information about each service that a broadcaster creates or has announced that it will be created within the DTV major channel assignment, as well as information about the broadcaster’s associated analog channel.

There are several Event Information Tables, each of which describes the events or television programs associated with each of the virtual channels listed in the VCT. Each EIT is valid 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 must always be present in every transport stream, and 24 are recommended.

2. BASIC PSIP REQUIREMENTS FOR BROADCASTERS

The three main tables (VCT, EIT, 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 must change and the VCT is the table that must be accurate each instant as it provides the actual connection path. 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. 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.

There are certain “must have” items and “must do” rules of operation. If the PSIP elements are missing or wrong, there may be severe consequences, which will vary depending on the type of receiver. The following are key elements that must be set and/or checked by each station:

- **Transport Stream Identification (TSID).** The TSID must be set correctly in all three locations (PAT, VCT common information, and virtual channel-specific information).
- **System Time Table (SST).** The SST time should be checked daily and locked to house time. The wide tolerance in the standard is to allow for extreme conditions and ideally should be inserted into the TS within a few milliseconds after each seconds-count increment of the house time.
- **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.).
- **Major Channel.** In most cases, the previously assigned, paired NTSC channel is the major channel number.
- **Service Type.** The service type selects DTV, NTSC, audio only, data, etc., and must be set as operating modes require.
- **Modulation Mode.** This parameter must be set appropriately.
- **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.
- **Service Location Descriptor (SLD).** The contents of each component of the programs—including a language code for audio—should be confirmed as required. The PIDs identified here and in the PMT must be the same for the elements of an event/program. Some deployed systems require separate manual setup, but PIDs assigned to a VC should not change (unless there is a good reason).

The maximum cycle time/repetition rate of the tables should be set or confirmed to conform with the suggested guidelines given in Table 1 for mandatory PSIP tables and Table 2 for optional PSIP tables.

Table 1 Mandatory PSIP Table Suggested Repetition Rates

PSIP Table	Value
MGT	Once every 150 ms
TVCT	Once every 400 ms
EIT-0	Once every 0.5 seconds
EIT-1	Once every three seconds
EIT-2 and EIT-3	Once every minute
STT	Once every second

Table 2 Optional PSIP Table Suggested Repetition Rates

PSIP Table	Value	
DCC	A/65A specifies the following repetition rates for DCC per specified conditions. ¹	
	DCC in progress	150 msec
	5 seconds following DCC	150 msec
	10 seconds prior to DCC	400 msec
	More than 5 seconds after DCC	5000 msec
	No DCC	n/a
DCCSCT	Once per hour	
ETT	Once every minute	
EIT-4 and higher	Once every minute	
DET	A later version of this Recommended Practice will address data services.	

1. Considering that random access to a re-directed virtual channel must be supported, it is suggested that a repeat interval of 400 ms be maintained throughout the effective period of channel re-direction.

It is recommended that broadcasters set up a minimal set of three days of tables. The primary cycle time guidelines are illustrated in Figure 2.

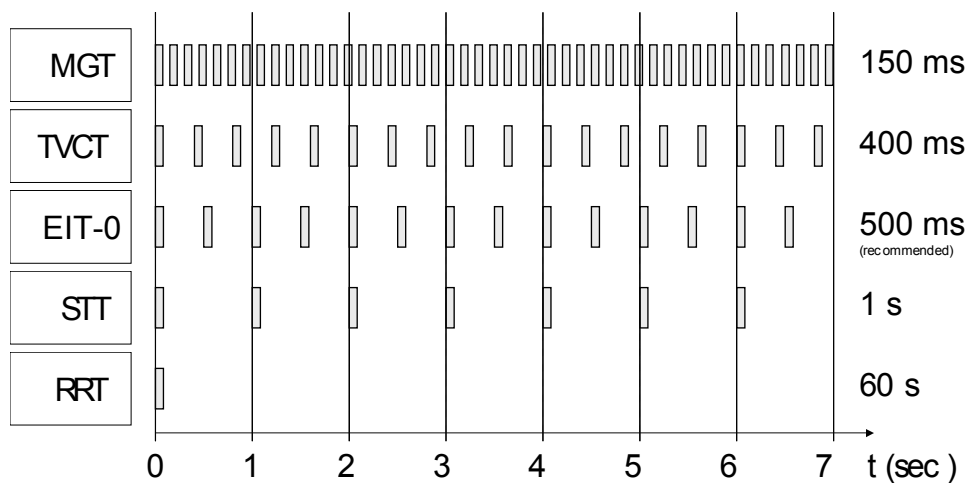


Figure 2 Recommended PSIP table cycle times.

The recommended table cycle times given here 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.

3. MOST COMMON MISTAKES

Experience has shown that certain errors are common in many PSIP implementations. These problems typically include the following:

- Missing tables, specifically 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 same in the three required places.
- System time missing or set to 00:00:00 on 1/6/1980

Some receivers react to these errors by not tuning to that station.

4. ABOUT THE VCT

There is *essential* station-specific VCT information that the broadcaster must input for viewers to be able to properly tune programs. This information is given in Table 3.

Table 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.)	2
minor channel numbers	Entered once.	1
analog and digital TSID	Entered once. (Assigned in consecutive pairs by the FCC during licensing of the new DTV assignment.)	1
service location descriptor	Entered once as pointers to each video, audio, and data stream.	2
source id	Entered once for each virtual channel or automatically generated.	7
service type	Entered once. (Tells the receiver whether the associated minor channel is providing digital or analog service.)	2
short name	Input once.	NABDT
modulation mode	Entered once for each virtual-minor number	0x04
carrier frequency	Recommend zero.	0
MPEG program number	Entered once for each virtual channel. The MPEG program number must be unique within the transport stream and shall not be zero.	1
ETM location	None	N/A
access controlled	yes/no	0
Hidden	yes/no	0
hide guide	yes/no	1

Because the VCT allows each minor channel to also be assigned a permanent short name and channel name, and since each minor channel will keep the same TSID, carrier frequency (zero or not), and modulation mode over time, the PSIP encoder system software should allow the user to create a local look-up table that associates each minor channel number with these fixed values so the user can then create new VCTs simply by entering the minor channel number of each desired minor channel to be put in the new VCT. The PIDs for each minor channel should not be

changed unless the nature of the virtual channel changes, as that is expected to increase the time it takes for the receiver to tune the station.

4.1 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 program on a new virtual channel is announced in the EIT, the PSIP standard requires that the VCT contain EIT VCT information, and vice versa. Because of this, it is recommended that broadcasters update the VCT first to reflect a change in the channel lineup and then 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. However, since a VCT normally describes the channels in the same transport stream, if virtual channels are added to the VCT at arbitrary times they will not be detected by the receiver until it is tuned to that particular transport stream. For this reason, it is highly recommended that channel addition be made in advance (with the *program_number* set to 0) to give receivers the opportunity to scan the frequencies and detect the channel presence. This is one reason for recommending three days of EITs be programmed for transmission. The system design assumes the receivers scan all RF channels at least once just after being turned off. Filling three days worth of EITs once a day should reduce the risk of not having information at the time of tuning to those sets which are never turned off or experience extended power outages.

5. EVENT INFORMATION TABLE

The Event Information Table (EIT) is the PSIP table that carries program schedule information for each virtual channel. MPEG-2 has a construct called a *program*, so 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 must go here)
- Caption service data (sometimes optional, but when present must go here)
- Audio service descriptor (required if audio is present)

Most of this data is provided ‘under the covers’ from other systems to the PSIP generator. The user just needs to enter what program is on when, and select the proper operating parameters.

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 PSIP Standard A/65A.

Daily updates of the EITs can be done for all programming, but the current EIT has some additional needs. It is strongly recommended that a daily update be done at or near the normal close of business and that this update have at least three days worth of station-correct programming announcements (24 EITs). As most receivers will be acquiring future EITs in the early morning hours while “off”, this enables receivers to miss one day of acquisition and still have the next days’ events. Adding one days’ worth of EITs will add about 1 kbps of data to the transport if the recommendations in this document are followed. It is desirable to send all 16 days worth of EITs to cover consumers’ setting of recorders during a vacation.

The EIT-0 has some special needs as it contains the closed caption, ratings information, and other essential data about the current program. The connection from master control 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.

All this information is carried in PSIP data packets called *descriptors*. It is recommended that at a minimum three descriptors be sent when needed:

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

6. MOVING FORWARD

The issues and specific suggestions relating to PSIP usage described in this report only scratch the surface of PSIP implementation. The draft ATSC Recommended Practice contains considerable detail on the various aspects of this important element of DTV station operation.