New Developments in System Information and Program Guide Standards

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In anticipation of North American broadcasters commencing digital transmissions in 1998, digital television standards work continued in earnest in 1997. In December, the Advanced Television System Committee (ATSC) adopted its newest standard, A/65, Program and System Information Protocol for Terrestrial Broadcast and Cable [(4)]. The ballot approval culminated over twelve months of work in the ATSC's T3/S8 Transport Documentation Specialists subcommittee with help from the Society of Cable Telecommunications Engineers (SCTE) Digital Video Subcommittee (DVS), where the standard was also approved by letter ballot in January. The acceptance of A/65 for use with both terrestrial broadcast and cable transmission media is a triumph for cooperative efforts in standards-setting and will facilitate interoperability between broadcast and cable as we move into the age of digital transmission.

This paper describes the new A/65 standard, beginning with the system functional requirements upon which it was based. An overview of the protocol is presented to give the reader a flavor of the features it provides. The relationship of A/65 to the prior ATSC standards for program guide and System Information, A/55 and A/56 respectively, is discussed. Finally, the use of A/65 on cable is explored.

OVERVIEW OF PROGRAM AND SYSTEM INFORMATION PROTOCOL (PSIP)

The ATSC A/65 *Program and System Information Protocol (PSIP) for Terrestrial Broadcast and Cable* is a standard method for delivery of program guide and system data tables carried in any compliant MPEG-2 multiplex. 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. Use of A/65 is mandatory for digital terrestrial broadcasts in North America, and it is expected that cable operators will support it as well to support cable-ready digital televisions and VCRs.

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 and EIA—the 66-72 MHz band. The situation changes, however, with advent of digital transmission—digital broadcasters will now have the freedom to define channel numbers independently of the RF frequency used to carry the signal. PSIP (like the original A/56) is architected 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 (VCT). So, when an end-user selects "channel 4" she is actually selecting the channel record associated with user channel number 4. The definition of the channel as given in the VCT includes its frequency and method of modulation, textual name, channel type (analog audio/video, digital a/v, audio only, data), and the channel number the user may use to access it.

The A/65 protocol introduces a new 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 EIA/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.

A/65 also standardizes the digital equivalent of the V-chip content advisory data now included in analog broadcasts in EIA-608A XDS packets. PSIP delivers a Rating Region Table (RRT) 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.

SYSTEM FUNCTIONAL REQUIREMENTS

US broadcasters were aware in early 1997 that the ATSC *Digital Television Standard* as written did not completely meet all of their needs. While they recognized the importance of providing program guide data along with digital broadcast programming, the standard indicated that use of the ATSC program guide standard (A/55) was "optional." Likewise, though the ATSC standard suite included the A/56 *System Information* standard that defined network data tables for various transmission media, use of A/56 for broadcast was also optional. In the case of SI, broadcasters were not even sure they had any use at all for the network data it provided. After all, they felt, receivers already know the standard 6 MHz frequency plan, and the MPEG-2 *Systems* standard itself defines ways of labeling the various parts of a digital multiplex that make up each service.

Early in 1997, the problem of finalizing program guide and navigation issues was assigned by ATSC to its T3/S8 Transport Documentation Specialists group. In May, the ATSC T3/S8 group began focusing on system functional requirements for what they coined the "Naming, Numbering and Navigation," or "N^3," problem.

The following presents the basic set of system functional requirements T3/S8 adopted as their starting point:

1. **Must support direct access to any channel.** The navigational model must support the ability to access any analog or digital channel by direct entry of its channel number or call letters.

R1. **Must 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 must include a grouping concept to support channel surfing within a set of related analog and digital channels.

R2. **Must preserve channel branding.** When a broadcaster begins a digital service, the system must allow him to associate the new programming with the channel label he has used in past years of advertising.

R3. **Must be harmonized with cable standards.** The chosen solution for broadcast N^3 must recognize that cable set-tops and cable-ready receivers will also employ navigational and channel naming methods. These must work in harmony with methods defined for terrestrial broadcast.

R4. **Must 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 must accommodate the wide variety of service structures possible via digital transport.

R5. **Must 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 of SDTV bandwidth to a college or community access channel, or to a government affairs (city politics) channel. It must be possible for that operator to label that channel separately from the other services he offers on that 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 EIA RF channel number he uses to transmit them. In other words, cable would use a "virtual channel" scheme. Each cable operator must be free to use whatever frequency slot he 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, he should be able to label it the same as the broadcaster does for televisions that receive it directly off-air.

At first glance, this arrangement might seem obvious. After all, most cable operators place each local broadcast channel at the same channel number which the broadcaster uses for his terrestrial broadcast. But consider that the cable operator may wish to take advantage of the faster data rate available when the digital signal is delivered on cable: 8-VSB modulation provides an information rate of about 19 Mbps, while 64-QAM modulation on cable allows 43% more bits at 27 Mbps. With 256-QAM modulation, the available data rate is double that of the terrestrial rate: 38.8 Mbps. The operator may wish to add together two broadcast multiplexes into a high-rate transport stream QAM modulated in a single 6 MHz frequency band. Despite this remultiplexing, any standard receiver connected to the cable must be able to determine how to present all the services to the user, and to promote ease of use, it should be able to label them consistently with their broadcast versions.

Lastly, two requirements were identified specific to terrestrial broadcasting. First, the system must accommodate terrestrial broadcast translators. Broadcasters don't want to have to re-process SI or the program guide data if they transmit the same MPEG-2 Transport Stream (TS) 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. For example, the receiver may be in the back of an RV traveling across the country.

THE PSIP SOLUTION

The A/65 PSIP standard 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 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 Digital Video Subcommittee (DVS) of SCTE was invited to participate in the development of the standard from the beginning and contributed important technical input. DVS voted and approved PSIP (as its document DVS-097) in January, 1998.

  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 (Ref. [(5)]) 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* [(1)] which mandated the use of the so-called "program paradigm" for broadcast television. (See *The "Program Paradigm"* below for a discussion of the program paradigm and why ATSC is moving to delete it from the ATSC standard).
- **Separate packaging of services**—PSIP states that for the US, in addition to using the major channel number that matches his analog broadcasting license for some services, a broadcaster may label one or more virtual channels on his multiplex with major channel numbers in the 70-99 range. Certain conditions must be met, however: assignment of major channel numbers must 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. Once the value of this feature is recognized, one might guess that the FCC would be called upon to coordinate such regional number assignments.
- **Cable virtual channels**—The requirement is met because PSIP is based on the virtual channel concept. The more significant aspect is that digital terrestrial broadcasting is now also based on virtual channels.
- **Broadcast translators—**If a digital broadcast is shifted in frequency at a translator, all SI and EPG information it carries remains correct except for frequency references. As it happens, even though carrier frequency information is included in the SI tables, a receiver can operate without it (or, more likely, compensate for frequency errors it might find). The techniques involved are discussed in *Identifying the Signals* below.
- **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 milliseconds. 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.

THE PROGRAM AND SYSTEM INFORMATION PROTOCOL— USER'S VIEWPOINT

Looking at it from a broad perspective, PSIP is a standard method for delivering the data that a digital TV or cable box needs to support basic navigation among digital services. The term "navigation" is used in this context to mean the process of discovering where one is; moving in the desired direction; and then reaching the desired destination within what could be an ocean of digital and analog service offerings.

The "Where am I?" question is answered in two ways by PSIP: a channel number and channel name. PSIP provides labels, with both a name and a two-part channel number, for each digital service offering. The answer might then be "I am watching WXYZ on channel 7.3." PSIP also defines the name of the program currently on-air, so a further answer can be "I am watching *Geraldo*."

The "Where am I going?" question in the context of TV watching might be re-phrased "where do I go when I hit the CHANNEL UP button?" PSIP organizes channels into groups by means of the two-part virtual channel numbering scheme: channels are sorted for navigation first by the group associated with their common major channel number and, within each group, the minor channel number. With this sorting, CHANNEL UP is expected to take a user to the next (higher) channel number within the sorted list of all channel numbers known to the receiver.

PSIP helps with the "How can I get where I want to go?" question also, by providing two mechanisms for travel to a known destination. In some cases, the user will know the destination by its channel number. Printed program guides such as what might be found in the newspaper will identify programs by their local channel number. If the channel number is known, the DTV or set-top box will likely support direct entry of the two-part number via the RCU as is done today with the single-part channel number.

Perhaps the most user-friendly way of getting to a destination is to interact with an Electronic Program Guide (EPG) application. PSIP provides the basic program title and schedule database the EPG uses to construct and display a program guide. A user can interact with the EPG to scroll through all the channels to find and select a program of interest.

THE TWO-PART CHANNEL NUMBER

We are all familiar with "TV channel numbers." For broadcast TV, we know VHF channels 2-13 and UHF channels 14-69. On cable, the numbers can range higher. Because it hasn't been seen before, the two-part channel number concept introduced by PSIP is one that might take some getting used to by consumers. PSIP does not say anything about how consumer equipment will operate from the point of view of a user interface. It doesn't even suggest what punctuation character should be used as a delimiter between the major and minor channel numbers when they are displayed or printed. All this is left for the marketplace, or popular opinion, to decide.

One might conclude that the Remote Control Unit (RCU) or TV front panel might require a new key: the "dash" key, if that is the preferred delimiter. In fact, options are possible that don't involve adding a new key. For example, the ENTER key found on many RCUs could be used to switch modes between entry of the major and minor numbers.

Another possibility worth considering was suggested to the ATSC T3/S8 committee by TeleTV: the use of a cluster of arrow keys on the RCU: "↑" "↓" "←" and "→". The up and down arrows would take the user from one channel group to the next (increment/decrement the major channel number), while the left/right arrows would allow navigation within the group (increment/decrement the minor channel number.

With this scheme, a mental model is formed of a two-dimensional "space" in which one navigates. In the following figure, three channel groups are shown, for major channels 6, 7 and 9. If the current channel is 7.2, an UP arrow would take the user to a channel in the 9 group (probably the most recently viewed channel in that group, though other methods are possible).

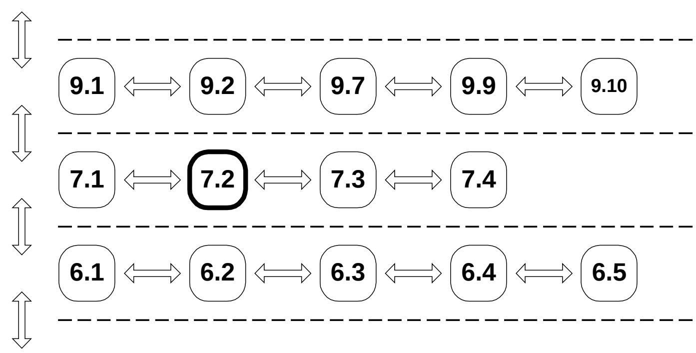

Figure 1. Example of Two-Dimensional Navigation

Entry of a left arrow from 7.2 would take the user down one minor channel to 7.1. A second left arrow would take the user either around to 7.4, or down to the highest minor channel in the next-lowest group (channel 6.5 in this case). A mental model that supports the latter interpretation is that all the channels are sorted like chapters and pages within a book, where each chapter starts numbering again from one. Use of the left/right arrows is then analogous to paging through the book, while use of up/down arrows is analogous to jumping from chapter to chapter. User testing will be needed to determine the most acceptable user interface among the many possibilities.

WHY ARE CHANNEL MAPS NEEDED?

Within the broadcaster community, the initial mindset was that channel mapping was not needed, and the extra complexity wasn't 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: tell the TV "47" and it will tune to the channel band assigned to channel 47 and acquire the program.

When the ATSC recognized that Standard Definition (SD) formats were possible and desirable, they acknowledged that a method was needed for selection of just one program in the multiplex. MPEG-2 *Systems* provides data called Program Specific Information (PSI) that included a parameter called a "program number" that seemed to fit this purpose. They felt that the user could specify or enter the MPEG-2 program number directly.

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 will be 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, they 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 following is a concrete example. Let's say one broadcast multiplex is transmitted terrestrially on physical channel 27, and it consists of four SD program sources. The consumer equipment uses the FCC channel number and the MPEG program number to identify and select these sources. If MPEG program numbers 1, 2, 3 and 4 were used, to the consumer, the four sources would be identified as 27.1, 27.2, 27.3, and 27.4.

Now consider what could happen at a cable headend. The off-air signal from channel 27 could be received, and the cable operator might want to combine it with another off-air multiplex to make most efficient use of cable bandwidth. Perhaps he wishes to combine channel 27 with an off-air channel 39 that is also available. Channel 39 also has four SD program sources, and these want to be labeled 39.1, 39.2, 39.3, and 39.4. Let's say the cable operator will put the combined multiplex on cable channel 27.

If consumer equipment connected to the cable used the physical channel/MPEG program number method for labeling and identifying services, the channel 39 services would have to be accessed in some awkward way, such as at 27.10, 27.11, 27.12, and 27.13. Much consumer confusion would result.

So, since cable *must* use a virtual channel scheme, this scheme was promoted to ATSC for PSIP.

The argument for virtual channels that held the most sway with broadcasters, though, was 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 his new digital broadcasts. Maybe the broadcaster is known locally as "Channel 8," but now would have to use "channel 41" for the added digital services. Will he feel good about changing his logo to say "8/41"? Probably not. But what is worse, when a user sits in front of the TV and surfs channels, there are lots of channels between the old "8" and the new group of "41" channels. 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.

THE "PROGRAM PARADIGM"

The broadcasters also wished to use the "program paradigm," a method whereby the PID values used for audio and video were related algorithmically to the MPEG program number. Using the paradigm limits flexibility, however. If one is using the program paradigm, for example, it is not possible to define a channel that shares a video component with another channel and at the same time offers a different audio track (e.g. a different language or language rating). PSIP references the MPEG-2 service directly and thus doesn't incur such limitations. The ATSC Digital Television Standard (A/53) and the guide to its use (A/54) specify the use of the program paradigm, but ATSC now recognizes that it should be removed from the standard.

THE PSIP TABLES

The Program and System Information Protocol consists of six different kinds of tables: Master Guide Table (MGT), System Time Table (STT), Virtual Channel Table (VCT), Rating Region Table (RRT), Event Information Table (EIT), and Extended Text Table (ETT). The VCT comes in two flavors, one specifically for terrestrial broadcast called the Terrestrial Virtual Channel Table (TVCT) and the other for cable, the Cable VCT (CVCT). The following sections describe the functions of these tables in more detail.

All PSIP tables follow the same basic structure for data transport, conforming to the MPEG-2 Program Specific Information (PSI) private section data format. The "long form" syntax provides sectioning and versioning information, as well as a 32-bit CRC for robust error detection.

Like the predecessor A/56 SI protocol, all PSIP tables are extensible via the descriptor method popularized by

Europe's Digital Video Broadcasting (DVB) SI protocol. 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. This extensibility is analogous to the extensions that have been made recently to the EIA-608 Vertical Blanking Interval protocol to define new Extended Data Services (XDS) packets for various uses.

One hard-coded PID value is 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. The A/55 and A/56 protocols used PIDs 0x1FFD and 0x1FFC, respectively. Choice of a base PID that does not conflict with those used in other protocols makes it possible for dual-carriage of SI or program data, if it is ever necessary.

With ATSC's adoption of A/65, all ATSC-compatible digital broadcast television multiplexes must carry at least the following instances of PSIP tables:

- the Master Guide Table, repeated at a minimum rate of once every 150 msec;
- the System Time Table, repeated at a minimum rate of once per second;
- the Rating Region Table, repeated at a minimum rate of once each minute;
- the Terrestrial Virtual Channel Table repeated at a minimum rate of once each 400 msec.; and
- the first four Event Information Tables (representing twelve hours of program schedules).

Further EITs may be transmitted if a broadcaster wishes to provide program schedules beyond half a day. The recommended repetition rate of the EITs is twice per second.

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

The A/65 standard defers to SCTE for specification of data rates on cable, but does state that the MGT, STT, RRT, and cable VCT are required. Cable systems may elect to supply program guide data in a format other than PSIP's EIT/ETT.

Master Guide Table

The Master Guide Table (MGT) provides three important functions in PSIP. For each instance of a PSIP table, the MGT provides:

1. its physical location in the Transport Stream (PID);
2. the current version of the table instance; and
3. the length, in bytes, of each.

If a receiver monitors the MGT, it can look for the availability of updates to any table it may have stored. The MGT also indicates the amount of memory that must be allocated to store the updated table.

MGT is extensible such that it can, in the future, describe other types of tables that may be standardized. For example, the ATSC T3/S13 data broadcast standards group is working to define a Data Information Table (DIT) that provides schedules for data events analogous to program events found in the EIT. The MGT can easily describe location, version, and length of any instances of the DIT.

Virtual Channel Tables

The virtual channel tables in PSIP function identically to the VCTs found in the original A/56 SI standard. A Virtual Channel Table consists of one or more virtual channel definitions, where each channel is characterized by:

- the two-part (major/minor) channel number the user will use to access the service;
- its textual name (up to seven characters)[1];
- how the service is physically delivered (carrier frequency and modulation mode);
- its MPEG-2 program_number;
- its "source ID" (see below);
- the type of service (analog TV, digital TV, audio only, data);

Other data specific to each terrestrial virtual channel includes a flag that tells whether the service is access controlled or not, and an indication as to whether or not "extended text" is available to provide a textual description of the service.

The Cable Virtual Channel data structure is identical to the terrestrial version, but it defines a few bit fields that are reserved in the other. A cable virtual channel can be labeled "out of band," or "hidden." Hidden channels may be used by a cable operator for system tests—they are unavailable to a consumer unit but are accessible to test equipment. Some cable systems use out of band channels that are structured like MPEG-2 Transport Streams. The

[1] PSIP provides a descriptor mechanism to define longer channel names as needed.

Cable VCT can define a service physically carried on an out of band channel, if desired.

Descriptors

Any VCT record can include descriptors to further describe the service. PSIP 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.

Another descriptor, usable only for terrestrial broadcast, quotes the PIDs used by each elementary stream component, saving the receiver from having to get this information from the MPEG Program Map Table (PMT). 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.

Source ID

PSIP also makes use of the "source ID" concept introduced in the A/56 SI standard. A source ID is defined as a number that uniquely identifies a source of scheduled programming. PSIP introduces 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.

A national database has already been set up to assign unique source ID values for program sources in the US, so that in this case the "network" is nationwide. When using network-scoped source IDs, a supplier of program guide data can create EPG data in EIT or other formats that can be used as-is throughout the network. Program title and schedule data records are tagged with source ID which is linked to whatever the Virtual Channel Table defines as services available to a given receiver.

The source ID concept may find other uses as well, for example as part of a Uniform Resource Locator (URL) scheme that would be used to target a programming service. Much like Internet domain names in regular Internet URLs, such an URL does not need to concern itself with the physical location of the referenced service.

Event Information Tables

The Event Information Table (EIT) is the PSIP table that carries program schedule information for each virtual channel. 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)
- caption service data (optional)
- audio service descriptor, which can list available languages (optional)

Note that descriptive text blocks are not included in the EIT itself, but instead are delivered in a separate data structure, the Extended Text Table. Separating the text from the basic schedule data allows an operator to send text at a slower rate, if desired, to make more efficient use of bandwidth.

Extended Text Tables

Each instance of an Extended Text Table carries one text block. 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.

System Time Table

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

Like A/56, the STT in A/65 bases its reference for time of day on Global Positioning Satellite (GPS) time, which is measured in terms of seconds since the first week of January, 1980. This count increments monotonically, and hence can be used as a reliable and predictable timebase for specification of future times of action.

A receiver needs one other piece of information to derive Coordinated Universal Time (UTC)[2]: 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 savings time status (whether or not daylight savings time is in effect), and indicates the day of the month and the hour that the next transition will occur.

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[2] The international standards bodies couldn't agree on an acronym that reflected either English or French word order, so they chose one that reflected neither!

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 savings 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 can be delivered by the system operator.

The System Time data is required to be no less accurate than plus or minus four seconds, which will make a DTV receiver one of the most accurate timepieces in the household.

The Rating Region Table—V-chip for Digital Television

The last type of PSIP table is the Rating Region Table (RRT). 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," etc.

Once a receiver learns the dimensions and levels of a rating system it can do two things: 1) provide a user interface to allow the user to set limits on program content and; 2) 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 (the V-chip function).

PSIP does not define the actual dimensions and levels of any rating region; it provides the transport mechanism to deliver the table. Specification of the actual systems for each region will be left to future standardization efforts to decide. One would hope that a standard definition for the US region can be reached in a spirit of cooperation among all interested parties.

The RRT concept originated in A/56, in almost the identical format. PSIP provides two important improvements, however:

- in PSIP, the number of rating dimensions for any region can be very large, whereas in A/56 it was limited to six;
- for added flexibility, the values that define a dimension can be declared to be based on a graduated scale, or not, as appropriate.

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 country, only the US Rating Region will be applicable. For areas close to the national border, however, a Canadian or Mexican rating table may be sent in addition.

In the committee meetings, broadcasters in the US repeatedly voiced their concern that the US rating system should not change often, if ever. Many felt that the system was too flexible in supporting dynamic changes to the content advisory system. A compromise was reached in that the document states that, for the US region, a "next version" of the RRT cannot be sent. The implication is that once a decision is reached by US policymakers, it will not be rescinded or altered.

With regard to the content advisory system, the architects of PSIP envisioned unity among delivery systems as a clear goal. Consider that one program sent down the cable might have originated at a local station or network affiliate, while another might have been delivered by satellite to the headend. Each of these programs should carry program content advisory data using a common rating system so as to present a consistent system view to the cable subscriber.

The same point can also be made another way. Consider what would happen if broadcasters rated TV programs using one scheme (which included some information about maturity level and sexual, violence, language, and dialog content), while cable-originated programming was rated with a similar but different scheme. (This is the case today!) If the broadcaster and cable community can't agree on the meaning of "mild violence" for example, then PSIP would have to have two "Violence" dimensions, one for network TV programming and another for cable. Users would likely be confused and annoyed by the redundancy. The fear is that if a system is too difficult to use, it isn't used at all.

EXAMPLE OF PSIP TABLES

Figure 2 shows a very simplified view of the relationship between the PSIP tables (the ETT is not shown).

As indicated, 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.

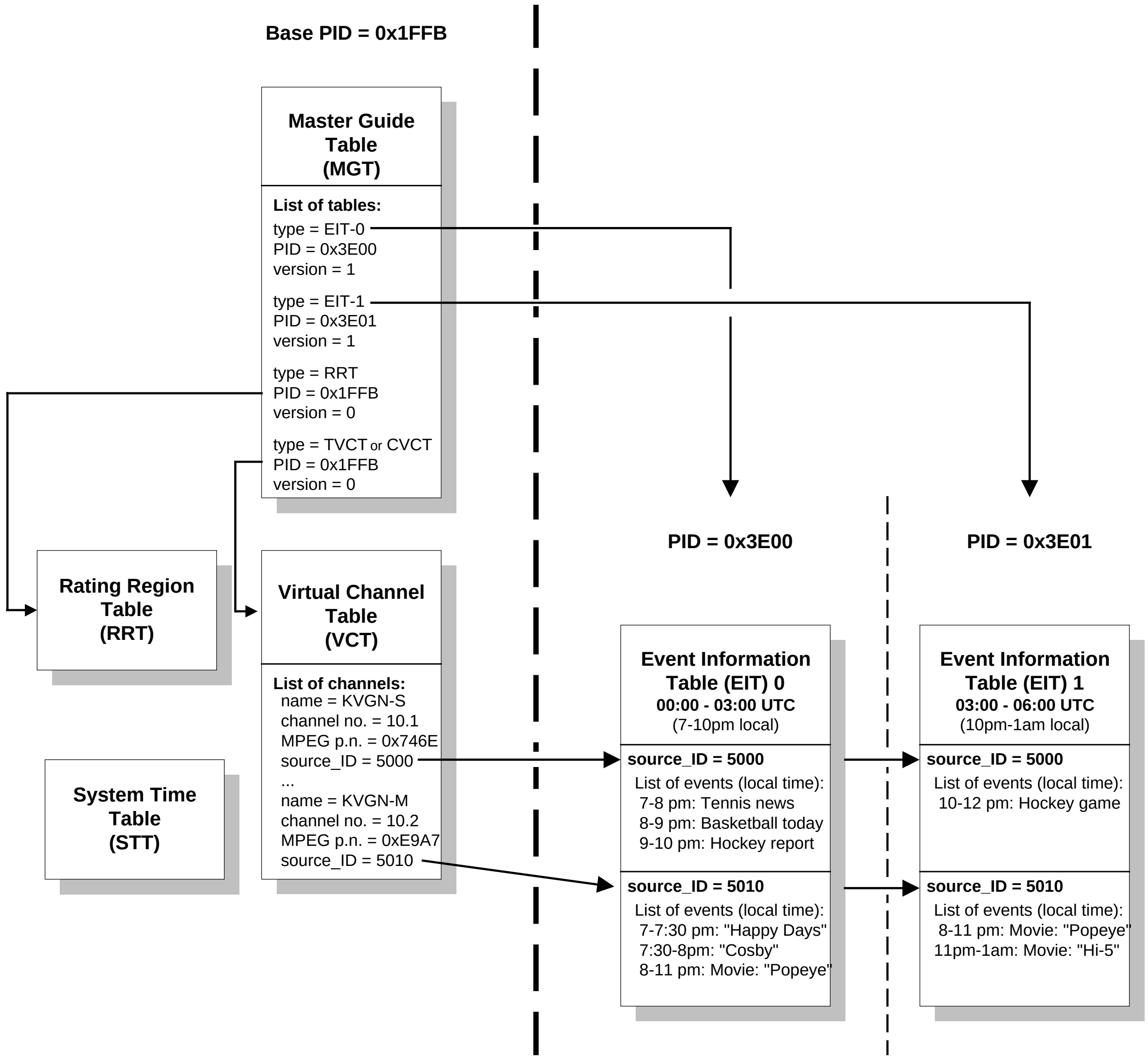

Figure 2. Relationship between PSIP tables

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

For cable use, the EIT and ETT are optional. Figure 3 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.

TEXT REPRESENTATION

Like the A/56 SI standard, PSIP uses Unicode character coding, and offers a similar method of Unicode character code page selection. But unlike A/55 or A/56, PSIP includes methods for text compression. Two Huffman encode/decode tables for English text are included in A/65. 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. These Huffman tables were provided to ATSC by General Instrument Corporation on an unlimited-use royalty-free basis. A compression efficiency approaching 2:1 can be expected.

Another difference between A/65 and A/56 relates to multilingual text support. In A/56, one would deliver separate instances of an SI table for each supported language. In PSIP, by contrast, the language selection occurs inside the text object itself. Any text block (channel description, program title, or program description) may be defined in one or more languages. Within a single EIT, a Spanish-language television channel, for example, might have all its program titles and descriptions given only in Spanish while the other channels in that same EIT are described only in English.

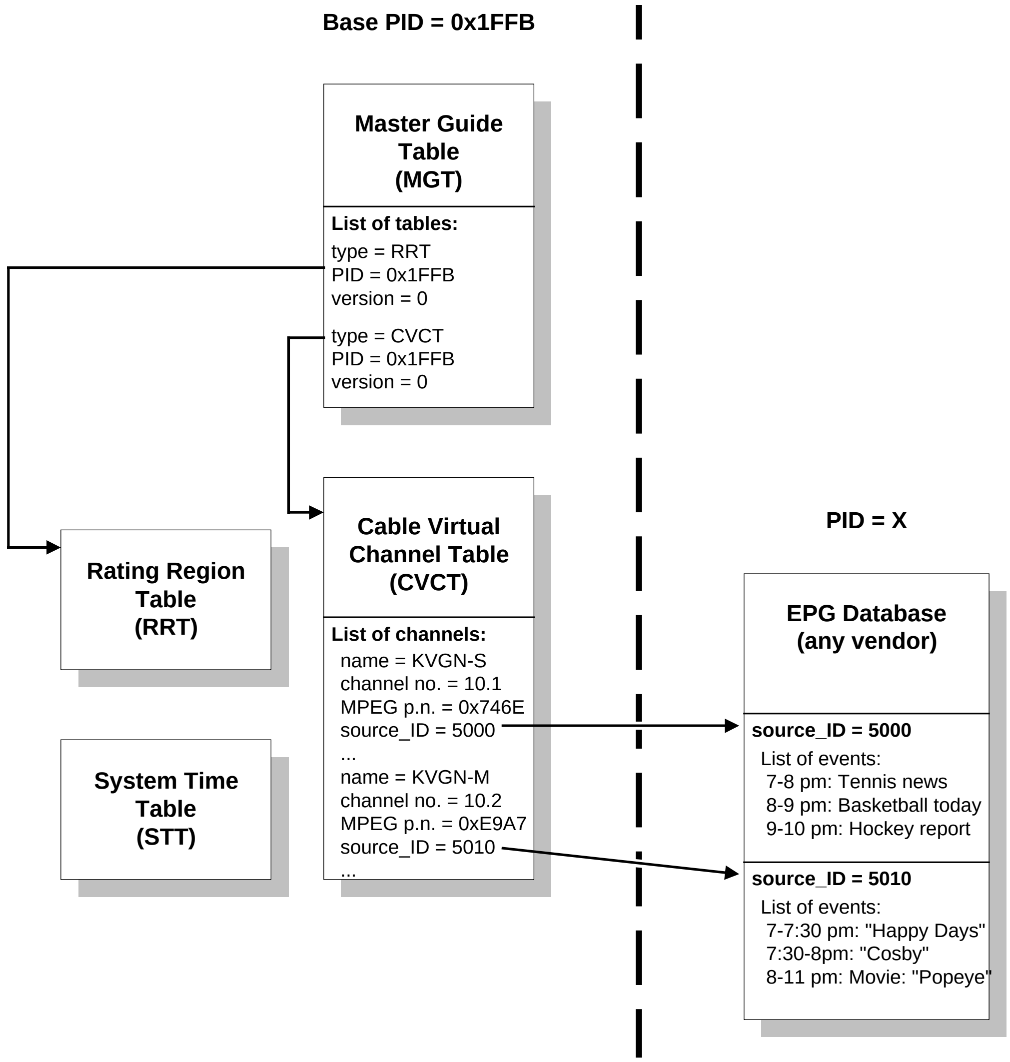

Figure 3. VCT for Cable Linked to a Proprietary EPG Database

IDENTIFYING THE SIGNALS

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 (TS).

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). PSIP indicates that, in the US, the FCC will allocate values of TSID to the broadcasters to ensure uniqueness. It is expected that Canada and Mexico will cooperate to use TSID values distinct from those assigned in the US. North America can be considered a "network" in the sense that TSID values must be unique within a network.

Analog signals, until recently, had no analogous identifying tag. As a result of the ATSC PSIP work, however, the EIA has now approved EIA-752 [(6)], an extension to the EIA-608 standard for NTSC VBI data which defines an analog Transmission Signal ID (the acronym is also TSID). This 16-bit number is also expected to be assigned by the FCC.

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. It will also very likely carry channel data and program guide information for the analog channel associated with the broadcast digital services. 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 virtually all cases a receiver won't be able to receive a signal other than the one referenced. That's because both the analog and digital transmitters are intended to serve the same geographic area. Receivers on the fringe areas or those with directional or movable antennas, however, may be able to pick up signals other than the one expected to be found at a given frequency. A check of TSID will allow the receiver to avoid incorrect displays of 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 even if the frequency data given in PSIP is incorrect. For example, a broadcast translator will shift the frequency of a transmitted signal. 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. The same logic applies for analog signals that have been moved to different carrier frequencies.

COMPARISON OF A/65 AND A/55-56

Some of the similarities and differences between the new A/65 standard and the predecessor SI and Program Guide standards A/55 and A/56 have already been mentioned. The following table summarizes similarities and differences.

Table 1. Comparision of A/55-56 with A/65 PSIP

Feature	A/55-56 SI/PG	A/65 PSIP
Table syntax	Mixture of MPEG long- and short-form syntax	Consistent use of long-form syntax; all tables use MPEG-2 sectioning and version control
PIDs used	A/55: 0x1FFD for MGT, plus others A/56: 0x1FFC for all Network data	PSIP uses 0x1FFB for MGT, VCT, RRT, and STT, plus others for EIT/ETT data
Text representation	A/55: ISO Latin-1, no compression A/56: Unicode based, no compression	Unicode, with two standard English language Huffman compression tables
Program rating system	A/55: hard-coded MPAA, sex, violence, and language ratings A/56: based on downloadable Rating Text Table (RTT) to define at most six dimensions	Rating system is downloadable via Rating Region Table (RRT); supports effectively unlimited number of rating dimensions
Content advisory data	A/55: included some content advisory data, not regionalized; no descriptor defined for content advisory data A/56: program rating descriptor was standardized in SCTE DVS-011	PSIP defines a descriptor usable in either the PMT or EIT; PSIP integrates content advisory data for individual programs (via PMT) with data for future programs (in EPG data)
System time	A/55: included time of day with daylight savings time indicated; A/56: included system time in GPS time format	Unified method for time representation throughout (GPS seconds); daylight savings time indication
Virtual channels	A/55: concept not present A/56: VCT is defined and utilized, with source ID linkage to EPG data	PSIP uses the A/56 VCT concept, including the source ID linkage to EPG data.

A/65 ON CABLE

Hundreds of thousands of General Instrument digital cable decoders have been deployed in North America by various cable operators conforming to the A/56 System Information standard. These decoders use an out-of-band (OOB) signaling channel to deliver network data (SI). At the current time, none of the in-band digital Transport Streams carry SI data or a Network PID.

Typical cable boxes use an out of band control channel for addressable control. The cable operator is thus afforded guaranteed access at all times to control or to update data tables in each box. SI or EPG data delivered on the OOB channel can flow at low data rates since 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 very high rate on the assumption that a receiver may not have had recent access to the data and needs to be refreshed as soon as possible.

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 as it is acquired and aggregate all the data into a larger channel map and EPG database. Digital cable-ready receivers and VCRs will most likely not be equipped to process out-of-band data, and will rely on in-band PSIP data for navigation. It appears likely that cable systems will move to include in-band PSIP data to support cable-ready consumer devices.

THE FUTURE

ATSC has recently finalized A/65 and already proposals for extending it are coming into the committees. As mentioned, the ATSC T3/S13 committee on data broadcasting standards is proposing a Data Information Table (DIT) analogous to the EIT, but for data “program events.” Another proposal to extend PSIP’s capabilities came in to the T3/S8 Transport Specialists group. The proponent wished to be able to target channel and program definitions to specific receivers, perhaps by their geographic location (via postal zip code, for example). This way, a broadcaster could better tailor programming to a target audience. Of course many variations are possible, and ATSC will have to find a procedural method to handle the many proposals that will be put on the table.

ACRONYMS

ATSC	Advanced Television Systems Committee
CVCT	Cable Virtual Channel Table
DIT	Data Information Table
DTV	Digital Television
DVB	Digital Video Broadcasting
DVS	Digital Video Subcommittee
EIA	Electronic Industry Association
EIT	Event Information Table
EPG	Electronic Program Guide
ETT	Extended Text Table
GPS	Global Positioning Satellite
MGT	Master Guide Table
MPAA	Motion Picture Assoc. of America
MPEG	Motion Picture Experts Group
PID	Packet Identifier
PMT	Program Map Table
PSI	Program Specific Information
PSIP	Program and System Information Protocol
QAM	Quadrature Amplitude Modulation
RCU	Remote Control Unit
RRT	Ratings Region Table
RTT	Ratings Text Table
SCTE	Society of Cable Telecommunications Engineers
SDTV	Standard Definition Television
SI	System or Service Information
SD	Standard Definition
STT	System Time Table
TSID	Transport Stream ID or Transmission Signal ID
TS	Transport Stream
TVCT	Terrestrial Virtual Channel Table
URL	Uniform Resource Locator
VBI	Vertical Blanking Interval
VCT	Virtual Channel Table
VSB	Vestigial Sideband

DOCUMENT REFERENCE

(1) ATSC A/53, ATSC Digital Television Standard, September 1995.

(2) ATSC A/55, Program Guide for Digital Television, January 1996.

(3) ATSC A/56, System Information for Digital Television, January 1996.

(4) ATSC A/65, Program and System Information Protocol for Terrestrial Broadcast and Cable, December 1997.

(5) ITU-T Rec. H.222.0 | ISO/IEC 13818-1:1996, Information Technology Generic coding of moving pictures and associated audio; Part 1: Systems.

(6) EIA-752, Transport of Transmission Signal Identifier (TSID) Using Extended Data Service (XDS).

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