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Working Draft Partitioning of ATSC Digital Television Standard (A/53) Revision E: Part 1 – Digital Television System

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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 Television 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.

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ATSC Digital Television Standard – Part 1: Digital Television System

1. SCOPE AND DOCUMENTATION STRUCTURE

The Digital Television Standard describes the system characteristics of the U. S. advanced television (ATV) system. The document and its normative Parts provide detailed specification of the parameters of the system including the video encoder input scanning formats and the pre-processing and compression parameters of the video encoder, the audio encoder input signal format and the pre-processing and compression parameters of the audio encoder, the service multiplex and transport layer characteristics and normative specifications, and the VSB RF/Transmission subsystem.

1.1 Documentation Structure

The documentation of the Digital Television Standard consists of this Part and several related Parts that provide a general system overview, a list of reference documents, and sections relating to the system as a whole. The system is modular in concept and the specifications for each of the modules are provided in other parts:

Part 1 – System (formerly the body, plus the former Annex F)

Part 2 – RF/Transmission System Characteristics (formerly Annex D)

Part 3 – Service Multiplex and Transport Subsystem Characteristics (formerly Annex C)

Part 4 – MPEG-2 Video System Characteristics (formerly Annex A)

Part 5 – AC-3 Audio System Characteristics (formerly Annex B)

Part 6 – High Efficiency Audio System Characteristics (formerly Annex G).

2. REFERENCES

2.1 Normative References

Specific normative references can be found in each Part of this Standard. In addition, the following normative references apply:

[1] ATSC Standard A/53-2:200x, “ATSC Digital Television Standard, RF/Transmission System Characteristics” [Document S9-301]

[2] ATSC Standard A/53-3:200x, “ATSC Digital Television Standard, Service Multiplex and Transport Subsystem Characteristics” [Document S8-625]

[3] ATSC Standard A/53-4:200x, “ATSC Digital Television Standard, MPEG-2 Video System Characteristics” [Document S6-399]

[4] ATSC Standard A/53-5:200x, “ATSC Digital Television Standard, AC-3 Audio System Characteristics” [Document S6-400]

[5] ATSC Standard A/53-6:200x, “ATSC Digital Television Standard, High Efficiency Audio System Characteristics” [Document S6-401]

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

2.2 Informative References

The Digital Television Standard is based on the ISO/IEC MPEG-2 Video Standard [15], the Digital Audio Compression (AC-3) Standard [7], and the ISO/IEC MPEG-2 Systems Standard [14]. Those references are listed here for the convenience of the reader. In addition, a guide to the use of the Digital Television Standard [8] is listed.

[7] ATSC A/52B: "Digital Audio Compression (AC-3)," Advanced Television Systems Committee, Washington, D.C., 14 June 2005.

[8] ATSC A/54A: "Guide to the Use of the ATSC Digital Television Standard," Advanced Television Systems Committee, Washington, D.C., 4 December 2003.

[9] ATSC A/65C: "Program and System Information Protocol for Terrestrial Broadcast and Cable," Advanced Television Systems Committee, Washington, D.C., 2 January 2006.

[10] ATSC Document A/90: "Data Broadcast Standard," Advanced Television Systems Committee, Washington, D.C., 2000.

[11] ATSC Document A/97: "Software Download Data Service," Advanced Television Systems Committee, Washington, D.C., 2004.

[12] ATSC A/110A: "Synchronization Standard for Distributed Transmission, Revision A," Advanced Television Systems Committee, Washington, D.C., 19 July 2005.

[13] ATSC "Code Point Registry," Advanced Television Systems Committee, Washington, D.C., 2005, http://www.atsc.org/standards/cpr.html.

[14] ISO/IEC IS 13818-1:2000 (E), International Standard, Information technology – Generic coding of moving pictures and associated audio information: systems.

[15] ISO/IEC IS 13818-2:2000 (E), International Standard, Information technology – Generic coding of moving pictures and associated audio information, video.

3. DEFINITIONS

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 shall be used [6]. Where an abbreviation is not covered by IEEE practice, or industry practice differs from IEEE practice, then the abbreviation in question will be described in Section 3.4 of this document. Many of the definitions included therein are derived from definitions adopted by MPEG.

3.1 Compliance Notation

As used in this document, "shall" denotes a mandatory provision of the standard. "Should" denotes a provision that is recommended but not mandatory. "May" denotes a feature whose presence does not preclude compliance, which may or may not be present at the option of the implementor.

3.2 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).

3.3 Terms Employed

For the purposes of the Digital Television Standard, the following definitions of terms apply:

ACATS – Advisory Committee on Advanced Television Service.

access unit – A coded representation of a presentation unit. In the case of audio, an access unit is the coded representation of an audio frame. In the case of video, an access unit includes all the coded data for a picture, and any stuffing that follows it, up to but not including the start of the next access unit. If a picture is not preceded by a group_start_code or a sequence_header_code, the access unit begins with a picture start code. If a picture is preceded by a group_start_code and/or a sequence_header_code, the access unit begins with the first byte of the first of these start codes. If it is the last picture preceding a sequence_end_code in the bit stream all bytes between the last byte of the coded picture and the sequence_end_code (including the sequence_end_code) belong to the access unit.

A/D – Analog to digital converter.

AES – Audio Engineering Society.

anchor frame – A video frame that is used for prediction. I-frames and P-frames are generally used as anchor frames, but B-frames are never anchor frames.

ANSI: American National Standards Institute.

Asynchronous Transfer Mode (ATM) – A digital signal protocol for efficient transport of both constant-rate and bursty information in broadband digital networks. The ATM digital stream consists of fixed-length packets called "cells," each containing 53 8-bit bytes—a 5-byte header and a 48-byte information payload.

ATM – See *asynchronous transfer mode*.

ATV – The U. S. advanced television system.

bidirectional pictures or **B-pictures** or **B-frames** – Pictures that use both future and past pictures as a reference. This technique is termed *bidirectional prediction*. B-pictures provide the most compression. B-pictures do not propagate coding errors as they are never used as a reference.

bit rate – The rate at which the compressed bit stream is delivered from the channel to the input of a decoder.

block – A block is an 8-by-8 array of pel values or DCT coefficients representing luminance or chrominance information.

bps – Bits per second.

byte-aligned – A bit in a coded bit stream is byte-aligned if its position is a multiple of 8-bits from the first bit in the stream.

channel – A digital medium that stores or transports a digital television stream.

coded representation – A data element as represented in its encoded form.

compression – Reduction in the number of bits used to represent an item of data.

constant bit rate – Operation where the bit rate is constant from start to finish of the compressed bit stream.

CRC – The cyclic redundancy check to verify the correctness of the data.

data element – An item of data as represented before encoding and after decoding.

DCT – See *discrete cosine transform*.

decoded stream – The decoded reconstruction of a compressed bit stream.

decoder – An embodiment of a decoding process.

decoding (process) – The process defined in the Digital Television Standard that reads an input coded bit stream and outputs decoded pictures or audio samples.

decoding time-stamp (DTS) – A field that may be present in a PES packet header that indicates the time that an access unit is decoded in the system target decoder.

discrete cosine transform – A mathematical transform that can be perfectly undone and which is useful in image compression.

DTS – See *decoding time-stamp*.

editing – A process by which one or more compressed bit streams are manipulated to produce a new compressed bit stream. Conforming edited bit streams are understood to meet the requirements defined in the Digital Television Standard.

elementary stream (ES) –A generic term for one of the coded video, coded audio, or other coded bit streams. One elementary stream is carried in a sequence of PES packets with one and only one stream_id.

elementary stream clock reference (ESCR) – A time stamp in the PES stream from which decoders of PES streams may derive timing.

encoder – An embodiment of an encoding process.

encoding (process) – A process that reads a stream of input pictures or audio samples and produces a valid coded bit stream as defined in the Digital Television Standard.

entropy coding – Variable length lossless coding of the digital representation of a signal to reduce redundancy.

entry point – Refers to a point in a coded bit stream after which a decoder can become properly initialized and commence syntactically correct decoding. The first transmitted picture after an entry point is either an I-picture or a P-picture. If the first transmitted picture is not an I-picture, the decoder may produce one or more pictures during acquisition.

ES – See *elementary stream*.

ESCR – See *elementary stream clock reference*.

event – An event is defined as a collection of elementary streams with a common time base, an associated start time, and an associated end time.

field – For an interlaced video signal, a "field" is the assembly of alternate lines of a frame. Therefore, an interlaced frame is composed of two fields, a top field and a bottom field.

forbidden – This term, when used in clauses defining the coded bit stream, indicates that the value shall never be used. This is usually to avoid emulation of start codes.

frame – A frame contains lines of spatial information of a video signal. For progressive video, these lines contain samples starting from one time instant and continuing through successive lines to the bottom of the frame. For interlaced video a frame consists of two fields, a top field and a bottom field. One of these fields will commence one field later than the other.

GOP – See *group of pictures*.

group of pictures (GOP) – A group of pictures consists of one or more pictures in sequence.

HDTV – See *high-definition television*.

High-definition television (HDTV) – High-definition television has a resolution of approximately twice that of conventional television in both the horizontal (H) and vertical (V) dimensions and a picture aspect ratio (H × V) of 16:9. ITU-R Recommendation 1125 further defines "HDTV quality" as the delivery of a television picture which is subjectively identical with the interlaced HDTV studio standard.

high level – A range of allowed picture parameters defined by the MPEG-2 video coding specification which corresponds to high definition television.

Huffman coding – A type of source coding that uses codes of different lengths to represent symbols which have unequal likelihood of occurrence.

IEC – International Electrotechnical Commission.

intra-coded pictures or **I-pictures** or **I-frames** – Pictures that are coded using information present only in the picture itself and not depending on information from other pictures. I-pictures provide a mechanism for random access into the compressed video data. I-pictures employ transform coding of the pel blocks and provide only moderate compression.

ISO – International Organization for Standardization.

ITU – International Telecommunication Union.

layer – One of the levels in the data hierarchy of the video and system specification.

level – A range of allowed picture parameters and combinations of picture parameters.

macroblock – In the advanced television system, a macroblock consists of four blocks of luminance and one each C_r and C_b block.

main level – A range of allowed picture parameters defined by the MPEG-2 video coding specification with maximum resolution equivalent to ITU-R Recommendation 601.

main profile – A subset of the syntax of the MPEG-2 video coding specification that is expected to be supported over a large range of applications.

Mbps – 1,000,000 bits per second.

motion vector – A pair of numbers which represent the vertical and horizontal displacement of a region of a reference picture for prediction.

MP@HL – Main profile at high level.

MP@ML – Main profile at main level.

MPEG – Refers to standards developed by the ISO/IEC JTC1/SC29 WG11, *Moving Picture Experts Group.* MPEG may also refer to the Group.

MPEG-2 – Refers to ISO/IEC standards 13818-1 (systems), 13818-2 (video), 13818-3 (Audio), 13818-4 (Compliance).

pack – A pack consists of a pack header followed by zero or more packets. It is a layer in the system coding syntax.

packet data – Contiguous bytes of data from an elementary data stream present in the packet.

packet identifier (PID) – A unique integer value used to associate elementary streams of a program in a single or multi-program transport stream.

packet – A packet consists of a header followed by a number of contiguous bytes from an elementary data stream. It is a layer in the system coding syntax.

padding – A method to adjust the average length of an audio frame in time to the duration of the corresponding PCM samples, by continuously adding a slot to the audio frame.

Part – A Part is an independently-maintainable portion of an ATSC document. It shares a common root document number with other Parts of the document.

payload – Payload refers to the bytes which follow the header byte in a packet. For example, the payload of a transport stream packet includes the PES_packet_header and its PES_packet_data_bytes or pointer_field and PSI sections, or private data. A PES_packet_payload, however, consists only of PES_packet_data_bytes. The transport stream packet header and adaptation fields are not payload.

PCR – See *program clock reference*.

pel – See *pixel*.

PES packet header – The leading fields in a PES packet up to but not including the PES_packet_data_byte fields where the stream is not a padding stream. In the case of a padding stream, the PES packet header is defined as the leading fields in a PES packet up to but not including the padding_byte fields.

PES packet – The data structure used to carry elementary stream data. It consists of a packet header followed by PES packet payload.

PES stream – A PES stream consists of PES packets, all of whose payloads consist of data from a single elementary stream, and all of which have the same stream_id.

PES – An abbreviation for packetized elementary stream.

picture – Source, coded, or reconstructed image data. A source or reconstructed picture consists of three rectangular matrices representing the luminance and two chrominance signals.

PID – See *packet identifier*.

pixel – "Picture element" or "pel." A pixel is a digital sample of the color intensity values of a picture at a single point.

PMT – Program Map Table. The collection of all the TS_program_map_section()s.

predicted pictures or **P-pictures** or **P-frames** – Pictures that are coded with respect to the nearest *previous* I- or P-picture. This technique is termed *forward prediction*. P-pictures provide more compression than I-pictures and serve as a reference for future P-pictures or B-pictures. P-pictures can propagate coding errors when P-pictures (or B-pictures) are predicted from prior P-pictures where the prediction is flawed.

presentation time-stamp (PTS) – A field that may be present in a PES packet header that indicates the time that a presentation unit is presented in the system target decoder.

presentation unit (PU) – A decoded audio access unit or a decoded picture.

profile – A defined subset of the syntax specified in the MPEG-2 video coding specification

program clock reference (PCR) – A time stamp in the transport stream from which decoder timing is derived.

program element – A generic term for one of the elementary streams or other data streams that may be included in the program.

program specific information (PSI) – PSI consists of normative data which is necessary for the demultiplexing of transport streams and the successful regeneration of programs.

program – A program is a collection of program elements. Program elements may be elementary streams. Program elements need not have any defined time base; those that do have a common time base and are intended for synchronized presentation.

PSI – See *program specific information*.

PTS – See *presentation time-stamp*.

PU – See *presentation unit*.

quantizer – A processing step which intentionally reduces the precision of DCT coefficients.

random access – The process of beginning to read and decode the coded bit stream at an arbitrary point.

reserved – This term, when used in clauses defining the coded bit stream, indicates that the value may be used in the future for Digital Television Standard extensions. Unless otherwise specified within this Standard, all reserved bits shall be set to "1".

SCR – See *system clock reference*.

scrambling – The alteration of the characteristics of a video, audio, or coded data stream in order to prevent unauthorized reception of the information in a clear form. This alteration is a specified process under the control of a conditional access system.

SDTV – See *standard-definition television*.

slice – A series of consecutive macroblocks.

SMPTE – Society of Motion Picture and Television Engineers.

source stream – A single, non-multiplexed stream of samples before compression coding.

splicing – The concatenation performed on the system level or two different elementary streams. It is understood that the resulting stream must conform totally to the Digital Television Standard.

standard-definition television (SDTV) – This term is used to signify a *digital* television system in which the quality is approximately equivalent to that of NTSC. This equivalent quality may be achieved from pictures sourced at the 4:2:2 level of ITU-R Recommendation 601 and subjected to processing as part of the bit rate compression. The results should be such that when judged across a representative sample of program material, subjective equivalence with NTSC is achieved. Also called standard digital television.

start codes – 32-bit codes embedded in the coded bit stream that are unique. They are used for several purposes including identifying some of the layers in the coding syntax. Start codes consist of a 24 bit prefix (0x000001) and an 8 bit stream_id.

STD input buffer – A first-in, first-out buffer at the input of a system target decoder for storage of compressed data from elementary streams before decoding.

STD – See *system target decoder*.

still picture – A coded still picture consists of a video sequence containing exactly one coded picture which is intra-coded. This picture has an associated PTS and the presentation time of succeeding pictures, if any, is later than that of the still picture by at least two picture periods.

system clock reference (SCR) – A time stamp in the program stream from which decoder timing is derived.

system header – The system header is a data structure that carries information summarizing the system characteristics of the Digital Television Standard multiplexed bit stream.

system target decoder (STD) – A hypothetical reference model of a decoding process used to describe the semantics of the Digital Television Standard multiplexed bit stream.

time-stamp – A term that indicates the time of a specific action such as the arrival of a byte or the presentation of a presentation unit.

transport stream packet header – The leading fields in a Transport Stream packet up to and including the continuity_counter field.

variable bit rate – Operation where the bit rate varies with time during the decoding of a compressed bit stream.

VBV – See *video buffering verifier*.

video buffering verifier (VBV) – A hypothetical decoder that is conceptually connected to the output of an encoder. Its purpose is to provide a constraint on the variability of the data rate that an encoder can produce.

video sequence – A video sequence is represented by a sequence header, one or more groups of pictures, and an end_of_sequence code in the data stream.

8 VSB – Vestigial sideband modulation with 8 discrete amplitude levels.

16 VSB – Vestigial sideband modulation with 16 discrete amplitude levels.

3.4 Symbols, Abbreviations, and Mathematical Operators

The symbols, abbreviations, and mathematical operators used to describe the Digital Television Standard are those adopted for use in describing MPEG-2 and are similar to those used in the "C" programming language. However, integer division with truncation and rounding are specifically defined. The bitwise operators are defined assuming two's-complement representation of integers. Numbering and counting loops generally begin from 0.

3.4.1 Arithmetic Operators

+	Addition.
–	Subtraction (as a binary operator) or negation (as a unary operator).
++	Increment.
- -	Decrement.
* or ×	Multiplication.
^	Power.
/	Integer division with truncation of the result toward 0. For example, 7/4 and –7/–4 are truncated to 1 and –7/4 and 7/–4 are truncated to –1.
//	Integer division with rounding to the nearest integer. Half-integer values are rounded away from 0 unless otherwise specified. For example 3//2 is rounded to 2, and –3//2 is rounded to –2.
DIV	Integer division with truncation of the result towards –∞.
%	Modulus operator. Defined only for positive numbers.
Sign( )	Sign(x) = 1 $x > 0$

$= 0 \quad x == 0$

$= -1 \quad x < 0$

NINT ( ) Nearest integer operator. Returns the nearest integer value to the real-valued argument. Half-integer values are rounded away from 0.

sin Sine.

cos Cosine.

exp Exponential.

√ Square root.

$\log_{10}$ Logarithm to base ten.

$\log_e$ Logarithm to base e.

3.4.2 Logical Operators

|| Logical OR.

&& Logical AND.

! Logical NOT.

3.4.3 Relational Operators

> Greater than.

≥ Greater than or equal to.

< Less than.

≤ Less than or equal to.

== Equal to.

!= Not equal to.

max [,...,] The maximum value in the argument list.

min [,...,] The minimum value in the argument list.

3.4.4 Bitwise Operators

& AND.

| OR.

>> Shift right with sign extension.

>> Shift left with 0 fill.

3.4.5 Assignment

= Assignment operator.

3.4.6 Mnemonics

The following mnemonics are defined to describe the different data types used in the coded bit stream.

bslbf	Bit string, left bit first, where “left” is the order in which bit strings are written in the Standard. Bit strings are written as a string of 1s and 0s within single quote marks, e.g. ‘1000 0001’. Blanks within a bit string are for ease of reading and have no significance.
uimsbf	Unsigned integer, most significant bit first.

The byte order of multi-byte words is most significant byte first.

3.4.7 Constants

π 3.14159265359...

e 2.71828182845...

3.4.8 Method of Describing Bit Stream Syntax

Each data item in the coded bit stream described below is in bold type. It is described by its name, its length in bits, and a mnemonic for its type and order of transmission.

The action caused by a decoded data element in a bit stream depends on the value of that data element and on data elements previously decoded. The decoding of the data elements and definition of the state variables used in their decoding are described in the clauses containing the semantic description of the syntax. The following constructs are used to express the conditions when data elements are present, and are in normal type.

Note this syntax uses the "C" code convention that a variable or expression evaluating to a non-zero value is equivalent to a condition that is true.

while (condition) {
data_element
. . .
}
	If the condition is true, then the group of data elements occurs next in the data stream. This repeats until the condition is not true.

do {
data_element
. . . }
while (condition)
	The data element always occurs at least once. The data element is repeated until the condition is not true.

if (condition) {
data_element
. . .
}
	If the condition is true, then the first group of data elements occurs next in the data stream.

else {
data_element
. . .
}
	If the condition is not true, then the second group of data elements occurs next in the data stream.

for (i = 0;i<n;i++) {
data_element
. . .
}
	The group of data elements occurs *n* times. Conditional constructs within the group of data elements may depend on the value of the loop control variable *i*, which is set to zero for the first occurrence, incremented to 1 for the second occurrence, and so forth.

As noted, the group of data elements may contain nested conditional constructs. For compactness, the {} are omitted when only one data element follows.

data_element [ ]	data_element [ ] is an array of data. The number of data elements is indicated by the context.
data_element [n]	data_element [n] is the n+1th element of an array of data.
data_element [m] [n]	data_element [m] [n] is the m+1,n+1 th element of a two-dimensional array of data.
data_element [l] [m] [n]	data_element [l] [m] [n] is the l+1,m+1,n+1 th element of a three-dimensional array of data.
data_element [m..n]	data_element [m..n] is the inclusive range of bits between bit m and bit n in the data_element.

Decoders must include a means to look for start codes and sync bytes (transport stream) in order to begin decoding correctly, and to identify errors, erasures or insertions while decoding. The methods to identify these situations, and the actions to be taken, are not standardized.

3.4.8.1 Definition of bytealigned Function

The function bytealigned( ) returns 1 if the current position is on a byte boundary; that is, the next bit in the bit stream is the first bit in a byte. Otherwise it returns 0.

3.4.8.2 Definition of nextbits Function

The function nextbits( ) permits comparison of a bit string with the next bits to be decoded in the bit stream.

3.4.8.3 Definition of next_start_code Function

The next_start_code( ) function removes any zero bit and zero byte stuffing and locates the next start code.

This function checks whether the current position is byte-aligned. If it is not, 0 stuffing bits are present. After that any number of 0 bytes may be present before the start-code. Therefore start-codes are always byte-aligned and may be preceded by any number of 0 stuffing bits.

Table 3.1 Next Start Code

Syntax	No. of Bits	Format
next_start_code(){		
while(!bytealigned())		
zero_bit	1	'0'
while(nextbits()!='0000 0000 0000 0000 0000 0001')		
zero_byte	8	'00000000'
}		

4. SPECIFICATION AND CONSTRAINTS (NORMATIVE)

4.1 ATSC System Definition

The Parts referenced below consider the characteristics of the subsystems necessary to accommodate the services envisioned.

The Physical layer shall be as defined in Part 2 [1].

The Transport Layer shall be as defined in Part 3 [2].

The Video encodings shall be as defined in Part 4 [3].

The Audio encodings shall be as defined in Part 5 [4] or in Part 6 [5].

The Parts contain the required elements and some optional elements. Additional ATSC standards may define other required[1] and/or optional[2] elements.

[1] See A/65 [9].

[2] See A/110A [12].

4.2 Digital Television Services

Digital television services are defined and signaled in the transport. The currently defined Service Types are listed in Table 4.1.

The Service Types are identified with a field named service_type which has a length of 6 bits, ordered as bit serial, most significant bit first. Some Service Types and associated values are indicated in Table 4.1. Other parts of this Standard and other Standards may use this field and define Service Types (and the associated service_type value). The ATSC Code Points Registry [13] contains a complete list.

Table 4.1 Service Types

service_type	Meaning
0x00	[Reserved]
0x01	Analog Television
0x02	ATSC Digital Television
0x03	ATSC Audio
0x04	ATSC Data Only Service
0x05	ATSC Software Download Service
0x06-0x3F	[Reserved – see ATSC Code Points Registry[3]]

Note: For service_type values 0x04 and 0x05, please see [10] and [11] respectively.

5. SYSTEM OVERVIEW (INFORMATIVE)

The Digital Television Standard describes a system designed to transmit high quality video and audio and ancillary data over a single 6 MHz channel. The system can deliver reliably about 19 Mbps of throughput in a 6 MHz terrestrial broadcasting channel and about 38 Mbps of throughput in a 6 MHz cable television channel. This means that encoding a video source whose resolution can be as high as five times that of conventional television (NTSC) resolution requires a bit rate reduction by a factor of 50 or higher. To achieve this bit rate reduction, the system is designed to be efficient in utilizing available channel capacity by exploiting complex video and audio compression technology.

The objective is to maximize the information passed through the data channel by minimizing the amount of data required to represent the video image sequence and its associated audio. The objective is to represent the video, audio, and data sources with as few bits as possible while preserving the level of quality required for the given application.

Although the RF/transmission subsystems described in this Standard are designed specifically for terrestrial and cable applications, the objective is that the video, audio, and service multiplex/transport subsystems be useful in other applications.

5.1 System Block Diagram

A basic block diagram representation of the system is shown in Figure 5.1. According to this model, the digital television system can be seen to consist of three subsystems.

[3] See the ATSC "Code Point Registry" [13] for a complete list.

- Source coding and compression
- Service multiplex and transport
- RF/transmission

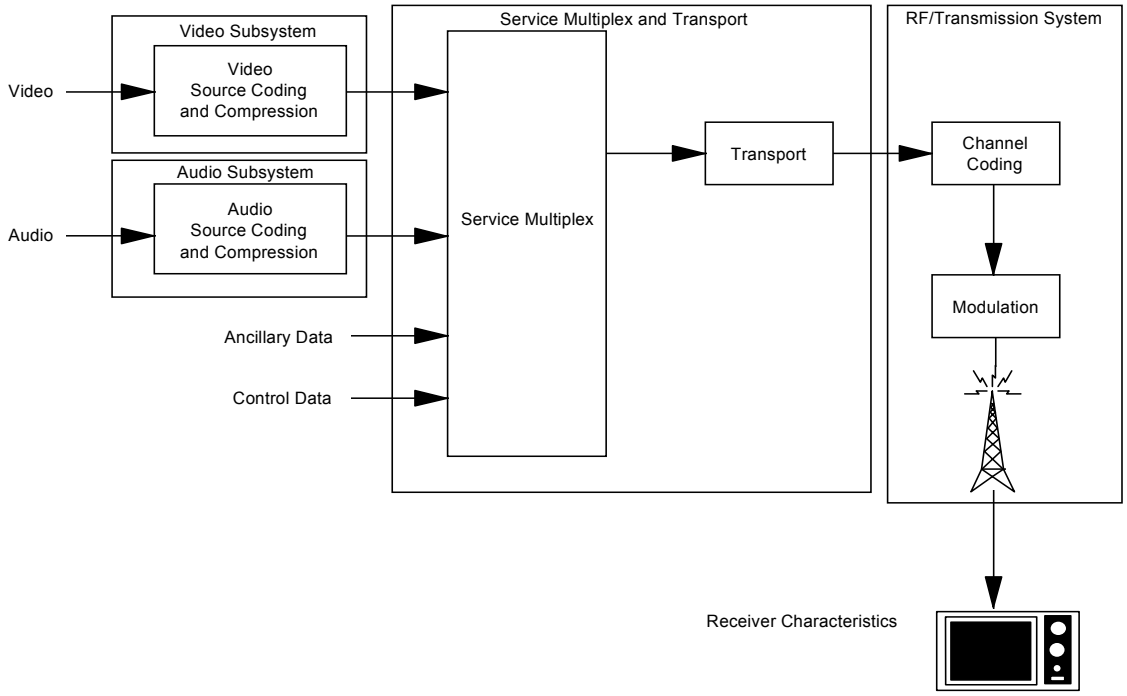

Figure 5.1 ITU-R digital terrestrial television broadcasting model.

"Source coding and compression" refers to the bit rate reduction methods, also known as data compression, appropriate for application to the video, audio, and ancillary digital data streams. The term "ancillary data" includes control data, conditional access control data, and data associated with the program audio and video services, such as closed captioning. "Ancillary data" can also refer to independent program services. The purpose of the coder is to minimize the number of bits needed to represent the audio and video information. The digital television system employs the MPEG-2 video stream syntax for the coding of video and the Digital Audio Compression (AC-3) Standard for the coding of audio.

"Service multiplex and transport" refers to the means of dividing the digital data stream into "packets" of information, the means of uniquely identifying each packet or packet type, and the appropriate methods of multiplexing video data stream packets, audio data stream packets, and ancillary data stream packets into a single data stream. In developing the transport mechanism, interoperability among digital media, such as terrestrial broadcasting, cable distribution, satellite distribution, recording media, and computer interfaces, was a prime consideration. The digital television system employs the MPEG-2 transport stream syntax for the packetization and multiplexing of video, audio, and data signals for digital broadcasting systems (ISO/IEC 13818-1) [14]. The MPEG-2 transport stream syntax was developed for applications where channel bandwidth or recording media capacity is limited and the requirement for an efficient transport

mechanism is paramount. It was designed also to facilitate interoperability with the ATM transport mechanism.

"RF/transmission" refers to channel coding and modulation. The channel coder takes the data bit stream and adds additional information that can be used by the receiver to reconstruct the data from the received signal which, due to transmission impairments, may not accurately represent the transmitted signal. The modulation (or physical layer) uses the digital data stream information to modulate the transmitted signal. The modulation subsystem offers two modes: a terrestrial broadcast mode (8-VSB), and a high data rate mode (16-VSB).

There are two subsystems within the system where a set of frequencies are related, the source coding subsystem and the channel coding (RF/transmission) subsystem. Those requirements are detailed in their respective Parts. The source coding clock and the symbol clock are not required to be frequency-locked to each other, and in many implementations will operate asynchronously. In such systems, the frequency drift can necessitate the occasional insertion or deletion of a null packet from within the transport stream, thereby accommodating the frequency disparity.

Annex A:
Historical Background (Informative)

1. FOREWORD

This Annex contains for historical reasons the background section that was originally published in A/53 on 16 December 1995.

2. HISTORICAL BACKGROUND

The Advanced Television Systems Committee, chaired by James C. McKinney, was formed by the member organizations of the Joint Committee on InterSociety Coordination (JCIC)[4] for the purpose of exploring the need for and, where appropriate, to coordinate development of the documentation of Advanced Television Systems. Documentation is understood to include voluntary technical standards, recommended practices, and engineering guidelines.

Proposed documentation may be developed by the ATSC, by member organizations of the JCIC, or by existing standards committees. The ATSC was established recognizing that the prompt, efficient and effective development of a coordinated set of national standards is essential to the future development of domestic television services.

On June 5, 1992, ATSC provided information to the Federal Communications Commission (FCC) outlining proposed industry actions to fully document the advanced television system standard. The FCC has recognized the importance of prompt disclosure of the system technical specifications to the mass production of advanced television system professional and consumer equipment in a timely fashion. The FCC has further noted its appreciation of the diligence with which the ATSC and the other groups participating in the standardization are pursuing these matters.[5]

Supporting this activity, the ATSC Executive Committee requested that the T3[6]/S1 Specialist Group on Macro Systems Approach meet and suggest which portions of an advanced television system broadcasting standard might require action by the FCC and which portions should be voluntary.

Subsequently, T3/S1 held meetings and developed recommendations in two areas:

1) Principles upon which documentation of the advanced television system should be based
2) A list of characteristics of an advanced television system that should be documented

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[4] The JCIC is presently composed of: the Consumer Electronics Association (CEA), the Institute of Electrical and Electronics Engineers (IEEE), the National Association of Broadcasters (NAB), the National Cable Television Association (NCTA), and the Society of Motion Picture and Television Engineers (SMPTE).

[5] FCC 92-438, MM Docket No. 87-268, "Memorandum Opinion and Order/Third Report and Order/Third Further Notice of Proposed Rule Making," Adopted: September 17, 1992, pp. 59–60.

[6] T3 is now known as TSG (Technology and Standards Group).

The list tentatively identified the industry group(s) that would provide the documentation information and the document where the information would likely appear.

The recommendations developed by the T3/S1 Specialist Group were modified by T3 to accommodate information and knowledge about advanced television systems developed in the period since June 1992. Some of the modifications to the recommendations ensued from the formation of the Grand Alliance. The modified guidelines were approved at the March 31, 1994, meeting of the T3 Technology Group on Distribution and are described in Section 4.4.

2.1 Advisory Committee on Advanced Television Service (ACATS)

A "Petition for Notice of Inquiry" was filed with the FCC on February 21, 1987, by 58 broadcasting organizations and companies requesting that the Commission initiate a proceeding to explore the issues arising from the introduction of advanced television technologies and their possible impact on the television broadcasting service. At that time, it was generally believed that high-definition television (HDTV) could not be broadcast using 6 MHz terrestrial broadcasting channels. The broadcasting organizations were concerned that alternative media would be able to deliver HDTV to the viewing public, placing terrestrial broadcasting at a severe disadvantage.

The FCC agreed that this was a subject of utmost importance and initiated a proceeding (MM Docket No. 87-268) to consider the technical and public policy issues of advanced television systems. The Advisory Committee on Advanced Television Service was empaneled by the Federal Communications Commission in 1987, with Richard E. Wiley as chairman, to develop information that would assist the FCC in establishing an advanced television standard for the United States. The objective given to the Advisory Committee in its Charter by the FCC was:

> "The Committee will advise the Federal Communications Commission on the facts and circumstances regarding advanced television systems for Commission consideration of technical and public policy issues. In the event that the Commission decides that adoption of some form of advanced broadcast television is in the public interest, the Committee would also recommend policies, standards, and regulations that would facilitate the orderly and timely introduction of advanced television services in the United States."

The Advisory Committee established a series of subgroups to study the various issues concerning services, technical parameters, and testing mechanisms required to establish an advanced television system standard. The Advisory Committee also established a system evaluation, test, and analysis process that began with over twenty proposed systems, reducing them to four final systems for consideration.

2.2 Digital HDTV Grand Alliance (Grand Alliance)

On May 24, 1993, the three groups that had developed the four final digital systems agreed to produce a single, best-of-the best system to propose as the standard. The three groups (AT&T and Zenith Electronics Corporation; General Instrument Corporation and the Massachusetts Institute of Technology; and Philips Consumer Electronics, Thomson Consumer Electronics, and the David Sarnoff Research Center) have been working together as the "Digital HDTV Grand

Alliance." The system described in this Standard is based on the Digital HDTV Grand Alliance proposal to the Advisory Committee.

2.3 Organization for Documenting the Digital Television Standard

The ATSC Executive Committee assigned the work of documenting the advanced television system standards to T3 specialist groups, dividing the work into five areas of interest:

- Video, including input signal format and source coding
- Audio, including input signal format and source coding
- Transport, including data multiplex and channel coding
- RF/Transmission, including the modulation subsystem
- Receiver characteristics

A steering committee consisting of the chairs of the five specialist groups, the chair and vice-chairs of T3, and liaison among the ATSC, the FCC, and ACATS was established to coordinate the development of the documents. The members of the steering committee and areas of interest were as follows:

- Stanley Baron T3 chair
- Jules Cohen T3 vice-chair
- Brian James T3 vice-chair
- Larry Pearlstein T3/S6 (video systems characteristics), chair
- Graham S. Stubbs T3/S7 (audio systems characteristics), chair
- Bernard J. Lechner T3/S8 (service multiplex/transport systems characteristics), chair
- Lynn D. Claudy T3/S9 (RF/transmission systems characteristics), chair
- Werner F. Wedam T3/S10 (receiver characteristics), chair
- Robert M. Rast Grand Alliance facilitator
- Robert Hopkins ATSC
- Robert M. Bromery FCC Office of Engineering and Technology
- Gordon Godfrey FCC Mass Media Bureau
- Paul E. Misener ACATS

2.4 Principles for Documenting the Digital Television Standard

T3 adopted the following principles for documenting the advanced television system standard:

1) The Grand Alliance was recognized as the principal supplier of information for documenting the advanced television system, supported by the ATSC and others. Other organizations seen as suppliers of information were EIA, FCC, IEEE, MPEG, NCTA, and SMPTE.
2) The Grand Alliance was encouraged to begin drafting the essential elements of system details as soon as possible to avoid delays in producing the advanced television system documentation.
3) FCC requirements for the advanced television system standard were to be obtained as soon as possible.

4) Complete functional system details (permitting those skilled in the art to construct a working system) were to be made publicly available.
5) Protection of any intellectual property made public must be by patent or copyright as appropriate.
6) The advanced television system documentation shall include the necessary system information such that audio and video encoders may be manufactured to deliver the system's full demonstrated performance quality.
7) The advanced television system documentation shall point to existing standards, recommended practices, or guideline documents. These documents shall be referenced in one of two ways as deemed appropriate for the application. In the first instance, a specific revision shall be specified where review of changes to the referenced document is required before changes might be incorporated into the advanced television system document. The second instance references the document without specificity to revision and allows any changes to the referenced documents to be automatically incorporated.
8) System specifications shall explain how future, compatible improvements may be achieved.
9) As ongoing improvements take place in the advanced television system, manufacturers of encoders and decoders should coordinate their efforts to insure compatibility.
10) The advanced television system standard must support backward compatibility of future improvements with all generations of advanced television system receivers and inherently support production of low cost receivers (not withstanding that cost reduction through reduced performance quality may also be used to achieve inexpensive products).
11) The advanced television system standard should not foreclose flexibility in implementing advanced television system receivers at different price and performance levels.
12) The advanced television system standard should not foreclose flexibility in implementing program services or in data stream modification or insertion of data packets by down-stream (local) service providers.
13) The advanced television system documentation shall address interoperability with non-broadcast delivery systems including cable.

The advanced television system standard shall identify critical system parameters and shall provide information as to the range of acceptable values, the method of measurement, and the location in the system where measurement takes place.

End of document