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Digital Video Broadcasting (DVB); Subtitling systems

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Foreword

This European Standard (Telecommunications series) has been produced by Joint Technical Committee (JTC) Broadcast of the European Broadcasting Union (EBU), Comité Européen de Normalisation ELECtrotechnique (CENELEC) and the European Telecommunications Standards Institute (ETSI).

NOTE: The EBU/ETSI JTC Broadcast was established in 1990 to co-ordinate the drafting of standards in the specific field of broadcasting and related fields. Since 1995 the JTC Broadcast became a tripartite body by including in the Memorandum of Understanding also CENELEC, which is responsible for the standardization of radio and television receivers. The EBU is a professional association of broadcasting organizations whose work includes the co-ordination of its members' activities in the technical, legal, programme-making and programme-exchange domains. The EBU has active members in about 60 countries in the European broadcasting area; its headquarters is in Geneva.

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Founded in September 1993, the DVB Project is a market-led consortium of public and private sector organizations in the television industry. Its aim is to establish the framework for the introduction of MPEG-2 based digital television services. Now comprising over 200 organizations from more than 25 countries around the world, DVB fosters market-led systems, which meet the real needs, and economic circumstances, of the consumer electronics and the broadcast industry.

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1 Scope

The present document specifies the method by which subtitles, logos and other graphical elements may be coded and carried in DVB bitstreams. The system applies Colour Look-Up Tables (CLUTs) to define the colours of the graphical elements. The transport of the coded graphical elements is based on the MPEG-2 system described in ISO/IEC 13818-1 [1].

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication and/or edition number or version number) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

[1] ISO/IEC 13818-1: "Information technology - Generic coding of moving pictures and associated audio information: Systems".

[2] ETSI EN 300 468: "Digital Video Broadcasting (DVB); Specification for Service Information (SI) in DVB systems".

[3] ITU-R Recommendation BT.601: "Studio encoding parameters of digital television for standard 4:3 and wide-screen 16:9 aspect ratios".

[4] ITU-R Recommendation BT.656-4: "Interfaces for digital component video signals in 525-line and 625-line television systems operating at the 4:2:2 level of Recommendation ITU-R BT.601 (Part A)".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

ancillary page: means of conveying subtitle elements that may be shared by multiple **subtitle services** within a **subtitle stream**

NOTE: For example, an ancillary page can be used to carry logos or character glyphs.

Colour Look-Up Table (CLUT): look-up table applied in each region for translating the objects' pseudo-colours into the correct colours to be displayed

CLUT-family: family of **CLUT**s which may consist of:

- one CLUT with 4 entries;
- one CLUT with 16 entries;
- one CLUT with 256 entries.

A CLUT-family is used in a region to define colours for decoders with different rendering capabilities.

NOTE: Three CLUTs are defined to allow flexibility in the decoder design. Not all decoders may support a CLUT with 256 entries, some may provide sixteen or even only four entries. A palette of four colours might be enough for graphics that are basically monochrome, like very simple subtitles, while a palette of sixteen colours allows for cartoon-like coloured objects or coloured subtitles with antialiassed edges.

composition page: means of conveying subtitle elements for one specific **subtitle service**

display set: set of **subtitle segments** of a specific **subtitle service** to which the same **PTS** value is associated

epoch: period of time for which the decoder maintains an invariant memory layout

NOTE: This layout may be altered by resets to the decoder state caused by receiving page composition segments with page state = "mode change". The end of an epoch therefore signals the "death" of a **page**. The epoch may, if so desired, be considered to be the highest level data structure in DVB subtitling.

object: graphical unit that can be positioned within a **region**; examples of an object include a character glyph, a logo, a map, etc.

NOTE: Each object has its own object_id.

Packet IDentifier (PID): Transport packet identifier

NOTE: See ISO/IEC 13818-1 [1].

page: Set of subtitles for a **subtitle service** during a certain period. A page consists of one or more **page instances**. Each page update or refresh will result in a new page instance. A page contains a number of **regions**, and in each region there may be a number of **objects**.

page composition: composition (use and positioning) of **regions** that may be displayed within the **page**

NOTE: At any new **page instance** the page composition may change; for example, some regions may not yet or no longer be displayed. At any one time, only one page composition can be active for displaying.

page instance: period of time during which that **page** does not change i.e. there is no change to the **page composition**, to any **region composition**, to any **object** within a **region** or any applicable **CLUT**

NOTE: Typically, a new page instance is defined by the **PTS** of a **display set**.

PES packet: See ISO/IEC 13818-1 [1].

pixel-data: string of data bytes that contains, in coded form, the representation of a graphical object

Presentation Time Stamp (PTS): See ISO/IEC 13818-1 [1].

region: rectangular area on the **page** in which **objects** can be positioned

NOTE: Regions may be shared by multiple **subtitling services** within the same **subtitle stream**. Objects that share one or more horizontal scan lines on the screen are included in the same region.

region composition: composition (use and positioning) of **objects** within a **region**

subtitle element: subtitle data used within a **page composition** and contained within a **subtitle segment**

NOTE: **Regions**, **region compositions**, **CLUTs** and **object** data are examples of subtitle elements.

subtitle segment: basic syntactical element of a **subtitle stream**

subtitle service: service that provides subtitling for a program for a certain purpose, such as subtitles in a specific language or for the hard of hearing

NOTE 1: A subtitle service is displayed as a series of one or more **pages.**

NOTE 2: Typically, a subtitle service meets a single communication requirement (e.g. the graphics to provide subtitles in one language for one program).

subtitle stream: stream of **subtitling segment**s carried in **transport packet**s identified by the same **PID**

NOTE: A subtitle stream contains one or more **subtitle services**.

transport packet: See ISO/IEC 13818-1 [1].

transport stream: stream of **transport packet**s carrying one or more MPEG programs

NOTE: See ISO/IEC 13818-1 [1].

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

bslbf	bit string, left bit first
Cb	Chrominance value
NOTE:	As defined in ITU-R Recommendation BT.601 [3], clause 7.2.3.
CLUT	Colour Look-Up Table
Cr	Chrominance value
NOTE:	As defined in ITU-R Recommendation BT.601 [3], see clause 7.2.3.
DVB	Digital Video Broadcasting
IRD	Integrated Receiver Decoder
MPEG	Moving Pictures Experts Group (WG11 in SC 29 of JTC1 of ISO/IEC)
PCR	Programme Clock Reference
PCS	Page Composition Segment
PES	Packetized Elementary Stream
NOTE:	As defined in ISO/IEC 13818-1 [1].
PID	Packet IDentifier
NOTE:	As defined in ISO/IEC 13818-1 [1].
PID	transport packet identifier
NOTE:	As defined in ISO/IEC 13818-1 [1].
PMT	Program Map Table
NOTE:	As defined in ISO/IEC 13818-1 [1].
PTS	Presentation Time Stamp
NOTE:	As defined in ISO/IEC 13818-1 [1].
RCS	Region Composition Segment
ROM	Read-Only Memory
T	Transparency value
TS	Transport Stream
NOTE:	As defined in ISO/IEC 13818-1 [1].
uimsbf	unsigned integer, most significant bit first
Y	luminance value
NOTE:	As defined in ITU-R Recommendation BT.601 [3], see clause 7.2.3.

4 Introduction to DVB subtitling system

The present document specifies the DVB subtitling system for the transport and coding of subtitles.

4.1 Overview

The DVB subtitling system defined in the present document provides a syntax for decoding **subtitle streams**. A subtitle stream conveys one or more **subtitle services**; each service containing the textual and/or graphical information needed to provide subtitles or glyphs for a particular purpose. Separate subtitle services may be used, for example, to convey subtitles in several languages.

Each subtitle service displays its information in a sequence of so-called **pages** that are intended to be overlayed on the associated video image. A subtitle page contains one or more **regions**, each region being a rectangular area with a specified set of attributes. These attributes include a region identifier, the horizontal and vertical size, pixel depth and background colour. A region is used as the background structure into which graphical **objects** are placed. An object may represent a character, a word, a line of text or an entire sentence; it might also define a logo or icon.

The use and positioning of objects within a region is defined by the **region composition segment**.

The use and positioning of regions within a page is defined by the **page composition segment**, in which a list of displayed regions is provided, each with their own spatial position. A page composition need not change when objects are added to or removed from a region. Furthermore regions may be declared but not used. By way of example one region can be used to display multiple subtitle fragments, as depicted in figure 1. First the text "Shall we?" is displayed in the region; subsequently this text is removed and the new text "Said the fly on the mirror" is displayed. It is possible to use more than one region at the same time; for example one region could be used to display subtitles on the bottom of the screen, while another one might be used to display a logo somewhere else on the screen.

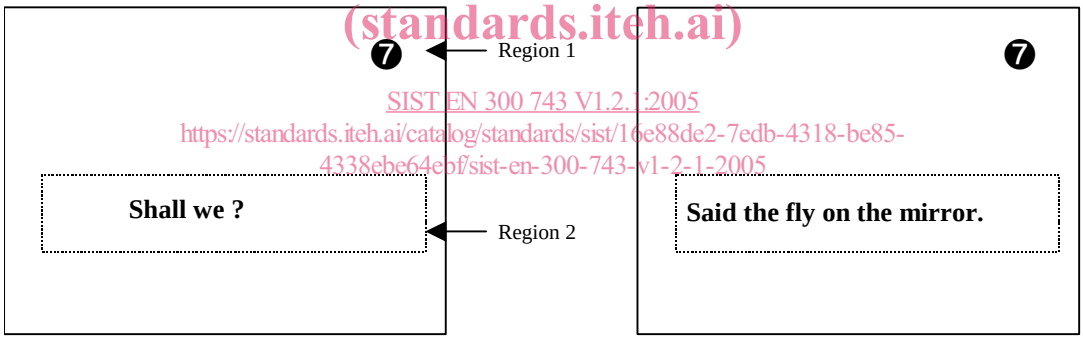

Figure 1: Two regions overlayed on top of video; one with a logo and another one with subtitles. The subtitles are positioned within the same region.

A DVB subtitle stream is carried in **PES packets** and the timing of their presentation is defined by the **PTS** in the PES header. Upon reception and decoding of the subtitle data for a page (such as the page composition, the region composition, the objects to be used and any other associated data) the page contents are displayed at the time indicated by the associated PTS. When objects are to be added, the decoder receives region composition updates and the data for the new objects, and will display the updated page at the time indicated by the new PTS. At the page update only page differences need be provided. To improve random access to DVB subtitling, a page refresh is also possible. At page refresh all the subtitling data needed to display a page is provided. Each page update or refresh will result in a new page instance. A page ceases to exist after the time-out of the page, or when a new page is defined.

To provide efficient use of display memory in the decoder the DVB subtitling system uses region based graphics with indexed pixel colours. Pixel depths of 2, 4 and 8-bits are supported allowing up to 4, 16 or 256 different pixel codes to be used in each region. Each region is associated with a single **CLUT** family to define the colour and transparency for each of the pixel codes. In most cases, one CLUT is sufficient to present correctly the colours of all objects in a region, but if it is not enough, the objects can be split horizontally into smaller objects across separate vertically adjacent regions with one CLUT each.

The use of CLUTs allows colour schemes to be dynamic. The colours that correspond to the entries within the region can be redefined at any suitable time, for instance in case of a CLUT with four entries from a black-grey-white scheme to a blue-grey-yellow scheme. Furthermore, a graphical unit may be divided into several regions each using a different CLUT, i.e. a different colour scheme may be applied in each of the regions. At the discretion of the encoder, objects designed for displays supporting 16 or 256 colours can be decoded into displays supporting fewer colours. A quantization algorithm is defined to ensure that the result of this process can be predicted by the originator. Use of this feature allows a single data stream to be decoded by a population of decoders with mixed, and possibly evolving, capabilities.

A subtitle stream may transport multiple subtitle service components. In this case the pages of one particular subtitle service are all identified by the same page-id value. This value is used when transporting the subtitling data so as to provide a mechanism to retrieve the data that is specific to a service from a subtitle stream. The subtitling system allows sharing of subtitling data between services within the same subtitle stream. A frequent *and often preferred* method is to convey the distinct services in different streams on separate **PID**s. In either case the appropriate PID, language and page-ids will be signalled in the program map table (**PMT)** for the television service of interest (language and page-id in the subtitling descriptor defined in DVB-SI [2]). These two approaches are illustrated in figure 2.

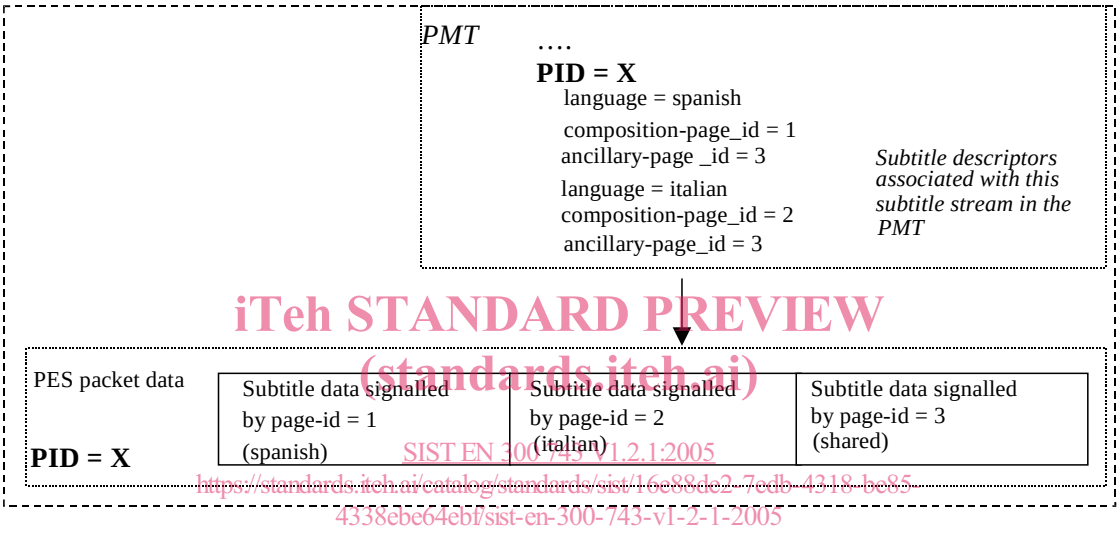

Figure 2a: Example of use of different page_ids to distinguish between different subtitle languages for the same service (shown with a shared ancillary page)

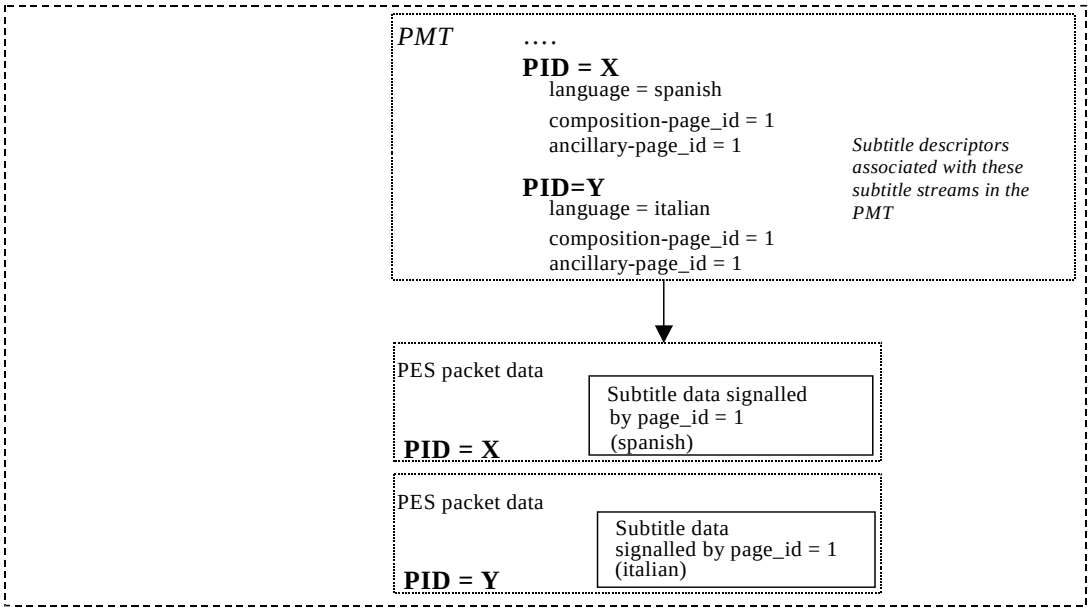

Figure 2b: Example of use of PIDs to distinguish between different subtitle languages for the same service (shown with no ancillary page)

Figure 2: Example of two ways of conveying dual language subtitles (one using shared data)

In summary, the DVB subtitling system provides a number of techniques that allow efficient transmission of the subtitling data:

- objects that occur more than once within a region need only be transmitted once, and then positioned multiple times within the region;
- objects used in more than one subtitle service need only be transmitted once;
- pixel data within objects are compressed using run-length coding;
- where the gamut of colours required for part of a graphical object is suitably limited, that part can be coded using a smaller number of bits per pixel and a map table. For example, an 8-bit per pixel graphical object may contain areas coded as 4 or 2-bits per pixel each preceded by a map table to map the 16 or 4 colours used onto the 256 colour set of the region. Similarly, a 4-bit per pixel object may contain areas coded as 2-bits per pixel;
- colour definitions can be coded using either 16 or 32-bits per CLUT entry. This provides a trade-off between colour accuracy and transmission bandwidth;
- only those CLUT values to be used need be transmitted.

The above features are fully supported within the DVB subtitling system.

In addition, functionality is provided to allow more efficient operation where there are private agreements between the data provider and the manufacturer of the decoder:

- objects resident in ROM in the decoder can be referenced;
- character codes, or strings of character codes, can be used instead of objects with the graphical representation of the character(s). This requires the decoder to be able to generate glyphs for these codes.

The private agreements required to enable these features are beyond the scope the present document.

4.2 Data hierarchy and terminology

The basic "building block" of a DVB subtitle stream is the **subtitling segment**. These segments are carried in **PES packets**, which are in turn carried by **transport packets**. The number of segments carried in a PES packet is only limited by the maximum length of a PES packet, as defined by ISO/IEC 13818-1 [1].

A subtitle stream shall be carried in transport packets identified by the same PID. A single subtitle stream can carry several different subtitle services. All the subtitling data required for a subtitle service shall be carried by a single subtitle stream. The different subtitle services can be subtitles in different languages for a common program. Alternatively, they could in principle be for different programs (provided that the programs share a common **PCR**).

Different subtitle services can also be supplied to address different display characteristics or to address special needs. For instance:

- different subtitle services might be provided for 4:3 and 16:9 aspect ratio displays;
- subtitle services might be provided specifically for viewers with impaired hearing. These may include graphical representations of sounds.

Within a subtitle stream, a page id value is assigned to each segment. Segments can either contain data specific for one subtitle service, or data that is to be shared by more than one subtitle service. The data for a subtitle service shall be carried in segments identified by at most two different page id values:

- one page id value signalling segments with data specific for that subtitle service; the use of this type of data is mandatory;
- one page id value signalling segments with data that may be shared by multiple subtitle services; the use of this type of data is optional.

For each subtitle service a subtitling_descriptor as defined in EN 300 468 [2] signals the page id values of the segments needed to decode that subtitle service. The subtitling descriptor shall be included in the PMT of the program and shall be associated to the PID that conveys the subtitle stream. In the subtitling descriptor the page id of segments with data specific to that service is referred to as the **composition page id**, while the page id of segments with shared data is referred to as the **ancillary page id**. For example, the ancillary page id might signal segments carrying a logo that is common to subtitles in several different languages.

The **PTS** in the PES packet header provides presentation timing information for the subtitling data, and is associated with the subtitle data in all segments carried in that PES packet. The PTS defines the time at which the associated decoded segments should be presented. This may include removal of subtitles, for example when an entire region is removed or when all objects in a region are removed. There may be two or more PES packets with the same PTS value, for example when it is not possible or desirable to include all segments associated to the same PTS in one PES packet.

The complete set of segments of a subtitle service that are associated to the same PTS is referred to as a **display set**. The last segment of a display set shall be followed by an "end_of-display-set segment", which signals that no more subtitling data associated to a certain PTS is needed for that service before decoding can commence. The display sets shall be delivered in their correct presentation-order, and the PTSs of subsequent display sets shall differ by more than one video frame period.

For carriage of multiple types of subtitling data, several segment types are defined, in particular:

- page composition segment; the decoding of a subtitle service will typically result in the display of subsequent pages, each consisting of one or more regions; the page composition segment carries information on the page composition, such as the list of included regions, the spatial position of each region, some time-out information for the page and the state of the page;
- region composition segment; in each region typically one or more objects are positioned, while using one specific CLUT, identified by a CLUT-id; the region composition segment carries information on the region composition and on region attributes, such as the horizontal and vertical size, the background colour, the pixel depth of the region, which CLUT is used and a list of included objects with their position within the region;
- CLUT definition segment; the CLUT definition segment contains information on a specific CLUT, identified by a CLUT-id, such as the colours used for a CLUT entry;
- object data segment; the object data segment carries information on a specific object; there are two types of objects, graphical objects and text objects. An object data segment with a graphical object contains run-length encoded bitmap colours, while a text object carries a string of one character codes;
- end of display set segment; the end of display set segment contains no internal information, but is used to signal explicitly that no more segments need to be received before the decoding of the current display set can commence.

The page id value of a segment containing data for a subtitle service shall be equal either to the value of the composition_page_id or the ancillary_page_id provided in the subtitle descriptor. Page compositions are not shared by multiple subtitle services; consequently, the page id of each page composition segment shall be equal to the composition_page_id value.

In summary, the data hierarchy is:

- Transport Stream (TS);
- transport packets with the same PID;
- PES packets, with PTSs providing timing information;
- subtitle service;
- segments signalled by the composition page id and optionally the ancillary page id;
- subtitle data, containing information on page composition, region composition, CLUTs, objects and end of display set.

4.3 Temporal hierarchy and terminology

At the segment level in the data hierarchy there is also a temporal hierarchy. The highest level is the epoch; in an epoch the page composition and the region composition may change - for example objects and regions may be added or removed. The concept of an epoch is analogous to that of an MPEG video sequence. No decoder state is preserved from one epoch to the next.

An epoch is a sequence of one or more page instances. Each page instance is a completed screen of graphics. Consecutive page instances may differ little (e.g. by a single word when stenographic subtitling is being used) or may be completely different. The set of segments needed to decode a new page instance is called a display set.

Within a display set the sequence of segments (when present) is:

- page composition;
- region composition;
- CLUT definition;
- object data;
- end of display set segment.

All segments signalled by the composition page id value shall be delivered before any segment signalled by the ancillary page id value. The ancillary page id value shall not signal page composition segments and region composition segments

5 Subtitle decoder model

The subtitle decoder model is an abstraction of the processing required for the decoding of a subtitle service within a subtitle stream. The main purpose of this model is to define requirements for compliant subtitling streams. The following figure shows the prototypical model of a subtitling decoder.

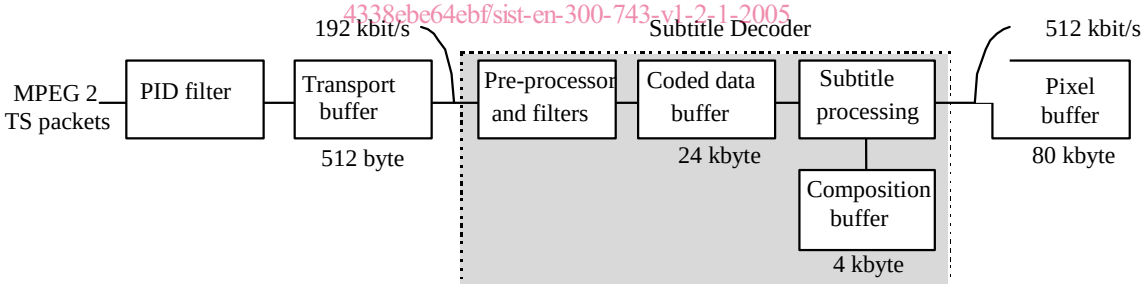

Figure 3: Subtitle decoder model

The input to the subtitle decoder model is an MPEG-2 Transport Stream (TS). After a selection process based on PID value, complete MPEG-2 Transport Stream packets containing the subtitle stream enter a transport buffer with a size of 512 byte. When there is data in the transport buffer, data is removed from this buffer at a rate of 192 kbit/s. When no data is present, this data rate equals zero.

The transport packets from the transport buffer are processed by stripping off the headers of the transport packets and of the PES packets. The Presentation Time Stamp (PTS) values are passed on to the next stages of the subtitling processing. In the pre-processor, the segments required for the selected subtitle service are filtered from the subtitle stream. Hence, the output of the pre-processor is a stream of subtitling segments which are filtered based on the page_id values signalled in the subtitling descriptor.

The selected segments enter into a coded data buffer which has a size of 24 kbyte. Only complete segments are removed from this buffer by the subtitle decoder. The removal and decoding of the segments is instantaneous (i.e. it takes zero time). If a segment produces pixel data, the subtitle decoder stops removing segments from the coded data buffer until all pixels have been transferred to the pixel buffer. The pixel data of objects that are used more than once, is transferred separately for each use. The data rate for the transport of pixel data into the pixel buffer is 512 kbit/s.