

ATSC Mobile DTV

Application Note

Products:

- | R&S® AEM100MUX | R&S® AVE264
- | R&S® AEM100S | R&S® AVE264-K1
- | R&S® AVE264-K2

This application note describes ATSC Mobile DTV standard A/153, ATSC-M/H. This standard is completely implemented in the R&S® AEM100 ATSC-M/H Emission Multiplexer.

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1 Overview

ATSC Mobile DTV (A/153) is based on vestigial sideband (VSB) modulation as does the standard ATSC A/53 broadcast service, coupled with additional error correction mechanisms. The video content is compressed with the efficient MPEG AVC (ISO/IEC 14496-10 or ITU H.264) video and HE AAC v2 audio (ISO/IEC 14496-3) coding. The video format is fixed to 416 pixels x 240 lines (16:9) to meet the requirements for mobile devices. The mobile data is carried with the Internet Protocol transport system.

The ATSC Mobile DTV service shares the same RF channel as ATSC A/53. The mobile system is enabled by using a portion of the total available 19.4 Mb/s bandwidth and is delivered via IP.

The system achieves the robustness needed for mobile reception by adding extra training sequences and forward error correction (FEC) in a Reed Solomon Frame (RS Frame). The system converts the 8-VSB emission into a dual-stream system without altering the emitted spectral characteristics. This is done by selecting some of the MPEG-2 Transport packets from the legacy ATSC A/53 stream and allocating the payloads in those segments to carry the ATSC Mobile DTV data in a way that legacy receivers will ignore.

One of the main preconditions with the introduction of ATSC Mobile DTV is that there may not be any adverse impact on legacy receivers. With the Rohde & Schwarz solution for ATSC Mobile DTV, the broadcaster's existing transmission infrastructure does not need be altered. The ATSC-M/H multiplexer has to be simply inserted into the main ATSC transmission chain and the existing exciter has to be upgraded to ATSC-M/H. All M/H-specific functions are concentrated in the ATSC-M/H Emission Multiplexer R&S® AEM100.

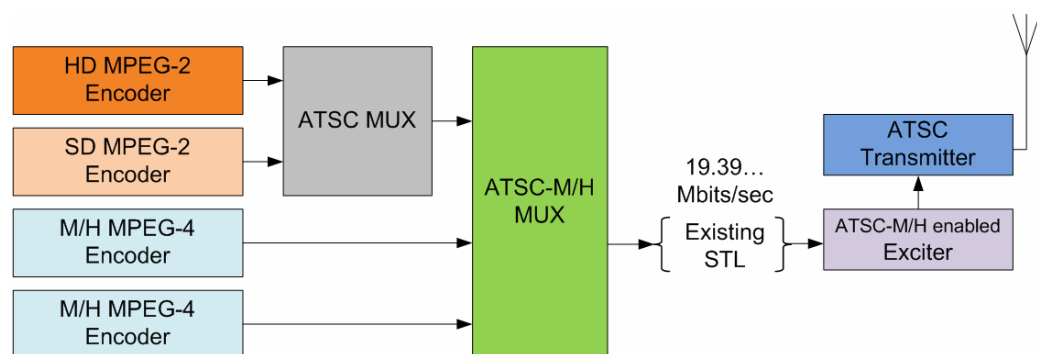


Figure 1: Block structure of ATSC-M/H Headend

In the ATSC Mobile DTV physical layer system, the data is transferred by a deterministic time-slicing mechanism so the mobile receivers have easier and better access to the mobile data. The device can always calculate the beginning of the next data slice. Each ATSC-M/H frame time interval of 968 ms (12,480 transport stream packets) is divided into five *subframes* of equal length. Each subframe is divided into four subdivisions of 48.4 ms in length. This is the time it takes to transmit one VSB frame. These VSB frame time intervals are partitioned into four *slots* each (i.e. 16 slots in each subframe). The M/H-data to be transmitted is packaged into a set of consecutive RS frames, and this set of RS frames forms an *Ensemble*. The RS frame is the basic data delivery unit into which the IP datagrams are encapsulated. The dimensions and therefore the capacity of the RS frame depend on the physical transmission mode. Each ensemble contains one or more *Services* and can be coded with a different level of error protection suitable for the respective application. Encoding includes FEC at both the packet and transmission level. The receiver can use the long, regularly-transmitted training sequences in the data stream for synchronization purposes.

The necessary signaling is separated into transmission, transport, and service guide. For the transmission, the Transmission Parameter Channel (TPC) is used to provide information for decoding. The transport signaling provides the logical structure and the binding of the services and ensembles. The main purpose of the Fast Information channel (FIC) is to efficiently deliver essential information for rapid service acquisition by the mobile receiver device. It can be extracted directly out of the RF layer. For interactive services, an Electronic Service Guide (ESG) that is based on the OMA BCASST Service Guide can be used on content level.

2 Standard

2.1 Evolution of the standard

Fundamental requirements of the new standard include:

- Backward compatibility with ATSC A/53
- Broadcasters can use their available license without restrictions
- Available ATSC receivers can be used unchanged to receive the ATSC/53 standard.

Mobile reception of digital stations using ATSC has been rather impossible in the past, especially when moving at vehicular speeds. To overcome this, there were ten proposals from various companies that report improved mobile reception. In the final phase, two remaining proposals were presented with transmitter and receiver prototypes:

- A-VSB (Advanced VSB) from Samsung and Rohde & Schwarz
- MPH (Mobile Pedestrian Handheld) from LG and Harris.

To find the best solution, the *Advanced Television Systems Committee* assigned the Open Mobile Video Coalition (OMVC) to test both systems. The result was that ATSC-M/H will be a hybrid of both proposals. The final standard draft was then created by the *Advanced Television Systems Committee*, specialist group S-4.

On December 1, 2008, the *Advanced Television Systems Committee* elevated its specification for mobile digital television to candidate standard status. By the middle of 2009, the industry will test the standard with potential customers and begin product development. Before it becomes an official standard, additional improvements will be proposed. A ratified A/153 standard ballot will be sent to ATSC members in July 2009.

2.2 Structure of ATSC Mobile DTV standard

The ATSC Mobile DTV standard is modular in concept. The single parts of A/153 are as follows:

Part 1 “Mobile/Handheld Digital Television System” covers the standard structure, the ATSC Mobile DTV system, and signaling requirements.

Part 2 “RF/Transmission System Characteristics” describes the Fast Information Channel (FIC), the Reed-Solomon (RS) Frame, and a Transmission Parameter Channel (TPC).

Part 3 “Service Multiplex and Transport Subsystem Characteristics” describes the service multiplex and transport subsystem that comprises several layers in the stack.

Part 4 “Announcement” defines the optional use of an Electronic Service Guide: Open Mobile Alliance (OMA) broadcast (BCAST).

Part 5 “Application Framework” defines mechanisms that allow the broadcaster to author and insert supplemental content to define and control various additional elements.

Part 6 “Service Protection” covers the protection of content (files or streams) during delivery to a receiver.

Part 7 “Video System Characteristics” defines the AVC Video System and additional elements as closed captioning (CEA 708) and Active Format Description (AFD).

Part 8 “Audio System Characteristics” characterizes the HE-AAC v2 Audio System. A signaling generator can be optionally integrated to generate OMA BCAST ESG and SMT.

3 Technology

3.1 Protocol stack

The ATSC-M/H protocol stack is an umbrella protocol that uses OMA ESG, OMA DRM, and MPEG-4 in addition to many IETF RFCs as well as ATSC-specific signaling at physical and transport layers.

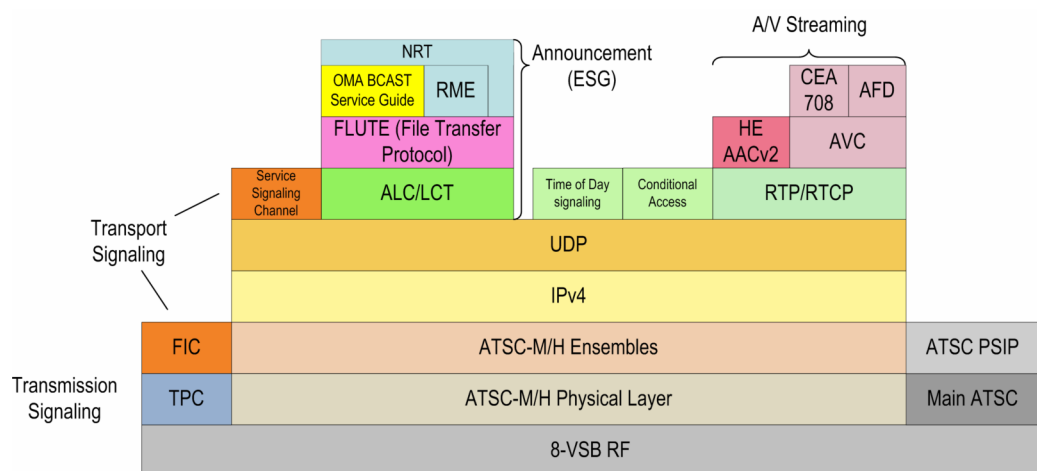


Figure 2: ATSC-M/H protocol stack

3.2 Transport data stream structure

The ATSC-M/H standard defines a virtual frame structure called an *M/H frame*. M/H frames have a fixed duration of 968 ms. This deterministic structure provides a mechanism for introducing additional training signals. On the contrary, the transport stream in ATSC has no fixed structure, so the position of the data can be chosen freely by the multiplexer.

The M/H frame consists of 5 M/H subframes. Each M/H subframe consists of 16 M/H slots that are numbered and called M/H-groups. This numbering is defined in the standard. Consecutive numbers of M/H groups are filled with mobile data. One M/H slot stretches out over 156 transport stream packets. If mobile data is transmitted in a slot, 118 transport stream packets contain the mobile data and 38 packets transport main ATSC data. If not, all 156 packets contain main ATSC data. One virtual M/H frame is physically based on 20 VSB frames (12,480 transport stream packets) and has an offset of 37 transport stream packets to the VSB frame structure.

A collection of 1 to 8 M/H groups is called an *M/H parade*. The data of a parade is channel-coded and interleaved during an M/H frame. The parade conveys one or two M/H ensembles that are logical pipes for IP datagrams carrying TV services and the signaling of the mobile content.

The mobile data is also protected by an additional FEC turbo code. To improve the performance of the receiver equalizer in a mobile channel, training sequences are introduced into the ATSC-M/H signal.

ATSC-M/H Transport Stream- and Frame Structure

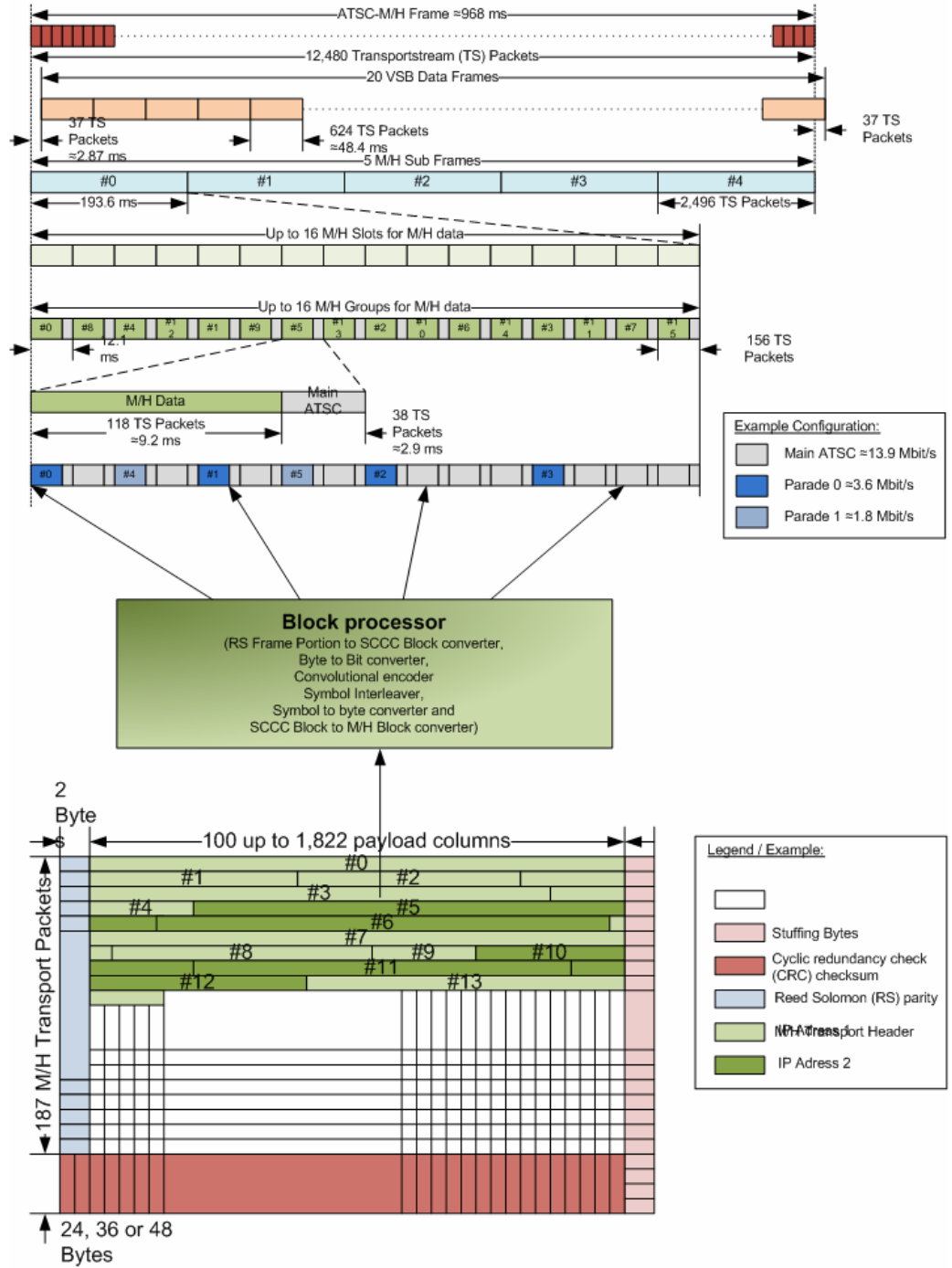


Figure 3: ATSC-M/H transport stream and frame structure

3.3 Error protection

ATSC-M/H uses two different mechanisms for error protection that can be combined. One is an outer transverse 2D Reed Solomon (RS) code that corrects defective bytes after the iterative Turbo Code decoding process in the receiver. An option exists to improve RS correction in bursty channels by using the CRC checksum in each RS row. By the using CRC checksum mechanism, an erasure can be set for the entire row (location of byte error is known in RS column). This allows RS erasure decoding to achieve 2X byte correction burst-type errors.

The number of RS parity bytes used can be either 24, 36, or 48 in each RS frame column. Using normal RS decoding, this yields a 12, 18, 24 byte error correction capability per RS column. By using RS erasure decoding this yields (2X) 24, 36, 48 byte error correction capability per column.

A new inner FEC in the form of a Turbo Code is then introduced by leveraging the deterministic M/H frame structure by virtually concatenating a new outer convolutional encoder and interleaver with the existing inner trellis encoders in 8-VSB to form a new Serial Concatenated Convolution Code (SCCC) or Turbo Code. This is a very powerful FEC technique that makes ATSC mobile service possible.

The RS frame is then partitioned into several segments of different sizes and assigned to specified regions in an M/H group. These regions are protected by various combinations of FEC that are selectable by the broadcaster.

4 ATSC M/H signaling and announcement

ATSC-M/H defines three different layers of signaling. The layers are organized hierarchically and optimized to characteristics of the transmission layer.

4.1 Transmission signaling system

The lowest layer is the Transmission Parameter Channel (TPC). It is described in ATSC A/153 Part 2 Section 5.5 and provides information that lets the receiver align itself on the virtual M/H frame structure and locate the correct slots with desired mobile program. The TPC also signals the FEC-mode parameters and the repetition cycles of a parade to the receiver.

To provide more robust performance, it uses a repetition scheme so that the same TPC is sent out for each group in an M/H frame.

4.2 Transport signaling system

The second layer is the Fast Information Channel (FIC) in combination with the Service Signaling Channel (SSC), cf. A/153 Part 3 sections 5 - 7. The FIC is a signaling channel separated from the data channel which is delivered through the RS frames. The main purpose of the FIC is to deliver essential information to allow rapid service acquisition by the receiver. The FIC primarily covers information about binding of ATSC-M/H services and ATSC-M/H ensembles (which carry services).

The Service Signaling Channel (SSC), in contrast to the FIC, is delivered within the data channel as a UDP packet stream. This stream consists of several different signaling tables. The information carried in these tables can be compared to the Program and System Information Protocol (PSIP) information of ATSC. The SSC provides mainly the basic information, the logical structure of the transmitted services and the decoding parameters for video and audio. The same generic MPEG2 table format is used and similar information is transported. The SSC is delivered for each ensemble with different schedules for diverse table types. The diverse tables delivered by SSC are:

- Service Map Table (SMT):
The SMT contains attributes of all services carried in an ensemble. This includes service acquisition information for IP streams (components) which form a service (IP address and port).
- Guide Access Table (GAT):
The GAT serves as a bootstrap for each Electronic Service Guide (ESG) of the M/H broadcast.

- **Cell Information Table (CIT):**
The CIT (optional, applies only in MFN mode) transports information about carrier frequency of selected transmitters in adjacent cells that are transmitting the same services. This allows the receiver to track a service when traveling between different coverage areas of M/H transmitters.
- **Service Labeling Table (SLT):**
The SLT provides names for all services of an M/H broadcast. This information is redundant as SMT and ESG also provide service names and descriptions. However, the receiver would either have to receive ESG or scan all SMTs of all ensembles to retrieve this information. Alternatively, with the help of the SLT, a receiver can perform a fast channel scan using the FIC data in combination with the SLT to present the list of available services of an M/H broadcast to the user.
- **Rating Region Table (RRT):**
The RRT is the same as described in ATSC A/65. It provides information about content advisory rating.

4.3 Announcement / Electronic service guide (ESG)

The highest layer of signaling is the OMA BCAST ESG. This Service Guide is also used in the mobile phone environment. The name is a abbreviation of Open Mobile Alliance (**OMA**) Broadcast Service Enabler Suite (**BCAST**) Electronic Service Guide (**ESG**), cf. A/153 Part 4. In the ATSC Mobile DTV standard, it is labeled as announcement. An ESG is delivered as a file data session as indicated by the GAT table of the SSC (ESG bootstrap). File Delivery over Unidirectional Transport (FLUTE) is used as delivery protocol. The ESG consists of several XML sections. With this structure, a program guide and enabled interactive services can be realized. The ESG carries the following information:

- **Service fragment:**
This fragment describes the content items at an aggregate level which form a broadcast service.
- **Schedule fragment**
The schedule fragment defines the timing of content given in the service fragment.
- **Content fragment:**
This fragment gives detailed information on type and language of the content.
- **Access fragment:**
This fragment describes how the content can be accessed during its lifespan (used delivery method).
- **Session description fragment**
This fragment provides the session information for access to a service in form of a Session Description Protocol (SDP) file. Typically this SDP file covers the used audio and video codecs of the given television content.
- **Purchase item, purchase data and purchase channel fragment:**
These fragments are used to provide information about pricing, subscription and accessing of content protected services.

- Preview data fragment:

This fragment contains information about presenting the user a preview of the content. It can include simple texts, images, and short video clips

The sections above reference each other resulting in the hierarchy building the complete ESG. ESG and SSC may contain conflicting data, in which case the SSC-information is used.

4.4 Signaling of video- and audio coding

Each video or audio decoder needs information about the coding parameters used, such as resolution and frame rate. To signal these parameters to the receiver, the MPEG-2 system, commonly used in ATSC, transmits this parameter information via the Sequence Parameter Set (SPS)/Picture Parameter Set (PPS). Both sets are embedded in the elementary stream of the video. In other transmission standards, such as T-DMB, these parameters are fixed per definition to avoid problems with the decoder.

Although these sets are still available in MPEG-4/AVC, IP-based mobile TV systems do not use them. Instead, the receiver uses information from the "Session Description Protocol File" (SDP file). The SDP file is a format that describes streaming media initialization parameters. The IETF published it as an IETF Proposed Standard. The SDP file can contain a wide range of additional information, such as e-mail, phone number, or time zone adjustments. It is an ASCII text file generated by the A/V encoder.

In ATSC-M/H, the SDP file is transmitted within the SMT table. Most of the information is coded as binary values and some are coded in the origin ASCII text format. In case of signaling with ESG, the complete SDP file is transmitted as an ASCII file. In this case, the ALC/Flute file protocol is used.

4.5 Single frequency network (SFN)

In an SFN, two or more transmitters with overlapping coverage send the same program content simultaneously on the same frequency.

An SFN when properly designed can be used to improve the quality of service to terrain-shielded or shadowed areas such as urban canyons and in indoor reception environments to support ATSC Mobile DTV services. The R&S® AEM100 offers an efficient and highly-scalable method of creating an ATSC-M/H SFN. This results in the emission of coherent RF symbols from each SFN transmitter that will appear like natural echoes to a ATSC-M/H receiver's equalizer and will thus be received. This makes it possible to use transmitter diversity to help improve the probability of reception in the mobile RF environment.

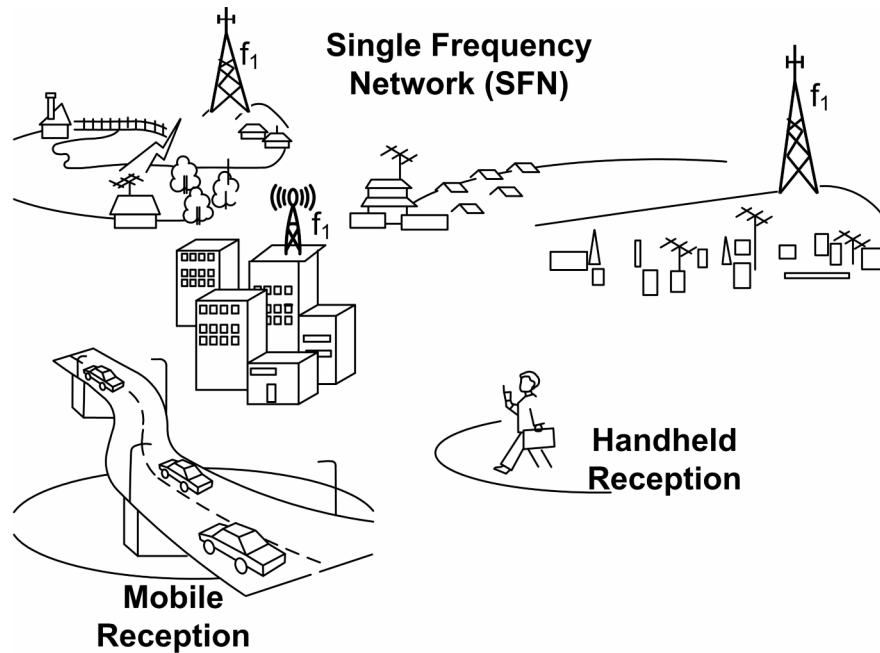


Figure 4: Field of application of a single frequency network

In such an SFN, the ATSC-M/H multiplexer and the ATSC-M/H transmitter are synchronized by a GPS reference. The ATSC-M/H multiplexer operates as a network adapter and inserts time stamps in the transport stream. The transmitter receives the transport stream via the Studio Transmitter Link (STL). The transmitter analyzes the time stamp and delays the transport stream before it is modulated and transmitted so different delays in the STL can be compensated. All SFN transmitters generate a synchronized signal on one frequency.

4.6 R&S ATSC-M/H system

Rohde & Schwarz offers network operators a single-source solution including encoders, multiplexer, and transmitter for ATSC Mobile DTV.

Network operators can also efficiently upgrade existing ATSC infrastructure for the new ATSC Mobile DTV services by using the R&S[®] AEM100 emission multiplexer. They can continue to use the existing infrastructure because the multiplexer can be easily integrated into the current system. ATSC Mobile DTV also makes it possible to set up frequency-efficient SFNs that can easily be implemented by deploying Rohde & Schwarz transmitters.

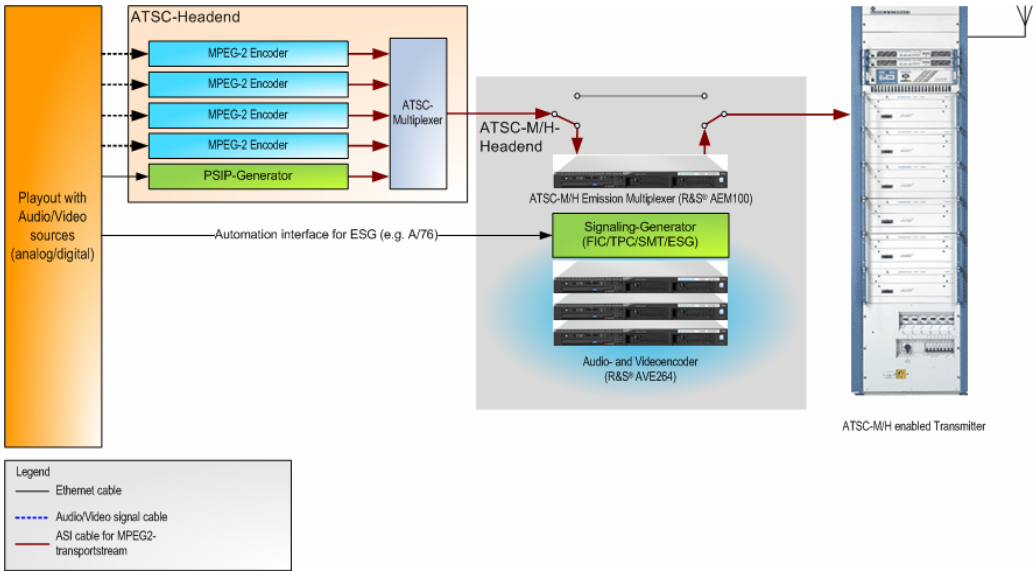


Figure 5: ATSC Mobile DTV system overview

5 Additional information

- ATSC Standard Documents:
<http://www.atsc.org/standards/>
- **R&S® AEM100 Technical specifications**
PD 5214.1666.22
- **R&S® ATSC Mobile DTV (Poster)**
PD 5214.2533.82
- **R&S® Take the Lead in Mobile DTV (Flyer)**
- **R&S® ATSC Mobile DTV White Paper: Mobile TV in the United States: Capitalizing on the Opportunities**

6 Ordering information

The complete ATSC-M/H headend can be realized with the R&S® AEM100MUX emission multiplexer. The R&S® AEM100S software enables the use of transmitters in single frequency networks. The R&S® AVE26 product family encodes the mobile video. The product contains software licensed by the Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institute (HHI)

Ordering information R&S® AEM100		
Designation	Type	Order No.
ATSC-M/H Emission Multiplexer Channel coding and signaling Encapsulation of IP-packets	R&S® AEM100MUX	5302.8532.02
ATSC-M/H SFN Adapter For single frequency networks in combination with the R&S® AEM100MUX	R&S® AEM100S	5302.8426.02
CBR Mobile Video Encoder H.264 Constant bit rate (CBR) for video in one encoder	R&S® AVE264 and R&S® AVE264-K1	5301.8000.12 5301.8039.13

About Rohde & Schwarz

Rohde & Schwarz is an independent group of companies specializing in electronics. It is a leading supplier of solutions in the fields of test and measurement, broadcasting, radiomonitoring and radiolocation, as well as secure communications. Established 75 years ago, Rohde & Schwarz has a global presence and a dedicated service network in over 70 countries. Company headquarters are in Munich, Germany.

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