tech 3288

Essential characteristics for a Eutelsat W earthstation having the minimum required performance for Eurovision

Contents

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Introduction

In 1998, the EBU's *Eurovision* satellite feeds were digitalized using MPEG (4:2:2P@ML) coding. This allows more efficient use to be made of the EBU's transponder capacity. Existing earth-stations, built to previous specifications [1], are being upgraded to allow digital operation. The receive chain and the transmit chain, excluding HPA amplifiers, are supplied by the EBU as one integrated package. This new specification, which applies to stations transmitting and receiving *Eurovision* digital carriers, is being released so as to give information to earthstation owners when procuring or updating earthstations. For this reason, and also for the sake of brevity, much of the supplied information is only in outline form.

The document is intended to specify the part of an EBU station that is procured by the broadcaster, and to provide information for the establishment of an earthstation specification. It is intended as a guide. Some requirements are mandatory. These requirements must be met by an earthstation before approval can be given for it to access the Eurovision system. Mandatory requirements are printed in italics as is this paragraph.

In the following text, paragraphs that relate to equipment supplied by the EBU (codecs, modems, up-converters and combiners) are identified by a single line margin as is this paragraph.

Paragraphs which repeat information from Eutelsat Document EESS 400 are identified by a double line margin as is this paragraph.

Many of the mandatory requirements are with reference to Eutelsat Document EESS 400 – *Minimum Technical and Operational Requirements for Earthstations Transmitting to Leased Capacity in the Eutelsat Space Segment* [2]. Future revisions of that document may change the status of Eutelsat's requirements or introduce new ones. It is the intention of the EBU to publicise such changes by means of Amendments to the present document. However, any mandatory Eutelsat requirements that appear in the version of EESS 400 which applies at the time of ordering the station must be taken into account, despite the lack of an appropriate Amendment to the present EBU document.

1. EBU tech 3265.
2. EESS-400 Issue 3, Rev. 0, December 6, 1996, is applicable at the time of writing.

Chapter 1:
General considerations for earthstations operating in the Eurovision network

1.1. Earthstation component parts

A block diagram of the implementation of a *Eurovision* earthstation which meets the requirements of this specification is shown in *Figs 1* and *2* [3]. The station comprises four main parts: antenna system, transmit system, receive system and control system.

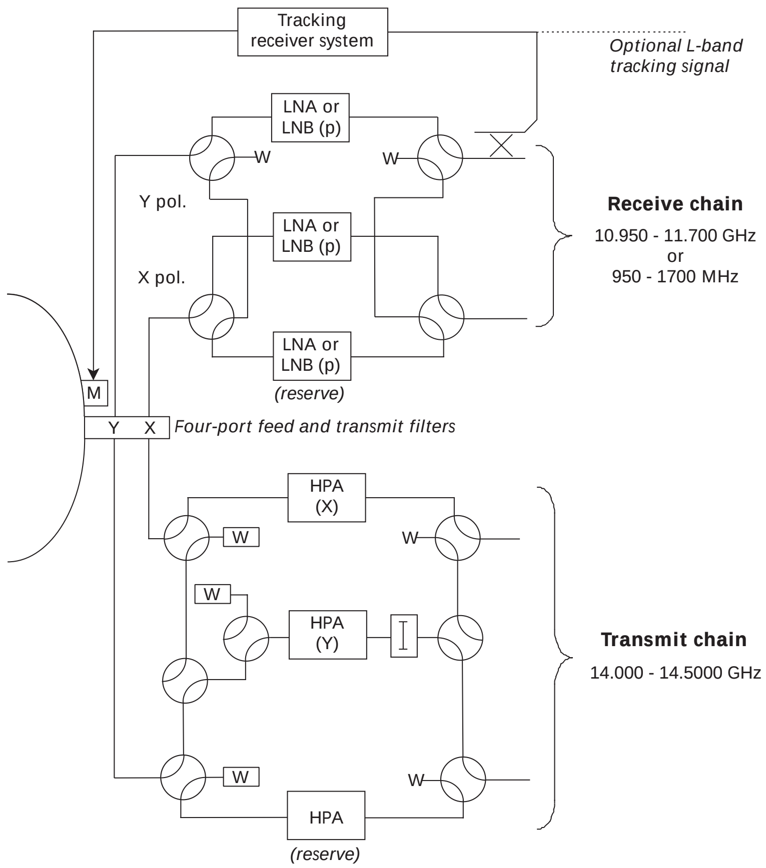

Figure 1
Example of EBU station, antenna and high-power amplifier subsystems.

3. It should be noted that other configurations are possible which can also meet the requirements of this specification.

The antenna system comprises an antenna with a broadband four-port feed (X & Y transmit and receive), and associated pointing and tracking systems.

The transmit system comprises:

⇨ high-power amplifiers (HPAs) and associated couplers and waveguide connections to the antenna, which provide high-power signals to feed the X transmit port, the Y transmit port and a switchable spare;

⇨ a number of modulators together with associated switching and multiplexing equipment, which allows the generation of X and Y signal feeds for the relevant HPA. Each of the feeds can consist of a number of modulated carriers;

⇨ a number of MPEG video encoders which feed the modulators via an optical fibre link or via a network with a G.703 interface. The signal carried on the optical fibre connection conforms to the DVB ASI specification.

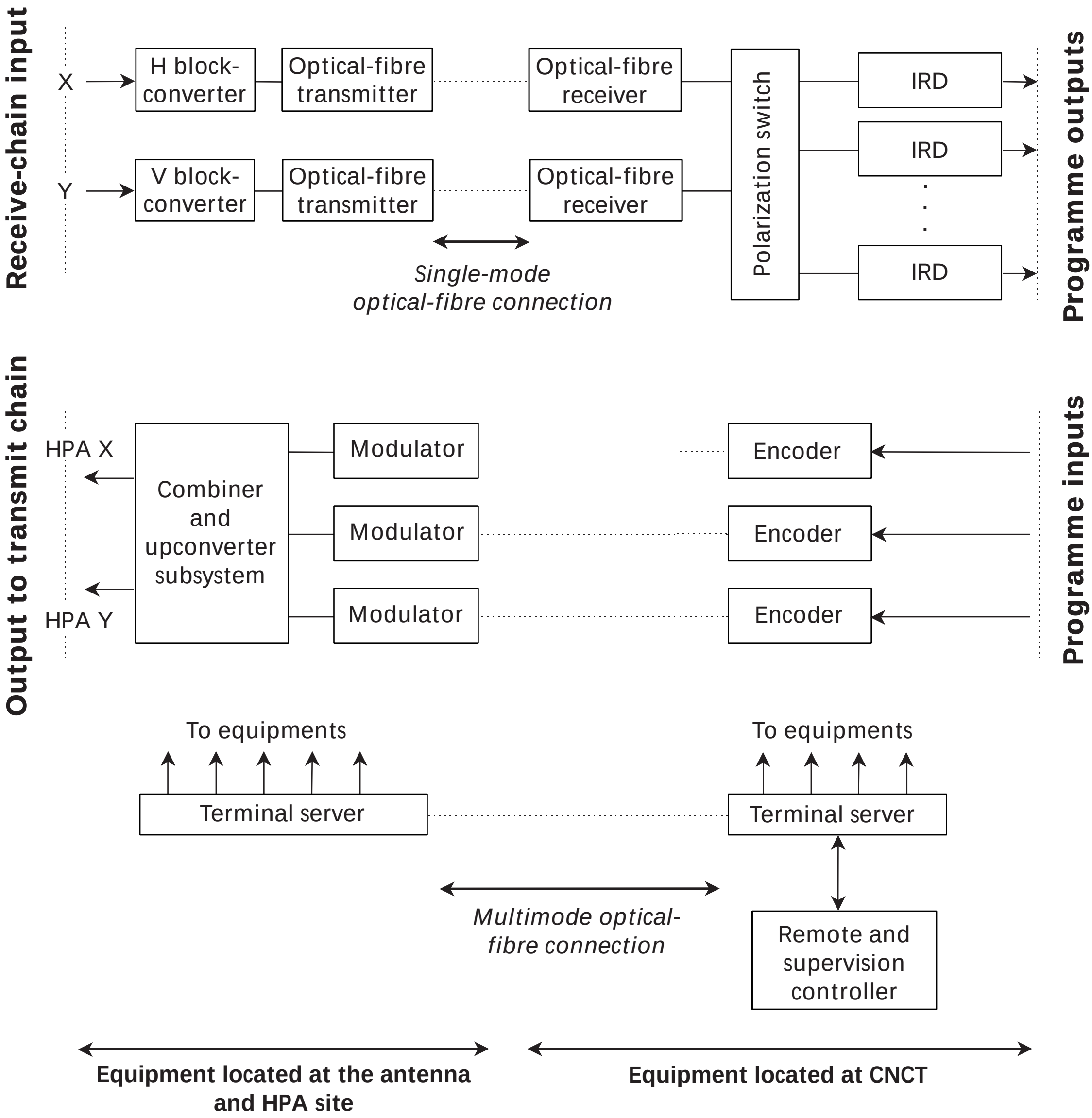

Figure 2
EBU-provided equipment: receive and transmit.

The receive system comprises:

- an X, Y and spare low-noise amplifier (LNA) together with associated waveguide switches, which provide amplification of the received signals;
- two, or more, block down-converters which convert the incoming signals to an L-band (~1 GHz) intermediate frequency [4];
- a set of integrated receiver-decoders (IRDs) which may be connected to the X or Y L-band feeds, via a switch;
- an optical fibre link, carrying L-band signals between the block converters and the IRDs.

An operational remote control system, supplied by the EBU, fulfils two tasks:

- control and monitoring of the RF parts, and antenna steering;
- control, monitoring and configuration of all equipment, including the settings and management of the conditional access (CA) parameters.

1.2. Satellite capacity

The earthstations are envisaged to operate with the Eutelsat W series of satellites. Earthstation parameters have been specified with this in mind, particularly as regards the range of antenna pointing angles, the frequency range, EIRP and G/T requirements. An Appendix lists the appropriate satellite values of G/T and EIRP in the direction of the locations where an EBU station is planned for the current main *Eurovision* transponders. *Fig. 3* provides some further details of the EBU transponder allocation.

1.3. Use of transportable earthstations

This document contains essential information relating to fixed earthstations which provide national gateways for the *Eurovision* network. Transportable earthstations may also be used as part of the network on occasions, to provide temporary facilities. Guidelines for transportable earthstations are given in *Chapter 7*.

1.4. Eurovision and other services carried in EBU transponders

A number of different services operate in the EBU transponders. Each of these uses a different set of carrier characteristics. Brief details of these are given in the following sections.

1.4.1. Eurovision – HBR TV (high bit-rate TV)

HBR TV are the main carriers of *Eurovision* signals, providing for the exchange of TV signals between broadcasters. MPEG 4:2:2P@ML coding is used, at a video coding rate of about

4. An alternative arrangement would be to use low-noise block converters (LNBs) in order to provide an L-band feed directly from the antenna head.

21 Mbit / s. The MPEG signal is a multiplex of the video component, up to four sound channels and a data allocation. The modulated signal uses QPSK at a symbol rate of 13.845 Msymb / s, including rate 7 / 8 Forward Error Correction (FEC). The signal is fully MPEG / DVB-compliant and uses a frequency allocation of 18 MHz in the transponder plan.

1.4.2. Eurovision – LBR TV (low bit-rate TV)

LBR TV carriers employ the same MPEG coding algorithm as the HBR TV carriers, but they use a lower video coding rate (~6 Mbit / s). This allows the use of a smaller frequency allocation (9 MHz) for applications where transponder space is at a premium. LBR TV carriers also permit the use of lower up-link powers (some 3 dB less than that required for HBR TV) which is

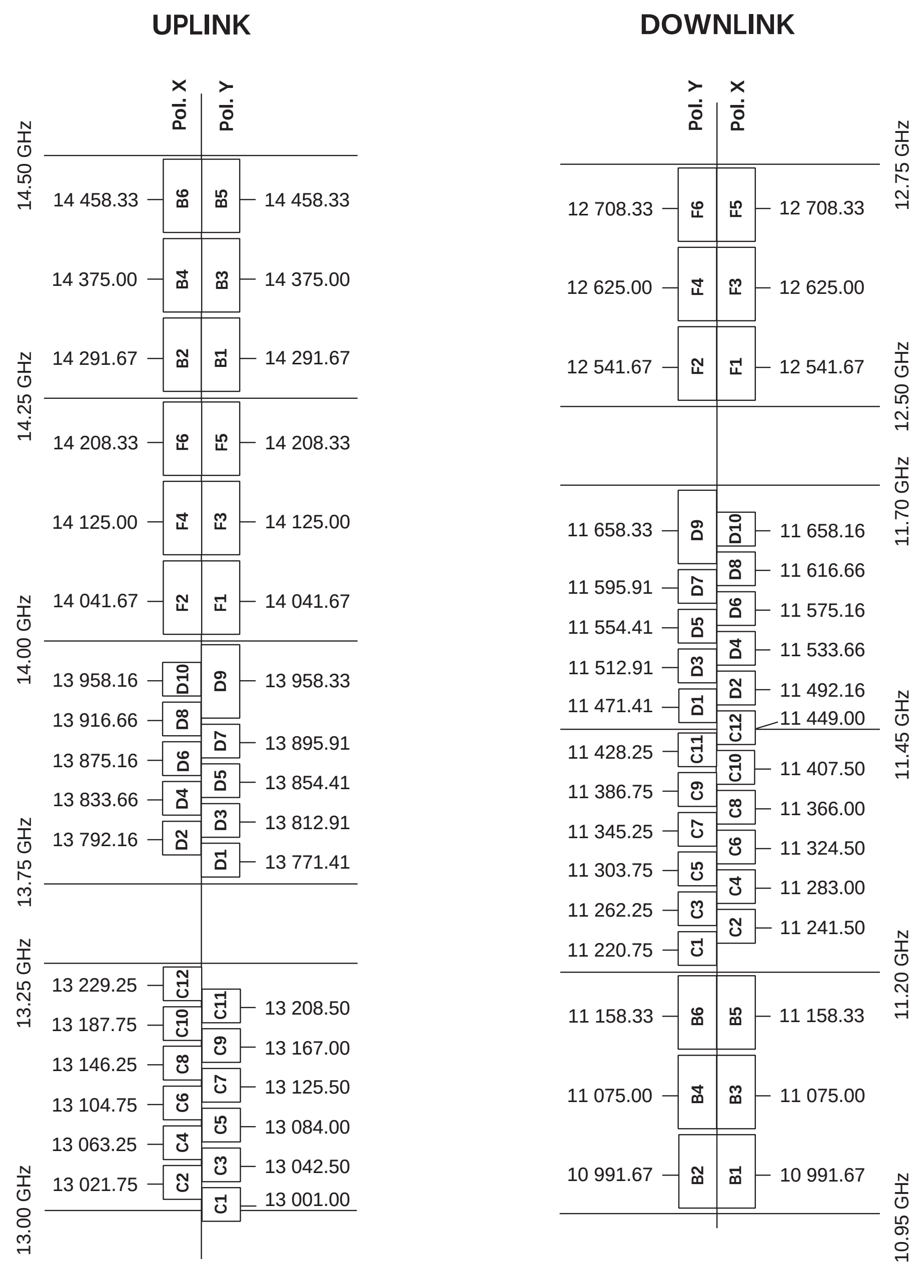

Figure 3
Eutelsat W frequency plan.

of benefit to those operations which rely on transportable and SNG equipment. Once again, the MPEG/DVB-compliant multiplex provides for audio and data channels alongside the video component.

In normal use, these two types of *Eurovision* signals will be encrypted, with access being controlled and managed by the *Eurovision Operations Department*. The encryption process is part of the EBU equipment, delivered by the EBU.

1.4.3. Euroradio

The *Euroradio* service provides a sound-programme interchange facility for EBU participants. The *Euroradio* carriers employ audio that is encoded in accordance with the ITU-T J.57 specification, at 2 Mbit/s and using QPSK modulation with rate 1/2 FEC. The bandwidth allocation used for *Euroradio* signals is 3 MHz. The service is designed so that reception is possible when using relatively small, fixed, dishes rather than a fully-specified *Eurovision* receive station.

Note that whilst the design of the earthstations specified in this document is consistent with the implementation of *Euroradio* channels, no specific provision is made for their implementation.

1.4.4. Ancillary communication channels

The use of ancillary communication channels – to facilitate the main *Eurovision* transmissions – are becoming commonplace. These channels are used to communicate between transportable earthstations and either the *Eurovision Control Centre* (EVC) or the parent broadcaster of the transportable station. These narrowband channels carry coded voice and data signals, using aggregate information rates of 64 kbit/s or less. It is expected that a frequency allocation of 3 MHz will be set aside for the use of a block of ancillary communication circuits.

Note that whilst the design of the earthstations specified in this document is consistent with the implementation of these ancillary channels, no specific provision is made for their implementation.

1.4.5. Other services

Work is under way to provide channels for other services which may be introduced from time to time. It is proposed to allocate 3 MHz slots of transponder capacity to carry a number of narrowband channels which may carry voice or data, typically coded at 32 or 64 kbit/s or at other data-rates up to about 2 Mbit/s.

1.5. General factors covering station design

1.5.1. System performance

The performance goal for digital *Eurovision* carriers is to ensure that, with a fully-loaded transponder and in normal operating conditions, sufficient margin will exist at the vast majority of earthstations – so that the HBR TV and LBR TV channels are “quasi error-free“ for at least 99% of the worst month. Quasi error-free reception means that less than one uncorrected error event occurs per transmission hour. This corresponds to a bit error-rate of about 10^{-10} at the input of the MPEG demultiplexer.

1.5.2. Equipment reliability

The equipment design should be of high reliability and should minimize the risk that the space segment will be jeopardized by errors affecting, for example, the transmitted carrier level or frequency.

1.5.3. Flexibility of design

The *Eurovision* network can be expected to undergo changes which may require a rapid response, for example the sudden failure of a satellite transponder. For this reason, good station design practice must be employed, giving simple, yet flexible, operational control. As an example of this, the equipment design should allow for rapid changes of the carrier frequency or signal polarization axis.

In addition, equipment design should allow for future expansion without undue difficulty.

1.5.4. Earthstation control

The facilities of the earthstation will be controlled from a National Technical Control Centre (CNCT). As well as defining the equipment configuration (receive frequency, modulation parameters etc.), the remote control system will also configure the equipment to permit the reception of encrypted transmissions. This EBU-supplied control system will conform to an open standard and, thus, it will allow a future management system to convert the existing multilink satellite configuration into a wide-area network (WAN).

1.5.5. Interchangeability of component parts

All of the major sub-units of the earthstation (HPA, etc.) must be easily interchangeable without any need for realignment to meet the performance limits.

1.6. Station acceptance and transponder frequency plans

Before any earthstation can be used to access a satellite, it must be approved by an appropriate authority. This authority is usually the Eutelsat Signatory for the territory in which the earthstation is operated. The procedure for applying for approval is defined in the Eutelsat Systems Operations Guide (ESOG).

The transmission plan, which defines the frequency assignment and the maximum radiated level of any carrier, must be approved by Eutelsat and will be provided to station operators via the EBU.

Chapter 2:
System design considerations

2.1. Principle of the system design

One principle behind the design of the equipment provided by the EBU is that it should allow separation of the RF and baseband equipment.

The **RF equipment** consists of:

⇨ modulators and multiplexer / up-converters in the transmission chain;

⇨ frequency conversion equipment, in the form of LNBs, in the reception chain.

The **baseband equipment** consists of:

⇨ digital encoders in the transmission chain;

⇨ an L-band splitter, with a set of IRDs, in the reception chain.

The RF and baseband parts of the equipment can be separated by a distance of up to 5 km – provided the connection is accomplished using fibre-optic cables.

Two single-mode optical fibres, within a 12-fibre cable, are used for feeding the L-band signals from the downconverters (at the antenna) to the IRDs at the baseband end of the chain.

A second (multimode) fibre-optic cable is used for the connection between the baseband encoders and the RF modulator equipment (situated close to the HPA equipment). This cable is also used by the control computer (situated at the baseband end) to control the modulating and upconverter / multiplexing equipment at the RF equipment location.

In some installations, the baseband and RF equipment will be placed in the same space. The use of a fibre-optical system here may be optional; however, the use of optical fibres will provide a galvanic separation of the antenna and RF equipment from the baseband equipment. This is desirable in most installations where a separate ground (i.e. earthing) system is used for the existing studio equipment. This may motivate the use of an optical system also in installations where the distance between the RF and baseband equipment is small.

The different parts of the system – the user-supplied antenna and HPA system – is depicted in *Fig. 1* and the EBU-supplied RF and baseband equipment is shown in *Fig. 2*.

2.2. Floor space

The equipment provided by the EBU will be delivered in pre-cabled 19“ 42-U racks. A typical installation – comprising three encoders and four (or up to eight) receivers – can be accommodated in three racks. One rack, which shall be placed near the HPA and the antenna system, contains the modulators, upconverters and L-band combiners.

At the baseband location, two racks are installed: one of these contains the encoders while the other contains the receivers together with the polarity-switching network.

Space should also be provided for the PC which runs the monitoring and control software. A suitable place for this would be at the CNCT.

2.3. Power consumption

Adequate power should be provided for the EBU-supplied equipment. A station with three digital encoders and four decoders will require a power of at least 1.4 kVA for the encoding part of the system, and approximately 0.5 kVA for the decoders and control equipment.

2.4. Continuous power

All equipment shall be connected to uninterruptable power supplies. Some parts of the equipment, such as the control computer and the digital encoders, require a long time for the initialization of the equipment, as the current settings would be lost during a power interruption.

2.5. Remote control of waveguide network

When the equipment is not transmitting, the output of the HPAs should be connected to a dummy load in order to avoid spurious noise being transmitted to the satellite. The waveguide system should be designed such that a signal in the form of a contact closure will automatically direct the HPA output signals to the respective dummy load. There will be one contact closure for each of the two polarizations, X and Y respectively.

2.6. HPA monitoring

Monitoring of the HPA and antenna system is not provided in the software originally supplied by the EBU. An appropriate means of monitoring the waveguide switches, HPAs and antenna controller should be included in the installation provided by the supplier of the antenna and the HPA.

Chapter 3:
Antenna and feed system

3.1. Antenna steering

3.1.1. Antenna steerability

The antenna steering system shall be capable of pointing the antenna in the direction of any satellite that is located in the visible part of the arc from 0° to 40° E, on the geostationary satellite orbit.

It should be possible to re-point the antenna from one satellite to another within a maximum of 30 minutes.

Operational considerations indicate the desirability of full steering capability. This will permit an on-site demonstration of compliance, with the specified sidelobe levels, and will allow easy operation with other satellites located in the visible arc of the geostationary orbit.

3.1.2. Beam pointing

The antenna main beam axis must not deviate by more than 0.2° from the normal direction of the satellite, along the geostationary orbit at all wind speeds at which the earthstation will have to operate.

3.1.3. Tracking modes

Earthstations shall be equipped with a "step-track" or other automatic tracking system and must use the satellite beacon transmission as a reference.

The beacon receiver shall be equipped with a synthesized local oscillator and shall be capable of being set to any beacon frequency currently in use by Eutelsat, or likely to be used, including the following for the Eutelsat W satellites:

- ⇨ *11698.000 MHz;*
- ⇨ *11698.600 MHz;*
- ⇨ *11699.200 MHz;*
- ⇨ *11699.800 MHz.*

It should be noted that the earthstation may be required to operate with Eutelsat satellites of other generations whose beacon characteristics could differ from those of Eutelsat W.

The Table below lists the main characteristics of the beacons carried on Eutelsat W satellites.

	Eutelsat W
Frequency stability over 7 years	± 50 kHz
Polarization (see *Section 3.6*)	X
Polarization discrimination	33 dB
Nominal EIRP	9 dBW
Modulation, carrier	Phase modulation, 1.0 rad_{p-p}
Modulating signal	Subcarrier at 32.7 kHz PCM/PSK modulated at 2048 bit/s

3.2. Feed system bandwidth

The feed system shall allow operation in the following frequency bands:

Receive feed system: *10.95 to 11.70 GHz*

Transmit feed system: *14.00 to 14.50 GHz*

It is recommended that new antennas and waveguide components are specified for the extended frequency range 13.75 to 14.50 GHz.

3.3. Gain-to-noise-temperature ratio

The gain to noise-temperature ratio of the receiving system at any frequency between 10.95 and 11.70 GHz, and for any antenna elevation angle when operating with a satellite located at any longitude in the visible part of the arc from 0° to 40° East on the geostationary satellite orbit, shall comply with:

$$G/T\ (dB/°K) \geq 30 - C_R$$

where: C_R *is the satellite EIRP at saturation of the transponder in the direction of the station, in dBW, minus 45.0 dBW;*

G *is the minimum receive antenna gain relative to an isotropic antenna, in the direction of the satellite, referred to the input of the receiving amplifier;*

T *is the receive system noise temperature, including noise contributions from the atmosphere, under clear sky conditions, referred to the input of the receiving amplifier. Clear sky is taken to be the condition of intrinsic atmospheric attenuation due to gases and water vapour (see ITU-R Recommendation P.838) without excess attenuation due to tropospheric precipitation such as rain and snow.*

The satellite EIRP at saturation of the transponder for a Eutelsat W satellite is given in the Appendix for a number of cities in the European Broadcasting Area. Those EIRP values shall be considered for the determination of C_R referred to above.

Note: When a satellite is used which results in elevation angles of less than 5°, reception difficulties may arise due to scintillation. In such cases, the G/T figure specified above will not be adequate to meet the performance goals.

3.4. Antenna off-axis gain

The mandatory requirements for antenna off-axis gain are defined in Eutelsat Document EESS 400. These data must be taken into account when ordering the antenna.

The minimum required performance, at the time of writing this document, is as follows.

3.4.1. Transmit

a) Recommendation

In the frequency range 13.75 to 14.5 GHz, it is recommended that the off-axis gain of the antenna, referred to the gain of an isotropic antenna, should not exceed:

$29 - 25 \log_{10}\Theta$	dBi	for	$2.5° < \Theta \leq 7.0°$
$+ 8$	dBi	for	$7.0° < \Theta \leq 9.2°$
$32 - 25 \log_{10}\Theta$	dBi	for	$9.2° < \Theta \leq 48°$
$- 10$	dBi	for	$\Theta > 48°$

In addition, in the cross-polarization plane, the off-axis gain of the antenna should not exceed:

$19 - 25 \log_{10}\Theta$	dBi	for	$1.8° < \Theta \leq 7.0°$
$- 2$	dBi	for	$7.0° < \Theta \leq 9.2°$

where: Θ is the angle, in degrees, between the main beam axis and any direction towards the geostationary satellite orbit and within the bounds between 3.5° North and 3.5° South of the geostationary satellite orbit (as seen from the centre of the earth).

b) Requirement

In the frequency range 13.75 to 14.5 GHz, no more than 10% of the antenna sidelobe peaks shall exceed the envelopes specified in Section 3.4.1a. Any individual peak shall not exceed those envelopes by more than 6 dB when Θ is greater than 9.2°, and by more than 3 dB when Θ is equal to or smaller than 9.2°.

The transmit off-axis gain must be such that the requirements of Section 3.5, for maximum off-axis EIRP density, are met.

3.4.2. Receive

a Recommendation

In the frequency range 10.95 to 11.70 GHz, it is recommended that the gain of the antenna, referred to the gain of an isotropic antenna, should not exceed:

$29 - 25 \log_{10}\Theta$	dBi	for	$2.5° < \Theta \leq 7.0°$
$+ 8$	dBi	for	$7.0° < \Theta \leq 9.2°$
$32 - 25 \log_{10}\Theta$	dBi	for	$9.2° < \Theta \leq 48°$
$- 10$	dBi	for	$\Theta > 48°$§

In addition, it is recommended that, in the cross-polarization plane, the gain of the antenna should not exceed:

$19 - 25 \log_{10}\Theta$	dBi	for	$1.8° < \Theta \leq 7.0°$
-2	dBi	for	$7.0° < \Theta \leq 9.2°$

where: Θ is the angle, in degrees, between the main beam axis and any direction towards the geostationary satellite orbit and within the bounds between 3.5° North and 3.5° South of the geostationary satellite orbit (as seen from the centre of the earth).

b) Requirement

In the frequency range 10.95 to 11.70 GHz, no more than 10% of the antenna sidelobe peaks shall exceed the envelopes specified in Section 3.4.2. Any individual peak shall not exceed those envelopes by more than 6 dB when Θ is greater than 9.2° and by more than 3 dB when Θ is equal to or smaller than 9.2° (see Section 3.4.1b).

3.5. Off-axis EIRP density

The off-axis EIRP, in any 40 kHz band, in the direction of an adjacent satellite shall not exceed the following values:

$33 - C_T - 25 \log_{10}\Theta$	dBW	for	$2.5° < \Theta \leq 7.0°$
$12 - C_T$	dBW	for	$7.0° < \Theta \leq 9.2°$
$36 - C_T - 25 \log_{10}\Theta$	dBW	for	$9.2° < \Theta \leq 48°$
$-6 - C_T$	dBW	for	$\Theta > 48°$

The orthogonally-polarized component of the off-axis EIRP, in any 40 kHz band, in the direction of an adjacent satellite shall not exceed the following values:

$23 - C_T - 25 \log_{10}\Theta$	dBW	for	$1.8° < \Theta \leq 7.0°$
$2 - C_T$	dBW	for	$7.0° < \Theta \leq 9.2°$

where: C_T *is the satellite G/T towards the station locations, minus the reference satellite G/T of 0 dB/°K;*

Θ *is the angle, in degrees, between the main beam axis and the direction considered.*

The off-axis EIRP as specified in Eutelsat Document EESS 400 must not be exceeded. The values shall be met with the maximum operating EIRP values defined in *Section 4.4.2.*

The values of the satellite G / T in the direction of a number of cities in the European Broadcasting Area, which shall be considered to determine the value of C_T above, are given in the Appendix.

3.6. Polarization

3.6.1. General

In Eutelsat satellites, the complete bandwidth is re-used by reception and transmission of two linear orthogonal polarizations. The two orthogonal polarizations are denoted X and Y. Signals received on one polarization (e.g. X) will be transmitted on the orthogonal polarization (e.g. Y). The X polarization plane is the plane defined by the antenna boresight and the satellite pitch axis (which is practically perpendicular to the orbit plane) rotated by about 93.5° in an anti-clockwise direction when looking towards the earth.

3.6.2. Polarization capability

The antenna feed shall be equipped for dual polarization (X and Y) operation, for both transmission and reception, in the frequency bands defined in Section 3.2.

3.6.3. Polarization alignment capability

It shall be possible to adjust the earthstation transmit and receive polarization planes to within 1° of the nominal satellite receive and transmit antenna polarization planes.

It is recommended that the resolution of the adjustment of the earthstation polarization plane be better than 0.2°.

3.6.4. Receive polarization discrimination

The polarization discrimination of the antenna and feed system, in the frequency band 10.95 to 11.70 GHz, shall be at least 35 dB within the 1 dB antenna beam width.

3.6.5. Transmit polarization discrimination

The polarization discrimination of the antenna and feed system, in the frequency band 13.75 to 14.5 GHz, shall be at least 35 dB within the 1 dB antenna beam width.

Chapter 4:
RF transmit chains

A transmitter amplifier chain extends from the RF output of the up-converter to the SHF input of the antenna transmit feed port.

4.1. Earthstation transmit capability

Depending on the operating conditions, the earthstation shall be equipped for multi-channel operation, without restriction on the choice of carrier frequency (within the normal operating range) or the polarization axis. As agreed between the EBU and its Members, the system should be capable of expansion to a three-chain HPA arrangement, thereby allowing two primary HPA chains – one for each of the two polarizations, plus one reserve HPA.

4.2. Input interface

The nominal value for the input to the transmit chain is Ku band (14.0 - 14.5 GHz). The input level for an HBR TV carrier will normally be in the range from – 25 dBm to – 20 dBm per HBR TV carrier. The interface is 50 Ω coaxial.

4.3. Amplifier bandwidth and frequency response

The amplitude and group delay characteristics of each transmit chain, measured from the amplifier's input to the transmit antenna feed port, shall be flat within ± 1 dB_{p-p} within the frequency range 14.0 to 14.5 GHz. The gain slope within the same frequency range shall not exceed ± 0.04 dB/MHz.

4.4. High power amplifier (HPA) requirements

The output power and operating point of the HPA must be consistent with achieving the earthstation EIRP requirements defined in this section, and the out-of-band requirements of the following section.

Due allowance should be made for multicarrier operation in a single HPA. It has been shown that for TWT-equipped HPAs, a total output back-off (OBO) of 9.5 dB allows for multicarrier operation [5]. This value is only valid for the carriers defined by the EBU with the assigned EIRP values given in *Section 4.4.2*.

5. The value of 9.5 dB is related to the specific situation of four HBR carriers in the HPA.

4.4.1. Definitions

The "assigned operating EIRP" is the EIRP assigned to a given carrier (for a particular station, transponder, satellite and orbital position) in a transmission plan approved by Eutelsat.

The maximum required operating EIRP is such that it will not be exceeded by the assigned operating EIRP, independently of the transponder, satellite or orbital position for stations located within the satellite's 0 dB / °K receive contour.

4.4.2. EIRP requirement

The earthstation shall be capable of radiating the maximum required operating EIRP (for a given carrier) at any frequency between 14.0 and 14.5 GHz, in the direction of the satellite, under clear-sky conditions and light wind, defined as follows:

$68 - C_T$ dBW	for High Bit-Rate TV carriers	(~13.845 Msymb/s)
$65 - C_T$ dBW	for Low Bit-Rate TV carriers	(~5.632 Msymb/s)

where: C_T *is the satellite G/T towards the station location, minus the satellite reference G/T of 0 dB/°K. The station shall be capable of radiating the above EIRP values while meeting the off-axis EIRP and the RF out-of-band emission requirements of Sections 3.5 and 4.5 and in particular for digital carriers, the spectral side-lobe requirements of Section 4.5.3 shall be met. In case of transmission of several digital carriers through the HPA, the intermodulation requirements of Section 4.5.2 shall also be met.*

The values of the satellite G/T in the directions of a number of cities in the European Broadcasting Area, which shall be considered to determine the value of C_T *referred to above, are given in the Appendix.*

All factors contributing to EIRP variations, e.g. transmit power variations and antenna beam pointing error, added on a root-sum-square (RSS) basis, shall be taken into account to determine the specified EIRP in the direction of the satellite under clear-sky conditions and light wind.

4.4.3. EIRP adjustment

Eutelsat may request changes to the assigned EIRP. It must be possible to adjust the EIRP of each carrier individually, over a range which extends to 20 dB below the value, specified above, for the maximum required operating EIRP.

4.4.4. EIRP stability

The EIRP in the direction of the satellite shall be within ± 0.5 dB of the operating EIRP assigned by Eutelsat in the transmission plan. This requirement shall take into account all factors contributing to EIRP variations, e.g. transmit power variations and antenna beam-pointing error, added on an RSS basis.

4.4.5. Idle state emissions

The residual carrier level, during periods when no signal is transmitted, shall be at least 50 dB below the assigned operating EIRP

4.5. Out-of-band emissions

The following requirements must be met when the earthstation transmits one or more carriers with the maximum required operating EIRP levels defined in the previous section.

4.5.1. Spurious radiation

The EIRP radiated by the earthstation outside the bandwidth allocated to the carrier and falling in the frequency range 14.0 GHz to 14.5 GHz – as the result of spurious tones, bands of noise or other undesirable signals, but excluding multi-carrier intermodulation products and carrier spectral sidelobes – shall not exceed 4 dBW in any 4 kHz band.

4.5.2. Intermodulation products

The maximum peak EIRP spectral density of the intermodulation products transmitted by the earthstation, and falling in the frequency range 14. 0 GHz to 14. 5 GHz, shall not exceed:

$(12 - C_T)$ dBW in any 4 kHz band

Additionally, it shall not exceed:

$(42 - C_T)$ dBW in any 12.5 MHz band

where: C_T is the G/T of the satellite in the direction of the transmitting earthstation, minus the reference G/T value of 0 dB/°K.

The values of the satellite G/T in the directions of a number of cities in the European Broadcasting Area, which shall be considered to determine the value of C_T referred to above, are given in the Appendix.

4.5.3. Carrier spectral sidelobes

The maximum peak EIRP density of the spectral sidelobes of a transmitted digital television carrier shall not exceed:

$(12 - C_T)$ dBW in any 4 kHz band

Additionally, it shall not exceed:

$(42 - C_T)$ dBW in any 12.5 MHz band

where: C_T is the G/T of the satellite in the direction of the transmitting earthstation, minus the reference G/T value of 0 dB/°K.

The values of the satellite G/T in the directions of a number of cities in the European Broadcasting Areas, which shall be considered to determine the value of C_T referred to above, are given in the Appendix.

Note that the above specification requires that the HPA be operated with appropriate back-off in order to meet the requirements for EIRP density of the spectral sidelobes and of *the intermodulation products as given in* Sections 4 5.3 *and* 4.5.2 *respectively*. In addition, the upconverter linearity must be sufficient, at all normal operating input levels and gain control settings, to ensure that the spectral sidelobe performance is determined largely by the HPA.

It should be noted that the upconverter system is part of the equipment provided by the EBU.

Chapter 5:
RF receive chains

An RF receive chain extends from the SHF output of the antenna feed port to the L-band output of the distribution system which feeds the IRDs. It includes cables or waveguide runs which connect the feed port to the low-noise RF amplifier, the block converter (including any transmit reject filter) and the L-band signal feed to the IRDs.

5.1. Earthstation receive capability

EBU stations should be equipped to receive, simultaneously, any four channels of the frequency plan without restriction on the choice of carrier frequency (within the normal operating range) or polarization axis. The number of IRDs in a station is determined by the volume of traffic carried.

5.2. Output interface

The L-band output of the receive chain covers the frequency range from 950 to 1750 MHz. The output level should be in the range from – 30 dBm to – 60 dBm for an HBR TV carrier. The interface is 75 Ω coaxial.

5.3. System frequency response and bandwidth

5.3.1. Receive system frequency range

The receiving equipment should be designed to receive any carrier in the frequency band, 10.95 to 11.70 GHz, on either the X or Y polarization axes.

5.3.2. Conversion frequency accuracy and phase noise

The conversion frequency accuracy and phase noise performance of the receive chain must comply with the Intelsat Intermediate Data-rate specification (IESS-308) for all data-rates between 64 kbit/s and 2 Mbit/s. In addition, to allow for carriers with data-rates exceeding 2 Mbit/s, the total double-sided phase jitter due to continuous (phase noise) and spurious phase modulation of the local oscillators, when integrated over the bandwidth 0.1 MHz to 13.8 MHz away from the carrier, shall not exceed 2.8° rms.

Chapter 6:
Baseband equipment

6.1. General considerations

The earthstations operating in the *Eurovision* network must be able to operate with digital television signal sources. However, in some cases the signal at the baseband interface will be analogue (625-line PAL).

6.2. Digital television interface

The digital television interface shall conform to ITU-R Recommendations BT.601 and BT.656.

6.3. Digital audio interface

The digital audio interface shall conform to ITU-R Recommendation BS.647-2 (AES/EBU).

6.4. Analogue audio interface

The interface for analogue audio shall be balanced line, with a high impedance input and a low impedance output. The physical interface should be via 3-pole XLR connectors.

6.5. Data interface

The data interface shall conform to ITU-T Recommendation V.24, with bit-rates up to 9.6 kbit/s.

Chapter 7:
Receive-only stations

7.1. General

Some stations within the EBU network may only need reception facilities. A receive station is substantially cheaper than a transmitting one. The antenna can be of a more simple design, as decided by the broadcaster. This section serves only to advise on the design of such a station.

7.2. Earthstation component parts

A receive earthstation comprises; antenna, broadband two-port feed (X and Y receive), low-noise block converters and IRDs. Motorization of the antennas without tracking system is optional; however, repointing and maintenance is much easier with a manual motor drive. For an antenna size above 3.7 m, an antenna tracking system is recommended, or at least the option should be provided for adding a motor drive later. It is essential that the mechanical construction is appropriate for the environmental (climatic) conditions in which it will be used.

7.3. Continuous power

The broadcaster may decide if the station shall be equipped with backup power or not. Should the loss of power occur, it should not interfere with the reception of EBU transmissions by third parties.

7.4. Antenna steerability and pointing accuracy

The earthstation shall be built such that it complies with the requirements of *Section 3.1.2*.

7.5. Gain-to-noise-temperature ratio

The selection of antenna size should take into account a possible performance degradation of the satellite over its design lifetime. This is included in the contractual minimum performance data published by Eutelsat (see the Appendix).

The gain-to-noise-temperature ratio at any frequency between 10.95 and 11.7 GHz, and for any operational elevation angle, shall comply with;

$$G / T\ (dB / °K)\ >\ 30 - C_R$$

where: C_R is the satellite EIRP at saturation of the transponder in the direction of the station, in dBW, minus 45.0 dBW;

G is the minimum receive antenna gain relative to an isotropic antenna, in the direction of the satellite, referred to the input of the receiving amplifier;

T is the receiving system noise temperature, including noise contributions from the atmosphere, under clear sky conditions, referred to the input of the receiving amplifier. Clear sky is taken to be the condition of intrinsic atmospheric attenuation due to gases and water vapour (see ITU-R Recommendation P.838) without excess attenuation due to tropospheric precipitation such as rain and snow.

The minimum satellite saturated EIRP varies within the *Eurovision* broadcasting area from about 39 dBW to 47 dBW for an Eutelsat W satellite.

In many cases a receiving station may have some backup solution if a failure occurs. For such a station, the antenna size could be less conservatively rated by using the expected satellite performance rather than the minimum data. This will lead to smaller receiving antennas at the risk of interrupted service if the space segment is degraded.

7.6. Antenna gain characteristics

The antenna gain characteristics are given in *Section 3.4.2a*. For reliable operation, the sidelobe characteristics of *Section 3.4.2b* should also be met.

7.6.1. Polarization

The polarization characteristics are given in *Section 3.6*.

7.7. RF receive chain

The RF receive chain usually include low-noise block converters (LNBs), one for each polarization, mounted at the antenna feed receive ports. The L-band output from the block converters are 950 MHz to 1750 MHz with a conversion frequency of 10 GHz. Downlink cable and power splitters then feed the IRDs. The output level to the IRDs should be in the range from – 30 dBm to – 60 dBm. Selection of the polarization can be made by a voltage-controlled polarization switch.

7.7.1. Frequency range

The receiving station should be equipped to receive any digital carrier in the frequency band from 10.95 GHz to 11.7 GHz, on both polarizations, X and Y.

7.7.2. Conversion frequency accuracy and phase noise

The conversion frequency accuracy and the phase noise performance of the receive chain shall comply with the Intelsat Intermediate Data-rate specification (IESS-308) for all data-rates between 64 kbit/s and 2 Mbit/s.

In addition, to allow for carriers with data-rates exceeding 2 Mbit/s, the total double-sided phase jitter due to continuous (phase noise) and spurious phase modulation of the local oscillators, when integrated over the bandwidth 0.1 MHz to 13.8 MHz away from the carrier, shall not exceed 2.8° rms.

7.8. Baseband interface

It is up to the broadcaster to provide an appropriate baseband interface for sound and vision. For data reception, the receivers shall conform to ITU-T Recommendation V.24, with bit-rates up to 9.6 kbit/s.

Chapter 8:
Digital SNG and transportable earthstations

8.1. System design considerations

SNG stations are often used to provide temporary contribution feeds. The stations are in general of small size and may be mounted in a vehicle or transported in flight cases. Due to the small size of the antenna system, the antenna is primarily optimized for transmission and usually offers only limited reception possibilities.

8.2. Earthstation component parts

An SNG station comprises four main parts: the antenna system, transmit system, receive system and control system.

The antenna system comprises an antenna with a broadband feed that can be adjusted or switched to transmit and receive in the X and Y polarization planes. Measuring equipment must be included in order to check the transmitted frequency and power levels, as well as for receiving the satellite's beacon frequencies for the purpose of antenna alignment and satellite identification.

The transmit system comprises:

a) high-power amplifiers (HPAs), associated couplers and waveguide systems;

b) modulators together with associated equipment to allow the generation of the RF carrier. More than one carrier may be transmitted through the station; however, careful design and operational discipline must be carried out in order to comply with the intermodulation and spurious emission constraints given in *Sections 4.4* and *4.5*.

c) MPEG encoders which feed the modulators.

The receive system typically comprises:

a) one or two low-noise block converters (LNBs) together with associated waveguide arrangements in order to convert the received signals in the X or Y polarization planes to L-band frequencies.

b) integrated receiver-decoders (IRDs) which may be connected to the X or Y L-band feeds.

8.3. Antenna and feed systems requirements

8.3.1. Antenna characteristics

The antenna transmit gain characteristics are given in Section 3.4 *and* 3.5. *The receive characteristics given in* Sections 3.4.2a *and* 3.4.2b *are recommended values.*

8.3.2. Antenna beam pointing

The antenna main beam axis must not deviate by more than 0.2° from the normal direction of the satellite along the geostationary orbit at all wind speeds at which the earthstation will have to operate.

8.3.3. Feed system bandwidth

The feed system shall allow operation in the following frequency bands:

Receive feed system:	*10.95 to 11.70 GHz*
Transmit feed system:	*14.00 to 14.50 GHz*

8.3.4. Beacon reception

For identification purposes and antenna alignment, the satellite beacon signal can be monitored. The frequencies, EIRP and modulation parameters are given in Section 3.1.3.

8.3.5. Polarization

The polarization characteristics are given in Section 3.6.

8.4. RF transmit chains

Depending on the operational conditions and the station design, the SNG earthstation may be equipped with one or more HPAs in order to provide redundancy. Sometimes, two HPAs will work in parallel, in a phase combination arrangement, in order to provide transmission continuity at the – 3 dB level, if one amplifier fails. The particular redundancy configuration varies from station to station.

Due allowance should be made for multicarrier operation if this is anticipated in a single HPA. It has been shown that for TWT-equipped HPAs, a total output back-off (OBO) of 9.5 dB allows for multicarrier operation. Single-carrier operation requires less amplifier back-off, usually in the range 1 to 5 dB. The actual value must satisfy the mandatory limits on the side-lobe power spectral density, as specified in Eutelsat document EESS-400.

8.4.1. Amplifier bandwidth and frequency response

The amplitude and group delay characteristics of each transmit chain, measured from the amplifiers input to the transmit antenna feed port, is recommended to be flat within ± 1 $dB_{p\text{-}p}$ in the frequency range

14.0 to 14.5 GHz. The gain slope, within the bandwidth used for transmission, shall not exceed ± 0.04 dB/MHz.

8.4.2. High-power amplifier (HPA) requirements

The output power and operating point of the HPA must be consistent with achieving the earthstation EIRP and out-of-band requirements of this section and Section 4.5.

8.4.3. EIRP requirement

The earthstation shall be capable of radiating the maximum required operating EIRP (for a given carrier) at any frequency between 14.0 and 14.5 GHz, in the direction of the satellite, under clear-sky conditions and light wind, defined as follows:

68 - C_T dBW	*for High Bit-Rate TV carriers (~13.845 Msymb/s)*
65 - C_T dBW	*for Low Bit-Rate TV carriers (~5.632 Msymb/s)*

where: C_T is the satellite G/T towards the station location, minus the satellite reference G/T of 0 dB/°K for Eutelsat W satellites. The station shall be capable of radiating the above EIRP values while meeting the off-axis EIRP and RF out-of-band emission requirements of Sections 3.5 and 4.5 and, in particular for digital carriers, the spectral side-lobe requirements of Section 4.5.3 shall be met. In the case of transmission of several digital carriers through the HPA, the intermodulation requirements of Section 4.5.2 shall also be met.

The values of the satellite G/T in the directions of a number of cities in the European Broadcasting Area, which shall be considered to determine the value of C_T referred to above, are given in the Appendix.

All factors contributing to EIRP variations, e.g. transmit power variations and antenna beam-pointing error, added on a root-sum-square (RSS) basis, shall be taken into account to determine the specified EIRP in the direction of the satellite under clear-sky conditions and light wind.

8.4.4. EIRP stability

The stability of the transmitted carrier should be maintained within ±0.5 dB of the assigned power level.

8.5. Modulation parameters

The modulation parameters should follow the DVB specification for SNG use. The pertinent data is found in ETSI specification EN 301 210, in which the possible modulation schemes are QPSK, 8-PSK and 16-QAM. However, transmission over the Eurovision network implies the use of the carrier characteristics as defined in Section 1.4. A Transmission Plan is issued by the EBU, containing the relevant data for accessing the space segment. The transmission parameters may be modified at some time in the future when the EBU issues a new Transmission Plan.

It is recommended that the modulation equipment is designed to carry Transport Stream bit-rates in the range 2.5 to 60 Mbit/s for programme material encoded at the MPEG-2 4:2:2 Studio Profile @ Main Level. For encoding at the MPEG-2 4:2:0 Main Profile @ Main Level, the recommended range of Transport Stream bit-rates are 2.5 to 15 Mbit/s. The Transport Stream bit-rates are quoted as multiplexer output rates without R-S error correction encoding.

8.6. Video and sound encoding parameters

There are several options for the video and sound encoding. The recommended video coding options are the minimum which accord with MPEG-2 4:2:0 Main Profile @ Main Level and MPEG-2 4:2:2 Studio Profile @ Main Level. The horizontal picture resolution should be 720 pixels and the vertical resolution, 480 lines (for 525 line systems) and 576 lines (for 625 line systems). The video encoding should follow the MPEG-2 standard, ISO/IEC 13818-2.

It is assumed that the encoding equipment is capable of encoding four sound channels arranged as two stereo pairs or four separate sound channels. The sound coding sampling rate should be 48 kHz; however, 32 and 44.1 kHz sampling rates are also an option. The encoder sound output rates are in the range between 32 and 384 kbit/s. Audio encoding should follow ISO/IEC 13818-3.

Transport Stream multiplexing should occur before adding forward error correction and modulation. The ensemble of datastreams should use DVB-compliant Transport Stream multiplexing according to ISO/IEC 13818-1.

The ISOG has defined a "Standard Mode" in order to ensure minimum requirements for interoperability. This mode is defined with the following set of parameters:

Video encoding data-rate:	7.5 Mbit/s
Audio data-rate (stereo):	256 kbit/s
Audio sampling rate:	48 kHz
Transport stream bit-rate (excluding R-S encoding):	8.448 Mbit/s
Reed-Solomon code rate:	204/188
Inner FEC code rate:	3/4
Transmitted symbol rate:	6.1113 Ms/s

In order to allow automated interoperability, the appropriate encoding parameters should be signalled in the PSI (Programme Specific Information) and SI (Service Information) data of the DVB Transport Stream multiplex.

8.7. Electromagnetic compatibility

The stations shall comply with the minimum performance criteria regarding electromagnetic compatibility, as defined in ETSI document ETS 300 673. It should be noted that this document is intended to become a harmonized EMC standard within the European Community.

Appendix:
Eutelsat W3 – minimum values of satellite G/T, CT, EIRP at saturation and CR in the direction of locations where an EBU earthstation is planned to operate

Country	City	Latitude	Longitude	C_T (G/T)	EIRP	C_R
Algeria	Algiers	36°50'N	03°00'E	+1.5	45.0	0.0
Jordan	Amman	31°57'N	35°56'E	–0.5	39.0	–6.0
Turkey	Ankara	39°50'N	32°50'E	+1.5	45.0	0.0
Greece	Athens	38°00'N	23°44'E	+1.5	45.0	0.0
Iraq	Baghdad	33°20'N	44°26'E	–0.5	39.0	–6.0
Lebanon	Beirut	33°52'N	35°30'E	–0.5	40.0	–5.0
Serbia and Montenegro	Belgrade	44°50'N	20°30'E	+1.5	45.0	0.0
Slovak Republic	Bratislava	48°10'N	17°10'E	+3.5	47.0	+2.0
Belgium	Brussels	50°50'N	04°21'E	+3.5	47.0	+2.0
Romania	Bucharest	44°25'N	26°07'E	+1.5	45.0	0.0
Hungary	Budapest	47°30'N	19°03'E	+1.5	45.0	0.0
Egypt	Cairo	30°03'N	31°15'E	+1.5	40.0	–5.0
Denmark	Copenhagen	55°43'N	12°34'E	+3.5	47.0	+2.0
Syria	Damascus	33°30'N	36°19'E	–0.5	39.0	–6.0
Ireland	Dublin	53°20'N	06°05'W	+1.5	45.0	0.0
Germany	Frankfurt	50°06'N	08°41'E	+3.5	47.0	+2.0
Portugal (Madeira)	Funchal	32°40'N	16°55'W	–0.5	40.0	–5.0
Switzerland	Geneva	46°13'N	06°09'E	+3.5	47.0	+2.0
Germany	Hamburg	53°33'N	10°00'E	+3.5	47.0	+2.0
Finland	Helsinki	60°08'N	25°00'E	+1.5	45.0	0.0
Netherlands	Hilversum	52°14'N	05°10'E	+3.5	47.0	+2.0
Israel	Jerusalem	31°47'N	35°13'E	–0.5	39.0	–6.0
Ukraine	Kiev	50°25'N	30°30'E	+1.5	45.0	0.0
Moldava	Kishinev	47°00'N	28°50'E	+1.5	45.0	0.0
Germany	Köln	50°56'N	06°58'E	+3.5	47.0	+2.0
Portugal	Lisbon	38°44'N	09°08'W	–0.5	43.0	–2.0

Country	City	Latitude	Longitude	C_T (G/T)	EIRP	C_R
Slovenia	Ljubjana	46°04'N	14°30'E	+3.5	47.0	+2.0
United Kingdom	London	51°30'N	00°10'W	+3.5	47.0	+2.0
Switzerland	Lugano	46°01'N	08°57'E	+3.5	47.0	+2.0
Luxembourg	Luxembourg	49°37'N	06°08'E	+3.5	47.0	+2.0
Spain	Madrid	40°25'N	03°43'W	+3.5	47.0	+2.0
Germany	Mainz	50°00'N	08°16'E	+3.5	47.0	+2.0
Republic of Belarus	Minsk	53°51'N	27°30'E	+1.5	45.0	0.0
Monaco	Monte Carlo	43°44'N	07°25'E	+3.5	47.0	+2.0
Russia	Moscow	55°45'N	37°42'E	–0.5	45.0	0.0
Cyprus	Nicosia	35°09'N	33°21'E	+1.5	45.0	0.0
Denmark	Odense	55°24'N	10°25'E	+3.5	47.0	+2.0
Norway	Oslo	59°56'N	10°45'E	+3.5	47.0	+2.0
France	Paris	48°52'N	02°20'E	+3.5	47.0	+2.0
Portugal (Azores)	Punta Delgada	37°29'N	25°40'W	–0.5	40.0	–5.0
Czech Republic	Prague	50°06'N	14°26'E	+3.5	47.0	+2.0
Morocco	Rabat	34°02'N	06°51'W	–0.5	43.0	–2.0
Iceland	Reykjavik	64°09'N	21°58'W	–3.5	40.0	–5.0
Latvia	Riga	56°53'N	24°08'E	+1.5	45.0	0.0
Italy	Rome	41°53'N	12°30'E	+3.5	47.0	+2.0
Spain (Canary Islands)	Santa Cruz	28°28'N	16°15'W	–0.5	40.0	–5.0
Bosnia & Herzegovina	Sarajevo	43°52'N	18°26'E	+1.5	45.0	0.0
Republic of Macedonia	Skopje	42°00'N	21°28'E	+1.5	45.0	0.0
Bulgaria	Sofia	42°40'N	23°18'E	+1.5	45.0	0.0
Sweden	Stockholm	59°20'N	18°05'E	+3.5	47.0	+2.0
Estonia	Tallinn	59°22'N	24°48'E	+1.5	45.0	0.0
Albania	Tirana	41°20'N	19°49'E	+1.5	45.0	0.0
Libya	Tripoli	32°54'N	13°11'E	–0.5	40.0	–5.0
Tunisia	Tunis	36°50'N	10°13'E	+1.5	45.0	0.0
Malta	Valetta	35°54'N	14°32'E	+1.5	45.0	0.0
Austria	Vienna	48°13'N	16°22'E	+3.5	47.0	+2.0
Lithuania	Vilnius	54°40'N	25°19'E	+1.5	45.0	0.0
Poland	Warsaw	52°15'N	21°00'E	+1.5	47.0	+2.0
Croatia	Zagreb	45°48'N	15°58'E	+3.5	47.0	+2.0
Switzerland	Zurich	47°23'N	08°33'E	+3.5	47.0	+2.0