TYPE APPROVAL AND CHARACTERIZATION PROCEDURES

ESOG 120

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eutelsat

Antenna and VSAT Type Approval/Characterization

ESOG 120 – Issue 8 - Rev. 1

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The Eutelsat S.A. Systems Operations Guide (ESOG) is published to provide all Eutelsat S.A. space segment users with the information that is necessary for the successful operation of earth stations within the Eutelsat S.A. satellite system.

The ESOG consists of 2 Volumes. They contain, in modular form, all the necessary details considered important for the operations of earth stations.

Volume I focuses on Earth Station and Antenna Approvals, System Management and Policy aspects.

Volume II describes the initial line-up of satellite links between earth stations and the commissioning of earth stations for Eutelsat S.A. services. The modules contained in this Volume relate to the services provided via Eutelsat S.A. satellites.

The ESOG can be obtained either by requesting a printed version from Eutelsat S.A. or by downloading it in PDF from the Eutelsat S.A. Website:

http://www.eutelsat.com/en/support/earth-stations/esog.html

1 Overview of the ESOG modules

1.1 Volume I: Eutelsat S.A. system management and policies

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2 Introduction

2.1 About this document

This document describes in detail the process to verify the compliance of earth stations with the Eutelsat specification EESS 502 standard M and of interactive satellite terminals (IST) with the Eutelsat specification EESS 503.

It is valid for all type of earth stations:

- Fixed Uplink dishes with diameters up to 2.4 m in Ku band and 1.8m in Ka band
- VSAT terminal
- IST interactive satellite terminal (also known as SmartLNB)
- Transportable uplink stations e.g. for SNG
- Mobile uplink terminals for the use on maritime, land mobile and aeronautical applications

Independent from the type of earth stations the Eutelsat approval process consists in principle of four different tests:

- Range test of three production samples
- Auto-deploy performance test
- Pointing accuracy test (also for manual pointing antennas)
- Wind stability test

The details of the test are outlined in the following document.

Antennas which are neither Type Approved nor Characterized by Eutelsat are subject to the provision of measured RF sidelobe patterns and/or to individual testing.

2.2 Disclaimer

The Eutelsat Type approval confirms conformity of the satellite terminal with the Eutelsat standard Type M stated in the document EESS 502 or with the Eutelsat standard stated in the document EESS 503, it explicitly does not indicate conformity with any other standards, such as ITU standards, ETSI standards.

2.3 Eutelsat certification

In the case of a Type Approval or a Characterization certification, based on the successful completion, demonstration, technical verification and certification of all the mandatory electrical performance characteristics, Eutelsat S.A. will issue a Type Approval or a Characterization certificate to the applicant.

A unique certificate will be assigned by Eutelsat S.A. This certificate will also contain a list of each piece of equipment (or equipment configuration) that was tested. In case of a change in the equipment and equipment configuration, the certificate will be not valid.

The list of type approved or characterized antennas and VSATs and their relevant configurations is published and regularly updated on the Eutelsat S.A. Web site.

2.3.1 Type Approval

The Type Approval of earth station antennas depends on the ability to manufacture the antenna system with repeated precision. Type Approval should be obtained if the production of more than 10 units of the same type of antenna configuration is intended. For lower numbers Eutelsat S.A. Characterization may be preferable.

The Type approval process consist of three different tests:

- Static antenna range test of three production samples
- Pointing accuracy test
- Wind stability test (if applicable)

Antenna/VSAT Type Approval is based on the following procedures and criteria:

- The present document ESOG 120
- EESS 502: https://www.eutelsat.com/files/PDF/support/EESS-502.pdf

Any modification on an already Type approved antenna system that may affect the geometry of the reflector, feed boom and feed or the combination of all three requires a new Type approval. Any modification effecting the antenna pointing, be it manual or motorized requires a new Eutelsat Type approval. In coordination with the manufacturer Eutelsat will decide if all tests are necessary or only selected tests.

This allows Eutelsat S.A. to offer a Type Approval procedure for two configurations, namely:

- The antenna system including the feed
- The complete earth station (e.g. VSAT).

Eutelsat S.A. Operators will then be able to introduce type approved antenna/earth station units, without the need for full verification testing or certification of the performance characteristics by simply notifying

Eutelsat S.A. as foreseen within the application form.

Eutelsat Type Approval is seen as the highest degree of antenna compliance. Normally three units of the same model selected at random by Eutelsat in the production need to be made available by the Manufacturer for testing. In case of tests performed on prototypes or pre-production units, the results shall be confirmed later on at least one production unit.

Manufacturers who have obtained this approval are allowed to use the Eutelsat Trademark and “Type Approved” label (see details in chapter 15). With this label, the system can be identified immediately as being **fully compliant** with Eutelsat specifications.

The antennas which are “Eutelsat type approved” are listed and detailed in the “Type Approval book” via the following Web site link:

http://www.eutelsat.com/files/contributed/satellites/pdf/typeapproval.pdf

Note: A Eutelsat Type Approval concerns the static antenna RF performance only. It is not applicable to the auto-pointing performance of the antenna system. Unless the Manufacturer has obtained a Type Approval for the static antenna performance and a Characterization of the associated auto-pointing system, he is not authorized to use the “Eutelsat Trademark” and “Eutelsat label” to designate both options.

If the repeatability of performance cannot be guaranteed, then to demonstrate minimum compliance with Eutelsat S.A specifications, the continual submission of test data on every station is necessary as well as ESVA tests (ref. ESOG 130). In order to avoid repeatedly performing individual ESVA tests, Eutelsat S.A. may propose a second type of approval: “Characterization”. This approval may be subject to restrictions.

2.3.2 Characterization

Characterization of an antenna system should be obtained if the production of more than 3 units and less than 10 units of the same type of antenna configuration is intended. For single stations an ESVA test of an individual station may be sufficient

The Characterization of earth station antennas is subdivided into two categories:

- Static Characterization;
- Auto-Pointing Characterization
- Wind Stability Test (when applicable)

Antenna/VSAT Characterization is based on the following procedures and criteria:

- The present document: ESOG 120
- ESOG 260

http://www.eutelsat.com/files/contributed/satellites/pdf/esog260.pdf

depending on whether or not an auto-pointing option is agreed

- EESS 502: https://www.eutelsat.com/files/PDF/support/EESS-502.pdf

The static Characterization of earth stations is a trade-off between a thorough and comprehensive Type Approval, which guarantees the repeatability of antenna type approved performance, and individual earth station testing.

The Auto-Pointing Characterization of earth stations is applied to systems which have either been type approved or whose static RF performance has been characterized beforehand.

The Auto-Pointing Characterization procedure is detailed in the ESOG 260.

Eutelsat Characterization is appropriate as an intermediate degree of antenna compliance. Normally one unit selected at random by Eutelsat in the production needs to be made available by the Manufacturer for testing. In case of tests performed on a prototype or a pre-production unit, the results shall be confirmed later on a production unit.

Manufacturers who have obtained this approval are allowed to use the Eutelsat Trademark and "Characterization label" (see details in chapter 15).

With this label, the system can be immediately identified as being **compliant** with Eutelsat specifications. Nevertheless, this compliance may be subject to **restrictions** and reservations including the guarantee of performance repeatability.

In order to verify this point, Eutelsat may request tests to be performed from time to time on individual earth stations (randomly chosen). The random tests would be offered on a complimentary basis to the end customer, but Characterization could be revoked in cases where a worsening in performance is noted between the Characterization data and the individual report.

The antennas which are "Eutelsat characterized" are listed and detailed via the following Web site links:

http://www.eutelsat.com/files/contributed/support/pdf/RF_Characterization.pdf

(static performance)

http://www.eutelsat.com/files/contributed/satellites/pdf/Autopointing_Antennas.pdf

(auto-pointing performance)

Note: a Characterization of static antenna performance cannot also apply to auto-pointing performance. Unless the Manufacturer has obtained both Characterizations (static and auto-pointing), he is not authorized to use the "Eutelsat Trademark" and" Eutelsat Label" to designate both options.

Antennas which are neither Type Approved nor Characterized by Eutelsat are subject to the provision of measured RF sidelobe patterns and/or to individual testing.

2.3.3 Type Approval for Eutelsat Broadband Services

The Type Approval process for antennas transmitting on Eutelsat broadband services is identical to the one shown in section 2.3.1.

Manufacturers who have obtained this approval are allowed to use the Eutelsat Trademark and "Type Approval for Broadband Services" label (see details in chapter 15). With this label, the system can be identified immediately as being fully compliant with Eutelsat specifications.

The list of the antennas and relevant configurations which are "Eutelsat type approved for Eutelsat broadband services" are published and regularly updated on the Eutelsat S.A. Web site, via the following link:

http://www.eutelsat.com/files/contributed/support/pdf/Eutelsat_Broadband_Services.pdf

2.3.4 Type Approval for Eutelsat Interactive Satellite Terminal

The Type Approval process for Interactive Satellite Terminals transmitting on Eutelsat satellites is indicated hereafter.

The Type approval process consists of three different tests:

- Static antenna range test of three production samples
- Pointing accuracy test
- Wind stability test

Interactive Satellite Terminal Type Approval is based on the following procedures and criteria:

- The present document: ESOG 120
- EESS 503: https://www.eutelsat.com/files/PDF/support/EESS-503.pdf

Any modification on an already Type approved antenna system that may affect the geometry of the reflector, feed boom and feed or the combination of all three requires a new Type approval. Any modification effecting the antenna pointing, be it manual or motorised requires a new Eutelsat Type approval. In coordination with the manufacturer Eutelsat will decide if all tests are necessary or only selected tests.

The Type Approval procedure addresses the antenna system including the feed and OMT.

Eutelsat Interactive Satellite Terminal Type Approval is seen as the highest degree of antenna compliance. Normally three units of the same model selected at random by Eutelsat in the production need to be made available by the Manufacturer for testing. In case of tests performed on prototypes or pre-production units, the results shall be confirmed later on at least one production unit.

Manufacturers who have obtained this approval are allowed to use the Eutelsat Trademark and "Type Approved for Interactive Satellite Terminal" label (see details in Chapter 15). With this label , the system can be identified immediately as being **fully compliant** with Eutelsat specifications.

The antennas which are "Eutelsat type approved" are listed and detailed in the "Interactive Satellite Terminal Type Approval book" via the following Web site link:

http://www.eutelsat.com/files/contributed/satellites/pdf/Eutelsat_IST_Services.pdf

Any IST which are regularly deployed on the Eutelsat satellites may be eligible for being included in the above linked list.

The criteria for inclusion are:

- Eutelsat is in possession of a full set of RF electrical characteristics related to the IST, measured on an accredited test range;
- The IST's RF performance fully meets the minimum Eutelsat requirements (EESS 503);
- There is no known record of operational problems or interference issues related to this IST;

- The IST shall be used solely in Eutelsat Broadcast Interactive System (EBIS) Networks which are conformed to the EU regulations (http://telecom.esa.int) for blanket license agreement;
- For drive-away systems, the use of stabilization jacks during operations is mandatory;
- The authorization to operate the terminal is conditioned to the procedure to access the Eutelsat S.A. Space Segment

(ref. http://www.eutelsat.com/files/contributed/satellites/pdf/esog140.pdf , ESOG 140).

Inclusion in the list is a decision which pertains uniquely and ultimately to Eutelsat alone.

At any moment a given VSAT may be removed from the list, should Eutelsat deem necessary to do so.

Note: This Interactive Satellite Terminal Type Approval program does not replace in any way the Eutelsat Type Approval program (see section 2.3.1).

2.4 Future operations

If, following the Type Approval or the Characterization, the equipment undergoes any modification that will affect either the configuration applied for or the repeatability of the tests, Eutelsat S.A. must be advised. Any further action will be agreed with the applicant, but further testing may be required, depending on the extent of the modification.

In the case of major changes affecting the antenna optics (new dish, new feed, new radome if applicable, etc.), a new full Type Approval campaign may be necessary.

If also during operations a problem occurs which raises concern about the repeatability of the measurements, Eutelsat S.A. reserves the right to require the tests to be repeated and to review the position regarding continued certification.

It shall be understood that prior to commencing the operation of a Type Approved earth station, registration must take place in the normal way, by applying for Approval to Access, as described in ESOG Module 110.

The prolongation of the Type Approval/Characterization Certificates is subject to the submission of production test results. The scope of testing and the frequency of the provision of production test reports should be suitably in line with the sales volumes for the product.

3 Reference documents

[1] EESS 502 – Earth Station Technical and Operational Requirements - Standard M, https://www.eutelsat.com/files/PDF/support/EESS-502.pdf

[2] EESS 503 – Interactive Satellite Terminal (IST) Standard - https://www.eutelsat.com/files/PDF/support/EESS-502.pdf

[3] ESOG 110 – Earth Station Access and Approval Procedures – Module 110 – Issue 4.2 - https://www.eutelsat.com/files/contributed/satellites/pdf/esog110.pdf

[4] ESOG 130 – Earth Station Verification and Assistance – Module 130 - https://www.eutelsat.com/files/contributed/satellites/pdf/esog130.pdf

[5] ARINC Characteristic 791-1, Aviation Ku-band and Ka-band satellite communication system, Part 1, Physical installation and aircraft interfaces

[6] ARINC Characteristic 791-2, Aviation Ku-band and Ka-band satellite communication system, Part 2, Electrical interfaces

[7] http://www.eutelsat.com/files/contributed/support/pdf/azimuth-elevation-polarization.pdf [TBC]

4 Antenna sidelobe pattern and cross polar discrimination (extract of EESS 502 standard M)

4.1 Sidelobes

Over the full extent of the antenna transmit frequency bands, the gain of the antenna sidelobe peaks should not exceed:

$$\begin{cases} 29 - 25 \cdot log_{10}\theta & dBi \quad for \quad \alpha < \theta \leq 7^\circ \\ +8 & dBi \quad for \quad 7^\circ < \theta \leq 9.2^\circ \\ 32 - 25 \cdot log_{10}\theta & dBi \quad for \quad 9.2^\circ < \theta \leq 48^\circ \\ -10 & dBi \quad for \quad 48^\circ < \theta \end{cases} \qquad \text{Equation 4-1}$$

α=1° or (100λ/D) whichever is the greater, where D is the antenna diameter and λ is the carrier wavelength.

In addition, in the case of linear polarization in the cross-polarization plane, the gain of the antenna sidelobe peaks should not exceed:

$$\begin{cases} 19 - 25 \cdot log_{10}\theta & dBi \quad for \quad 1.8^\circ < \theta \leq 7^\circ \\ -2 & dBi \quad for \quad 7^\circ < \theta \leq 9.2^\circ \end{cases} \qquad \text{Equation 4-2}$$

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° North and 3° South of the geostationary satellite orbit (as seen from the centre of the earth).

For antennas with a D/λ ratio less than or equal to 30, over the full extent of the antenna transmit frequency bands, the gain of the antenna sidelobe peaks should not exceed:

$$\begin{cases} 32 + 10\left(1 - \frac{1}{0.3\alpha}\right) - 25log_{10}\theta & dBi\, for \quad \alpha \leq \theta < 48^\circ \\ -\frac{10}{0.3\alpha} & dBi\, for \quad \theta \geq 48^\circ \end{cases} \qquad \text{Equation 4-3}$$

In case of non circular apertures, D is the dimension of the antenna aperture in the plane of the geostationary orbit.

4.2 Tolerance and overshoot policy

Over the full extent of the antennas transmit frequency bands, the antenna side-lobe peaks shall not exceed the mask envelopes specified in section 4.1 for the angular ranges [α,9.2°] and [9.2°,180°] taken separately.

Any individual peak shall not exceed those envelopes by more than 6 dB when θ is greater than 9.2° for the 10% of the range [1°, 48°] , and by more than 3 dB when θ is equal to or smaller than 9.2° for the 10% of the interval [α,9.2°]. This tolerance margins do not apply to the cross-pol behavior of the antenna.

For very small antennas with $D/\lambda \leq 30$ the tolerance is applied as described in the following formula applicable on the 10% of the angular interval [α,48°].

$$\begin{cases} 32 + 10\left(1 - \frac{1}{0.3\alpha}\right) - 25log_{10}\theta + 3dB & dBi\,for \quad \alpha \leq \theta < 9.2° \\ max\left\{\begin{matrix} 32 + 10\left(1 - \frac{1}{0.3\alpha}\right) - 25log_{10}\theta + 3dB, \\ 32 - 25log_{10}\theta + 6\,dB \end{matrix}\right\} & dBi\,for \quad 9.2° \leq \theta < 48° \\ max\left\{-\frac{10}{0.3\alpha} + 3dB\,, \quad -10 + 6\,dB\right\} & dBi\,for \quad \theta \geq 48° \end{cases}$$

Equation 4-4

In addition to the study in the interval [1°, 48°] described above the overshoots outside this interval shall be considered. At least 30 dB [TBC] of isolation is required between the main lobe and any side-lobe regrowth at angles over 48°.

In addition, the transmit sidelobe pattern of the antenna shall be such that the off-axis EIRP density limits specified in chapter 8 of [1] can be met for any given operating conditions as may be required in practical situations.

4.3 Cross Polarization Discrimination

The Type Approval/Characterization requirements for the Cross Polarization Discrimination at the - 1 dB contour of the main lobe depend on the type of polarization, frequency band, the type of service, the total RF installed power, as in the following table:

Total installed RF power	**Linear polarization**			**Circular polarization**		
>50 W	C-band	Ku- and K-bands	Ka-band	C-band	Ku- and K-bands	Ka-band
Type Approval	XPD $\geq$ 35 dB	XPD $\geq$ 35 dB	XPD $\geq$ 35 dB	XPD $\geq$ 27 dB	XPD $\geq$ 30 dB	XPD $\geq$ 30 dB

Characterization	XPD ≥ 30 dB	XPD ≥ 30 dB	XPD ≥ 30 dB	XPD ≥ 22 dB	XPD ≥ 25 dB	XPD ≥ 25 dB

Total installed RF power	**Linear polarization**			**Circular polarization**		
≤ 50 W	C-band	Ku- and K-bands	Ka-band	C-band	Ku- and K-bands	Ka-band
Type Approval	XPD ≥ 30 dB	XPD ≥ 30 dB	XPD ≥ 30 dB	XPD ≥ 22 dB	XPD ≥ 30 dB	XPD ≥ 20 dB
Characterization	XPD ≥ 25 dB	XPD ≥ 25 dB	XPD ≥ 25 dB	XPD ≥ 18 dB	XPD ≥ 25 dB	XPD ≥ 20 dB

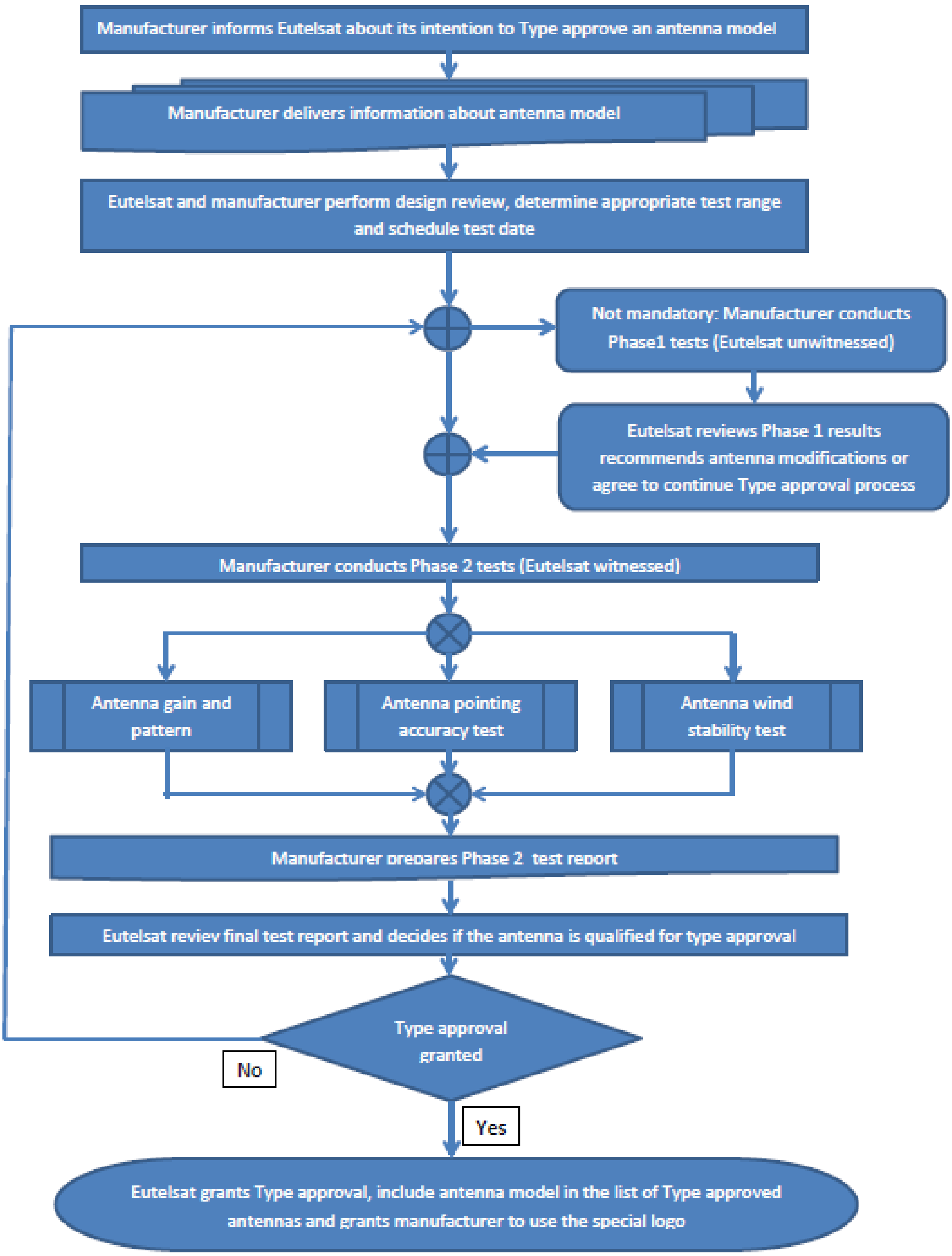
For IST services only:

Total installed RF power	**Linear polarization**			**Circular polarization**		
≤ 50 W	C-band	Ku- and K-bands	Ka-band	C-band	Ku- and K-bands	Ka-band
Type Approval **Professional Grade**	Not applicable	XPD ≥ 25 dB	Not applicable	XPD ≥ 22 dB	Not applicable	XPD ≥ 20 dB
Consumer Grade	Not applicable	XPD ≥ 20 dB	Not applicable	XPD ≥ 18 dB	Not applicable	XPD ≥ 20 dB

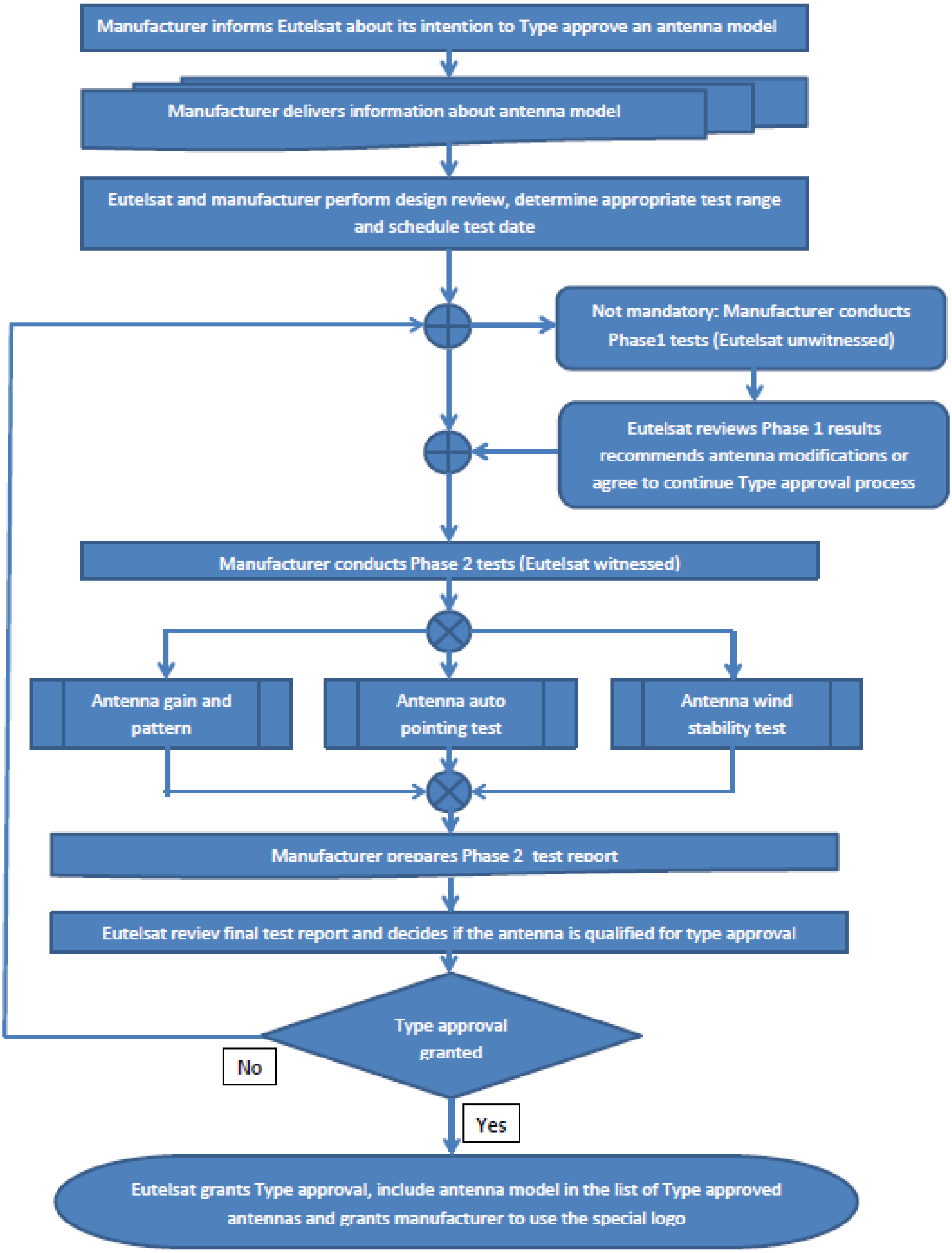
Table 4-1 Eutelsat requirements for the Cross Polarization Discrimination (XPD) at the - 1 dB contour of the main lobe

5 Approval process

5.1 Type Approval process for fix Antennas and VSATs



5.2 Type Approval process for auto-pointing antennas



5.3 Step-by-step process

The basic steps to be followed by the applicant to obtain type approval are:

1. Obtain Eutelsat S.A. Documentation as appropriate. => Paragraph 2.3.1
2. Notify Eutelsat S.A. of the intention to qualify an antenna or a VSAT for "Type Approval" or "Characterization"=> Chapter 5
3. Provide Eutelsat S.A. with the required technical information.
4. Review Meeting with Eutelsat S.A.
5. Under the coordination and control of Eutelsat S.A., conduct type approval or characterization verification testing.
6. Range test => Chapter 7
7. Pointing Accuracy test => Chapter 8
8. G/T measurement for integrated VSAT => Chapter 9
9. Auto-Deploy tests (if applicable) => Chapter 10
10. Wind stability test => Chapter 11
11. For antennas on the move the pointing accuracy test and wind stability test are replaced by the dynamic pointing test => Chapters 13 and 14
12. Evaluate test results in coordination with Eutelsat S.A.,
13. Produce Type Approval or Characterization Verification Test Report for submission to Eutelsat S.A.
14. Obtain Eutelsat S.A. Type Approval or Characterization for the equipment in question.

5.4 Data to be submitted

The data to be submitted to Eutelsat S.A. shall include the following details:

15. Application form and questionnaire duly filed out before stating the antenna approval process;
16. Antenna/VSAT drawings (tri-dimensional view plus front view, side view and top view) with dimensions;
17. Operating instructions including assembly manual;
18. Measured electrical characteristics, including RF patterns of the antenna/VSAT and details on the radio unit design in the case of VSATs if available;
19. Wind load test/analysis results if available;
20. Description of the manufacturing process (integrity, repeatability …) for all antenna/VSAT subsystems (reflector, feed, mount etc.) if available;

21. Analysis of the mechanical margins and predictions of variations that could impair the electrical performance if available;
22. Quality Assurance and Control Procedures (ISO 9001 etc.);
23. Packaging and shipment handling;
24. Any other details that could impair the repeatability of the manufacturing or on-site installation process or the standard of quality of the product if available;
25. Operating instructions including assembly manual.

All information supplied to Eutelsat S.A. will be treated in the strictest confidence and will not be disclosed to any third party.

5.5 Engineering support

Eutelsat will provide engineering support in order to witness the actual Type Approval or Characterization tests as necessary. It will also arrange the necessary initial meetings relating to the test plan and design review.

5.6 Design review

After reviewing the data submitted by the applicant relating to the earth station's antenna system or VSAT, Eutelsat will arrange a meeting to discuss the technical aspects and confirm the program of tests.

5.7 Type Approval and Characterization tests

The tests relating to type approval are considered in the next section but the final plan of tests should be agreed at the design review meeting.

Eutelsat requires the following tests carried out by the applicant in coordination with Eutelsat.

- Range test of three productions samples the antenna system;
- Auto-deploy performance tests (if applicable);
- Pointing accuracy test; Wind stability test;

Together with the applicant Eutelsat will fix the definitive test procedure and inform about appropriate test facilities.

5.8 Financial charges

There are not any financial charges from Eutelsat. The applicant will be charged only of the fees for the usage of the laboratory/test range.

5.9 Test facilities

The applicant is responsible for the provision of appropriate testing facilities, any support materials and staff for the entire testing period, in accordance with Eutelsat S.A. requirements.

A full description of the test facilities shall be provided in order to assess their suitability for the Eutelsat S.A Type Approval or Characterization campaign. Eutelsat may support the applicant by providing contact information about appropriate test facilities.

Currently used range test facilities in Europe and the US:

Thales Alenia Space - Centre d'Essais de Cannes

Mr. Herald Garcia Lopez del Amo
Head of compact Antenna Test Range (CATR) & EMC
Service CCPIF/AER
Office : M06-315
5 allée des Gabians - BP 99 - 06156 Cannes La Bocca cedex - France

Phone: +33 (0)4 92 92 64 99; Fax: +33 (0)4 92 92 75 50
E-mail: herald.garcia@thalesaleniaspace.com

Far field test range at Politecnico di Torino

Prof. Riccardo Maggiora
Director, Laboratory of Antennas and EMC
Dipartimento di Elettronica e Telecomunicazioni
Politecnico di Torino
Corso Duca degli Abruzzi 24
10129 Torino, Italy

Phone: +39 011 0904162
E-mail: riccardo.maggiora@polito.it

Compact Test Range at University Munich

Prof. Dr.-Ing. Georg Strauß
Munich University of Applied Sciences
Department of Electrical Engineering and Information Technology
Laboratory for Satellite Communications
Compensated Compact Antenna Test Range
Lothstr. 64, D-80355 München, Germany (Faculty Office)

Phone #1: +49 89 1265 3423; Mobile: +49 172 89 47 453
Fax: +49 89 1265 3403
E-Mail: strauss@ee.hm.edu
Homepage: www.compactrange.de

SAAB AB - Compact Antenna Test Range

Mr. Bengt Svensson
SE-412 89 Gothenburg, Sweden
Visiting address: Solhusgatan 10

Phone: +46 31 7478757; Mobile: +46 734 378757
E-mail: bengt.i.svensson@saabgroup.com
Web: www.saab.com/A15_antenna_measurements

Compact test range at PBI in Marietta, Georgia, USA

Mr Scott Cook
Pro Brand International, Inc.
1900 West Oak Circle
Marietta, GA 30062 United States of America

Phone: +1 678 741 2254 ; Mobile: +1 678 522 9939
E-mail: scook@pbigroup.com
Web: www.pbigroup.com

Compact test range of ND Satcom Immenstaad, Germany

Mr. Alfons Fischer, Mr. Guillaume Aris
Graf von Soden Strasse
88090 Immenstaad Germany

Tel+49 7545 939 8114
Email: alfons.fischer@ndsatcom.com , guillaume.aris@ndsatcom.com

Near Field Test Range at IMST GmbH Kamp-Lintfort, Germany

Dr.-Ing. Simon Otto
Antennas & EM Modelling
Carl-Friedrich-Gauß Str. 2
47475 Kamp-Lintfort, Germany

Tel. +49 (0)2842 981 311, Fax +49 (0)2842 981 499
E-Mail: otto@imst.de

Near Field Range in TTI, Spain

Mr. Manuel J. Gonzales
RF Engineer
TTI (Technologies of Telecommunications and Information)
Parque Cientifico y Tecnológico de Cantabria
C/ Albert Einstein nr. 14
39011 Santander (Spain)

+34 942 29 12 12
E-mail: mjgonzales@ttinorte.es

Far Field Test Range at Satellite Applications Catapult, United Kingdom

Mrs Lorraine Moody
Head of Operational Services
Electron Building, Fermi Avenue,
Harwell Campus, Didcot, Oxfordshire,
OX11 0QR, United Kingdom
Phone: +44 (0) 1235 567 999; Fax: +44 (0) 7867 488594
E-mail: Facilities@sa.catapult.org.uk

6 Request for Type Approval or Characterization

To request Type Approval or Characterization, complete the form as shown on the next page and forward to the Head of Ground Segment Operations at Eutelsat S.A. The mail address is typeapproval@eutelsat.com

All tests shall be witnessed by a Eutelsat S.A. test engineer or authorized representative.

The application form, hereafter, shall be filled by the applicant, in addition to Section IV specific for these terminals.

Eutelsat ☐ Application for Type Approval ☐ Application for Characterization

Please tick the relevant case

To:

Applicant: Date: Ref.:

Company Name:
Address:
Telephone: E-mail:

The Application for Type Approval or Characterization consists in an 11-point list, detailed in the following pages.

In case of antenna terminals to be used for SNG purposes (manually or automatically pointed) or mobile antenna terminals (aeronautical, maritime or land mobile), the applicant shall provide together with the information 1 to 8 below, additional information as detailed in paragraphs to 9.7, as applicable.

By the submission of this document, the applicant requests a Type Approval or a Characterization of the following earth station antenna & equipment for operation in [TBD] space segment.

The applicant certifies that the information provided in this application to EUTELSAT S.A. and in the attached documents describes as close as possible the properties and performance of the Antenna/VSAT terminal concerned. Any technical modifications or manufacturing change introduced to this system in future will be reported to EUTELSAT S.A. immediately.

Responsible Company Officer:

Place: .... Date: ....

Signature/Company Stamp: ....

Questionnaire for detailed information about the antenna under test.

Please fill out carefully and as complete as possible

(SECTION I – GENERAL)

1. TEST FACILITIES

1.1. Planned commencement of test campaign:

1.2. Proposed antenna test range:

1.3. Number of antennas available for witnessed verification testing:

2. SCOPE OF PRODUCTION

2.1. Anticipated number of production units (par year):

3. APPLICABLE STANDARDS

Please describe the standards which are currently met by your product (ITU, FCC, ETSI, etc.) and the future standards and Gain masks which the type approval is supposed to fulfil.

4. CERTIFICATION

Complete this application with the following mandatory documents:

- ❑ Full set of available radiation patterns of the system, including:
- ❑ Tx and Rx Cuts for each axis of the antenna
- ❑ Tx and Rx Cuts for both Azimuth and Elevation
- ❑ Cuts for both for co-pol and cross-pol contours and each polarization sense
- ❑ The applicable Gain masks for the antenna type
- ❑ Indication of the beam width for 3 and 10 dB
- ❑ Radome if applicable.
- ❑ The origin of these data (e.g. simulation, prototype testing, etc.)
- ❑ Overview drawing and photos of complete antenna system including block diagram
- ❑ Commercial documentation/datasheets
- ❑ Screen shots of spectrum analyzer of HPA output spectrum with indication of out-of-band radiations
- ❑ 24 hours stability test records including consideration of beam pointing stability and tracking

(SECTION II – ANTENNA)

5. SUB-FUNCTION

☐ Drive away
- ☐ Fly away..
- ☐ Suitcase antenna
- ☐ Vehicle mounted SNG
- ☐ Maritime antenna
- ☐ Satcom on the move
- ☐ Fixed
- ☐ Aeronautical ....
- ....☐ Other (please state): ....

6. ANTENNA DATA

6.1. Manufacturer:

6.1.1. Model (including options):
6.1.2. f/D (focal length to diameter ratio):

6.2. If the antenna system is an integration from another system, please precise the following information:
6.2.1. Original manufacturer:
6.2.2. Original model:

6.3. Pointing system

☐ Manual

☐ Auto-pointing Manufacturer:

Model & type:

☐ Built in firmware compliance with applicable satellite operations (in particular Polarization .skew angles)

☐ Motorized

☐ Retrofit of motors feasibility

6.4. Main reflector

☐ Circular Diameter: ..... m

☐ Elliptical Hor. Axis: ..... m / Ver. Axis: ... m, equivalent to ... m circular

☐ Diamond Equivalent to .... m circular

☐ Batwing Equivalent to .... m circular

☐ Radome Manufacturer:

Model & type:

☐ De-icing equipped Manufacturer:

Model & type:

☐ Retrofit of de-icing feasibility

6.5. Tracking

☐ Monopulse

☐ Program

☐ Step

☐ Step (with memory)

☐ Conical scanning (Conscan)

☐ None

☐ Other

6.6. Type

☐ Front fed

☐ Cassegrain

☐ Gregorian

☐ Offset front fed

☐ Offset cassegrain

☐ Offset gregorian

☐ Back-fire feed

☐ Phase-array

☐ Other

6.7. Beam pointing accuracy: maximum deviation of beam………………° at wind speed of ………………km/h

6.8. Feed System:

6.8.1. Reference Manufacturer: ………………

Model: …………………………

6.8.2. Ports ☐ Tx Nr. Ports: ………………

☐ Rx Nr. Ports: ………………

6.8.3. ☐ Feed blower

6.9. Polarization: ☐ Linear

☐ Circular

6.10. Frequency Bands

Rx Frequency Band (GHz)	Tx Frequency Band (GHz)
Gain (dBi) at Frequency (GHz)	Gain (dBi) at Frequency (GHz)
☐ 2.20 - 2.29 ....dBi at ....GHz	☐ 2.08 - 2.095 ....dBi at ....GHz
☐ 3.60-4.20 ....dBi at ....GHz	☐ 5.80-6.40 .... dBi at ....GHz

☐ 7.25-7.75 ....dBi at ....GHz
☐ 10.70-10.95 ....dBi at ....GHz
☐ 11.20-11.70 ....dBi at ....GHz
☐ 11.70-12.50 ....dBi at ....GHz
☐ 12.50-12.75 ....dBi at ....GHz
☐ 18.40-19.70 ....dBi at ....GHz
☐ 17.30-20.20 ....dBi at ....GHz
☐ 17.70-20.20 ....dBi at ....GHz
☐ 19.70-20.20 ....dBi at ....GHz
☐ 20.20-21.20 ....dBi at ....GHz
☐ 21.40-22.00 ....dBi at ....GHz

☐ 7.90-8.40 .... dBi at ....GHz
☐ 12.75-13.00 ....dBi at ....GHz
☐ 13.75-14.00 ....dBi at ....GHz
☐ 14.00-14.50 ....dBi at ....GHz
☐ 17.30-18.10 ....dBi at ....GHz
☐ 18.10-18.40 ....dBi at ....GHz
☐ 27.50-29.50 ....dBi at ....GHz
☐ 28.50-29.00 ....dBi at ....GHz
☐ 29.50-30.00 ....dBi at ....GHz
☐ 30.00-31.00 ....dBi at ....GHz

6.11. G/T: .... dB/K at .... GHz
LNA/LNB/LNC noise temperature .... K

At elevation angle ....degrees

6.12. Specified on-axis cross-pol isolation ....dB (Tx) ....dB (Rx)

6.13. Specified off-axis cross-pol isolation within -1 dB contour of the main beam

.............dB (Tx)............. dB(Rx)

6.14. Axial ratio (for C-Band circular)............ (Tx).............(Rx)

6.15 Generation of MUTE command by (applicable only to “Satcom on the Move” and maritime systems):

☐ Not applicable

☐ Modem

☐ ACU

De-connexion time .... seconds

7. TRANSMIT EQUIPMENT

7.1. HPA’s

7.1.1. Type	☐ TWTA	Number of units:	Rating (Watt): ....
	☐ Klystron	Number of units:	Rating (Watt): ....
	☐ SSA	Number of units:	Rating (Watt): ....
	☐ SSPA	Number of units:	Rating (Watt): ....
	☐ BUC	Number of units:	Rating (Watt): ....

7.1.2. Loss Post HPA loss: ………………… dB

7.1.3. Combiner

☐ Phase combiner

☐ Multiplexer

☐ Redundancy switch

7.2. Uplink EIRP

7.2.1 Maximum capability: ……. dBW

7.2.2.Overall RMS stability in the direction of the satellite: ……………. dB over 24 hours

7.2.3. Out-of-band EIRP spectral density ……………………………….. dBW per 4 kHz

……………………………….. dBW per 12.5 MHz

7.2.4. Measuring equipment for transmit power: ☐ IF ☐ RF

7.2.5. EIRP measurement / adjustment:

7.3. UPPC mechanism controlled by:

☐ Not applicable

☐ Beacon level

☐ Sky noise temperature

☐ Operational carrier

☐ Other, please state: ……………………..

8. FREQUENCY CONVERTERS

8.1. TX frequency stability tolerance: …………. kHz

8.2. Number of up converters:

8.3. Number of down converters:

8.4. Number of block up converters:

8.5. Number of LNA/LNB/LNC:

(SECTION III – COMPONENT LIST)

In order to unambiguously identify the terminal configuration, you are requested to provide, where applicable, the make and type numbers for the components listed below and complete for other essential parts as necessary:

Component	Model	Type Number
Antenna mount:		
Actuator elevation		
Actuator azimuth		
Subreflector:		
Feedhorn:		
Ortho-mode transducer (OMT):		
LNA/LNB/LNC:		
RF-unit:		
Power amplifier:		
Indoor unit:		
UPPC:		
Antenna Control Unit (ACU)		
Modem		
Others, please specify		

(SECTION IV – SPECIAL MODELS)

9. AUTO-DEPLOY TERMINAL ADDITIONAL INFORMATION MOTION

- Azimuth minimum angular manual movement resolution (degrees),
- Elevation minimum angular manual movement resolution (degrees),
- Polarization minimum angular manual movement resolution (degrees),
- Azimuth minimum slew speed (degrees/sec),
- Elevation minimum slew speed (degrees/sec),
- Polarization minimum rotational speed (degrees/sec),
- Resolvers manufacturer, model and type (optical, etc.),
- Resolvers resolution (number of bits). Example for a 360° Azimuth slew, 16 bits would yield a resolution of 360/2E16= 0.005°,
- The minimum step for the step-by-step slew should be 0.1°or smaller to ensure the correct evaluation of the pointing error,
- The expected operational and survival wind conditions and the methods which have been used to prove them (e.g. wind load analysis),
- Temperature and humidity operational conditions
- Auto-deploy terminal expected backlash,
- Maximum operating tilt of the antenna.

9.1 Auto-deploy operations and procedures

- Describe the pointing algorithms used (beacon reception, DVB-S reception, dedicated signal from a Hub, NORAD parameters, etc.),
- Describe the polarization alignment method (calculation, cross-polarization nulling etc.). It applies for linear polarized antennas only,
- Expected pointing accuracy (Azimuth, Elevation, Polarization (linear polarization only) in degrees),
- Satellite pointing process (describe),
- Satellite peaking process (describe),
- Polarization alignment and optimization method (describe). It applies for linear polarized antennas only,
- The angle of the polarization plane of the satellites with respect to the equatorial plane (skew angle) needs to be taken into account whenever the polarization alignment of the antenna is optimized by calculation. Describe satellite skew look up tables, see Annex B. It applies for linear polarized antennas only,
- Transmission enable procedures (describe).

9.2 Transmitter

- Manufacturer/model and number, please provide a list of all compatible units,
- Type of transmitters (TWTA, SSPA etc.),
- Transmitter rating,
- Post HPA losses.
- Is it possible to limit the input power of the system? If so, describe the process,
- Is it possible to limit the output power of the system? If so, describe the process,
- Is it possible attach a transmitter to the system which is considerably higher in specified power than your antenna system was designed for?

9.3. Modem(s)

- Manufacturer/model, please provide a list of all compatible units.

9.4. Monitoring systems

- Transmit RF Carrier monitoring system (type, manufacturer, model),
- Transmit coupling factor,
- Post-coupler loss,
- Demodulator (type, manufacturer, model).

9.5. Other parts

- Cover/radome manufacturer/model,
- Jacks manufacturers/model, number and position,
- GPS manufacturer/model,
- Compass(es) manufacturer/model,
- Vehicle manufacturer/model (drive away),
- Transportation case(s) and mount manufacturer/model (fly away).

9.6. Installation and operations handbook

9.7. Mobile antenna tests

For the specific case of antennas for the aeronautical, maritime and land mobile, additional tests on the tracking system will be performed to assess the Beam Pointing Error (BPE).

Test facilities to assess the BPE shall be made available by the applicant in order to simulate movements on the 3 axis, at predetermined speeds and accelerations.

The maximum acceptable BPE is normally set to $\pm$ 0.4°.

Additional tests shall be performed to prove the ability of the terminal to cease transmission (mute) when the BPE exceeds a target value and the ability to resume transmission when the BPE falls below a target value.

The applicant shall provide also a block diagram showing how the mute function is implemented (e.g. muting directly the transmitter or through the modem)

7 Type Approval/Characterization tests

7.1 Antenna range tests

The minimum tests to be performed to obtain Type Approval or Characterization status are listed below:

- Transmit gain and e.i.r.p.
- Transmit copolar pattern
- Transmit crosspolar pattern
- Transmit crosspolar discrimination
- Receive antenna gain
- Receive crosspolar discrimination
- Receive copolar pattern
- Receive crosspolar pattern
- Tx raster scan copolar
- Tx raster scan crosspolar

The duration objective for the RF pattern tests should not exceed five working days for the type approval program and two working days for the Characterization program.

The purpose of the tests will be to determine the mean electrical performance characteristics of the antenna series and the statistical deviations.

All antenna sidelobe patterns shall be tested on a test range agreed beforehand by Eutelsat.

For guidance on the Eutelsat S.A. requirements, an extract from them covering the antenna sidelobe pattern is provided in Paragraph 4.1.

An agreed number of units will be tested and every effort will be made to ensure that the units are "typical" and representative of units operating in the field.

Normally three units are chosen for a type approval certification and one unit is chosen for a characterization. Pointing tests (auto or manual) require normally one antenna only to be tested.

It is essential that the units to be tested are:

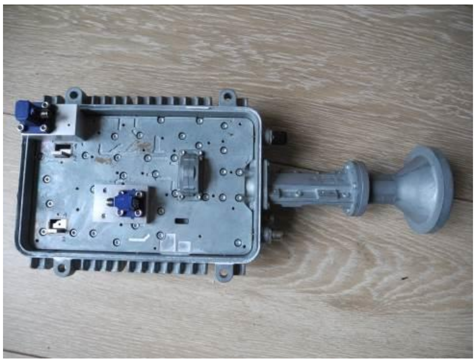
- Assembled and installed in accordance with the processes described for normal operations by personnel possessing levels of skill and experience that would be expected in the field;
- Selected at random;

- Installed on the test range in their full operational configuration, i.e. including all sub-systems (radome, hosting pods, HPAs, feed covers etc.) which can affect the antenna sidelobe performance.

It is suggested that sample units be randomly selected at a rate to be agreed.

If the antenna system has a large number of mechanical components, Eutelsat S.A. may request that samples be randomly selected at a rate based upon the projected length of the production run.

The manufacturer shall provide an appropriate test adapter which allows the direct connection of the test range facilities directly behind the OMT for RX and for TX without any electronics in order to have precise measurement data. **This adapter need to be provided only once for all three antennas under test for Eutelsat** Type approval. Pictures of such adapters below:



7.2 Integrated transceiver VSAT tests

In addition to the antenna tests, the applicant shall provide data on the VSAT transceivers and the RF carrier management of the network used. The data will primarily focus on the stability aspects of the RF amplifier stages as well as on the determination of the terminal EIRP and carrier characteristics e.g. ACM.

These aspects will be addressed on a case by case basis in cooperation with the manufacturer concerned.

Details on VSAT ODU (Outdoor Units) type approval are shown in ESOG Module 160.

7.3 Mobile antenna tests

For the specific case of antennas for aeronautical (AES), maritime (ESV) and land mobile (VMES), additional tests on the tracking system will be performed to assess the Beam Pointing Error (BPE) and the mute functions.

In the case of a Type Approval certification, adequate test facilities to assess the BPE and mute functions shall be made available by the applicant in order to simulate movements on the 3 axes, at predetermined speeds and accelerations (e.g. motion table).

In the case of a Characterization of the static RF performance of an antenna system, Eutelsat S.A. will decide on a case by case basis how to assess the BPE and mute functions (e.g. through test drives for VMES or un-witnessed test results for ESV systems).

The maximum acceptable BPE is normally set at ± 0.4°.

For further information on the tests on ESV terminals, see Chapter 13.

For further information on the tests on VMES terminals, see Chapter 14.

7.4 Typical antenna tests for Eutelsat Type Approval or Characterization

Eutelsat Type Approval requires normally the witness-testing of 3 antennas of the same model; Eutelsat Characterization requires normally the witness-testing of one antenna of the same model.

The typical pattern tests for Eutelsat Type Approval/Characterization are summarized in the following tables.

7.4.1 C band

Test	Frequencies [GHz]	Angular span
TX Gain LHCP	5.80-6.40	Frequency-swept
TX Gain RHCP	5.80-6.40	Frequency-swept
RX Gain LHCP	3.60-4.20	Frequency-swept
RX Gain RHCP	3.60-4.20	Frequency-swept
Tx on-axis XPD LHCP	5.80-6.40	Frequency-swept
Tx on-axis XPD RHCP	5.80-6.40	Frequency-swept
TX AZ LHCP Co & Cross	5.80, 6.10, 6.40	Co +/-180°
TX AZ RHCP Co & Cross	5.80, 6.10, 6.40	Co +/-180°
TX EL LHCP Co & Cross	5.80, 6.10, 6.40	Min +/-10°
TX EL RHCP Co & Cross	5.80, 6.10, 6.40	Min +/-10°
RX AZ LHCP Co & Cross	3.60, 3.90, 4.20	Co +/-180°
RX AZ RHCP Co & Cross	3.60, 3.90, 4.20	Co +/-180°
RX EL LHCP Co & Cross	3.60, 3.90, 4.20	Min +/-10°
RX EL RHCP Co & Cross	3.60, 3.90, 4.20	Min +/-10°
Tx Contour plots LHCP Co &	5.80, 6.10, 6.40	+/- YY° Az and El
Tx Contour plots RHCP Co&	5.80, 6.10, 6.40	+/- YY° Az and El
Rx Contour plots LHCP Co &	6.10	+/- YY° Az and El
Rx Contour plots RHCP Co&	6.10	+/- YY° Az and El

1. Typically on the Co +/-180° with zooms, zoomed spans are +/- 10° and +/- 30°;
2. For antenna units 2 and 3 (if applicable) some frequencies may be skipped (e.g. Rx side);
3. For antenna units 2 and 3 (if applicable), at certain frequencies angular spans may be limited to +/-30° with zooms +/-10°;
4. Cross-polar pattern tests are always limited to +/-9.2°;
5. Minimum step size for gain swept measurements is 10 MHz. If Tx/Rx Gain frequency swept tests are not possible, discrete Tx and Rx Gain at the frequencies of the patterns shall be tested instead. The applicant shall request the authorization for waiving swept gain measurements prior to the test campaign;
6. If the test range cannot measure contour plots, tests with the antenna skewed at +/-45° shall be performed instead on at least a +/-10° angular span;
7. +/- YY span depends on the antenna and frequency and shall be such to include at least the first sidelobe;

8. All envelope masks of the co-polar antenna patterns shall be traced starting from 0.5°, independent of the value of $\alpha = 100\lambda/D$;
9. For antennas operating under radome, all tests shall be performed with the radome in place.

7.4.2 Ku band

Test	Frequencies [GHz]	Angular span	First antenna	Second and further antenna
TX Gain H	12.75-14.50	Frequency-swept	X See note 5	X See note 5
TX Gain V	12.75-14.50	Frequency-swept	X See note 5	X See note 5
RX Gain H	10.70-12.75	Frequency-swept	X See note 5	
RX Gain V	10.70-12.75	Frequency-swept	X See note 5	
Tx On axis cross-pol H	12.75-14.50	Frequency-swept	X	X
Tx On axis cross-pol V	12.75-14.50	Frequency-swept	X	X
TX Az H Co	12.75, 13.00, 13.25, 13.75,14.00, 14.25, 14.50	Co +/-180°	X See note 4	
Tx Az V Co	12.75, 13.00, 13.25, 13.75,14.00, 14.25, 14.50	Co +/-180°	X See note 4	
TX Az H Co & Cross	12.75, 13.00, 13.25, 13.75,14.00, 14.25, 14.50	Min +/-10°	X See note 4	X
Tx Az V Co & Cross	12.75, 13.00, 13.25, 13.75,14.00, 14.25, 14.50	Min +/-10°	X See note 4	X
TX Az H Co & Cross +/- 30° polarization skew	12.75, 13.00, 13.25, 13.75,14.00, 14.25, 14.50	Co +/- 10°	X See note 1, 4	
Tx Az V Co & Cross +/- 30° polarization skew	12.75, 13.00, 13.25,13.75,14.00, 14.25, 14.50	Co +/-10°	X See note 1, 4	
Tx El H Co & Cross	12.75, 13.00, 13.25, 13.75,14.00, 14.25, 14.50	Min +/-10°	X See note 4	X
Tx El V Co & Cross	12.75, 13.0, 13.25,13.75,14.00, 14.25, 14.50	Min +/-10°	X See note 4	X
Rx Az H Co & Cross	10.70, 10.95, 11.70, 12.50, 12.75	Min +/-10°	X	
Rx Az V Co & Cross	10.70, 10.95, 11.70, 12.50, 12.75	Min +/-10°	X	

Rx El H Co & Cross	10.70, 10.95, 11.70, 12.50, 12.75	Min +/-10°	X	
Rx El V Co & Cross	10.70, 10.95, 11.70, 12.50, 12.75	Min +/-10°	X	
Tx Contour plots H Co & Cross	12.75, 13.00, 13.25, 13.75,14.00, 14.25, 14.50	+/- YY° Az and El	X See note 2, 4, 6	X
Tx Contour plots V Co& Cross	12.75, 13.00, 13.25, 13.75,14.00, 14.25, 14.50	+/- YY° Az and El	X See note 2, 4, 6	X
TX H antenna skewed +/- 45° Co and Cross	12.75, 13.00, 13.25,,13.75,14.00, 14.25, 14.50	Min +/-10°	X See note 2, 4	X
TX V antenna skewed +/- 45° Co and Cross	12.75, 13.00, 13.25, 13.75,14.00, 14.25, 14.50	Min +/-10°	X See note 2, 4	X
Rx Contour plots H Co & Cross	11.70	+/- YY° Az and El	X See note 3	
Rx Contour plots V Co& Cross	11.70	+/- YY° Az and El	X See note 3	

1. Tests at +/-30° feed skew not required if antenna aligns with the GSO arc;
2. TX contour plots are preferred. Only in case TX contour plots are not possible TX H/V antenna skewed +/- 45° are required;
3. RX contour plots only required in case of substantial differences between the 10° RX pattern and the 10° TX pattern in AZ and El. To be decided during test. Frequencies 12.75, 13.00 , 13.25 GHz can be dropped on request of manufacturer and is stated in approval document;
4. Cross-polar pattern tests are always limited to +/-9.2°;
5. Minimum step size for gain swept measurements is 10 MHz. If Tx/Rx Gain frequency swept tests are not possible, discrete Tx and Rx Gain at the frequencies of the patterns shall be tested instead. The applicant shall request the authorization for waiving swept gain measurements prior to the test campaign;
6. +/- YY span depends on the antenna and frequency and shall be such to include at least the first sidelobe;
7. All envelope masks of the co-polar antenna patterns shall be traced starting from 1°, independent of the value of $\alpha = 100\lambda/D$;
8. Earth stations operating in the 12.75 to 13.25 GHz band and in the 13.75 to 14.00 GHz have to follow special requirements from the ITU specifications;
9. The transmit frequencies referred as AP30B (from the ITU FSS Plan – Appendix 30B) in the range 12.75- 13-25 GHz have been defined for specific applications. Eutelsat or the manufacturer shall specify if these frequencies has to be tested.

10. For antennas operating under radome, all tests shall be performed with the radome in place.

7.4.3 K-Band (DBS) linear polarization

Test	Frequencies [GHz]	Angular span	First antenna	Second and further antenna
TX Gain H	18.10 – 18.40	Frequency-swept	X See note 5	X See note 5
TX Gain V	18.10 – 18.40	Frequency-swept	X See note 5	X See note 5
RX Gain H	10.70-12.75 or 21.20 to 22.00	Frequency-swept	X See note 5	
RX Gain V	10.70-12.75 or 21.20 to 22.00	Frequency-swept	X See note 5	
Tx On axis cross-pol H	18.10 – 18.40	Frequency-swept	X	X
Tx On axis cross-pol V	18.10 – 18.40	Frequency-swept	X	X
TX Az H Co	18.10, 18.25, 18.40	Co +/-180°	X See note 4	
Tx Az V Co	18.10, 18.25, 18.40	Co +/-180°	X See note 4	
TX Az H Co & Cross	18.10, 18.25, 18.40	Min +/-10°	X See note 4	X
Tx Az V Co & Cross	18.10, 18.25, 18.40	Min +/-10°	X See note 4	X
TX Az H Co & Cross +/-30° polarization skew	18.10, 18.25, 18.40	Co +/- 10°	X See note 1, 4	
Tx Az V Co & Cross +/-30° polarization skew	18.10, 18.25, 18.40	Co +/-10°	X See note 1, 4	
Tx El H Co & Cross	18.10, 18.25, 18.40	Min +/-10°	X See note 4	X
Tx El V Co & Cross	18.10, 18.25, 18.40	Min +/-10°	X See note 4	X
Rx Az H Co & Cross	10.70, 10.95, 11.70, 12.50, 12.75 or 21.20, 21.60, 22.00	Min +/-10°	X	
Rx Az V Co & Cross	10.70, 10.95, 11.70, 12.50, 12.75 or21.20, 21.60, 22.00	Min +/-10°	X	
Rx El H Co & Cross	10.70, 10.95, 11.70, 12.50, 12.75 or 21.20, 21.60, 22.00	Min +/-10°	X	
Rx El V Co & Cross	10.70, 10.95, 11.70, 12.50, 12.75 or 21.20, 21.60, 22.00	Min +/-10°	X	

Tx Contour plots H Co & Cross	18.10, 18.25, 18.4	+/- YY° Az and El	X See note 2, 4, 6	X
Tx Contour plots V Co& Cross	18.10, 18.25, 18.4	+/- YY° Az and El	X See note 2, 4, 6	X
TX H antenna skewed +/- 45° Co and Cross	18.10, 18.25, 18.40	Min +/-10°	X See note 2, 4	X
TX V antenna skewed +/- 45° Co and Cross	18.10, 18.25, 18.40	Min +/-10°	X See note 2, 4	X
Rx Contour plots H Co & Cross	10.70, 10.95, 11.70, 12.50, 12.75 or 21.20, 21.60, 22.00	+/- YY° Az and El	X See note 3	
Rx Contour plots V Co& Cross See note 3	10.70, 10.95, 11.70, 12.50, 12.75 or 21.20, 21.60, 22.00	+/- YY° Az and El	X See note 3	

1. Tests at +/-30° feed skew not required if antenna aligns with the GSO arc;
2. TX contour plots are preferred. Only in case TX contour plots are not possible TX H/V antenna skewed +/- 45° are required;
3. RX contour plots only required in case of substantial differences between the 10° RX pattern and the 10° TX pattern in AZ and El. To be decided during test. Frequencies 12.75, 13.00 , 13.25 GHz can be dropped on request of manufacturer and is stated in approval document;
4. Cross-polar pattern tests are always limited to +/-9.2°;
5. Minimum step size for gain swept measurements is 10 MHz. If Tx/Rx Gain frequency swept tests are not possible, discrete Tx and Rx Gain at the frequencies of the patterns shall be tested instead. The applicant shall request the authorization for waiving swept gain measurements prior to the test campaign;
6. +/- YY span depends on the antenna and frequency and shall be such to include at least the first sidelobe;
7. All envelope masks of the co-polar antenna patterns shall be traced starting from 1°, independent of the value of $\alpha = 100\lambda/D$;
8. For antennas operating under radome, all tests shall be performed with the radome in place.

7.4.4 Ka Band circular polarization (KASAT)

Test	Frequencies [GHz]	Angular span	First antenna	Second and further antenna
TX Gain LHCP	29.50-30.00	Frequency-swept	X	X
TX Gain RHCP	29.50-30.00	Frequency-swept	X	X
RX Gain LHCP	19.70-20.20	Frequency-swept	X	
RX Gain RHCP	19.70-20.20	Frequency-swept	X	
Tx on-axis XPD LHCP	29.50-30.00	Frequency-swept	X	X
Tx on-axis XPD RHCP	29.50-30.00	Frequency-swept	X	X
TX AZ LHCP Co	29.50, 29.75, 30.00	Co +/-180°	X	
TX AZ RHCP Co	29.50, 29.75, 30.00	Co +/-180°	X	
TX AZ LHCP Co & Cross	29.50, 29.75, 30.00	Min +/-10°	X	X
TX AZ RHCP Co & Cross	29.50, 29.75, 30.00	Min +/-10°	X	X
TX EL LHCP Co & Cross	29.50, 29.75, 30.00	Min +/-10°	X	X
TX EL RHCP Co & Cross	29.50, 29.75, 30.00	Min +/-10°	X	X
RX AZ LHCP Co & Cross	19.70, 19.95, 20.20	Co +/-180°	X	
RX AZ RHCP Co & Cross	19.70, 19.95, 20.20	Co +/-180°	X	
RX EL LHCP Co & Cross	19.70, 19.95, 20.20	Min +/-10°	X	
RX EL RHCP Co & Cross	19.70, 19.95, 20.20	Min +/-10°	X	
Tx Contour plots LHCP Co & Cross	29.50, 29.75, 30.00	circa +/- 4° Az and El	X See note 1	X See note 1
Tx Contour plots RHCP Co& Cross	29.50, 29.75, 30.00	circa +/- 4° Az and El	X See note 1	X See note 1
TX AZ Antenna skew +/- 45° LHCP Co & Cross	29.50, 29.75, 30.00	Min +/-10°	X note 1, 2	X note 1, 2
TX AZ Antenna Skew +/- 45° RHCP Co & Cross	29.50, 29.75, 30.00	Min +/-10°	X note 1, 2	X note 1 ,2
Rx Contour plots LHCP Co & Cross	19.70, 19.95, 20.20	circa +/- 5° Az and El	X See note 2	
Rx Contour plots RHCP Co& Cross	19.70, 19.95, 20.20	circa +/- 5° Az and El	X See note 2	

1. TX contour plots are preferred. Only in case TX contour plots are not possible TX H/V antenna skewed +/- 45° are required. Also, for the study of low profile antennas

(elliptical, rectangular or similar) it is preferred to proceed with cuts over different plans at regular angles from -90° to +90°;

2. RX contour plots only required in case of substantial differences between the 10° RX pattern and the 10° TX pattern in AZ and El. To be decided during test;
3. Cross-polar pattern tests are always limited to +/-9.2°;
4. Minimum step size for gain swept measurements is 10 MHz. If Tx/Rx Gain frequency swept tests are not possible, discrete Tx and Rx Gain at the frequencies of the patterns shall be tested instead. The applicant shall request the authorization for waiving swept gain measurements prior to the test campaign;
5. All envelope masks of the co-polar antenna patterns shall be traced starting from 1°, independent of the value of $\alpha = 100\lambda/D$;
6. For antennas operating under radome, all tests shall be performed with the radome in place.

7.4.5 Ka Band circular polarization (Konnect)

Test	Frequencies [GHz]	Angular span	First antenna	Second and further antenna
TX Gain LHCP	29.50-30.00	Frequency-swept	X	X
TX Gain RHCP	29.50-30.00	Frequency-swept	X	X
RX Gain LHCP	17.70-20.20	Frequency-swept	X	
RX Gain RHCP	17.70-20.20	Frequency-swept	X	
Tx on-axis XPD LHCP	29.50-30.00	Frequency-swept	X	X
Tx on-axis XPD RHCP	29.50-30.00	Frequency-swept	X	X
TX AZ LHCP Co	29.50, 29.75, 30.00	Co +/-180°	X	
TX AZ RHCP Co	29.50, 29.75, 30.00	Co +/-180°	X	
TX AZ LHCP Co & Cross	29.50, 29.75, 30.00	Min +/-10°	X	X
TX AZ RHCP Co & Cross	29.50, 29.75, 30.00	Min +/-10°	X	X
TX EL LHCP Co & Cross	29.50, 29.75, 30.00	Min +/-10°	X	X
TX EL RHCP Co & Cross	29.50, 29.75, 30.00	Min +/-10°	X	X
RX AZ LHCP Co & Cross	17.70, 18.20, 18.70, 19.20, 19.70, 20.20	Co +/-180°	X	
RX AZ RHCP Co & Cross	17.70, 18.2, 18.7, 19.2, 19.7, 20.20	Co +/-180°	X	
RX EL LHCP Co & Cross	17.70, 18.20, 18.70, 19.20, 19.70, 20.20	Min +/-10°	X	
RX EL RHCP Co & Cross	17.70, 18.20, 18.70, 19.20, 19.70, 20.20	Min +/-10°	X	
Tx Contour plots LHCP Co & Cross	29.50, 29.75, 30.00	circa +/- 4° Az and El	X See note 1	X See note 1
Tx Contour plots RHCP Co& Cross	29.50, 29.75, 30.00	circa +/- 4° Az and El	X See note 1	X See note 1
TX AZ Antenna skew +/- 45° LHCP Co & Cross	29.50, 29.75, 30.00	Min +/-10°	X See note 1, 2	X See note 1, 2
TX AZ Antenna Skew +/- 45° RHCP Co & Cross	29.50, 29.75, 30.00	Min +/-10°	X See note 1, 2	X See note 1, 2
Rx Contour plots LHCP Co & Cross	17.70, 18.20, 18.70, 19.20, 19.70, 20.20	circa +/- 5° Az and El	X See note 2	

Rx Contour plots RHCP Co& Cross	17.70, 18.20, 18.70, 19.2, 19.7, 20.20	circa +/- 5° Az and El	X See note 2	

1. TX contour plots are preferred. Only in case TX contour plots are not possible TX H/V antenna skewed +/- 45° are required. Also, for the study of low profile antennas (elliptical, rectangular or similar) it is preferred to proceed with cuts over different plans at regular angles from -90° to +90°
2. RX contour plots only required in case of substantial differences between the 10° RX pattern and the 10° TX pattern in AZ and El. To be decided during test.
3. Cross-polar pattern tests are always limited to +/-9.2°;
4. Minimum step size for gain swept measurements is 10 MHz. If Tx/Rx Gain frequency swept tests are not possible, discrete Tx and Rx Gain at the frequencies of the patterns shall be tested instead. The applicant shall request the authorization for waiving swept gain measurements prior to the test campaign;
5. All envelope masks of the co-polar antenna patterns shall be traced starting from 1°, independent of the value of $\alpha = 100\lambda/D$;
6. For antennas operating under radome, all tests shall be performed with the radome in place.

7.4.6 Other tests

For specific applications additional mandatory tests apply:

- ANTENNAS INCLUDING THE MOUNT
  - Wind load Testing
- STATIONS AND TERMINALS FITTED WITH TRANSMITTERS
  - Out-of-band radiation levels
- VSAT
  - BUC temperature stability tests

7.4.7 Presentation of range test results

The antenna range test report shall contain the following information:

- Short description of the test range, main technical range data and range capabilities like frequency range, dynamic measurement range, instruments used, frequency conversion etc.
- Statement of the range measurement accuracy and identification of range uncertainties.
- Photos of the antenna under test and detail photos of the test adapter used.
- Test plan with reference to the diagrams in the report
- Table of antenna gain at different frequencies that is used for the antenna pattern diagrams.
- Antenna patterns according to test plan for each cut and each frequency according to the example outlined hereafter plus for each antenna cut a superposition of the patterns for all frequencies measured.
- Antenna raster scan according to test plan. The raster scan shall show the difference between the measured three dimensional pattern and the Eutelsat mask in different colors with and minimum accuracy of 1 dB per color.
- For antenna Type approval there should be an individual report for each antenna tested

7.4.7.1 Antenna pattern diagrams

Antenna model, unit No., Pol., Frequency, Az/El/+/- 45° cut

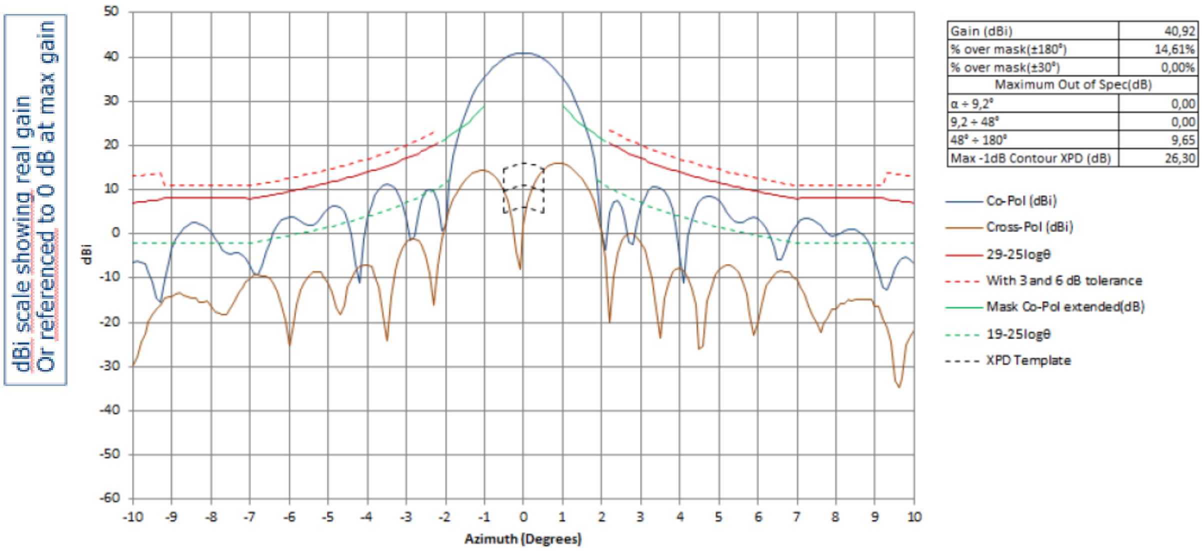
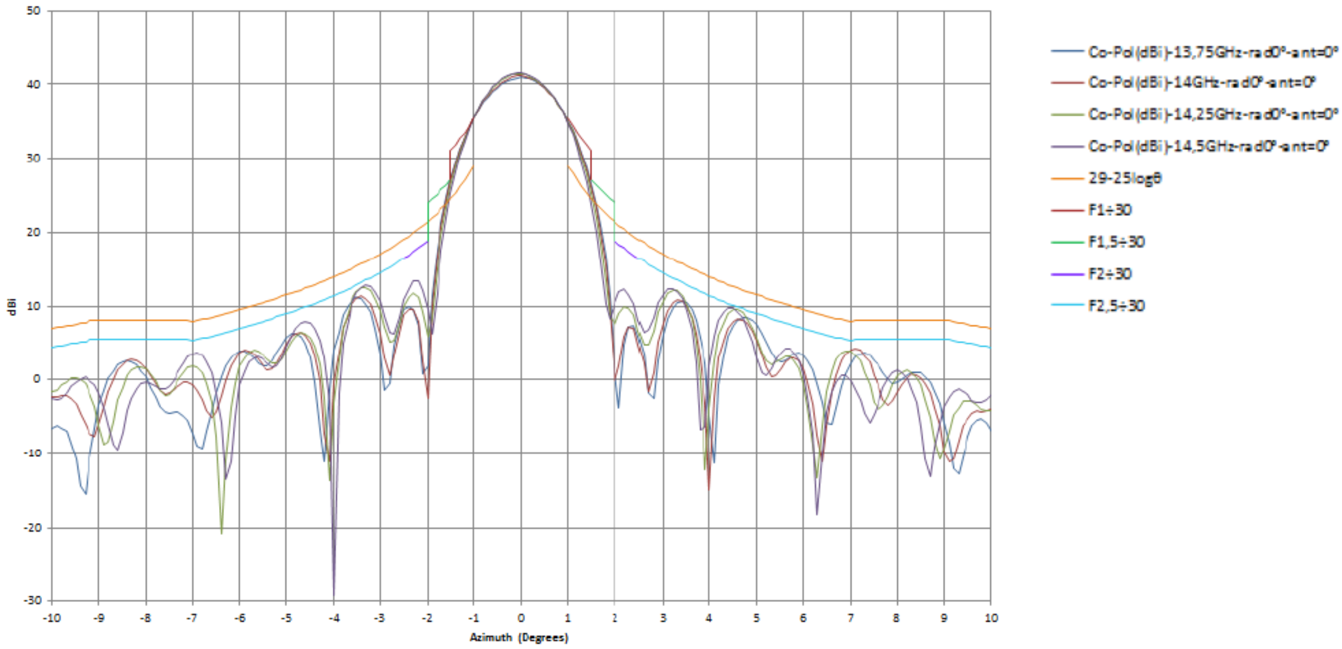


Figure 7-1: example 1 of antenna pattern diagrams

Note: The Eutelsat mask to calculate the Off-Axis EIRP density shall start at 1° in any case

7.4.7.2 Example 2: antenna pattern diagrams



Frequency (GHz)	13,75	14	14,25	14,5
1 ÷ 1,5 [deg]	-6,51	-6,50	-6,53	-6,52
1,5 ÷ 2 [deg]	-2,51	-2,28	-1,63	-0,63
2 ÷ 2,5 [deg]	2,55	2,98	2,96	2,92
2,5 ÷ 3 [deg]	2,55	2,98	2,96	2,92

Azimuth	
F1÷30	-6,53
F1,5÷30	-2,51
F2÷30	2,55
F2,5÷30	2,55

Figure 7-2: example 2 - antenna pattern diagrams

The report will show a synthesis of the results, which may be comprehensive at first glance. This synthesis will specify the maximum overruns from the Eutelsat specifications (co-polarization and cross-polarization), as per the example 2 of Chapter 5.

7.4.7.3 Example 3: raster scan

Each point of the image, at a given Azimuth and Elevation angle and corresponding θ polar coordinate, represents the difference between the level of the co-polar sidelobe pattern at this point and the corresponding Eutelsat mask $29 - 25log\ \theta$, where θ is the radial distance in degrees measured from the center of the image.

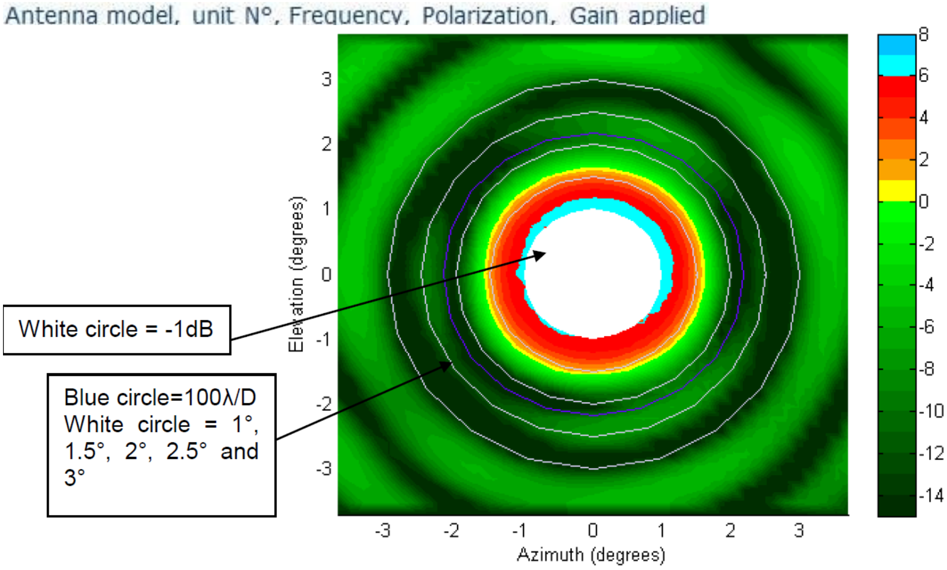


Figure 7-3: co-polar normalized raster scan

7.4.7.4 Example 4: Raster Scan (cross – polarization)

Each point of the image, at a given Azimuth and Elevation angle, represents the difference between the maximum level of the co-polar Gain and the level of the cross-polar sidelobe pattern at this point. The circle represents the -1 dB contour of the co-polar main lobe.

Antenna model, unit N°, Frequency, Polarization, Gain applied

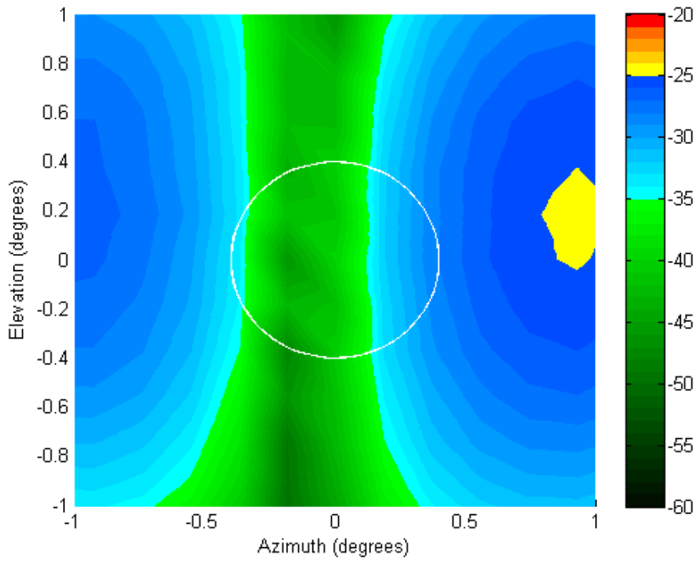


Figure 7-4: cross-polarization normalized raster scan

In addition to the range test report Eutelsat reserves the right to receive the raw data of all the antenna measurement performed. Eutelsat will keep all data received strictly confidential.

7.4.7.5 Example 5: summary of test results

The image shall present the minimum cross-polarization results at within -1 dB contour and the maximum co-polar peak above the Eutelsat mask $29 - 25\log\theta$, at every Factor (F1 (0.5°-1°), F2 (1°-1.5°), F3 (1.5°-2°), etc.) as shown below.

Summary of Azimuth Plane Range Measurements

Frequency GHz	Pol	Gain dBi	XPD within -1 dB	% over mask α_{az}°-180°	Peak level above mask 29-25logθ						
					0.5°-1°	1°-1.5°	1.5°-2°	2°-2.5°	α_{az}°-9.2°	9.2°-48°	48°-180°
10.70	VV	41.56	30.6 dB	13%	6.8 dB	6.7 dB	1.8 dB	0.0 dB	0.0 dB	5.7 dB	4.7 dB
10.95	VV	41.64	30.4 dB	8%	7.2 dB	7.1 dB	2.7 dB	0.0 dB	0.0 dB	4.9 dB	4.9 dB
11.7	VV	42.17	20.1 dB	7%	6.6 dB	6.3 dB	0.0 dB	0.0 dB	0.0 dB	5.7 dB	1.0 dB
12.5	VV	43.19	36.2 dB	12%	6.9 dB	6.3 dB	0.0 dB	0.0 dB	0.0 dB	5.3 dB	0.8 dB
12.75	VV	43.34	34.5 dB	9%	6.8 dB	6.0 dB	0.0 dB	0.0 dB	0.0 dB	5.8 dB	0.9 dB
10.70	HH	41.56	33.1 dB	16%	6.7 dB	6.5 dB	1.3 dB	0.0 dB	0.0 dB	7.1 dB	5.4 dB
10.95	HH	41.64	40.7 dB	14%	6.7 dB	6.6 dB	2.3 dB	0.0 dB	0.0 dB	4.8 dB	6.3 dB
11.7	HH	42.27	26.5 dB	14%	6.4 dB	5.9 dB	0.0 dB	0.0 dB	0.0 dB	6.6 dB	4.7 dB
12.5	HH	43.19	34.7 dB	16%	6.7 dB	5.8 dB	0.0 dB	0.0 dB	0.0 dB	6.4 dB	6.1 dB
12.75	HH	43.04	35.1 dB	18%	6.6 dB	5.7 dB	0.0 dB	0.0 dB	0.0 dB	6.1 dB	5.7 dB
13.75	VV	43.23	31.8 dB	2%	6.3 dB	5.1 dB	0.0 dB	0.0 dB	0.0 dB	19. dB	0.0 dB
14.00	VV	43.46	32.9 dB	8%	6.3 dB	5.2 dB	0.0 dB	0.0 dB	0.0 dB	4.5 dB	0.2 dB
14.25	VV	43.89	35.7 dB	8%	6.5 dB	5.1 dB	0.0 dB	0.0 dB	0.0 dB	5.1 dB	2.0 dB
14.50	VV	44.02	36.4 dB	8%	6.3 dB	4.6 dB	0.0 dB	0.0 dB	0.0 dB	5.9 dB	0.6 dB
13.75	HH	43.43	34.1 dB	14%	6.4 dB	5.4 dB	0.0 dB	0.0 dB	0.0 dB	8.1 dB	2.2 dB
14.00	HH	43.66	35.7 dB	11%	6.3 dB	5.1 dB	0.0 dB	0.0 dB	0.0 dB	7.2 dB	1.5 dB
14.25	HH	44.09	35.5 dB	13%	6.4 dB	4.6 dB	0.0 dB	0.0 dB	0.0 dB	8.6 dB	2.9 dB
14.50	HH	44.22	32.9 dB	11%	6.4 dB	4.3 dB	0.0 dB	0.0 dB	0.0 dB	6.2 dB	1.3 dB
13.75	VV+30°	43.23	36.1 dB	-	6.3 dB	5.1 dB	0.0 dB	0.0 dB	0.0 dB	-	-
14.0	VV+30°	43.46	36.7 dB	-	6.3 dB	5.1 dB	0.0 dB	0.0 dB	0.0 dB	-	-
14.25	VV+30°	43.89	33.7 dB	-	6.4 dB	4.9 dB	0.0 dB	0.0 dB	0.0 dB	-	-
14.5	VV+30°	44.02	36.0 dB	-	6.2 dB	4.2 dB	0.0 dB	0.0 dB	0.0 dB	-	-
13.75	VV-30°	43.23	31.7 dB	-	6.1 dB	4.7 dB	0.0 dB	0.0 dB	0.0 dB	-	-
14.00	VV-30°	43.46	30.1 dB	-	6.1 dB	4.7 dB	0.0 dB	0.0 dB	0.0 dB	-	-
14.25	VV-30°	43.89	31.4 dB	-	6.2 dB	4.5 dB	0.0 dB	0.0 dB	0.0 dB	-	-
14.50	VV-30°	44.02	32.2 dB	-	6.2 dB	4.3 dB	0.0 dB	0.0 dB	0.0 dB	-	-
13.75	HH+30°	43.43	38.2 dB	-	6.3 dB	5.1 dB	0.0 dB	0.0 dB	0.0 dB	-	-
14.0	HH+30°	43.66	35.2 dB	-	6.4 dB	5.2 dB	0.0 dB	0.0 dB	0.0 dB	-	-
14.25	HH+30°	44.09	32.9 dB	-	6.3 dB	4.8 dB	0.0 dB	0.0 dB	0.0 dB	-	-
14.5	HH+30°	44.22	32.9 dB	-	6.1 dB	3.8 dB	0.0 dB	0.0 dB	0.0 dB	-	-
13.75	HH-30°	43.43	37.0 dB	-	6.4 dB	5.3 dB	0.0 dB	0.0 dB	0.0 dB	-	-
14.00	HH-30°	43.66	33.8 dB	-	6.6 dB	5.5 dB	0.0 dB	0.0 dB	0.0 dB	-	-
14.25	HH-30°	44.09	32.3 dB	-	6.6 dB	5.0 dB	0.0 dB	0.0 dB	0.0 dB	-	-
14.50	HH-30°	44.22	34.7 dB	-	6.5 dB	4.5 dB	0.0 dB	0.0 dB	0.0 dB	-	-

Figure 7-5

7.5 Maximum EIRP density for different satellite spacing

Eutelsat requires, in order to calculate the maximum authorized EIRP density for different satellite spacing (1°, 1.5°, 2°, 2.5° and 3°), to determine the worst transmit overshoots (called also F-factors) in the angular regions from 0.5°, 1°, 1.5°, 2° and 2.5° respectively (the 0.5° difference between satellite spacing and angular region considered is to take into account the maximum tolerated cumulative pointing and wind errors, assumed to be 0.5°).

This applies to antennas which show a perfect coincidence between the RX and TX main-beam axis.

However if the measurements show that there is a tilt between the TX and RX main beams, this tilt will need to be taken into account for the calculation of the maximum authorized EIRP density for different satellite spacing, as follows:

Orbital separation > 1.0°: review overshoots from $\sqrt{0.5^2 + T_b^2}$

Orbital separation > 1.5°: review overshoots from $\sqrt{1.0^2 + T_b^2}$

Orbital separation > 2.0°: review overshoots from $\sqrt{1.5^2 + T_b^2}$

Orbital separation > 2.5°: review overshoots from $\sqrt{2.0^2 + T_b^2}$

Orbital separation > 3.0°: review overshoots from $\sqrt{2.5^2 + T_b^2}$

Where T_b is the worst measured tilt angle.

8 Antenna pointing tests for fixed and transportable antennas (not for antennas on the move)

This Annex describes the measurement of the pointing errors and the pointing repeatability by using the laser beam method.

These test procedures are recommended for antennas operating in circular polarization (Ka-band, C-band) or for antennas in linear polarization without encoders.

The purpose of this test is to verify the capability of the antenna to point with an accuracy of maximum 0,4° to the desired satellite under all reasonable circumstances. This for fixed manual driven antennas, fixed motorized manual controlled antennas, as well as motorized auto-pointing antennas.

The applicant has to provide one antenna in full operational condition this includes the antenna capability for manual movement in AZ and EL and if necessary Polarization with a desired speed down to 0.2°/sec. If necessary, the applicant may need to send staff to operate the antenna.

In coordination with the applicant Eutelsat may provide appropriate satellite capacity for this test purpose. The applicant has to make sure that the antenna RF equipment is capable to transmit a clean carrier with defined output power.

The picture below gives an overview about the test arrangement.

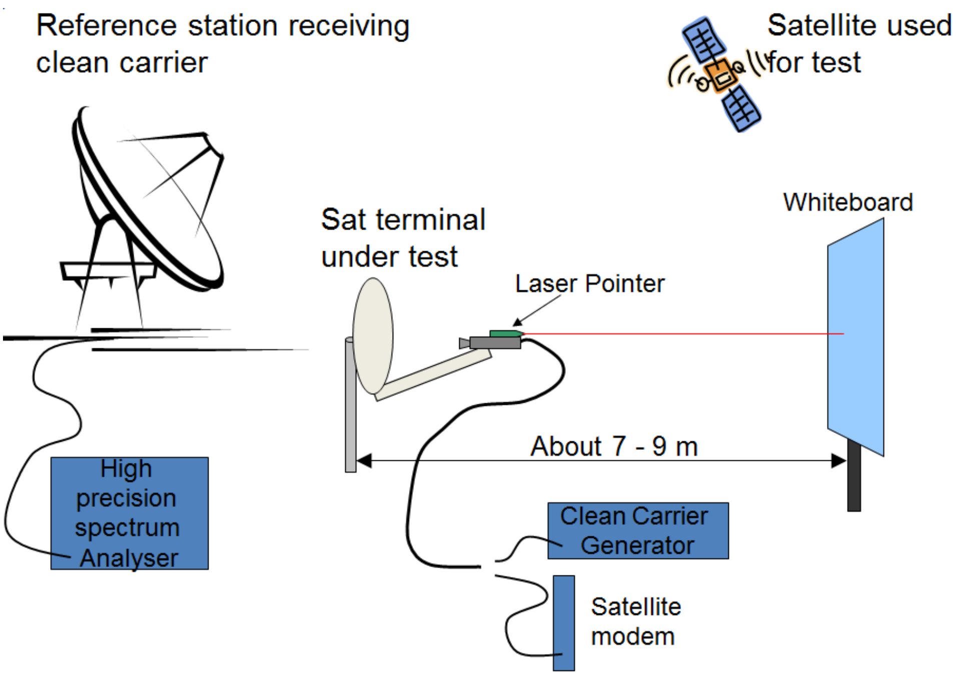


Figure 8-1

The test step by step:

- The applicant points the antenna according to his operational procedures to the desired Eutelsat satellite

- The whiteboard is put in place in a distance of 7 to 9 meters so that the laser beam points into the middle of the board. The Point is marked.
- The applicant and/or Eutelsat put on a clean carrier in accordance with the Eutelsat operational procedures and checks that the reference stations can and display it on the precision spectrum analyzer. The amplitude settings of the spectrum analyzer have to be set to present minimum 1 dB per division or less.
- The Applicant and /or Eutelsat will move the station manually or manually controlled slowly in first in Az, then in El and finally in polarization to the maximum value of the carrier on the spectrum analyzer of the reference station.
- Once this is reached the EIRP difference will be noted and the new laser pointing on the white board marked.
- The distance between the two laser points, the offset x has to be measured. From this offset x the de-pointing angle is calculated using the following equation:

$$x = \mathrm{l} \times \tan(0.4) \qquad \text{Equation 8-1}$$

The length l has to be measured from the center of the reflector to the white board.

In particular for roof mount SNG antennas or other motorized antennas this pointing process is repeated minimum 4 times where the antenna base is turned each time by about 90°.

A 5th time measurement is done while the antenna remains in one position but is tilted by about 5°.

A 6th time measurement is done while the antenna remains in one of the previous positions and the pointing process is repeated minimum 4 times to check the pointing repeatability.

The resulting deviation angle for all measurements shall be under no circumstances exceed 0.4°.

The results shall be inserted in the following Table.

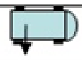
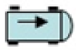
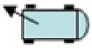
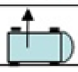
Antenna model	Antenna size	Motorised or Manual pointing	Controller used	Test date	Test location
Pointing Test results	Pointing direction	Distance to board (Meter)	Deviation on board (mm)	pointing error (degrees)	Delta EIRP (dB)
					
					
					
					
Antenna tilt >5°					
Pointing repeatability test					

Table 8-1: formatted results table

9 G/T measurement

To measure the gain-to-equivalent noise temperature ratio (G/T) of the earth station receive section.

Verification of correct function of the receive chain(s) by confirmation of the expected G/T value at IF interface.

9.1 Principle

In contrast to separate evaluation of antenna gain and system noise temperature, the following procedure implies the direct measurement of the G/T. Therefore, it is required to measure the receive level (PC) of a reference carrier at the station under test. Then, the antenna under test is pointed to the cold sky and the noise level (PN) is measured in a defined bandwidth. From these two values, the G/T is computed.

$$G/T_{SUT} = L_{fs,SUT} + L_{at,SUT} + B + K - EIRP_{SAT/SUT} + R$$ Equation 9-1

$$R = 10 \times log_{10}\left[10^{(P_c - P_N)/10} - 1\right]$$ Equation 9-2

$$if \qquad P_c - P_N > 20 \text{ dB}$$ Equation 9-3

the Equation 9-2 can be simplified into:

$$R = P_c - P_N$$ Equation 9-4

G/T_{SUT} : Gain to equivalent noise temperature ratio of SUT [dB/K]

$L_{fs,SUT}$: Free space loss towards $SUT = 20 * log_{10}(4.B.d.f\ /\ c)$ [dB]

f = frequency (Hz)

d = distance (m)

c = 299792458 (m/s)

$L_{at,SUT}$: Atmospheric attenuation at SUT [dB]

B : Equivalent noise bandwidth [dBHz]

K : Boltzmann's constant:

(1.38051.10-23 Ws/K ≈ -228.60 dBWs/K) [dBWs/K]

$EIRP_{SAT/SUT}$: Satellite EIRP towards SUT [dBW]

P_C : Carrier level (C + N) [dBm]

P_N : Noise level (N) [dBm]

R : Power ratio $\frac{C}{N}$ [dB]

NOTE: For the atmospheric attenuation, the following values are assumed under clear sky conditions:

11 GHz range: 0.20 dB

12 GHz range: 0.25 dB

NOTE: For spectrum analyzer measurements, Equation 9-3 must be valid at resolution bandwidth even if readout is normalized to 1 Hz.

The satellite EIRP towards the SUT is computed from the measured value of satellite EIRP towards the ERS.

$$EIRP_{SAT/SUT} = EIRP_{SAT/ERS} + L_{OA/ERS} - L_{OA/SUT} \qquad \text{Equation 9-5}$$

where

$EIRP_{SAT/ERS}$: Satellite EIRP towards ERS [dBW]

$L_{OA/ERS}$: Off-axis loss towards ERS [dB]

$L_{OA/SUT}$: Off-axis loss towards SUT [dB]

As the measurement is generally carried out by a spectrum analyzer, corrections of the displayed noise level for bandwidth and detection must be applied. In modern analyzers this correction is achieved by an internal routine which provides a direct readout of the normalized noise level (noise marker). Where this facility is unavailable, the operator must refer to the relevant instrument application notes (e.g. HP 8-series) to obtain the applicable values.

The following figures for correction of the displayed noise level are typical:

Translation from resolution bandwidth to noise bandwidth:	-0.8 dB
Combined correction for detector characteristics and logarithmic shaping:	+2.5 dB
The total typical correction is therefore:	+1.7 dB

In this case, the actual noise level is 1.7 dB higher than the displayed figure. Therefore the "displayed" C/N is 1.7 dB better than the actual value of C/N.

Care must be taken to avoid inaccuracy of the noise level measurement due to the contribution of the spectrum analyzer. To confirm correct function of the whole receive chain, it is recommended to carry out the measurement at RF and IF level.

9.2 Step-by-step procedure

9.2.1 Transmission of reference carrier

1) If required, CSC arrange for change of transponder gain setting on request of ERS. ERS transmit the reference carrier at the frequency and EIRP as specified in the EUTELSAT test plan.

   NOTE: Disregard Step 1 if the G/T measurement is performed by the satellite beacon.

9.2.2 Measurement of carrier level

2) ERS measure the satellite EIRP of the reference carrier and compute the corresponding EIRP towards the SUT.
3) With the antenna at boresight, SUT measure the reference carrier level at RF and IF interfaces. For beacon measurements, the applicable resolution bandwidth shall be agreed between ERS and SUT. . SUT report the value to the ERS.

9.2.3 Measurement of noise level

4) At a small frequency offset (e.g. 100 kHz), SUT measure the noise level.
5) SUT move the antenna off to the satellite, preferably in azimuth by at least 5°. While slewing the antenna, SUT monitor the noise level. The antenna movement may be stopped when the noise level does no longer decrease.
6) SUT terminate the spectrum analyzer input and read the noise level. Report the value to the ERS.
7) SUT connect the spectrum analyzer to the RF interface. With identical settings of Steps 5, 6 above, SUT measure the noise level (Figure 3). SUT reports the value to the ERS.
8) Repeat Step 7 with the analyzer connected to the IF interface.

9.2.4 Evaluation

9) If applicable, SUT report the relevant correction factors and the bandwidth to ERS. SUT return the antenna to boresight.
10) ERS communicate value of the satellite EIRP to SUT and calculate the value of the G/T.

9.3 Example for spectrum analyzer settings

9.3.1 Measurement of Carrier Level

(Note: ERS may advice to apply different settings)

Reference level	: 5 dB above level of reference carrier
Attenuator	: 0 dB
Scale	: 10 dB/Division
Centre frequency	: ERS down-link frequency as per test plan (RF or IF range)
Span	: 100 kHz
Resolution bandwidth	: 3 kHz
Video bandwidth	: 100 Hz
Video average	: ON (10 samples)
Sweep time	: Auto (typically 1.5s)
Marker noise	: OFF
ΔMarker	: OFF, Marker peak search
Trace	: Clear write A

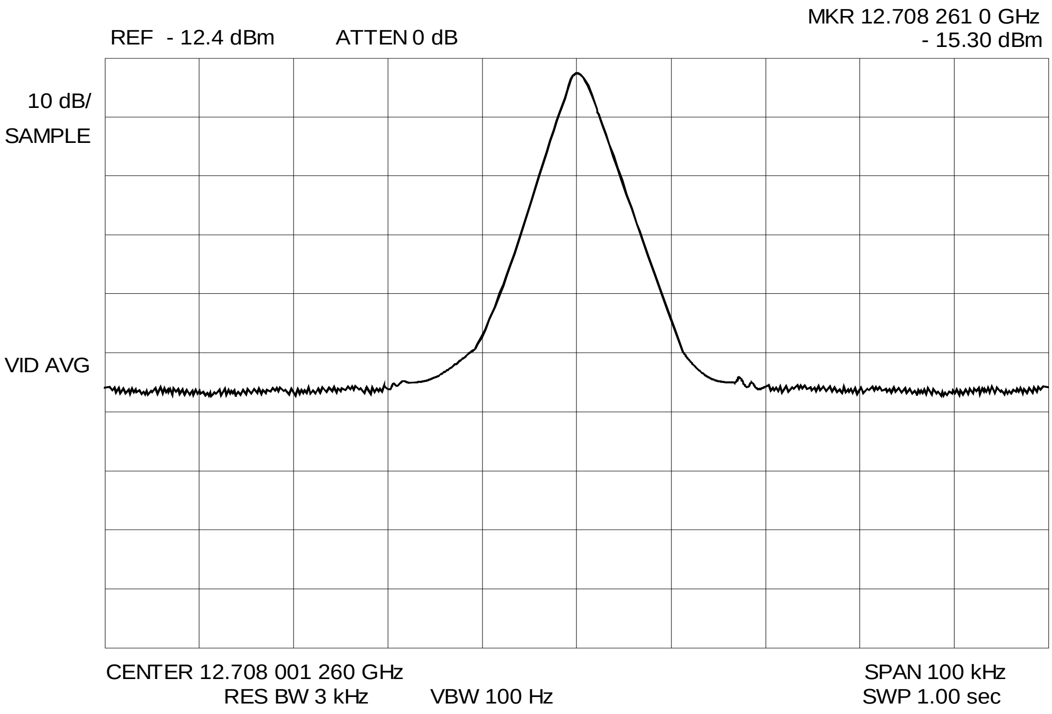


Figure 9-1: Spectrum Analyzer Display during G/T Measurement (Carrier Level)

NOTE: The example applies to measurements where the spectrum analyzer is connected to the LNA output. In case of measurements at IF, the alternator has to be set according to the actual level (in order to avoid over drive).

9.3.2 Measurement of beacon Level

(Note: ERS may advice to apply different settings)

Reference level	: 5 dB above beacon level
Attenuator	: 0 dB
Scale	: 10 dB/Division
Centre frequency	: Beacon frequency as per test plan (RF or IF range)
Span	: 1 MHz
Resolution bandwidth	: 3 kHz
Video bandwidth	: 30 Hz
Video average	: ON (10 samples)
Sweep time	: Auto (typically 1.5s)
Marker noise	: OFF
ΔMarker	: OFF, Marker peak search
Trace	: Clear write A

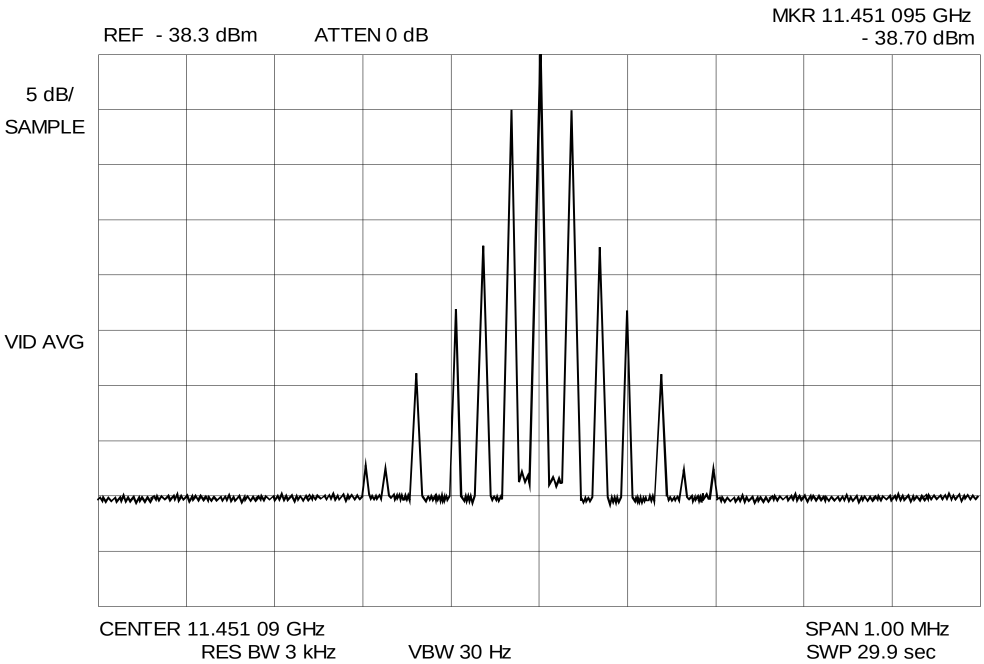


Figure 9-2: Spectrum Analyzer Display during G/T Measurement (Carrier Level)

9.3.3 Measurement of noise Level

(Note: ERS may advice to apply different settings)

Reference level	: 5 dB above noise floor
Attenuator	: 0 dB
Scale	: 10 dB/Division
Centre frequency	: Beacon frequency as per (RF or IF range)
Span	: 100 kHz
Resolution bandwidth	: 3 kHz
Video bandwidth	: 100 Hz
Video average	: ON (10 samples)
Sweep time	: Auto (typically 1.5s)
Marker noise	: ON
Marker Frequency	: 200 kHz below carrier beacon frequency
ΔMarker	: OFF
Trace	: Clear write A
Display line	: ON

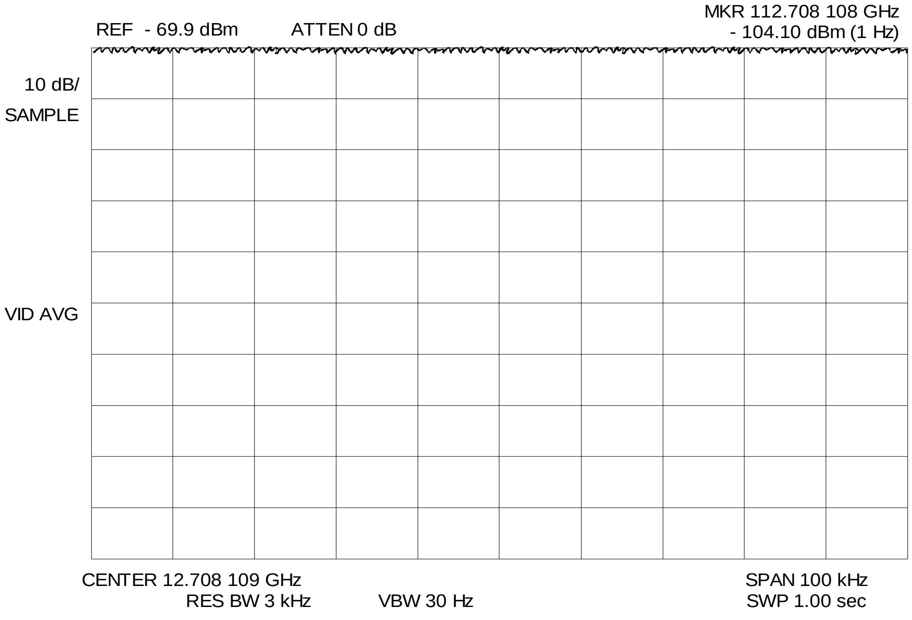


Figure 9-3: Spectrum Analyzer Display during G/T Measurement (Noise Level)

NOTE: The above are generally applicable if the spectrum analyzer is connected to an LNA output. The attenuator setting to 0 dB may be inappropriate in case of connection to the output of a down-convertor, line-amplifier, etc. In any case, the carrier level indicated must be independent of the attenuation setting, i.e. when changing the attenuator no change of carrier level should be observed.

10 Auto-deploy performance tests procedures

The list of the “auto-deploy” tests to be performed is described in Annex B.

Tests need to be performed via satellite, in conjunction with a Eutelsat S.A. Reference Station (ERS).

10.1 Auto-deploy tests over the satellite

The operator of the SUT (Station Under Test) shall register the auto-deploy terminal with the Eutelsat S.A. Earth Station Approval Office, in advance to the start of the tests.

Once the auto-deploy terminal is approved, the SUT’s operator will receive a test plan few days before the commencement of the tests, including a questionnaire, see Annex F, that will need to be returned to Eutelsat S.A., the Earth Station Approval Office, prior to the start of the tests.

In view of a characterization of the auto-deploy terminal, satellite tests need to be witnessed by a Eutelsat S.A. staff member or a representative accredited by Eutelsat S.A.

Un-witnessed satellite tests can be performed prior or after formal witnessed tests uniquely as a preparation or for troubleshooting purposes.

10.2 Location of the tests

With the exception of auto-deploy terminals for operations on EUTELSAT

KA-SAT 9A, there are no specific recommendations for the location of the auto-deploy terminal other than visibility of the satellite geostationary arc.

In case of auto-deploy terminals for operations on EUTELSAT KA-SAT 9A, the location of the tests has to be studied as a function of the Spots allocation table, in such a way that the ERS (Eutelsat S.A. Reference Station) will be able to receive the signals transmitted from the SUT.

10.3 On site design review

Prior to the start of the tests a design review meeting will be held, to check the data provided, identify any possible shortfall or missing element and review the mandatory tests which will be performed, in line with Annex B.

The Test Record of Annex C will be filled in and signed.

The test area where the auto-deploy terminal is located will be reviewed, to ensure that the satellites to be accessed for the tests are visible and free of obstacles (trees, buildings, metallic structures etc.).

It is recommended that some basic workshop tools be available during the tests.

The auto-deploy terminal to be tested will be inspected and the operator will explain its main features and functions.

The operator of the auto-deploy terminal shall ensure that there will be adequate RF spectrum monitoring capabilities available, and that in case of low resolution resolvers it will be possible to use the laser beam method (availability of laser beam tools, digital inclinometer and white board target).

Ensure that the minimum step on the antenna controller is at least 0.1° or smaller, to ensure a sufficient accuracy of the pointing error determination.

In case that a DVB-S2 carrier is used to achieve the auto-pointing process, verify that its frequency is in the receive band of the LNB.

The auto-deploy terminal undertakes an ESVA test, specifically tailored to verify the auto-deploy performance.

10.4 Step-by-step procedures

The Eutelsat S.A. representative and the operator of the SUT meet at the test site, and review the step by step procedure.

Principle of the tests:

The ERS (Eutelsat S.A. Reference Station), through its antenna, monitors the signal transmitted from the SUT.

After auto-deploy completed, the ERS instructs the SUT to optimize (driving manually the motors of the auto-deploy terminal) the position of the antenna (Azimuth, Elevation) until maximizing the monitored signal. Then ERS instructs SUT to optimize the polarization (driving manually the polarization motor) until the cross-polar component of the monitored signal is minimized. To perform these tests the ERS shall ensure that the same frequency slots in the co-polar and cross-polar transponders are available. To be able to minimize the cross-polar component, the ERS antenna must have a receive gain sufficient for detecting small signal out of the spectrum analyzer noise floor.

The test results will be based on the readouts of Azimuth, Elevation and Polarization available at SUT.

The following methods to obtain the pointing data can be used:

- SUT's own resolvers readouts,
- Laser beam indications

Definitions:

The abbreviations “AAZ”, “AEL”, “APOL”, “AXPD” and “AEIRP” represent the respective values (azimuth, elevation, polarization angle, XPD (Cross-Polarization Discrimination) and EIRP) achieved when deploying the antenna automatically.

“MAZ”, “MEL”, “MPOL”, “MXPD” and “MEIRP” are the values after manual optimization.

1) SUT establishes a telephone call with the ERS (Eutelsat S.A. Reference Station), review the ESVA test plan and the following check list:

General check list:

- ☐ Satellite orbital position, polarization, transmit and receive frequencies, polarizations,
- ☐ Azimuth slew speed,
- ☐ Elevation slew speed,
- ☐ Polarizer rotational speed,
- ☐ Possibility to transmit a CW carrier,
- ☐ Weather and wind conditions at SUT and at ERS,
- ☐ Geostationary arc visibility,
- ☐ Carrier (Beacon, DVB-S2, Hub carrier etc.) or method (NORAD etc.) used to achieve the auto-pointing process,
- ☐ Transmit RF Carrier monitoring system (type, manufacturer, model),
- ☐ Transmit coupling factor,
- ☐ Post-coupler loss.

2) For reflectors with petals, assemble the reflector under control of the Eutelsat S.A. representative.
3) The Eutelsat S.A. representative will review the monitoring tools available at SUT and ensure that no transmission is possible prior to the completion of the auto-deploy process.

Ensure that the auto-deploy terminal start from STOW position. On instruction from ERS, SUT will enable the auto-deploy function. The Eutelsat S.A. representative will measure the elapsed time from STOW to the completion of the Auto-deploy process.

If the auto-deploy process does not complete, repeat the process once again. If it still fails, the Eutelsat S.A. representative, ERS and SUT will decide if tests can continue with a different position of the auto-deploy terminal or a different satellite or tests need to be cancelled.

If the auto-deploy process completes, confirm that the SUT is correctly pointed on the satellite and with the correct polarization, by verifying reception of a test carrier transmitted from ERS.

IMPORTANT: In case of doubts at SUT on the satellite being pointed, ERS will switch on and off few times its test carrier and SUT's operator will monitor it to ensure that the auto-deploy terminal is pointed on the targeted satellite.

DO NOT PROCEED TO STEP 4 UNTIL THIS IS CONFIRMED.

4) In coordination with ERS, SUT will transmit a CW carrier, at a frequency and EIRP determined in the test plan. The CW will be power balanced by the ERS, see detailed procedure in ESOG Vol. 1 Section 4.3 Module 130 refers. Report in table G1 and in table G3 the relevant test parameters and SUT configuration.

5) Azimuth optimization

   Ensure that the antenna is still in the position reached at the end of the auto-deploy process, record the auto-deploy terminal's AAZ, AEL, APOL. The ERS will calculate and communicate to the SUT the value of AEIRP and AXPD.

   Disable all satellite tracking functions, ensure that the SUT will not automatically re-adjust its pointing and under co-ordination of the ERS and the Eutelsat S.A. representative, carefully slew a step at a time the antenna Azimuth Right until the position AAZ+2°. ERS will monitor the variation of the level of the carrier at each step. Slew back the antenna until reaching AAZ-2°.

   In co-operation with the ERS, perform a few iterations until the ERS will determine the optimum point maximizing the value received at ERS.

6) Elevation optimization

   Under co-ordination of the ERS and the Eutelsat S.A. representative, carefully slew a step at a time the antenna Elevation up until the position AEL+2°. ERS will monitor the variation of the level of the carrier. Slew back the antenna until reaching AEL-2°.

   In co-operation with the ERS, perform a few iterations until the ERS will determine the optimum point maximizing the value received at ERS. Report in table D2 of Annex D the value of MEL.

   Asymmetric antennas (e.g. elliptical ones) have usually a small dimension in the Elevation plane. In this case it may be difficult to accurately optimize the elevation of the SUT. To improve the accuracy, slew the antenna under coordination of the ERS Elevation up until reaching a level reduction of 3 dB wrt the boresight level, record the corresponding angle, then slew Elevation down until reaching again 3 dB level reduction and record the corresponding value. The average between the two values yields the optimum elevation value.

   Alternatively, from the initial MEL, move back to AEL. If the level does not vary, the Elevation pointing error can be considered as zero.

7) Azimuth re-optimization

   Repeat step 4 to further optimize the MAZ value. The ERS will calculate and communicate to the SUT the value of MEIRP. Report in table G2 the value of MAZ and MEIRP.

8) Cease transmission and stow the antenna.

9) Repeat Steps 3 and 4.

10) Polarization optimization

This step needs to be performed uniquely for auto-deploy terminals operating with linearly polarized signals.

Record the auto-deploy terminal's AAZ, AEL, APOL and AEIRP.

ERS will measure the AXPD of the auto-deploy terminal (by power balancing the residual cross polarized component transmitted by SUT on the opposite transponder) and will communicate it to the SUT. Report in table G3 the value of AXPD.

Disable all satellite tracking functions and under co-ordination of the ERS and the Eutelsat S.A. representative, gauge carefully the antenna polarizer clock-wise until the position APOL+10°. ERS will monitor the variation of the level of the carrier on the opposite (cross-polar) satellite's transponder. Gauge counter-clock-wise back the antenna until reaching APOL-10°.

In co-operation with the ERS, perform a few iterations while reducing at every step the angular range, until the ERS will determine the optimum point minimizing the value of the cross-polarized carrier received at ERS on the opposite transponder. The ERS will calculate and communicate to the SUT the value of MXPD. Report in table G2 the value of MPOL and MXPD.

11) Measurement of the 9 points XPD box after automatic pointing

The XPD is evaluated within a cone centered on the main beam axis, with the cone defined by the pointing error or the - 1dB contour of the main beam axis, whichever is greater.

For EUTELSAT KA-SAT 9A auto-deploy terminals, the pointing error may be larger than -1 dB contour, and in this case the XPD should be assessed at the pointing error and the 9 points XPD box should be determined by angle rather than level of the carrier. If β is the pointing error, replace 0.5 dB with $\beta/2$ and 1 dB with β

Cease transmission, stow the antenna and repeat Steps 3 and 4. Record the auto-deploy terminal's AAZ, AEL, APOL and AEIRP. Repeat steps 5 to 7 (Azimuth and Elevation optimization).

Disable all satellite tracking functions and under co-ordination of the ERS and the Eutelsat S.A. representative, perform the 9 points XPD box verification starting from the APOL initial value.

The procedure for the 9 points XPD box verification is detailed in the ESOG Vol. 1 Section 7 Module 130 refers (see 1.1).

It is recommended in addition to the 9 points to measure 4 additional points, corresponding to the -1 dB contour on the Azimuth left and right and Elevation up and down planes.

In case that the ΔAZ= AAZ-MAZ and/or ΔEL=AEL-MEL were greater than the angles corresponding to the -1 dB contour of the main lobe, the 9 and 4 points shall be verified taking into account the overall de-pointing angle rather than the angles corresponding to the -1 dB contour.

Report in table G4.1 and G4.2 the corresponding measured XPD values.

Cease transmission and stow the auto-deploy terminal.

For antennas with petals, disassemble the antenna.

Repeat tests 2 to 11 for the other polarization.

AUTO-DEPLOY TESTS ON TILTED TERMINAL

Move the auto-deploy terminal in such a way that there will be an angle δ of at least 5° (or higher, depending on the auto-deploy terminal maximum tilt specification) formed by the auto-deploy terminal wrt a level ground. In case of a vehicle-mounted auto-deploy terminal, insert a wedge under one or more of the tires of the vehicle.

Repeat steps 2 to 13.

12) Auto-deploy tests with different orientation of the auto-deploy terminal wrt the satellite

    Under co-ordination of the Eutelsat S.A. representative, change the ground orientation of the auto-deploy terminal (or the position of it on the positioner of the test range) wrt the satellite of at least 60° in Azimuth.

    Repeat steps 2 to 13.

13) Auto-deploy tests on a satellite at a different orbital location

    To make sure that the auto-deploy terminal performance is maintained irrespective of the satellite being accessed, the Eutelsat S.A. test plan will normally require repeating the auto-deploy tests on a second and possibly third satellite, at a different orbital location.

    Repeat step 1 to 15 for a new satellite at a different orbital position. Not applicable for EUTELSAT KA-SAT 9A.

    NOTE: Use of inclined orbit satellites should be avoided for auto-deploy terminals not equipped with tracking sub-system.

    TEST RESULTS

    At the end of each test session, for a given satellite and polarization, SUT's operators and the Eutelsat S.A. representative will fill in and sign the test results summary sheet as per tables G2 to G4.

10.5 Ancillary Tests and Verifications

These tests are recommended to verify additional parameters and operational processes of the auto-deploy terminal.

10.6 Pointing Repeatability

Stow and auto-deploy the SUT several times, without changing its position on the ground. At each auto-deploy exercise, report in table G5 the values of AAZ, AEL and APOL. Calculate the arithmetic average and the standard deviation.

10.7 Backlash

The backlash will be assessed by reviewing the data provided by the integrator of the auto-deploy terminal.

A possible way to test the backlash is to slew the antenna to predetermined angles away from boresight, e.g. 10° by using the auto-deploy terminal's motors. With the laser method (see Annex H), mark on the target each position and relevant angles readouts. Then slew the antenna back to boresight and mark the laser position on the target corresponding to the previous readouts. Measure the difference. Repeat in the other direction e.g.-10° and back to boresight.

10.8 Rain Fade

This test simulates a rain fade during the auto pointing process.

Apply a wet towel to the cap of the antenna's feed to simulate a rain fade.

Verify the corresponding level of attenuation on the Eb/No of the received signal.

Perform steps 2 to 13 of Section 7.4 and by iterations determine at which Eb/No the auto-deploy terminal is still capable of performing the auto- deploy function correctly.

10.9 Auto-deploy Operations

To complement the tests results, the following important operational aspects will be verified and discussed.

Carriers:

This test assesses the auto pointing performance when using narrow band signals for the pointing procedure.

For this purpose select if possible a satellite and an SCPC carrier with the minimum bandwidth as specified for the auto-deploy terminal, lock into and start the procedure to auto deploy the terminal.

Verify if the terminal is still able to complete the auto deploy process without impairments (accuracy, time to auto-deploy).

Transmit enable:

Verify that it is not possible for the operator to enable transmission of a carrier until the auto-deploy process. In case this was possible, verify that a warning message is issued to the operator.

Transmit cease:

Verify the time needed in order to interrupt the auto-pointing process when the operator ceases the auto-pointing operations. Verify that no carrier is transmitted.

Table 10-1: Summary of Auto-Deploy Tests Results Steps 1-10

Test Conf N°/ Pol (***)	AAZ [Deg]	AEL [Deg]	APOL [Deg]	AEIRP [dBW]	AXPD [dB]	MAZ [Deg]	MEL [Deg]	MPOL (*) [Deg]	MEIRP [dBW]	MXPD [dB]	ΔAZ,ΔEL, ΔPOL (**) [Deg]
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

(*) Does not apply for auto-deploy terminals operating in circular polarization

(**) Pol error does not apply for auto-deploy terminals operating in circular polarization

(***) Specify if X/Y or Y/X for linear polarization; LHCP/RHCP or RHCP/LHCP for circular polarization

Provide a separate result's sheet for each satellite and polarization

Table 10-2: Notes on the Test Configurations of Table 1 Chapter 7

Test Conf. N°	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
Add test configurations as necessary	
Date/Record compiled by:	
Other notes:	

Provide a separate sheet for each accessed satellite

Table 10-3: 9 Points-XPD Box AXPD (auto-deploy XPD) results for Terminal-STEP 11

Satellite Identification Orbital Location	Frequency Up/Down [GHz]	Polarization Up/Down	Weather SUT/ERS

Test N°	Pola-rization (***)	1	2	3	4	5	6	7	8	9
1										
2										
3										
4										
5										

Table 10-4: - Additional 4 Points-box AXPD (auto-deploy XPD) results for Terminal

Test N°	Polarization (***)	10 (AZ+)	11 (AZ-)	12 (EL+)	13 (EL-)
1					
2					
3					
4					
5					

Provide a separate result's sheet for each satellite and polarization
(***) Specify if X/Y or Y/X for linear polarization; LHCP/RHCP or RHCP/LHCP for circular polarization

Angular Increments for Points 1-9 and 10-13

	AI (EL) in dB	AI (AZ) in dB
Points (1 – 9)	14.1421 * (λ/D)	AI (EL) / Cos (EL)
Points (10 – 13)	20 * (λ/D)	

(ITU – R BO.1213)

Table 5 of Chapter 7 - Auto-Deploy Pointing Repeatability for Terminal

Attempt N°	Polarization (***)	Azimuth	Elevation	Polarization
1				
2				
3				
4				
5				

Provide a separate result's sheet for each satellite and polarization

(***) Specify if X/Y or Y/X for linear polarization; LHCP/RHCP or RHCP/LHCP for circular polarization

Troubleshooting Check List

- ☐ The signal where the terminal shall lock is visible on the monitoring equipment (e.g. spectrum analyzer),
- ☐ The CW of ERS is visible on the monitoring equipment,
- ☐ The CW of SUT is transmitted at requested frequency and polarization,
- ☐ Modem is locked on the modulated signal prior to transmission,
- ☐ If ERS switches off the CW, carrier is not visible any more on the monitoring equipment.

11 Windload tests procedures

11.1 Introduction

This certification procedure enables ground station antennas to certify themselves for Eutelsat Wind Load Certification and Acceptance.

Ground station antennas using the Eutelsat space segment have to complete successfully a certification test procedure against wind loads to show their resistance against movement out of a 0.4° pointing direction limit.

During the test procedure simulated wind load forces are initiated on the antenna under test. These forces result from an approaching fluid vector in axial direction (axial force) and in pitch and yaw torques which are responsible for elevation and azimuth movements. The test force simulates a wind speed of 20 m/s on the antenna.

The boundary conditions of this test procedure are listed in table below.

Table 11-1: Base values for the wind load certification

Maximum fluid speed	**20 m/s**
Adiabatic exponent	1.4
Atmospheric pressure	101325 Pa
Temperature	273.15 K
Air density	1.293 kg/m^3
Antenna diameter	0.5 – 1.8 M
Maximum allowed de-pointing angle	0.4°
Safety coefficient	1.1

11.2 Antenna preparation and mounting

This section includes the conditions which ensure smooth implementation of wind load certification procedure, namely:

- Preparation of antenna under test.
- Estimation of certification forces.
- Efficient and ergonomic coordination of testing.

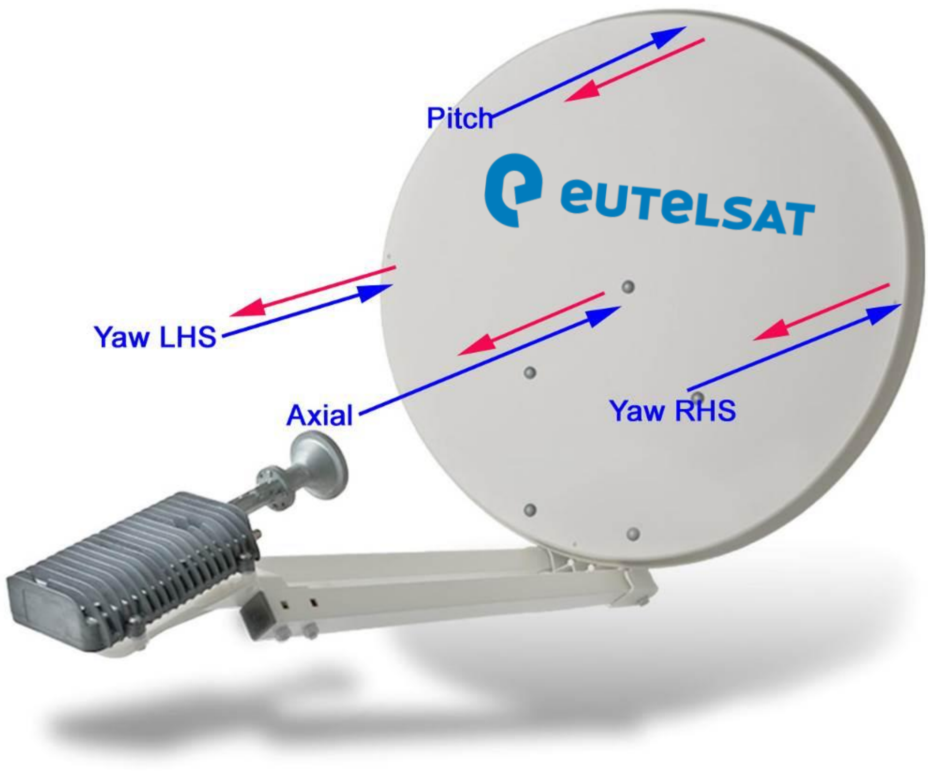


Figure 11-1: Parabolic antenna forces, measured for wind load certification procedure

11.2.1 Antenna preparation

Test and certification of parabolic antennas require a fixed mounting to avoid any moving of the antenna structure or antenna reflector which could lead to a failed certification process.

The antenna has to be mounted either perpendicular on a wall (e.g. small VSATs on KONNECT) or standing on the ground (e.g. fly-away antennas).

In the first case, mounting material has to correspond to the dimension of the antenna diameter. A large antenna requires a heavier mounting structure due to higher wind loads around all axes. The correct attitude of the antenna should be checked by using a water level.

In the second case, the terminal has to be set up in its operational configuration with the appropriate weights for the specified wind speeds.

It has to be checked that the antenna hangs freely moveable in the air. The mid of the reflector should be around 1.5 m above the ground due to ergonomic reasons.

The picture above shows a Ka band VSAT and the direction of the forces which will need to be applied for the wind load certification. To simulate the correct wind forces on the antenna, the LNA should be mounted on the boom. Feed and boom mountings may have high influence on the aerodynamic forces.

11.2.2 Pre-certification check list

Completion of the following check-list, before starting certification activities will prevent delays.

- ☐ Antenna Preparation
    - ☐ Antenna is mounted on a pole or fixed to a wall
    - ☐ Antenna direction is perpendicular to the ground
    - ☐ Feed is mounted
    - ☐ Antenna direction is checked with water level

- ☐ Test equipment is available
    - ☐ Test equipment for one of the certification methods is available

11.2.3 Wind load certification procedure with laser

One idea of the test scenario is to use a laser to measure the antenna de-pointing due to wind loads. At the initial condition the laser is pointing parallel to the ground on a white board with an offset diagram (Figure 2). After injecting a defined test force N on the reflector, the reflector is moving to an offset position where the offset x has to be measured. From this offset x the de-pointing angle is calculated using the following equation.

$$x = l \times \tan(0.4) \qquad \text{Equation 11-1}$$

The length l has to be measured from the center of the reflector to the white board, shown in Figure 11-2. It is recommended to use a length l of around 7.5 m.

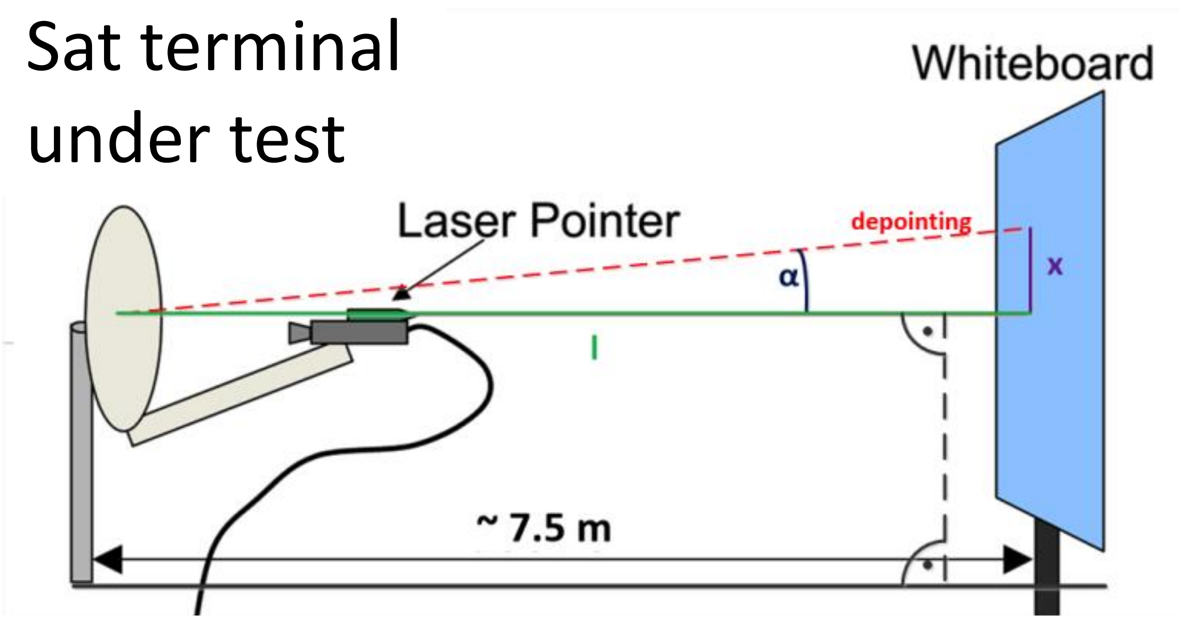


Figure 11-2: de-pointing tests using a laser pointer

11.2.4 Test equipment

The certification process requires test material listed in Table 11-2 mount the antenna, to inject the forces on the antenna system and to measure the depointing of the antenna due to simulated wind forces.

Table 11-2: summary of equipment for test procedure with laser

Material	Purpose
1 – 2 steel cables (~ 1 mm diameter)	Force injection on antenna system
Standard laser pointer	Measure depointing of antenna
Whiteboard on a wall	Display the laser pointer dot on a table to measure the offset
Force gauge	To inject specific test forces on the reflector

In Figure 11-3 some examples for the test equipment are shown:

a) Steel cable for force injection

b) Force gauge

c) White board to display offset with an offset diagram

d) Laser pointer

e) Offset diagram

a) 

b) 


c)


d)

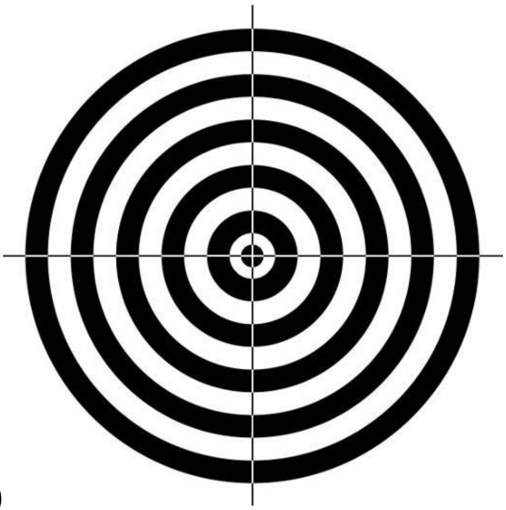

e)

Figure 11-3: exemples of tools for the measurement with the laser

11.2.5 Axial load certification

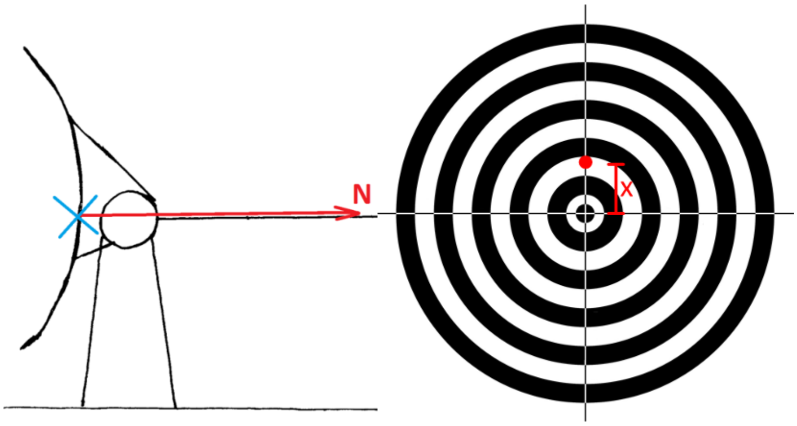


Figure 11-4: Applying the test force N on the antenna under test (left). Example for an ideal offset due to axial load on offset diagram (right)

Figure 11-4 left shows the procedure to test axial loads on the antenna:

- N describes the axial wind force resulting from wind speeds of 20 m/s. The calculated forces N (and corresponding weights) are listed in Table 11-4 depending on the antenna diameter and has to be applied on the antenna with a force gauge. Alternatively weights (for example buckets filled with water) can be used for force injection.
- The test result can be seen immediately on the offset diagram. An example is shown in Figure 11-4 right.

11.2.6 Pitch load certification

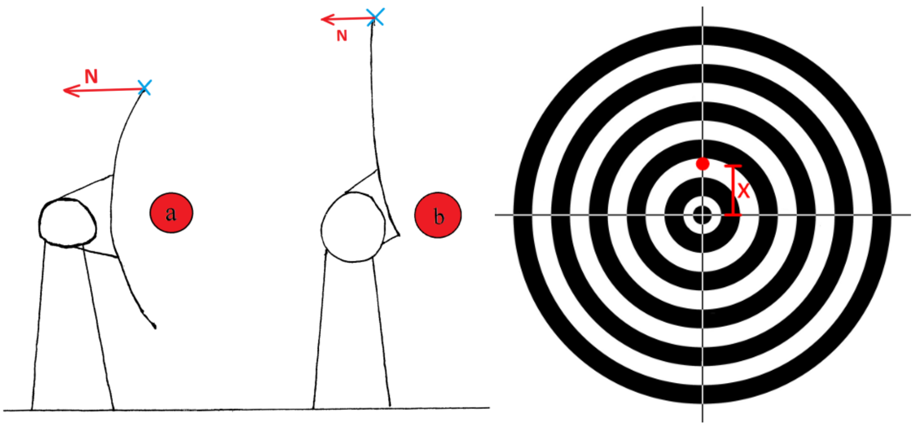


Figure 11-5: Pitch load certification; a) antenna with central reflector mounting; b) offset mounted antenna. On the right example for an ideal offset due to pitch loads on offset diagram

Figure 11-5 left shows the certification process for pitch loads. The mounting point for the force gauge is on the upper most edge. The calculated pitch forces N (and corresponding weights) for the certification process are listed in Table 11-5. For certification of offset-mounted antennas the force injection point remains on the upper most edge of the reflector, Figure 11-5 left. A laser offset example is shown in Figure 11-5 right.

11.2.7 Yaw load certification

Figure 11-6 shows the certification process for yaw loads. The mounting point for the force gauge is on the right or left edge of the reflector. The calculated pitch forces N (and corresponding weights) for the certification process are listed in Table 11-6. A possible offset-diagram from yaw loads is shown in Figure 11-7.

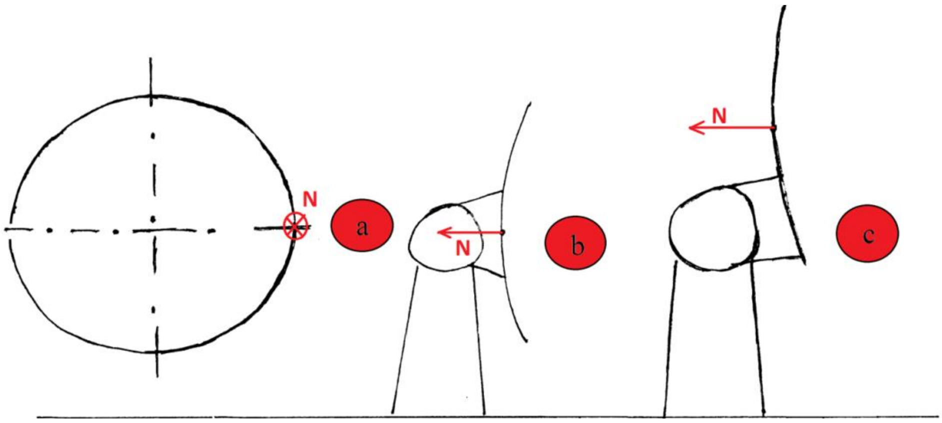


Figure 11-6: Yaw load certification. A) front view of reflector with mounting points for force gauge; b) side view; c) mounting points for offset-mounted antennas.

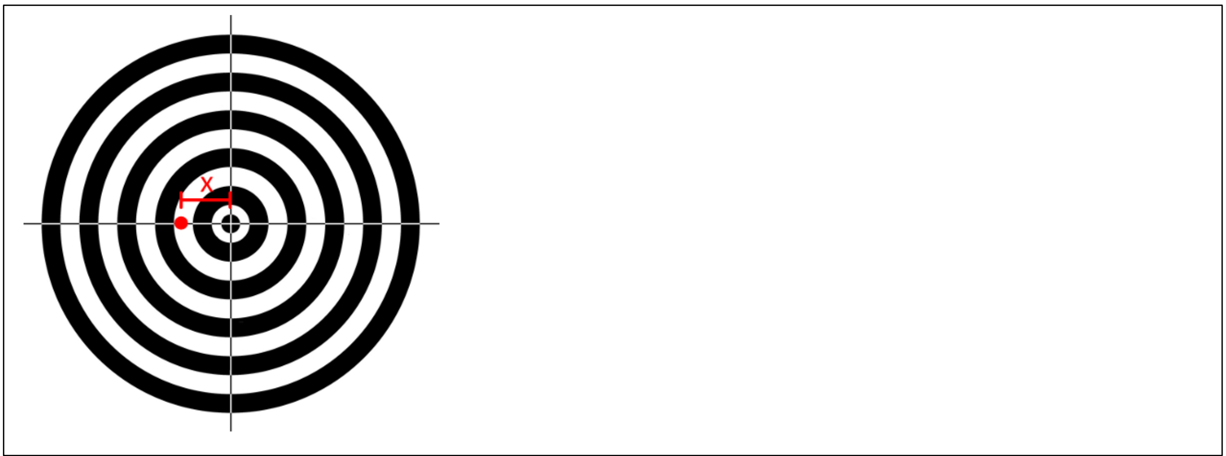


Figure 11-7: Example for an ideal offset due to yaw loads on offset diagram

11.2.8 Certification check list

- ☐ Axial Load Certification
    - ☐ Laser pointer is in level (around pitch axes and around yaw axes!)
    - ☐ Distance from antenna mounting point to the offset diagram l is measured and noted down (Figure 11-2, should be ~7.5 m)
    - ☐ Correct force is taken from Table 11-4
    - ☐ Force is injected to antenna system
    - ☐ Distance x is measured on offset diagram (Figure 11-2)
    - ☐ Depointing angle is calculated using Equation 11-1(Paragraph 11.2.3)
    - ☐ Pass/Fail decision is made
- ☐ Pitch Load Certification
    - ☐ Laser pointer is in level (around pitch axes and around yaw axes!)
    - ☐ Distance from antenna mounting point to offset diagram l is measured noted down (Figure 11-2, should be ~7.5 m)
    - ☐ Correct force is taken from Table 11-5
    - ☐ Force is injected to antenna system
    - ☐ Distance x is measured on offset diagram (Figure 11-2)
    - ☐ Depointing angle is calculated using Equation 11-1(Paragraph 11.2.3)
    - ☐ Pass/Fail decision is made
- ☐ Yaw Load Certification
    - ☐ Laser pointer is in level (around pitch axes and around yaw axes!)
    - ☐ Distance from antenna mounting point to offset diagram l is measured noted down (Figure 11-2, should be ~7.5 m)
    - ☐ Correct force is taken from Table 11-6
    - ☐ Force is injected to antenna system
    - ☐ Distance x is measured on offset diagram (Figure 11-2)
    - ☐ Depointing angle is calculated using Equation 11-1(Paragraph 11.2.3)
    - ☐ Pass/Fail decision is made

Table 11-3: test results table

Antenna model	Antenna size	Motorised or manual pointing	Controller used	Test date	Test location
Axial Force (N)		Pitch force (N)		Yaw Force (N)	
Reference force (table)		Reference force (table)		Reference force (table)	
Measured force value		Measured force value		Measured force value	
Push		Push		Push	
Pull		Pull		Pull	

Table 11-4: Axial force to simulate wind load for different reflector diameters

Reflector diameter D [m]	Axial Force [N]	Axial Weight [kg]
0.50	67.6	6,9
0.55	81.8	8,3
0.60	97.3	9,9
0.65	114.2	11,6
0.70	132.5	13,5
0.75	152.1	15,5
0.80	173.0	17,6
0.85	195.3	19,9
0.90	219.0	22,3
0.95	244.0	24,9
1.00	270.3	27,6
1.05	298.0	30,4
1.10	327.1	33,3
1.15	357.5	36,4
1.20	389.3	39,7
1.25	422.4	43,1
1.30	456.9	46,6
1.35	492.7	50,2
1.40	529.8	54,0
1.45	568.4	57,9
1.50	608.2	62,0
1.55	649.5	66,2
1.60	692.0	70,5
1.65	736.0	75,0
1.70	781.3	79,6
1.75	827.9	84,4
1.80	875.9	89,3
1.85	925.2	94,3
1.90	975.9	99,5

1.95	1027.9	104,8
2.00	1081.3	110,2
2.05	1136.1	115,8
2.10	1192.2	121,5
2.15	1249.6	127,4
2.20	1308.4	133,4
2.25	1368.6	139,5
2.30	1430.1	145,8
2.35	1492.9	152,2
2.40	1557.1	158,7

Table 11-5: Axial force to simulate wind load for different reflector diameters

Reflector diameter D [m]	Pitch Force [N]	Pitch Weight [kg]	Pitch Force for offset mounted [N]	Pitch Weight for offset mounted[kg]
0.50	26.9	2.7	13.5	1,4
0.55	32.6	3.3	16.3	1,7
0.60	38.8	4.0	19.4	2,0
0.65	45.5	4.6	22.7	2,3
0.70	52.7	5.4	26.4	2,7
0.75	60.6	6.2	30.3	3,1
0.80	68.9	7.0	34.4	3,5
0.85	77.8	7.9	38.9	4,0
0.90	87.2	8.9	43.6	4,4
0.95	97.1	9.9	48.6	5,0
1.00	107.6	11.0	53.8	5,5
1.05	118.7	12.1	59.3	6,0
1.10	130.3	13.3	65.1	6,6
1.15	142.4	14.5	71.2	7,3
1.20	155.0	15.8	77.5	7,9
1.25	168.2	17.1	84.1	8,6
1.30	181.9	18.5	91.0	9,3

1.35	196.2	20.0	98.1	10,0
1.40	211.0	21.5	105.5	10,8
1.45	226.3	23.1	113.2	11,5
1.50	242.2	24.7	121.1	12,3
1.55	258.6	26.4	129.3	13,2
1.60	275.6	28.1	137.8	14,0
1.65	293.1	29.9	146.5	14,9
1.70	311.1	31.7	155.5	15,9
1.75	329.7	33.6	164.8	16,8
1.80	348.8	35.6	174.4	17,8
1.85	368.4	37.6	184.2	18,8
1.90	388.6	39.6	194.3	19,8
1.95	409.3	41.7	204.7	20,9
2.00	430.6	43.9	215.3	21,9
2.05	452.4	46.1	226.2	23,1
2.10	474.7	48.4	237.4	24,2
2.15	497.6	50.7	248.8	25,4
2.20	521.0	53.1	260.5	26,6
2.25	545.0	55.6	272.5	27,8
2.30	569.4	58.0	284.7	29,0
2.35	594.5	60.6	297.2	30,3
2.40	620.0	63.2	310.0	31,6

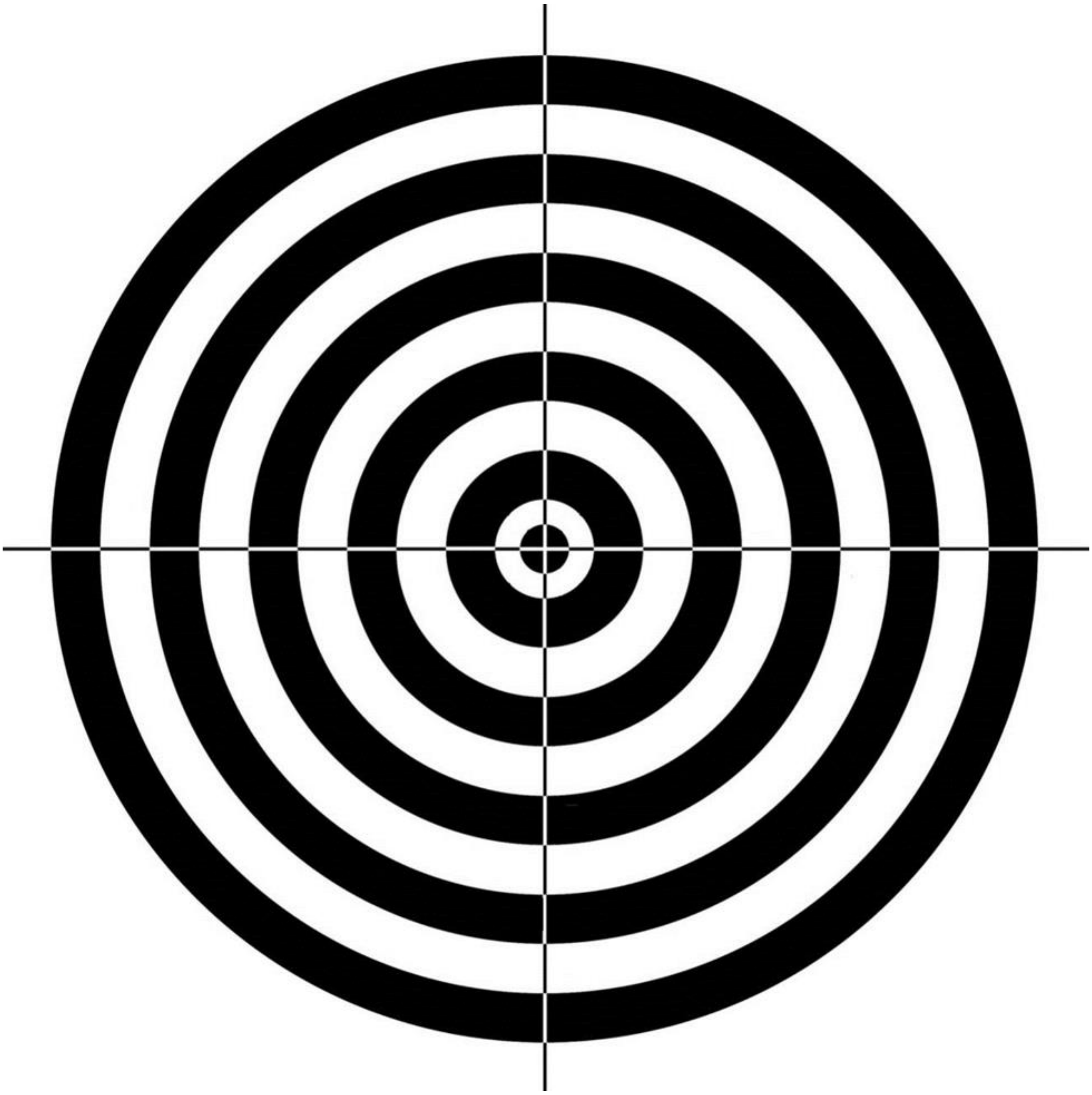
Table 11-6: Axial force to simulate wind load for different reflector diameters

Reflector diameter D [m]	Yaw Force [N]	Yaw Weight [kg]
0.50	18,0	1.8
0.55	21,8	2.2
0.60	26,0	2.6
0.65	30,5	3.1
0.70	35,3	3.6
0.75	40,6	4.1
0.80	46,1	4.7

0.85	52,1	5.3
0.90	58,4	5.9
0.95	65,1	6.6
1.00	72,1	7.3
1.05	79,5	8.1
1.10	87,2	8.9
1.15	95,4	9.7
1.20	103,8	10.6
1.25	112,7	11.5
1.30	121,9	12.4
1.35	131,4	13.4
1.40	141,3	14.4
1.45	151,6	15.4
1.50	162,2	16.5
1.55	173,2	17.7
1.60	184,6	18.8
1.65	196,3	20.0
1.70	208,4	21.2
1.75	220,8	22.5
1.80	233,6	23.8
1.85	246,8	25.1
1.90	260,3	26.5
1.95	274,2	27.9
2.00	288,4	29.4
2.05	303,0	30.9
2.10	318,0	32.4
2.15	333,3	34.0
2.20	349,0	35.6
2.25	365,0	37.2
2.30	381,4	38.9
2.35	398,2	40.6

2.40	415,3	42.3

11.3 Laser pointing diagram



12 Polarization offset of the Eutelsat satellites, circular, linear or dual polarization

12.1 General

The details contained in this chapter are provided in complement to chapter 11.

The linear polarization planes (defined as X and Y and orthogonal to each other) of most of the Eutelsat S.A. satellites are not parallel/orthogonal to the equatorial plane.

For historical reasons, the polarization planes of the satellites are inclined at an angle with respect to the equatorial plane. This angle is referred to as the polarization offset.

This value is of fundamental importance for the following types of antenna, whenever the polarization alignment is performed in open loop (calculated):

- Earth Stations on Vessels (ESVs),
- Satcom-On-The Move (SOTM),
- Airborne mounted Earth Stations (AESs)
- Auto-pointing terminals.

If the pointing and polarization alignment software of an auto-pointing terminal falling within the above categories did not duly take into account this skew value, the polarization discrimination achieved at the end of the alignment would suffer a major degradation with respect to the value which the antenna optics could theoretically yield, with a consequent high risk of interference to other services on the opposite polarization and the achievable performance would not be met.

12.2 Values of the skew of the Eutelsat SA satellites

The reference X-polarization (horizontal) is defined as that polarization whose plane makes an angle of 93.535° in an anti-clockwise direction, looking towards the earth, about a reference vector with respect to a plane containing this vector and the pitch axis. The reference vector is defined as the vector from the satellite in the direction 0.21° towards west and 6.07° towards north in satellite coordinates. The reference Y-polarization (vertical) is defined as that polarization whose plane is orthogonal to the X-polarization plane and the reference vector defined above. In other words the polarization offset angle of the EUTELSAT satellites is +3.535°, clock-wise when looking at the satellite from the earth, from anywhere on the meridian (in the northern hemisphere) corresponding to the orbital location of the satellite. In the southern hemisphere the polarization offset angle of the EUTELSAT satellites is +183.535°, clock-wise, from anywhere on the meridian corresponding to the orbital location of the satellite.

Please refer to the table shown on the next page.

12.3 Table of Eutelsat SA satellites

EUTELSAT Name	Other Designations	EUTELSAT Code	International Designator	Orbital Location	Pol Skew Angle for LP (VO*-1)	Linnear / Circular Polarization
EUTELSAT 117 West A	SATMEX 8	**E117WA**	13012A	-116.8		LP
EUTELSAT 117 West B	SATMEX9	**E117WB**	16038B	-117.0		LP
EUTELSAT 115 West B	SATMEX 7	**E115WB**	15010B	-114.9		LP
EUTELSAT 113 West A	SATMEX 6	**E113WA**	06020A	-113.0		LP
	SATMEX 10			-113.0		LP (Future Satellite)
EUTELSAT 65 West A		**E65WA**	14006A	-65.2	0.000	C & Ku-Band: LP; Ka CP Q/V - LP (X-Horizontal)
EUTELSAT 12 West B	Atlantic Bird 2; AB2; New Bird; E8WA	**E12WB**	01042A	-12.5	3.535	LP
EUTELSAT 12 West C	QUANTUM; AnySat	**E12WC**		-12.5	3.535	*Future Satellite*
EUTELSAT 8 West B	AB2A	**E8WB**	15039B	-8.0	3.535	LP
EUTELSAT 7 West A	AB4R; AB7; AB4A	**E7WA**	11051A	-7.3	3.535	Ku-Band: LP; C-Band CP
EUTELSAT 5 West A	Atlantic Bird 3; Stellat 5	**E5WA**	02035A	-5.0	0.000	LP
EUTELSAT 5 West B		**E5WB**		-5.0		*Future Satellite*
EUTELSAT 3B	Newsat	**E3B**	14030A	3.1	3.535	LP
EUTELSAT 7A	W3A	**E7A**	04008A	7.0	3.535	LP
EUTELSAT 7B	E3D; W3D	**E7B**	13022A	7.0	3.535	LP
EUTELSAT 7C	E7X	**E7X**				*Future Satellite*
EUTELSAT 9B	ESA Data Relay; EDRS-A	**E9B**	16005A	9.0	3.535	LP
EUTELSAT KA-SAT 9A	KaSAT	**KA9A**	10069A	9.0	3.535	CP (LP for beacon)
EUTELSAT 10A	W2A	**E10A**	09016A	10.0	3.535	Ku-Band: LP; C-Band CP
BB4A	African Broadband Satellite (HTS)					*Future Satellite*
EUTELSAT HOT BIRD 13B	HB8	**HB13B**	06032A	13.0	3.535	LP
EUTELSAT HOT BIRD 13C	HB9	**HB13C**	08065A	13.0	3.535	LP
EUTELSAT HOT BIRD 13E	HB7A; Eurobird 9A; E9A	**HB13E**	06007B	13.0	3.535	LP
EUTELSAT 16A	W3C	**E16A**	11057A	16.0	3.535	LP
EUTELSAT 21B	W6A	**E21B**	12062B	21.6	3.535	LP
EUTELSAT 25B	Es'hail; EB2A	**E25B**	13044A	25.5	3.535	Ku & DBS Band: LP Ka-Band: CP

EUTELSAT Name	Other Designations	EUTELSAT Code	International Designator	Orbital Location	Pol Skew Angle for LP (VO*-1)	Linnear / Circular Polarization
EUTELSAT 28E	ASTRA 2E	**E28E**	13056A	28.5	0.000	
EUTELSAT 28F	ASTRA 2F	**E28F**	12051A	28.2	0.000	
EUTELSAT 28G	ASTRA 2G	**E28G**	14089A	28.2	0.000	
EUTELSAT 33C	W1R; E28A	**E33C**	01011A	33.1	3.535	LP
EUTELSAT 33E	HB10; AB4A; E3C; HB13D	**E33E**	09008B	33.1	3.535	LP
EUTELSAT 36B	W7	**E36B**	09065A	35.9	3.535	LP
EUTELSAT 36C	EXPRESS AMU1	**E36C**	15082A	36.1	3.535	LP
Y1B	Yahsat 1B	**Y1B**	12016A	47.6	0.000	
EUTELSAT 48D	E28B; W2M	**E48D**	08065B	48.1	3.535	LP
EUTELSAT 53A	EXPRESS-AM6; EXPRESS-AM22; SESAT 2	**E53A**	03060A	53.0	0.000	LP
YAMAL 402	2012-070	**Yamal402**	12070A	54.9		
EUTELSAT 56A	Express AT1	**EXPRESS AT1**	14010A	56.0		CP
EUTELSAT 70B	W5A	**E70B**	12069A	70.5	3.535	LP
EUTELSAT 140A	EXPRESS AT2	**EXPRESS AT2**	14010B	140.0		CP
EUTELSAT 172B		**E172B**	17029B	172.0	0.000	LP
EUTELSAT 174A	AMC23; GE-23;AMC 23, Worldsat 3, GE 2i,E172A	**E174A**	05052A	174.0	0.000	LP

Status: May 2018

*Note: VALUE OF THE SKEW OF THE EUTELSAT SATELLITES

The reference X-polarization (horizontal) is defined as that polarization whose plane makes an angle of 93.535° in an anti-clockwise direction, looking towards the earth, about a reference vector with respect to a plane containing this vector and the pitch axis. The reference vector is defined as the vector from the satellite in the direction 0.21° towards West and 6.07° towards north in satellite coordinates. The reference Y-polarization (vertical) is defined as that polarization whose plane is orthogonal to the X polarization plane and the reference vector defined above. In other words the polarization offset angle of the EUTELSAT satellites is +3.535°, clock-wise when looking at the satellite from the earth, from anywhere on the meridian (in the northern hemisphere) corresponding to the orbital location of the satellite. In the southern hemisphere the polarization offset angle of the EUTELSAT satellites is +183.535°, clock-wise, from anywhere on the meridian corresponding to the orbital location of the satellite.

Refer to for updates of the table above.

13 ESV Type Approval/Characterization process

13.1 General

ESV (Earth Stations on Vessels) are terminals with tracking facilities which are operated under motion on the ship where they are embarked.

This section describes the Eutelsat S.A. conditions to obtain the type approval/characterization of ESV terminals and the relevant test criteria and requirements. Further reference can be found in the documents ETSI EN 302 340 (Ku-band) and ETSI EN 303 978 (Ka band).

Tests and verifications on an ESV terminal shall comprise:

- “Static” tests to measure the RF sidelobe performance;
- “Dynamic” tests to measure the pointing and tracking functionalities;
- Additional verifications (Antenna inspection, Tx mute control, look-up tables of the polarization offset, spectrum re-growth, factory tour).

The “Static” tests shall verify compliance of the RF sidelobe performance against the Eutelsat Earth Station Minimum Technical and Operational Requirements, EESS 502 paragraph 4.1.

The “Dynamic” tests shall verify compliance with the maximum beam pointing error of + 0.4° under all circumstances, EESS 502 paragraph 4.3.2 refers.

For type approval applications all tests shall be witnessed by a Eutelsat S.A. test engineer or authorized representative.

For applications for characterization only, Eutelsat S.A. may exceptionally accept to review un-witnessed dynamic tests results.

The application form (Chapter 5) shall be filled by the applicant, in addition to point 9.7 specific for ESV terminals.

13.2 Static tests for ESV terminals

The static tests baseline is described in Chapter 6. This section describes the additional test criteria and measurements necessary to type approve/characterize ESV terminals.

13.3 Number of ESV systems

- **Type Approval**: three antennas and three associated radomes of the same model shall be made available.
- **Characterization**: one antenna and one radome shall be made available.

13.4 Test set up

- All tests shall be performed on an agreed test range and shall be performed at the Input and Output ports of the antenna OMT (Ortho Mode Transducer). For antennas to be operated on Ka-sat, the mTRIA adapter (see following picture) shall be made available by Eutelsat at the test range, so as to make the input and output ports of the OMT accessible.

Figure 13-1:

- The manufacturer shall ensure that the positioner of the antenna shall be firmly fixed by mechanical implements so as to set the antenna at the required elevation angles inside the radome (i.e.30°-35° or 0°).
- The antenna of ESV terminals is necessarily protected by a radome and static tests shall be performed with the radome ON, with one exception, see below.
- All tests shall be performed with the feed protective cap ON, if applicable.

13.5 Test configurations

The following configurations of the ESV terminal shall be tested:

- To evaluate the effect of the incidence of the radiation patterns on the curved part of the radome, all RF sidelobe patterns should be measured with the antenna positioned inside the radome at an Elevation angle set at a value comprised between 30°-35°. For this, a special fixture wedge-shaped should be prepared and inserted between the upper part of the range's positioner and the base of the radome, so as to incline the radome with respect to the horizontal by an angle comprised between 30°-35°. The manufacturer shall ensure that the antenna inside the radome is firmly positioned to the required elevation angle.

- Assuming the radome is symmetrical in rotation, with the antenna positioned at an Elevation of 30°-35° inside the radome, Azimuth TX RF sidelobe patterns shall be re-measured by rotating the radome wrt its base to evaluate the uniformity of the radome thickness and the effect of the junctions of the radome segments. This evaluation shall be implemented by rotating the radome at different angles to be agreed with the Eutelsat S.A. representative, depending on the number and positions of the radome attach holes (e.g. 90°, 150° , 270°), while maintaining the antenna in the same position with respect to the transmitter of the test range.
- One set of tests shall be performed without radome, to assess the radome loss and the intrinsic RF sidelobe performance of the antenna. These tests shall be performed at mid TX frequency in Azimuth for both polarizations.
- To evaluate the effect of the incidence of the radiation patterns on the straight part of the radome, one set of measurements without the 30°-35° fixture shall be performed at the TX frequencies in Azimuth and Elevation for both polarizations. The manufacturer shall ensure that the antenna inside the radome is firmly re-positioned to a 10° elevation angle.

  The summaries of the **additional** tests for C, Ku, K (DBS) and Ka- bands and relevant angular spans are shown in Tables 1 to 4 here after.

Test	Frequencies [GHz]	Angular span	Elevation	Radome position
See Tests of Section 7.4.1 to be conducted with radome in nominal position			30°-35°	0° (nominal)
TX Az RHCP Co & Cross	6.10	Co +/-180°, Cross +/-9.2°	30°-35°	90° or equivalent
Tx Az LHCP Co & Cross	6.10	Co +/-180°, Cross +/-9.2°	30°-35°	90° or equivalent
TX Az RHCP Co & Cross	5.80, 6.10, 6.40	Co +/-30°, Cross +/-9.2°	30°-35°	90° or equivalent
Tx Az LHCP Co & Cross	5.80, 6.10, 6.40	Co +/-30°, Cross +/-9.2°	30°-35°	90° or equivalent
TX Az RHCP Co & Cross	6.10	Co +/-180°, Cross +/-9.2°	30°-35°	150° or equivalent
Tx Az LHCP Co & Cross	6.10	Co +/-180°, Cross +/-9.2°	30°-35°	150° or equivalent
TX Az RHCP Co & Cross	5.80, 6.10, 6.40	Co +/-30°, Cross +/-9.2°	30°-35°	150° or equivalent
Tx Az LHCP Co & Cross	5.80, 6.10, 6.40	Co +/-30°, Cross +/-9.2°	30°-35°	150° or equivalent
TX Az RHCP Co & Cross	6.10	Co +/-180°, Cross +/-9.2°	30°-35°	270° or equivalent
Tx Az LHCP Co & Cross	6.10	Co +/-180°, Cross +/-9.2°	30°-35°	270° or equivalent
TX Az RHCP Co & Cross	5.80, 6.10, 6.40	Co +/-30°, Cross +/-9.2°	30°-35°	270° or equivalent
Tx Az LHCP Co & Cross	5.80, 6.10, 6.40	Co +/-30°, Cross +/-9.2°	30°-35°	270° or equivalent
TX Az RHCP Co & Cross	6.10	Co +/-30°, Cross +/-9.2°	30°-35°	Without radome
Tx Az LHCP Co & Cross	6.10	Co +/-30°, Cross +/-9.2°	30°-35°	Without radome
TX Gain RHCP	5.80-6.40	Frequency-swept or at 3 discrete frequencies	30°-35°	Without radome
TX Gain LHCP	5.80-6.40	Frequency-swept or at 3 discrete frequencies	30°-35°	Without radome
TX Az RHCP Co & Cross	5.80, 6.10, 6.40	Co +/-30°, Cross +/-9.2°	0° See note 1	0°
Tx Az LHCP Co & Cross	5.80, 6.10, 6.40	Co +/-30°, Cross +/-9.2°	0° See note 1	0°
Tx El RHCP Co & Cross	5.80, 6.10, 6.40	Co $\geq$ +/-10°, Cross +/-9.2°	0° See note 1	0°
Tx El LHCP Co & Cross	5.80, 6.10, 6.40	Co $\geq$ +/-10°, Cross +/-9.2°	0° See note 1	0°

1. If required, elevation angle may be adapted to the specific antenna/radome configuration on a case-by-case basis

Table 13-1: additional ESV tests for C-band

Test	Frequencies [GHz]	Angular span	Elevation	Radome position
See Tests of Section 5.4.2 to be conducted with radome in nominal position			30°-35°	0° (nominal)
TX Az H Co & Cross	14.25	Co +/-180°, Cross +/-9.2°	30°-35°	90° or equivalent
Tx Az V Co & Cross	14.25	Co +/-180°, Cross +/-9.2°	30°-35°	90° or equivalent
TX Az H Co & Cross	12.75, 13.00, 13.25, 13.75, 14.00, 14.25, 14.50	Co +/-30°, Cross +/-9.2°	30°-35°	90° or equivalent
Tx Az V Co & Cross	12.75, 13.00, 13.25, 13.75, 14.00, 14.25, 14.50	Co +/-30°, Cross +/-9.2°	30°-35°	90° or equivalent
TX Az H Co & Cross	14.25	Co +/-180°, Cross +/-9.2°	30°-35°	150° or equivalent
Tx Az V Co & Cross	14.25	Co +/-180°, Cross +/-9.2°	30°-35°	150° or equivalent
TX Az H Co & Cross	12.75, 13.00, 13.25, 13.75, 14.00, 14.25, 14.50	Co +/-30°, Cross +/-9.2°	30°-35°	150° or equivalent
Tx Az V Co & Cross	12.75, 13.00, 13.25, 13.75, 14.00, 14.25, 14.50	Co +/-30°, Cross +/-9.2°	30°-35°	150° or equivalent
TX Az H Co & Cross	14.25	Co +/-180°, Cross +/-9.2°	30°-35°	270° or equivalent
Tx Az V Co & Cross	14.25	Co +/-180°, Cross +/-9.2°	30°-35°	270° or equivalent
TX Az H Co & Cross	12.75, 13.00, 13.25, 13.75, 14.00, 14.25, 14.50	Co +/-30°, Cross +/-9.2°	30°-35°	270° or equivalent
Tx Az V Co & Cross	12.75, 13.00, 13.25, 13.75, 14.00, 14.25, 14.50	Co +/-30°, Cross +/-9.2°	30°-35°	270° or equivalent
TX Az H Co & Cross	14.25	Co +/-30°, Cross +/-9.2°	30°-35°	Without radome
Tx Az V Co & Cross	14.25	Co +/-30°, Cross +/-9.2°	30°-35°	Without radome
TX Gain H	13.75-14.50	Frequency-swept or at 4 discrete frequencies	30°-35°	Without radome
TX Gain V	13.75-14.50	Frequency-swept or at 4 discrete frequencies	30°-35°	Without radome
TX Az H Co & Cross	12.75, 13.00, 13.25, 13.75, 14.00, 14.25, 14.50	Co +/-30°, Cross +/-9.2°	0° See note 1	0°
Tx Az V Co & Cross	12.75, 13.00, 13.25, 13.75, 14.00, 14.25, 14.50	Co +/-30°, Cross +/-9.2°	0° See note 1	0°
Tx El H Co & Cross	12.75, 13.00, 13.25, 13.75, 14.00, 14.25, 14.50	Co $\geq$ +/-10°, Cross +/-9.2°	0° See note 1	0°
Tx El V Co & Cross	12.75, 13.00, 13.25, 13.75, 14.00, 14.25, 14.50	Co $\geq$ +/-10°, Cross +/-9.2°	0° See note 1	0°

1. If required, elevation angle may be adapted to the specific antenna/radome configuration on a case-by-case basis
2. The transmit frequencies 12.74 – 13.25 GHz referred as AP30B (from the ITU FSS Plan – Appendix 30B) have been defined for specific applications.

Table 13-2: additional ESV tests for Ku-band

Test	Frequencies [GHz]	Angular span	Elevation	Radome position
See Tests of Section 5.4. to be conducted with radome in nominal position			30°-35°	0° (nominal)
TX Az H Co & Cross	29.75	Co +/-180°, Cross +/-9.2°	30°-35°	90° or equivalent
Tx Az V Co & Cross	29.75	Co +/-180°, Cross +/-9.2°	30°-35°	90° or equivalent
TX Az H Co & Cross	29.50, 29.75, 30.00	Co +/-30°, Cross +/-9.2°	30°-35°	90° or equivalent
Tx Az V Co & Cross	29.50, 29.75, 30.00	Co +/-30°, Cross +/-9.2°	30°-35°	90° or equivalent
TX Az H Co & Cross	29.75	Co +/-180°, Cross +/-9.2°	30°-35°	150° or equivalent
Tx Az V Co & Cross	29.75	Co +/-180°, Cross +/-9.2°	30°-35°	150° or equivalent
TX Az H Co & Cross	29.50, 29.75, 30.00	Co +/-30°, Cross +/-9.2°	30°-35°	150° or equivalent
Tx Az V Co & Cross	29.50, 29.75, 30.00	Co +/-30°, Cross +/-9.2°	30°-35°	150° or equivalent
TX Az H Co & Cross	29.75	Co +/-180°, Cross +/-9.2°	30°-35°	270° or equivalent
Tx Az V Co & Cross	29.75	Co +/-180°, Cross +/-9.2°	30°-35°	270° or equivalent
TX Az H Co & Cross	29.50, 29.75, 30.00	Co +/-30°, Cross +/-9.2°	30°-35°	270° or equivalent
Tx Az V Co & Cross	29.50, 29.75, 30.00	Co +/-30°, Cross +/-9.2°	30°-35°	270° or equivalent
TX Az H Co & Cross	29.75	Co +/-30°, Cross +/-9.2°	30°-35°	Without radome
Tx Az V Co & Cross	29.75	Co +/-30°, Cross +/-9.2°	30°-35°	Without radome
TX Gain H	29.50-30.00	Frequency-swept or at 3 discrete frequencies	30°-35°	Without radome
TX Gain V	29.50-30.00	Frequency-swept or at 3 discrete frequencies	30°-35°	Without radome
TX Az H Co & Cross	29.50, 29.75, 30.00	Co +/-30°, Cross +/-9.2°	0° See note 1	0°
Tx Az V Co & Cross	29.50, 29.75, 30.00	Co +/-30°, Cross +/-9.2°	0° See note 1	0°
Tx El H Co & Cross	29.50, 29.75, 30.00	Co $\geq$ +/-10°, Cross +/-9.2°	0° See note 1	0°
Tx El V Co & Cross	29.50, 29.75, 30.00	Co $\geq$ +/-10°, Cross +/-9.2°	0° See note 1	0°

1. If required, elevation angle may be adapted to the specific antenna/radome configuration on a case-by-case basis.

Table 13-3: additional ESV tests for Ka-band (linear)

Test	Frequencies [GHz]	Angular span	Elevation	Radome position
See Tests of Section 5.4.4 to be conducted with radome in nominal position			30°-35°	0° (nominal)
TX Az RHCP Co & Cross	29.75	Co +/-180°, Cross +/-9.2°	30°-35°	90° or equivalent
Tx Az LHCP Co & Cross	29.75	Co +/-180°, Cross +/-9.2°	30°-35°	90° or equivalent
TX Az RHCP Co & Cross	29.50, 29.75, 30.00	Co +/-30°, Cross +/-9.2°	30°-35°	90° or equivalent
Tx Az LHCP Co & Cross	29.50, 29.75, 30.00	Co +/-30°, Cross +/-9.2°	30°-35°	90° or equivalent
TX Az RHCP Co & Cross	29.75	Co +/-180°, Cross +/-9.2°	30°-35°	150° or equivalent
Tx Az LHCP Co & Cross	29.75	Co +/-180°, Cross +/-9.2°	30°-35°	150° or equivalent
TX Az RHCP Co & Cross	29.50, 29.75, 30.00	Co +/-30°, Cross +/-9.2°	30°-35°	150° or equivalent
Tx Az LHCP Co & Cross	29.50, 29.75, 30.00	Co +/-30°, Cross +/-9.2°	30°-35°	150° or equivalent
TX Az RHCP Co & Cross	29.75	Co +/-180°, Cross +/-9.2°	30°-35°	270° or equivalent
Tx Az LHCP Co & Cross	29.75	Co +/-180°, Cross +/-9.2°	30°-35°	270° or equivalent
TX Az RHCP Co & Cross	29.50, 29.75, 30.00	Co +/-30°, Cross +/-9.2°	30°-35°	270° or equivalent
Tx Az LHCP Co & Cross	29.50, 29.75, 30.00	Co +/-30°, Cross +/-9.2°	30°-35°	270° or equivalent
TX Az RHCP Co & Cross	29.75	Co +/-30°, Cross +/-9.2°	30°-35°	Without radome
Tx Az LHCP Co & Cross	29.75	Co +/-30°, Cross +/-9.2°	30°-35°	Without radome
TX Gain H	29.50-30.00	Frequency-swept or at 3 discrete frequencies	30°-35°	Without radome
TX Gain V	29.50-30.00	Frequency-swept or at 3 discrete frequencies	30°-35°	Without radome
TX Az RHCP Co & Cross	29.50, 29.75, 30.00	Co +/-30°, Cross +/-9.2°	0° See note 1	0°
Tx Az LHCP Co & Cross	29.50, 29.75, 30.00	Co +/-30°, Cross +/-9.2°	0° See note 1	0°
Tx El RHCP Co & Cross	29.50, 29.75, 30.00	Co $\geq$ +/-10°, Cross +/-9.2°	0° See note 1	0°
Tx El LHCP Co & Cross	29.50, 29.75, 30.00	Co $\geq$ +/-10°, Cross +/-9.2°	0° See note 1	0°

1. If required, elevation angle may be adapted to the specific antenna/radome configuration on a case-by-case basis.

Table 13-4: additional ESV tests for Ka-band (circular – KASAT and KONNECT)

13.6 Dynamic Tests

The recommended approach to characterize the pointing error performance of ESV terminals is to test them on a motion table (also known as sea simulator) which emulates the velocity and accelerations that the terminal will be subject to during operations.

This approach provides quantitative results and is easily reproducible. Testing the pointing error performance with the ESV transmitting during navigation is not recommended because of the complex logistics and the fact that the sea conditions may not be representative enough to validate the pointing error in the operational worst case.

The antenna sub-system shall be placed on a motion table, via a special ad hoc mechanical adapter.

The motion profile is normally defined along three axis: Roll, Pitch and Yaw, see Figure below.

Tests for Heave, Sway and Surge movements are not required.

The Roll and Pitch motion shall normally be represented by a sinusoidal motion, the Yaw motion shall normally be represented by a saw-tooth variation.

In case of two axis motion tables, the manufacturer may set different trajectories in order to simulate the Yaw motion via a combination of Roll and Pitch motions.

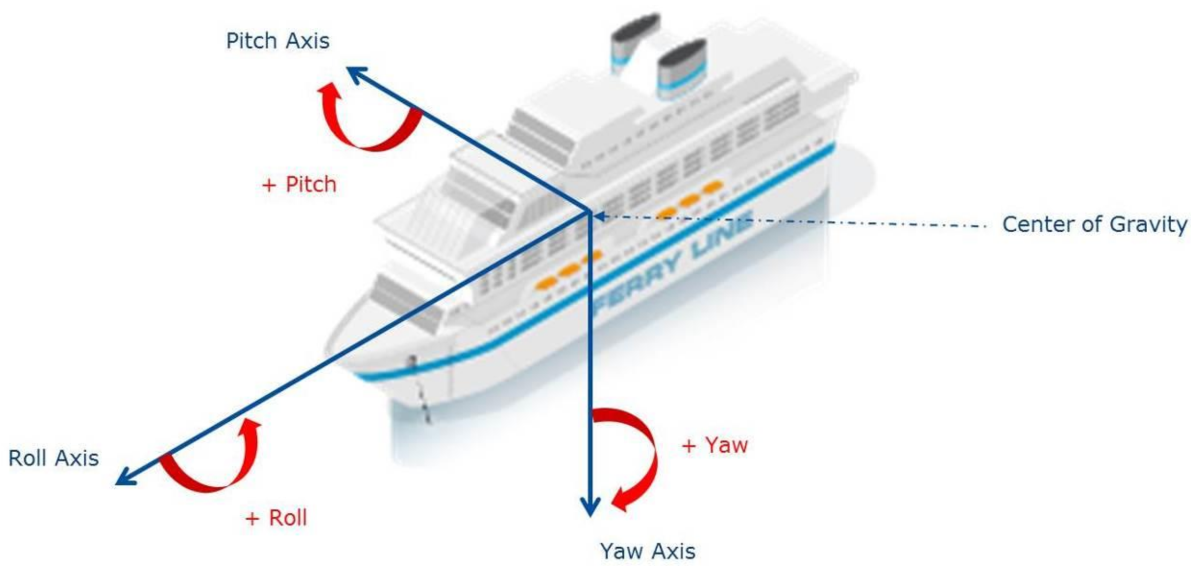


Figure 13-2: the axis of the vessel motion. To be observed that the yaw axis is directed to the centre of the earth

For each axis, a maximum velocity (expressed in degrees/sec) and acceleration (expressed in degrees/sec^2) shall be provided by the manufacturer, according to the intended operational use of the terminal. In general, the motion profile tends to be more demanding for smaller ships. The transformation of the three axis trajectories to actual sea level scales (e.g. Pierson-Moskowitz or the Beaufort scales) is problematic because it depends on the ship tonnage and size. By the way of an example, a sea-state 7 will have a significant effect on a 25 m yacht but little effect on a multi-thousand-ton tanker.

Example of sinusoidal motion conditions to be defined by the manufacturer:

Roll = ±30° over 6 sec period

Pitch = ±30° over 6 sec period

Yaw = ±30° over 10 sec period

13.7 Test method and configurations

The recommended method to assess the pointing errors (co-polar and cross-polar) of the ESV terminal is to measure and log over time the level variations of a carrier transmitted (or received) by the ESV terminal while in tracking mode and positioned on a table set into motion with a motion profiles up to the maximum values defined by the manufacturer (full dynamics).

The ESV terminal shall acquire on a suitable carrier while the motion stable is still. Once the signal locked, the ESV terminal shall be set in tracking mode, the logging started and after approximately 30 seconds the motion table started according to the predefined motion profile.

Tests shall be in accordance with one of the following set ups:

- Tests via satellite; the ESV terminal transmits a CW or modulated carrier and a fixed earth station pointed to the same satellite logs over time the variations of the signal received from the ESV terminal;
- Tests via satellite; the ESV terminal transmits a CW or modulated carrier and a Eutelsat Reference Station (ERS) pointed to the same satellite logs over time the variations of the signal received from the ESV terminal;
- Tests via satellite; the ESV terminal receives a predefined outbound modulated carrier and logs its variations over time. The signal used for tracking in this case shall be sufficiently powerful to ensure that the receive C/N at the ESV terminal does not fall below threshold during the motion tests. Tests via Ka-sat shall be performed according to this method;
- Tests on line-of-sight; the ESV terminal receives a CW carrier transmitted by a distant antenna (satellite simulator) and logs its variations over time.

The tests shall be performed for two different values of pitch (elevation) of the antenna, i.e. set to medium (50°), low (10°) and, whereas foreseen by the tracking architecture, high (about 90°).

Tests shall be normally performed with the radome fitted on. However, it is not expected that the radome would affect the tracking performance significantly and exceptionally, in cases where installation of the radome was not possible (space and/or weight constraints), tests without radome could be performed instead, following agreement of the Eutelsat S.A. representative.

13.8 Tests of the main polarization pointing accuracy

13.8.1 References

The following definitions are applicable any cutting plane assuming the antenna is operating normally.

Pointing Error: the average pointing angle referred to the satellite direction in a given cut plane. If the antenna tracking is correct the Pointing Error is 0. Non-zero values of the pointing errors are indicative of an offset in the antenna pointing.

Pointing Accuracy: the standard deviation of the pointing angle with the antenna in auto-track.

13.8.2 Computation procedures

Even if in principle it is possible to estimate the Pointing Error and Pointing Accuracy also on the move, in order to simplify the procedure the tests are performed installing the antenna on a motion table as described above.

Additionally, these tests must rely on the angle measurement provided by the Antenna Control Unit (ACU) which can be easily verified once knowing the reflector patterns.

The estimation of the antenna pointing error and accuracy must be done following the procedure applicable to both elevation and azimuth planes and any other cutting plane :

- Point manually the antenna and read the reference angle $\varphi_0$provided by the ACU. This value is the angle optimizing the antenna pointing.
- Put the antenna in auto-tracking mode. Logs N ≥ 1000 consecutive measurements of the angle φ_i during at least 1 period of the angular scan.
- The pointing error is estimated as the average of the samplings, i.e.

$$Error = \frac{1}{N}\sum_{i=1}^{N} \varphi_i - \varphi_0 \qquad \text{Equation 13-1}$$

- The smr accuracy σ_φ estimation is computed with the formula

$$\sigma_\varphi = \sqrt{\frac{1}{N}\sum_{i=1}^{N} (\varphi_i - \varphi_0 - Error)^2} \qquad \text{Equation 13-2}$$

- Use the two values in the comparison with the EESS patterns assuming the angle

$$\theta + \delta\theta = \theta + abs(Error) + \sigma_\varphi \qquad \text{Equation 13-3}$$

The following motion profiles shall be set:

- No motion profile, the antenna is tracking;
- Roll maximum velocity and acceleration;
- Pitch maximum velocity and acceleration;
- Yaw maximum velocity and acceleration. Certain motion table may only be two axis, Roll and Pitch. In this case the manufacturer shall explain how to simulate the Yaw motion via combined Roll and Pitch motion trajectories;
- Combination of Roll, Pitch and Yaw maximum velocity and acceleration (full dynamics);
- As an option for certain manufacturers, additional test with a combination of Roll, Pitch and Yaw reduced velocity and acceleration (half dynamics);
- All tests above shall be performed twice, one for each polarization. For two port ESV terminals, one carrier per polarization shall be identified and used for acquisition and tracking.

For each test profile the log time should be agreed with the manufacturer who will provide the period of scanning in seconds. The sampling period will be ¼ the scanning period or less and the duration must be set to

$$max\{300\ seconds, 1000\ sampling\ period\} \qquad \text{Equation 13-4}$$

At the start and end of the each log recording, the motion table shall be set to still conditions for duration of approximately 30 seconds.

For asymmetric antenna diagrams (e.g. low profile aperture antennas) where the main lobe has not rotational (circular) characteristics, the pointing error shall be assessed on a pattern skewed by an angle corresponding to the polarization angle of the ESV terminal during the tests.

13.8.3 Tests of the cross-polarization adjustment accuracy (linear polarization only)

In addition to the assessment of the pointing error, the ESV's cross-polarization discrimination shall be determined. The measurement test set-up and motion profiles shall be the same as those used for the co-polar pointing error. In case of tests via satellite, two orthogonal tests slots signal-free at the same frequency shall be used.

The level of the cross-polar component of the ESV terminal shall be measured and logged over time by a fixed antenna available at the same location of the ESV terminal or alternatively by and in co-ordination with the ERS (Eutelsat Reference Station) in the frame of a specific ESVA test via satellite.

In case that the logging of the cross-polar component is performed at the ESV terminal set in receive mode, a re-configuration of the OMT connections may be necessary e.g. in order to bypass reject filters.

If simultaneous measurements of the co-polar and cross-polar components are possible, the cross-polar discrimination shall be derived by subtracting the level of the cross-polar component form the level of the co-polar component.

If simultaneous measurements of the co-polar and cross-polar components are not possible, the level of the cross-polar component shall be subtracted from the maximum level of the co-polar component recorded during the co-polar pointing tests.

13.9 Additional verifications and requirements

13.9.1 ESV antenna inspections

Prior to the start of the static tests there is a number of inspections which should be carried out on the ESV terminal:

a) In case of splash feed optics, verification of the attach points of the feeder to the main reflector. These should be such to guarantee the perfect symmetric alignment of the feeder wrt to the reflector, to guarantee rotational symmetric RF sidelobe performance.

b) In case of splash feed optics, verification of the fitting of the sub-reflector to the feeder. It is very important that the sub-reflector be parallel to the feed aperture, to guarantee rotational symmetric RF sidelobe performance. In case of doubts the feeder shall be removed and positioned on a turning device e.g. a lathe, for verification.

c) Verification of the way the main reflector is fixed to the back structure, to ensure that the back structure does not create any deformation in the reflector.

d) Verification of the construction of the radome. The inspection shall be performed to ensure that there are no scratches, slits and that the outer surface is polished and smooth. The same verification shall be performed inside the radome, checking for local non uniformities, e.g. in the joints between segments. Local differences in the thickness of the radome may be cause of reflections which could considerably raise the level of the sidelobes.

e) Sealing of the radome to its base.

13.9.2 TX mute tests

Tests are to be performed to confirm that the ESV carrier is automatically switched off in case of pointing error exceeding values defined by the manufacturer or in case of loss of the satellite signal.

The response time of the ESV terminal to mute the carrier, T, shall be communicated by the manufacturer and shall not exceed 5 seconds (ETSI 302 340 paragraph 4.2.6.2 refers). The response time to re-enter the carrier ON state shall not exceed 2 x T seconds.

TX mute tests should take place with the antenna pointed and tracking on the satellite or a transmitter simulating the satellite in case of measurements performed on a test range or in a laboratory.

An oscilloscope should be used to display the time necessary for the mute command to be generated from the ACU and/or received at the BUC output monitoring point, if available.

The following tests should be performed:

a) Remove the antenna radome and physically move it rapidly away from pointing, by e.g. strongly pulling the reflector rim. The de-pointing shall be induced in succession on two orthogonal directions, e.g. to de-point in Azimuth or in Elevation;

b) Move in and out in front of the antenna aperture an absorber panel until the tracking error exceeds the maximum expected pointing error;

c) Switch off the satellite simulator, in case of tests range or laboratory measurements.

Tests a) and b) should confirm that the ESV terminal has correctly detected that the induced pointing error has exceeded the pointing error threshold and that the transmission of the carrier is muted in a time not exceeding T seconds. The time response to re-enter the carrier ON state shall also be measured from the time when the de-pointing conditions cease.

Eutelsat S.A. expects that the transmission be switched off automatically in presence of mute conditions via a mute command sent from the ACU to the BUC, directly or via appropriate switches (modem included).

13.9.3 Look-up tables for the Eutelsat polarization offset (linear polarization only)

The linear polarization planes (defined as X and Y and orthogonal to each other) of most of the Eutelsat satellites are not parallel/orthogonal to the equatorial plane. For historical reasons, the polarization planes are inclined by an angle with respect to the equatorial plane. This angle is referenced as the polarization offset.

This skew is of fundamental importance in order to correctly set the polarization of the ESV terminal whenever the polarization alignment is performed in open loop (calculated).

When operators or installers program the transmit parameters of an ESV terminal, a human error in entering the skew of the satellite cannot be excluded, because of lack of correct information, operator mistakes or the widespread presumption that the skew is equal to 0 degrees.

These errors cannot be identified in a straightforward manner and can be potentially a source of interference to services carried in the opposite polarization. This is namely the case of the services carried on the Eutelsat satellites where the skew of most satellites is equal to +3.535° (see point 10.2). In fact if the skew was set to 0° instead of 3.535°, the cross-polar discrimination error because of this would be equal to $20 \times log_{10}[\sin(3.535°)] = 24.2\ dB$.

Consequently, in order to qualify for a type approval/characterization, appropriate look-up tables embedded in the software/firmware of the ESV terminals shall be implemented in order to secure that the correct skew value will be used, independently of any possible human error.

The manufacturer shall demonstrate that the value of the polarization offset of the look-up table shall be maintained, irrespective of the skew data manually entered by the operator/installer.

An example of the look-up table is as follows:

Longitude of the satellite	Polarization offset
-15°	0.0°
-12.5°	3.535°
-8°	3.535°
-7°	3.535°
-5°	0.0°
+3°	3.535°
+4°	3.535°
+7°	3.535°
+9°	3.535°
+10°	3.535°
+13°	3.535°
+16°	3.535°
+21.5°	3.535°
+25.5°	3.535°
+28.5°	3.535°
+33°	3.535°
+36°	3.535°
+48°	3.535°
+53°	0.0°
+70°	3.535°
+70.5°	3.535°
+172°	0.0°

Table 13-5: satellite skew table

13.9.4 Spectral regrowth tests

The manufacturer shall provide measurements of the spectrum re-growth of the HPA(s) used in conjunction with the ESV terminal. The measurements shall be performed either in laboratory or via satellite. For additional information on the Eutelsat S.A. requirements, see ESOG Vol. II module 210 (Annex E) and 220 (Annex C).

13.9.5 Factory tour

In case of a type approval program, the Eutelsat S.A. representative shall conduct a factory tour at the manufacturer's factory.

During the tour the following topics shall be addressed, as a minimum:

- Inspect machinery, tooling and jigs,
- Review procedures for reception, inspection and validation of performance and characteristics of parts and/or sub-systems,
- Inspect the terminal integration pads and review integration procedures,
- Review QA/QC procedures,
- Review final acceptance tests and validation procedures for finished systems (both 100% and sample testing),
- Review storage of parts, sub-systems and finished ESV terminal, packaging and shipment methods.

13.9.6 ESV Terminals Questionnaire

ANTENNA RF CHARACTERISTICS

- ☐ Transmit frequencies of operations,
- ☐ Receive frequencies of operations,
- ☐ Polarization (linear, circular),
- ☐ Tx and Rx Gains,
- ☐ Mode of operations: Tx/Rx orthogonal, TX/Rx parallel,
- ☐ G/T calculations or measurements.

ANTENNA PARTS

- ☐ Antenna manufacturer/model,
- ☐ Feed manufacturer/model,
- ☐ If applicable, manufacturer of the sub-reflector holder,
- ☐ OMT, Rotary Joint, BPF, LPF, diplexers manufacturer/model,
- ☐ Feedboom or feeder manufacturer/model,
- ☐ Back structure manufacturer/model.

ANTENNA PHYSICAL CHARACTERISTICS

- ☐ Diameter (for non circular antennas, major and minor axis),
- ☐ Type of geometry (Ring focus Gregorian, Prime focus, Dual offset Gregorian etc.),
- ☐ Type of feed (mode matched, corrugated, smooth etc.),
- ☐ If mode matched feed is used describe how the feed alignment is verified,
- ☐ Reflector material (SMC, metallic, carbon fiber, glass fiber etc.),
- ☐ Reflector built (solid, petals, etc.),
- ☐ Sub reflector material (if applicable),
- ☐ Sub-reflector holder material (if applicable),
- ☐ Total weight of the system including positioner but without radome.

ANTENNA MANUFACTURING

- ☐ Describe the manufacturing processes of the reflector(s),
- ☐ For double optics systems, describe the manufacturing process of the sub-reflector and feedhorn,
- ☐ Describe the manufacturing processes of the OMT,
- ☐ For double optics systems, describe the assembly process of the sub-reflector to the feedhorn.

ANTENNA MANUFACTURING CONTROL

- ☐ Surface RMS accuracy of the reflector(s),
- ☐ For double optics systems, expected manufacturing tolerances of the sub-reflector holder,
- ☐ Describe rms verifications and inspections on reflector(s),
- ☐ For double optics systems, describe verifications on the position of the sub-reflector wrt the feedhorn,
- ☐ For double optics systems, describe verifications on the position of the feedhorn wrt the main reflector,
- ☐ Provide drawings with the expected distances between predetermined points on the feed, reflector and sub reflector (if applicable) and the accepted tolerances,
- ☐ For double optics systems, describe budget position error of the sub-reflector wrt the main reflector and the relevant verifications performed,
- ☐ Percentage of systems for which full verifications and inspections are applied.

SHOCK AND VIBRATION

- ☐ Describe applicable standards,
- ☐ Describe the test procedures to measure the shock and vibration performance,
- ☐ Provide shock and vibration test results.

ANTENNA POSITIONER

- ☐ Positioner manufacturer and model,
- ☐ Antenna’s positioner description (materials, tolerances, QA and QC controls etc.),
- ☐ Number of axis of the antenna,
- ☐ Antenna’s positioner range of operations (Gimbal, El, XEL, Polarization), time to rewind when applicable,
- ☐ Motors: number, type, manufacturers,
- ☐ Bearings: manufacturer, model, need for lubrication,
- ☐ MTBF of motors, belts,
- ☐ Describe periodic maintenance requirements.

RADOME

- ☐ Radome manufacturer,
- ☐ Radome expected attenuation in Tx and Rx bands,
- ☐ Structure of the radome and materials,
- ☐ Dimensions, weight and tolerances,
- ☐ Variation of the attenuation versus manufacturing tolerance,
- ☐ Describe step-by-step the radome manufacturing process,

- ☐ Describe the radome sealing method,
- ☐ Describe the verifications and inspections performed on the radome and percentage of units inspected,
- ☐ Describe periodic maintenance requirements.

ANTENNA CONTROL UNIT

- ☐ ACU manufacturer and model,
- ☐ Software vendor, designation and version number.

TRACKING SUB-SYSTEM AND PERFORMANCE

- ☐ Tracking maximum pointing error,
- ☐ Vessel's Roll, Pitch and Yaw maximum angular velocity (degrees/seconds) and acceleration (degrees/seconds^2) versus maximum pointing error (full dynamics),
- ☐ As above but with reduced velocity and acceleration (half dynamics),
- ☐ Tracking sub-system: describe principle and functional parameters e.g. circle diameter, time, number of samples,
- ☐ Encoders type, manufacturer and model,
- ☐ Encoders resolution (detail for each applicable axis),
- ☐ Tracking receiver manufacturer and model,
- ☐ Rate sensors, GPS, compass: manufacturers and models,
- ☐ Methods to ensure that transmission takes place on the wanted satellite,
- ☐ Pointing error at which the transmission is muted and time to mute,
- ☐ Describe all other criteria to mute transmission,
- ☐ Describe the criteria to restart transmission (automatically) from mute and time to retransmit,
- ☐ Describe methods to disable transmission of the BUC when mute conditions apply,
- ☐ Describe the polarization alignment method,
- ☐ Expected maximum polarization alignment error,
- ☐ Describe the polarization look-up tables (if applicable) necessary to compensate the polarization skew of most Eutelsat satellites,
- ☐ Describe the polarization skew control for automatic beam switching applications,
- ☐ Expected operational and survival wind conditions.

TRANSMITTER AND LNB

- ☐ Manufacturer(s) and model(s),
- ☐ Transmitter rating(s),
- ☐ Expected EIRP and frequency stability,

- ☐ Provide measurement of the Out-of-Band radiation versus output back off,
- ☐ LNB manufacturer(s) and model(s).

MODEM(S)

- ☐ Manufacturer(s) and model(s),

MONITORING AND CONTROL SYSTEMS

- ☐ Transmit RF Carrier monitoring system (type, manufacturer, model),
- ☐ Describe the EIRP set-up and control functions.

INSTALLATION AND OPERATIONS HANDBOOK

- ☐ Describe the packaging of the antenna and of the radome,
- ☐ Describe the verifications performed on the integrity of the antenna and radome at reception on the vessel,
- ☐ Describe the installation process of the antenna on the vessel,
- ☐ Provide a copy of the operations handbook,
- ☐ Provide a template of the expected radiation-safe zone around the antenna.

14 Low profile antennas Type Approval/Characterization process

14.1 General

AES (Airborne Earth Stations) and Vehicle Mounted Earth Stations (VMES) are terminals with tracking facilities which are operated under motion on the airplane and on vehicles (car, bus, trains) where they are embarked.

This section describes the Eutelsat S.A. conditions to obtain the type approval/characterization of AES terminals and the relevant test criteria and requirements. Further reference can be found in the documents ETSI EN 302 186, ETSI EN 302 977, ETSI EN 302 448 (Ku band) and ETSI EN 303 978 (Ka-band).

The conditions include also that the antenna is compliant with the standard applicable to the different environments. E.g. ETSI EN 50 155 and ETSI EN 45 545 for railway applications or ARINC 791 for avionic antennas.

Tests and verifications on an AES and VMES terminal shall comprise:

- “Static” tests to measure the RF sidelobe performance;
- “Dynamic” tests to measure the pointing and tracking functionalities;
- Additional verifications (Antenna inspection, Tx mute control, look-up tables of the polarization skew, spectrum re-growth, factory tour).

The “Static” tests shall verify compliance of the RF sidelobe performance against the Eutelsat Earth Station Minimum Technical and Operational Requirements, EESS 502 paragraph 4.1.

The “Dynamic” tests shall verify compliance with the maximum beam pointing error of + 0.4° under all circumstances, EESS 502 paragraph 4.4 refers.

For type approval applications all tests shall be witnessed by a Eutelsat S.A. test engineer or authorized representative.

For applications for characterization only, Eutelsat S.A. may exceptionally accept to review un-witnessed dynamic tests results.

The application form (Chapter 6) shall be filled by the applicant, in addition to point 9.7 specific for AES and VMES terminals.

14.2 Static tests for AES and VMES terminals

The static tests baseline is described in Chapter 7. This section describes the additional test criteria and measurements necessary to type approve/characterize AES and VMES terminals.

14.3 Number of AES or VMES systems

- ***Type Approval***: three antennas and three associated radomes of the same model shall be made available.

- ***Characterization***: one antenna and one radome shall be made available.

14.4 Cases study

The technology or the optic configuration adopted for AES and VMES shall be classified as follows.

a) Ultra small aperture (USA). In general, small circular reflectors or small square phased array tail-mounted on small airborne or UAV.

b) Low profile antennas with mechanical steering. In this case the antennas are composed by elliptical reflectors or rectangular phased array, with mechanical steering. Unless a full control of the skew is available, the low profile antennas suffers from limitations with skew.

c) Flat antennas. The radiating surface is horizontal in order to assure a very low impact on the aerodynamic profile of the airplane or the train. The tracking is in general electronic in Electronic Steering Antennas (ESA) but there are mechanical exceptions based on patented solutions (Variable Inclination Continuous Transverse Stubs –VICTS or antennas based on Rothmann lenses). Also in this case the skew can be a limitation but the most important peculiarity of this antenna is that the gain and the pattern shape is variable with the steering angle. For this reason, we will dedicated a specific chapter to the flat antennas.

14.5 General tests conditions

- All tests shall be performed on an agreed test range and shall be performed at the Input and Output ports of the antenna OMT (Ortho Mode Transducer) or duplexer (if co-polar operation are considered).
- The manufacturer shall ensure that the positioner of the antenna shall be firmly fixed by mechanical implements so as to set the antenna at the required elevation angles inside the radome (i.e.30°-35° or 0°).
- The antenna of AES and VMAS terminals is necessarily protected by a radome and static tests shall be performed with the radome ON.

14.6 Tests on USA

Despite the fact these antennas have a symmetric optic (circular or square) they are frequently protected by radomes that have axis of asymmetry. Examples of radome are reported in the following pictures.

Additionally, in most cases the antenna manufacturer does not know the radome characteristics because it is built the airborne manufacturer/integrator.

Whereas the radome is not available, one possibility here proposed is making the measurement of the antenna without radome, followed by measurements of all the radomes that will be used with that antenna in order to determine the distortions introduced.

Figure 14-1: Examples of radomes with asymmetries

14.6.1 USA tests without radome

Considering the symmetries of the USA (i.e. circular or square apertures) the tests without radome can be performed following the indications of the chapters 7.4.2 for Ku band or 7.4.4 and 7.4.5 for Ka band.

Nevertheless, a consideration should be done about the aperture size and the fact that their beam-width can be > 3º. It is the case of 30cm parabola in Ku band typical for UAV applications or even smaller apertures in Ka band.

For these case a raster scan on a 3°x3° window does not give any information except for the XPD pattern. It is preferable to produce a sequence of patterns on cuts taken at regular steps (of at least 10°) from -90° to +90°.

14.6.2 Low profile antennas without radome

Elliptical or rectangular antennas presents a boar-side beam that is large in the vertical plane and narrow in the horizontal one. Antenna with a high ratio between the two axis of the ellipse (or the two side of the rectangle) present also a beam that is very thin and high.

Example: a very low profile Ku band antenna is composed by a radiating panel with dimensions 120cm x 30cm. The 3dB beam-width will be about 4.5º in the vertical cut and 1.2º in the horizontal cut.

Therefore, for very elliptical antennas, the measurement of the raster scan over a 3º x 3º window is not effective. In addition, it is required to determine the operational conditions as function of the skew angle. For this reasons, it is preferable to produce a sequence of patterns on cuts taken at specific angles from -90º to +90º. The angular steps of the cuts can be non-uniform as showed in the Figure 14-2.

The measurement of the patterns at different cuts allows to determine what is the operational skew limit or, in no the contrary, what are the PSD limits for each skew angle.

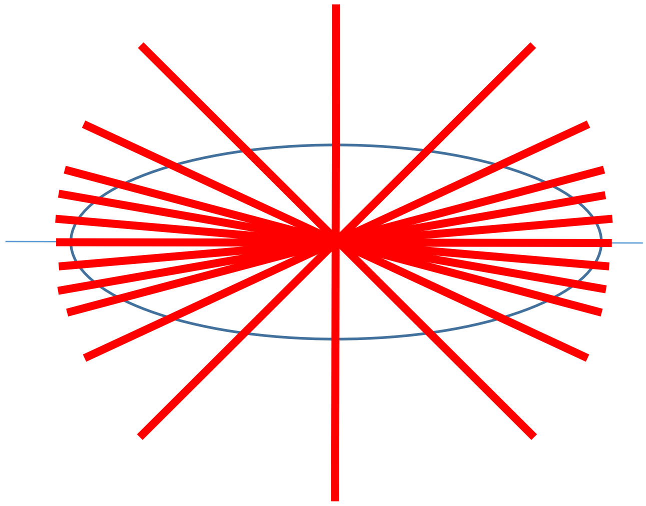


Figure 14-2: example of non-uniform cuts used to be used during the tests

14.7 Test configurations with radome

The basic idea is to exploit the symmetries of the radome in order to reduce the number of tests.

If the radome presents a cylindrical symmetry, the tests will be repeated, as indicated in chapter 11 for the ESV, turning the radome in 4 different directions.

Whereas the radome has a single plane of symmetry (e.g. longitudinal symmetry as typically is on airplanes and trains), the effects on the radiation patterns due to the incidence angle on the radome's surface depends on the antenna position. Therefore the RF off-axis gain patterns (see section 7.4) should be measured considering the most exhaustive number of positions of the antenna referred to the radome. These positions are defined in cooperation the applicant but the following drawing (Figure 14-3) is an example.

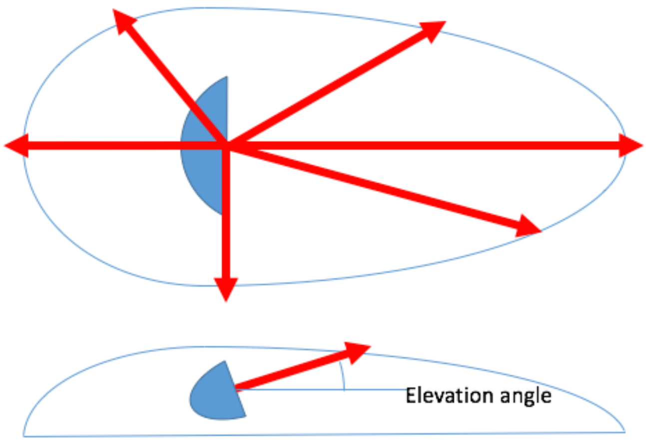


Figure 14-3: example of directions where teh tests should be repeated

Since the airborne antenna's radome integrate strips for the electrostatic discharge, particular care should be taken in selecting the directions of measurement with reference to the position of these strips. These strips are in general the shape of transversal arcs that could impact the pattern shape.

The range positioner should ensure that the antenna inside the radome is firmly positioned to any required elevation angle and azimuth angle measured with reference to the radome symmetry axis.

- One set of tests shall be performed without radome, to assess the radome loss and the intrinsic RF off-axis performance of the antenna. These tests shall be performed at mid TX frequency in azimuth and elevation for both polarizations. This part of tests shall be also used in order to determine the center of the main lobe of the antenna, before proceeding in testing the antenna with the radome
- The tests without radome mentioned in the previous point must be taken as reference in the identification of asymmetrical deformation of the beam due to the radome itself. It is the case, for example, of the introduction of a beam squint which could impact the performances of the satellite link and could require to be compensated by the positioner.

The summaries of the additional tests for Ku- and Ka- bands and relevant angular spans are shown in Table 14-1 and Table 14-2.

Test	Frequencies [GHz]	Angular span	Elevation	Radome position
See Tests of Section 7.4.2 to be conducted with radome in nominal position			30°-35°	0° (nominal)
TX Az H Co & Cross	14.25	Co +/-180°, Cross +/-9.2°	30°-35°	positions to be defined on the base of the radome shape
Tx Az V Co & Cross	14.25	Co +/-180°, Cross +/-9.2°	30°-35°	
TX Az H Co & Cross	13.75,14.00, 14.25, 14.50	Co +/-30°, Cross +/-9.2°	30°-35°	
Tx Az V Co & Cross	13.75,14.00, 14.25, 14.50	Co +/-30°, Cross +/-9.2°	30°-35°	
TX Az H Co & Cross	14.25	Co +/-30°, Cross +/-9.2°	30°-35°	Without radome
Tx Az V Co & Cross	14.25	Co +/-30°, Cross +/-9.2°	30°-35°	
TX Gain H	13.75-14.50	Frequency-swept or at 4 discrete frequencies	30°-35°	
TX Gain V	13.75-14.50	Frequency-swept or at 4 discrete frequencies	30°-35°	
TX Az H Co & Cross	13.75,14.00, 14.25, 14.50	Co +/-30°, Cross +/-9.2°	0° See note 1	0°
Tx Az V Co & Cross	13.75,14.00, 14.25, 14.50	Co +/-30°, Cross +/-9.2°	0° See note 1	
Tx El H Co & Cross	13.75,14.00, 14.25, 14.50	Co $\geq$ +/-10°, Cross +/-9.2°	0° See note 1	
Tx El V Co & Cross	13.75,14.00, 14.25, 14.50	Co $\geq$ +/-10°, Cross +/-9.2°	0° See note 1	

1. If required, elevation angle may be adapted to the specific antenna/radome configuration on a case-by-case basis.

Table 14-1: additional AES tests for Ku band

Test	Frequencies [GHz]	Angular span	Elevation	Radome position
See Tests of Section 7.4.4 and 7.4.5 to be conducted with radome in nominal position			30°-35°	0° (nominal)
TX Az H Co & Cross	29.75	Co +/-180°, Cross +/-9.2°	30°-35°	positions to be defined on the base of the radome shape
Tx Az V Co & Cross	29.75	Co +/-180°, Cross +/-9.2°	30°-35°	
TX Az H Co & Cross	29.50, 29.75, 30.00	Co +/-30°, Cross +/-9.2°	30°-35°	
Tx Az V Co & Cross	29.50, 29.75, 30.00	Co +/-30°, Cross +/-9.2°	30°-35°	
TX Az H Co & Cross	29.75	Co +/-30°, Cross +/-9.2°	30°-35°	Without radome
Tx Az V Co & Cross	29.75	Co +/-30°, Cross +/-9.2°	30°-35°	
TX Gain H	29.50-30.00	Frequency-swept or at 3 discrete frequencies	30°-35°	
TX Gain V	29.50-30.00	Frequency-swept or at 3 discrete frequencies	30°-35°	
TX Az H Co & Cross	29.50, 29.75, 30.00	Co +/-30°, Cross +/-9.2°	0° See note 1	0º
Tx Az V Co & Cross	29.50, 29.75, 30.00	Co +/-30°, Cross +/-9.2°	0° See note 1	
Tx El H Co & Cross	29.50, 29.75, 30.00	Co $\geq$ +/-10°, Cross +/-9.2°	0° See note 1	
Tx El V Co & Cross	29.50, 29.75, 30.00	Co $\geq$ +/-10°, Cross +/-9.2°	0° See note 1	

1. If required, elevation angle may be adapted to the specific antenna/radome configuration on a case-by-case basis.

Table 14-2: additional AES tests for Ka-band

14.8 Qualification of the radome only

Frequently, in aviation antennas, the radome is dissociated from the remaining parts of the antenna: in several cases the radiating aperture (reflector, flat panels, etc.) and its integration with the Ku/Ka band Radio Frequency Unit (KRFU) and Ku/Ka band Aircraft Networking Data Unit (KANDU, see [5] for the terminology) are responsibility of the antenna manufacturer, while the radome is produced and integrated by avionic components manufacturers.

Therefore, it is not uncommon that the same radio aperture is used with different radomes. In this case, instead of repeating all the tests for any radome, a subset of verifications is proposed.

By repeating the same scheme presented in Figure 14-3 it is possible to do a subset of tests as indicated in the following table.

The test plan indicates a base-line elevation value of 30°-35°. Nevertheless, it is recommended to repeat the tests on at least three reference elevations: around 0°, around 30° and around 60°.

For what concerns the cuts, depending on the range set-up, it could be not possible to make the capture on the three cuts indicated. Optionally it can be done the horizontal and vertical cut.

<table>
<tr><th>Test</th><th>Frequencies</th><th>Angular span</th><th>Base-line Elevation</th><th>Radome position</th></tr>
<tr><td colspan="5">Find the maximum of the beam without radome and measure de gain in the applicable reference frequencies</td></tr>
<tr><td>Measurement of the new maximum position and computation of the beam squint</td><td rowspan="3">TX and RX ref. frequencies</td><td>-</td><td>30°-35°</td><td rowspan="4">Select one representative position</td></tr>
<tr><td>Measurement of the gain variation</td><td>-</td><td>30°-35°</td></tr>
<tr><td>TX Az H Co & Cross patterns on three cuts (0°, 30°, 60°).</td><td>Co +/- 30°, Cross +/-9.2°</td><td>30°-35°</td></tr>
<tr><td colspan="4">Repeat previous tests on both polarizations</td></tr>
<tr><td colspan="5">Repeat the previous tests selecting another representative radome position</td></tr>
</table>

Table 14-3: tests for the qualification of a radome

The tests described above assume the usage of far field ranges. The usage of near field range will provide more complete information but the duration of the tests would risk to be too long.

14.9 Dynamic tests

The recommended approach to characterize the pointing error performance of AES terminals is to test them on a motion table (similar to the sea simulator).

This approach provides quantitative results and is easily reproducible.

The antenna sub-system shall be placed on a motion table, via a special ad hoc mechanical adapter. The motion profile is normally defined along three axis: Roll, Pitch and Yaw, see Figure 14-4 below. Tests for Heave movements are not required. The motors of the motion table are driven in order to simulate the flight movements on the bases of models provided by the airplane operators.

For each axis, a maximum velocity (expressed in degrees/sec) and acceleration (expressed in degrees/sec^2) shall be provided by the manufacturer, according to the intended operational use of the terminal.

Whereas the antenna positioner requires a stream of data coming from an external Inertial Reference Unit (IRU) it is necessary to install such a device in the motion table itself. The manufacturer shall provide the necessary IRU with the right and tested interface to the.

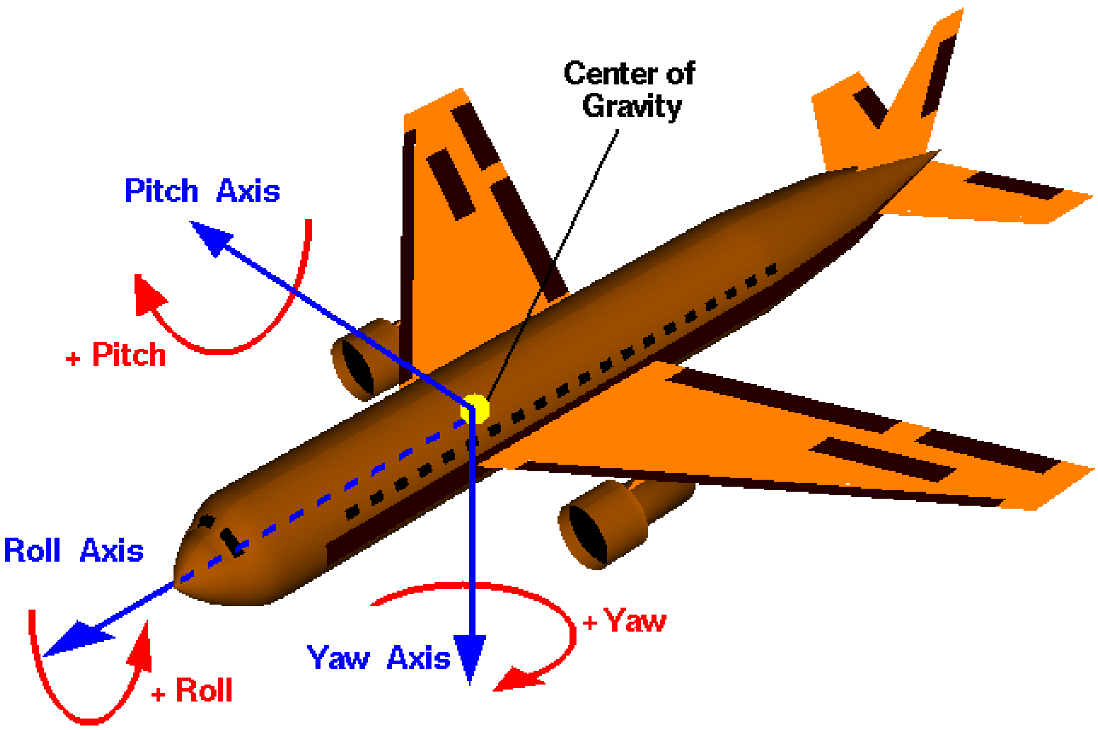


Figure 14-4: airborne roll, pitch and yaw. To be observed that the z axis (or yaw axis) is oriented to the bottom of the airplane.

Example of information to be provided by the manufacturer is reported in Table 14-4 below.

	Pitch	Roll	Yaw
Operational Range	-22° ÷ +25°	+/- 22°	+/- 24°
Velocity	+/- 34 °/s	+/- 33 °/s	+/- 35 °/s
Acceleration	+/- 220 °/s^2	+/- 220 °/s^2	360 °/s^2

Table 14-4: roll pitch and yaw (example reported from a flight simulator). The values are variable and depends on the aircraft type.

14.10 Test method and configurations

The recommended method to assess the pointing errors (co-polar and cross-polar) of the AES terminal is to measure and log over time the level variations of a carrier transmitted (or received) by the AES terminal while in tracking mode and positioned on a table set into motion with a motion profiles up to the maximum values defined by the manufacturer (full dynamics).

The AES terminal shall acquire on a suitable carrier while the motion stable is still. Once the signal locked, the AES terminal shall be set in tracking mode, the logging started and after approximately 30 seconds the motion table started according to the predefined motion profile.

Tests shall be in accordance with one of the following set ups:

- Tests via satellite; the AES terminal transmits a CW or modulated carrier and a fixed earth station pointed to the same satellite logs over time the variations of the signal received from the AES terminal;
- Tests via satellite; the AES terminal transmits a CW or modulated carrier and a Eutelsat Reference Station (ERS) pointed to the same satellite logs over time the variations of the signal received from the AES terminal;
- Tests via satellite; the AES terminal receives a predefined outbound modulated carrier and logs its variations over time. The signal used for tracking in this case shall be sufficiently powerful to ensure that the receive C/N at the AES terminal does not fall below threshold during the motion tests. Tests via Ka-sat shall be performed according to this method;
- Tests on line-of-sight; the AES terminal receives a CW carrier transmitted by a distant antenna (satellite simulator) and logs its variations over time.

The tests shall be performed for two different values of pitch (elevation) of the antenna, i.e. set to high (50°) and low (20°). The wanted pitch of the antenna Pa shall be obtained by setting the pitch Pm of the motion table with respect to the horizontal to the value Pm = Pa.

Tests shall be normally performed with the radome fitted on. However, even if a deviation of the beam cannot be neglected (the radome shape could be the origin of a beam squint), it is not expected that the radome would affect the tracking performance significantly.

Therefore, exceptionally in cases where installation of the radome was not possible (space and/or weight constraints), tests without radome could be performed instead, following agreement of the Eutelsat S.A. representative.

14.11 Test of the co-polar pointing error

14.11.1 Definitions

The following definitions are applicable any cutting plane assuming the antenna is operating normally.

Pointing Error: the average pointing angle referred to the satellite direction in a given cut plane. If the antenna tracking is correct the Pointing Error is 0. Non-zero values of the pointing errors are indicative of an offset in the antenna pointing.

Pointing Accuracy: the standard deviation of the pointing angle with the antenna in auto-track.

14.11.2 Computation procedures

Even if in principle it is possible to estimate the Pointing Error and Pointing Accuracy also on the move, in order to simplify the procedure the tests are performed installing the antenna on a motion table as described above.

Additionally, these tests must rely on the angle measurement provided by the Antenna Control Unit (ACU) which can be easily verified once knowing the reflector patterns.

The estimation of the antenna pointing error and accuracy must be done following the procedure applicable to both elevation and azimuth planes and any other cutting plane :

- Point manually the antenna and read the reference angle $\varphi_0$provided by the ACU. This value is the angle optimizing the antenna pointing.
- Put the antenna in auto-tracking mode. Logs N ≥ 1000 consecutive measurements of the angle φ_i during at least 1 period of the angular scan.
- The pointing error is estimated as the average of the samplings, i.e.

$$Error = \frac{1}{N}\sum_{i=1}^{N}\varphi_i - \varphi_0 \qquad \text{Equation 14-1}$$

- The smr accuracy σ_φ estimation is computed with the formula

$$\sigma_{\varphi} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(\varphi_i - \varphi_0 - Error)^2} \qquad \text{Equation 14-2}$$

- Use the two values in the comparison with the EESS patterns assuming the angle

$$\theta + \delta\theta = \theta + abs(Error) + \sigma_{\varphi} \qquad \text{Equation 14-3}$$

The following motion profiles shall be set:

- No motion profile, the antenna is tracking;
- Roll maximum velocity and acceleration;
- Pitch maximum velocity and acceleration;
- Yaw maximum velocity and acceleration. Certain motion table may only be two axis, Roll and Pitch. In this case the manufacturer shall explain how to simulate the Yaw motion via combined Roll and Pitch motion trajectories;
- Combination of Roll, Pitch and Yaw maximum velocity and acceleration (full dynamics);
- As an option for certain manufacturers, additional test with a combination of Roll, Pitch and Yaw reduced velocity and acceleration (half dynamics);
- All tests above shall be performed twice, one for each polarization. For two port ESV terminals, one carrier per polarization shall be identified and used for acquisition and tracking.

For each test profile the log time should be agreed with the manufacturer who will provide the period of scanning in seconds. The sampling period will be ¼ the scanning period or less and the duration must be set to

$$max\{300\ seconds, 1000\ sampling\ period\} \qquad \text{Equation 14-4}$$

At the start and end of the each log recording, the motion table shall be set to still conditions for duration of approximately 30 seconds.

For asymmetric antenna diagrams (e.g. low profile aperture antennas) where the main lobe has not rotational (circular) characteristics, the pointing error shall be assessed on a pattern skewed by an angle corresponding to the polarization angle of the ESV terminal during the tests. The manufacturer shall indicate any capability of compensating the skew angle.

Except for EUTELSAT KA-SAT 9A terminals, the maximum peak-to-peak received level variation ΔL shall be determined at the receive earth station for each motion profile. The corresponding angular pointing error shall be assessed by estimating the angle corresponding to the ΔL variation on the main lobe of the type approved/characterized Azimuth antenna patterns, chosen at the polarization and closest frequency of the test.

14.12 Polarization tracking error (linear polarization only)

In addition to the assessment of the pointing error, the AES's cross-polarization discrimination shall be determined. The measurement test set-up and motion profiles shall be the same as those used for the co-polar pointing error. In case of tests via satellite, two orthogonal tests slots signal-free at the same frequency shall be used.

The level of the cross-polar component of the AES terminal shall be measured and logged over time by a fixed antenna available at the same location of the AES terminal or alternatively by and in co-ordination with the ERS (Eutelsat Reference Station) in the frame of a specific AESA test via satellite.

In case that the logging of the cross-polar component is performed at the AES terminal set in receive mode, a re-configuration of the OMT connections may be necessary e.g. in order to bypass reject filters.

If simultaneous measurements of the co-polar and cross-polar components are possible, the cross-polar discrimination shall be derived by subtracting the level of the cross-polar component form the level of the co-polar component.

If simultaneous measurements of the co-polar and cross-polar components are not possible, the level of the cross-polar component shall be subtracted from the maximum level of the co-polar component recorded during the co-polar pointing tests.

14.13 Beam squint (circular polarization only)

It is well known that offset antennas with circular polarization are subjected to beam squint. The divergence between the tx beam and rx beam can be already appreciated with the static measurements. Anyway, there are others optics that are not actually impacted (i.e. axial optics or phase array optics) except when shaped radomes are used. In that case the variable radome curvature could introduce beam squint which must be measured in static and should be compensated electronically by the steering mechanism of the antenna.

The manufacturer shall give the details of the compensation, if any.

14.14 Additional verification requirements

14.14.1 Antenna inspections

Prior to the start of the static tests there is a number of inspections which should be carried out on the AES terminal.

First the radome inspection shall be performed to ensure that there are no scratches, slits and that the outer surface is polished and smooth. The same verification shall be performed inside the radome, checking for local non uniformities, e.g. in the joints between segments. Local differences in the thickness of the radome may be cause of reflections which could considerably raise the level of the sidelobes.

To complement the other visual inspection the manufacturer shall provide information on the antenna, as shown in section 13.9.6 for the vessels.

14.14.2 TX mute tests

Tests are to be performed to confirm that the AES carrier is automatically switched off in case of pointing error exceeding values defined by the manufacturer or in case of loss of the satellite signal.

The response time of the AES terminal to mute the carrier, T, shall be communicated by the manufacturer and shall not exceed 5 seconds (ETSI 302 340 paragraph 4.2.6.2 refers). The response time to re-enter the carrier ON state should not exceed 2 x T seconds.

Tx mute tests should take place with the antenna pointed and tracking on the satellite or a transmitter simulating the satellite in case of measurements performed on a test range or in a laboratory.

An oscilloscope should be used to display the time necessary for the mute command to be generated from the ACU and/or received at the BUC output monitoring point, if available.

The following tests should be performed:

a) Remove the antenna radome and physically move it rapidly away from pointing, by e.g. strongly pulling the reflector rim. The de-pointing shall be induced in succession on two orthogonal directions, e.g. to de-point in Azimuth or in Elevation;

b) Move in and out in front of the antenna aperture an absorber panel until the tracking error exceeds the maximum expected pointing error;

c) Switch off the satellite simulator, in case of tests range or laboratory measurements.

Tests a) and b) should confirm that the AES terminal has correctly detected that the induced pointing error has exceeded the pointing error threshold and that the transmission of the carrier is muted in a time not exceeding T seconds.

The time response to re-enter the carrier ON state shall also be measured from the time when the de-pointing conditions cease.

Eutelsat S.A. expects that the transmission be switched off automatically in presence of mute conditions via a mute command sent from the ACU to the BUC, directly or via appropriate switches.

Except for EUTELSAT KA-SAT 9A terminals, a transmission switch off command sent from the ACU to the modem is not recommended, because potential interference risks and the Eutelsat S.A. Type Approval/ Characterization shall not be granted in these cases.

14.14.3 Look-up tables for the Eutelsat polarization skew (linear polarization only)

The linear polarization planes (defined as X and Y and orthogonal to each other) of most of the Eutelsat satellites are not parallel/orthogonal to the equatorial plane. For historical reasons, the polarization planes are inclined by an angle with respect to the equatorial plane. This angle is referenced as the polarization skew.

This skew is of fundamental importance in order to correctly set the polarization of the ESV terminal whenever the polarization alignment is performed in open loop (calculated).

When operators or installers program the transmit parameters of an ESV terminal, a human error in entering the skew of the satellite cannot be excluded, because of lack of correct information, operator mistakes or the widespread presumption that the skew is equal to 0 degrees.

These errors cannot be identified in a straightforward manner and can be potentially a source of interference to services carried in the opposite polarization. This is namely the case of the services carried on the Eutelsat satellites where the skew of most satellites is equal to +3.535° (see point 10.2). In fact if the skew was set to 0° instead of 3.535°, the cross-polar discrimination error because of this would be equal to $20 \times log_{10}[\sin(3.535°)] = 24.2\ dB$.

Consequently, in order to qualify for a type approval/characterization, appropriate look-up tables embedded in the software/firmware of the ESV terminals shall be implemented in order to secure that the correct skew value will be used, independently of any possible human error.

The manufacturer shall demonstrate that the value of the polarization skew of the look-up table shall be maintained, irrespective of the skew data manually entered by the operator/installer.

A non-exhaustive example of the look-up table is as follows. For updated values please contact esapproval@eutelsat.com .

Longitude of the satellite	Polarization skew
-15°	0.0°
-12.5°	3.535°
-8°	3.535°
-7°	3.535°
-5°	0.0°
+3°	3.535°
+4°	3.535°
+7°	3.535°
+9°	3.535°
+10°	3.535°
+13°	3.535°
+16°	3.535°
+21.5°	3.535°
+25.5°	3.535°
+28.5°	3.535°
+33°	3.535°
+36°	3.535°
+48°	3.535°

+53°	0.0°
+70°	3.535°
+70.5°	3.535°
+172°	0.0°

Table 14-5: satellite skew table

14.14.4 Spectrum re-growth tests

The manufacturer shall provide measurements of the spectrum re-growth of the HPA(s) used in conjunction with the AES terminal. The measurements shall be performed either in laboratory or via satellite. For additional information on the Eutelsat S.A. requirements, see ESOG Vol. II module 210 (Annex E) and 220 (Annex C).

14.14.5 Factory tour

In case of a type approval program, the Eutelsat S.A. representative shall conduct a factory tour at the manufacturer's factory.

During the tour the following topics shall be addressed, as a minimum:

- Inspect machinery, tooling and jigs,
- Review procedures for reception, inspection and validation of performance and characteristics of parts and/or sub-systems,
- Inspect the terminal integration pads and review integration procedures,
- Review QA/QC procedures,
- Review final acceptance tests and validation procedures for finished systems (both 100% and sample testing),
- Review storage of parts, sub-systems and finished AES terminal, packaging and shipment methods.

15 Eutelsat certification and labels

The labels which can identify an equipment which is Eutelsat approved are the ones below, depending on the procedures and the results of tests which are described in the ESOG 120 book and which are applicable to this equipment.

15.1 Trademarks and condition of use

15.1.1 Contents

1. Introduction
2. Terms and Conditions of Use
3. “type approved” label
4. “characterized” label
5. Labels for Eutelsat Broadband Services
6. Labels for Eutelsat Interactive Services
7. Reproduction Colors and Formats
8. Contact Details

15.2 Introduction

This Chapter describes the conditions whereby Eutelsat authorizes the Manufacturer to use the “EUTELSAT” trademarks including the “eutelsat type approved” labels and the “eutelsat characterized” labels, in view to general services, for Eutelsat broadband services specifically or for Interactive satellite terminals.

Use of these trademarks **implies** full acceptance by the Manufacturer of the conditions set forth below.

Depending on the relevant agreement, any deviation from the specifications contained in these labels and in this Annex would result in the immediate cancellation of this authorization.

The “Eutelsat Type Approval”(*) specifications are detailed in the following link:

http://www.eutelsat.com/files/contributed/satellites/pdf/typeapproval.pdf

The “Eutelsat Characterization”(**) specifications are detailed in the following links:

http://www.eutelsat.com/files/contributed/support/pdf/RF_Characterization.pdf (static performance)
http://www.eutelsat.com/files/contributed/satellites/pdf/Autopointing_Antennas.pdf (auto-pointing performance)

(*): A Eutelsat Type Approval concerns the static antenna RF performance only. It is not applicable to the auto-pointing performance of the antenna system.

Unless the Manufacturer has obtained a Type Approval for the static antenna performance and a Characterization of the associated auto-pointing system, he is not authorized to use the “Eutelsat Trademark” and “Eutelsat Label” to designate both options and must ensure that Eutelsat trademarks (including the “eutelsat type approved” label) are not applied on the auto-pointing product or on any of its components.

(**): Characterization may be conducted both for a classical configuration and for a system including auto-pointing functions.

Should Characterization be conducted for the classical configuration only, the Manufacturer must ensure that Eutelsat trademarks (including the "eutelsat characterized" label) are not applied on the auto-pointing product or on any of its components.

For specific Eutelsat Services such as Broadband Services and IST Services, Type Approvals and Characterizations are delivered separately.

- The "Eutelsat Broadband Services" specifications are detailed in the following link:

http://www.eutelsat.com/files/contributed/support/pdf/Eutelsat_Broadband_Services.pdf

- The "Eutelsat IST Services" specifications are detailed in the following link:

http://www.eutelsat.com/files/contributed/support/pdf/Eutelsat_IST_Services.pdf

15.3 Terms and conditions of use

- Eutelsat grants to the Manufacturer (hereinafter referred to as the "Licensee") a non-exclusive and non-transferable right, on a worldwide and royalty-free basis, to use the "EUTELSAT" trademarks including the labels which are described in this Chapter on all Equipment-related applications defined hereafter:
  - ⇨ Front panels (antenna reflector)
  - ⇨ Labels
  - ⇨ Packaging
  - ⇨ Printed material (brochures, data sheets etc.)
  - ⇨ Advertising (both printed and video)
- The trademarks shall be used only in the form and manner specified in this document. The Licensee is strictly prohibited from using the trademarks in any other form.
- The Licensee agrees that all of its products using the trademarks shall conform to the specifications set forth in this document.
- The Licensee agrees that it will not sell, market, promote nor distribute any piece of Equipment bearing the trademarks that has not obtained the relevant type Approval or Characterization by Eutelsat.
- The right to use the trademarks is only valid for a specific antenna/VSAT/IST system as a complete unit. Any mechanical and/or electrical modifications to the antenna/VSAT/IST system will require an independent new approval process namely:
  a. for using a conventional antenna/VSAT/IST for a fly away or auto deploy system AND
  b. for using the trademarks only in close conjunction with the specific system and not as a general statement.

- Eutelsat has the right at any time and without any prior notice to test a specific piece of Equipment. In the event that the tested unit does not comply with the Eutelsat specifications, Eutelsat shall immediately inform the Licensee. Within two weeks of the date of information, the Licensee is required to prove that the terminals in production comply with the Eutelsat specifications at the Licensee's expense. If not, the Licensee shall immediately cease the use of the trademarks and shall withdraw the trademarks from the non-compliant products.
- The Licensee shall inform Eutelsat without delay of any known use of the trademarks as well as any act attempting to Eutelsat rights in respect of trademarks. Eutelsat shall have the option, as it considers appropriate, to initiate legal action against the infringing party, with technical assistance from the Licensee. The Licensee shall abstain from any action in that whole process, except with the prior approval and coordination of Eutelsat.
- The Licensee shall be solely responsible for Equipment manufacture and distribution. The Licensee shall indemnify and hold harmless Eutelsat from any loss, damage and expenses suffered by Eutelsat as a result of claims, actions, allegations or proceedings brought by any third party in respect of Equipment manufacture and/or distribution.

a) This Agreement shall be governed by the laws of France. All disputes between the parties hereto arising out or in connection with Eutelsat Characterization proceedings shall be finally settled by the courts of Paris (France).

15.4 "Type Approved" label

15.4.1 Documentation

The specifications of the antenna/VSAT approved under the Eutelsat Type Approval are detailed in the "Type Approval book", available on the following link:

http://www.eutelsat.com/files/contributed/satellites/pdf/typeapproval.pdf

The antenna/VSAT Type Approval is based on the following procedures and criteria:

i. ESOG 120 (http://www.eutelsat.com/files/contributed/satellites/pdf/esog120.pdf)

ii. EESS 502 (on demand)

15.4.2 Description of label

The Manufacturer must use the label which is displayed below.

It is not allowed to change the label in any way; this includes the colors and the aspect ratio of the label, adding any text or graphics or taking away any text or graphics.

15.5 “Characterized” label

15.5.1 Documentation

The specifications of the antenna/VSAT approved under the Eutelsat Characterization are detailed in the “Characterization book”, available on the following link:

http://www.eutelsat.com/files/contributed/support/pdf/RF_Characterization.pdf

The antenna/VSAT characterization is based on the following procedures and criteria:

- ESOG 120 (http://www.eutelsat.com/files/contributed/satellites/pdf/esog120.pdf)
- ESOG 260 (http://www.eutelsat.com/files/contributed/satellites/pdf/esog260.pdf), depending on whether or not an auto-pointing option is agreed
- EESS 502 (on demand)

15.5.2 Description of label

The Manufacturer must use the label which is displayed below.

It is not allowed to change the label in any way; this includes the colors and the aspect ratio of the labels, adding any text or graphics or taking away any text or graphics.

15.6 Labels for broadband services

15.6.1 Documentation

The Manufacturer has completed with the Eutelsat Type Approval or Characterization for a specific model of terminal as detailed in the "Eutelsat IST Services book" that is available on the following link:

http://www.eutelsat.com/files/contributed/support/pdf/Eutelsat_Broadband_Services.pdf

The specific terminal must have passed the full Type Approval or Characterization process according the Certification of Conformity Specifications and Process set out in Chapter 3:

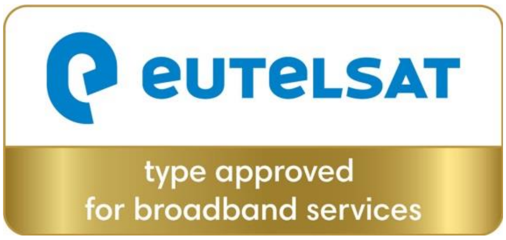
i. Three antenna production samples on range test for Type Approval or one antenna production sample on range test for Characterization.

ii. Antenna pointing accuracy test

iii. Wind stability test

15.6.2 Description of Labels

The Manufacturer must use the labels which are displayed below, for the Type Approval or the
Characterization respectively.



It is not allowed to change or modify in any way the labels, this includes the colors and the aspect ratio of the labels, adding any text or graphics or taking away any text or graphics.

15.7 Labels for IST services

15.7.1 Documentation

The Manufacturer has completed with the Eutelsat Type Approval or Characterization for a specific model of terminal for Interactive Satellite Terminals, as detailed in the "Eutelsat IST Services book" that is available on the following link:

http://www.eutelsat.com/files/contributed/support/pdf/Eutelsat_IST_Services.pdf

The specific terminal must have passed the full Type Approval or Characterization process according the Certification of Conformity Specifications and Process set out in Chapter 3:

i. Three antenna production samples on range test for Type Approval or one antenna production sample on range test for Characterization.
ii. Antenna pointing accuracy test
iii. Wind stability test

15.7.2 Description of Label

The Manufacturer must use the labels which are displayed below, for the Type Approval or the Characterization respectively.

It is not allowed to change or modify in any way the label, this includes the colors and the aspect ratio of the labels, adding any text or graphics or taking away any text or graphics.

15.8 Reproduction colors and formats

The label types, as detailed previously, are the only ones to be used. The use of a label type implies compliance by your communications service, service providers (communication agency, printers, etc.) with its form and colors. No changes may be made to the items comprising the label type (Eutelsat logo, typography…).

The proper label type is provided by The Earth Station Approval Office (esapproval@eutelsat.com, or typeapproval@eutelsat.com) when the agreement is granted.

15.8.1 Color references

a) Eutelsat logo

PSC 3005C

Pantone, for work that will be printed in offset

CYAN	100
MAGENTA	30
YELLOW	00
BLACK	00

CMYK, for work that will be printed digitally

HTML# 007DBA

RED	00
GREEN	125
BLUE	186

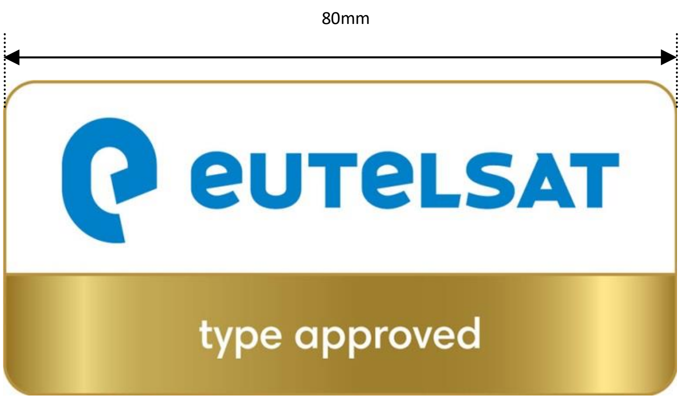
RGB, for work that will be displayed on screen

b) Gold ribbon

c) Silver ribbon

15.8.2 Format reference, for all labels

Label types must as a priority be used with the width of 80mm, or in a larger size (example below)



If the label type were to be used in a smaller size, it should not be smaller than 40mm (example below).

In order to ensure its visibility of the label, it has to be surrounded with sufficient clear space. Free of type, graphics, and other elements that might cause visual clutter.

15.9 Contact details

For any questions or suggestions, please contact the Eutelsat Earth Station Approval Team. mail: typeapproval@eutelsat.com

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Resource Engineering Group e-mails : dsvplan@eutelsat.com ltplan@eutelsat.com	Voice: +33-1-53.98.42.50 Fax: +33-1-53.98.30.00
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Eutelsat S.A. Corporate Web	http://www.eutelsat.com
Eutelsat Extranet **(password protected)**	https://services.eutelsat.fr

EUTELSAT S.A. TYPE APPROVAL/CHARACTERIZATION CONTACT POINTS

e-mail: typeapproval@eutelsat.com	Voice: +33-1-53.98.39.45 +33-1-53.98.49.97 +33-1-53.98.39.25 +33-1-53.98.46.13

EUTELSAT S.A. INTERACTIVE SATELLITE TERMINALS CONTACT POINTS

Terminal Approval e-mail: efeltrin@eutelsat.com	Voice: +33-1-53.98.39.45
Terminal Approval (backup) e-mail: opulvirenti@eutelsat.com	Voice: +33-1-53.98.46.80

Eutelsat is one of the world's leading and most experienced operators of communications satellites.

Our extensive network of high-performance satellites, located between 133° West and 174° East, provides capacity to clients that include broadcasters and broadcasting associations, pay-TV operators, video, data and Internet service providers, enterprises and government agencies.

Eutelsat's satellites provide ubiquitous coverage of Europe, the Middle East, Africa, Asia-Pacific and the Americas, enabling video, data, broadband and government communications to be established irrespective of a user's location.

Headquartered in Paris, with offices and teleports around the globe, Eutelsat represents a workforce of 1,200 men and women from 46 countries who are experts in their fields and work with clients to deliver the highest quality of service.
fields and work with clients to deliver the highest quality of service.