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MANUAL AND AUTO-DEPLOY TERMINALS HANDBOOK

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EUTELSAT S.A.

SYSTEMS OPERATIONS GUIDE

ESOG	Module 260
MANUAL AND AUTO-DEPLOY TERMINALS HANDBOOK	
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Volume II

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FOREWORD

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

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

Volume I concentrates 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 which are 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 to Eutelsat S.A. **or** in Acrobat format from the Eutelsat S.A. Web:

http://www.eutelsat.com

Paris, 25-07-2011

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Earth Station Standards.......Module 100
Earth Station Access and Approval Procedures.......Module 110
Earth Station Type Approval.......Module 120
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VOLUME II

EUTELSAT S.A. SYSTEMS OPERATIONS AND PROCEDURES

Digital Services Handbook.......Module 210
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Manual and Auto-Deploy Terminals Handbook.......Module 260

1. INTRODUCTION

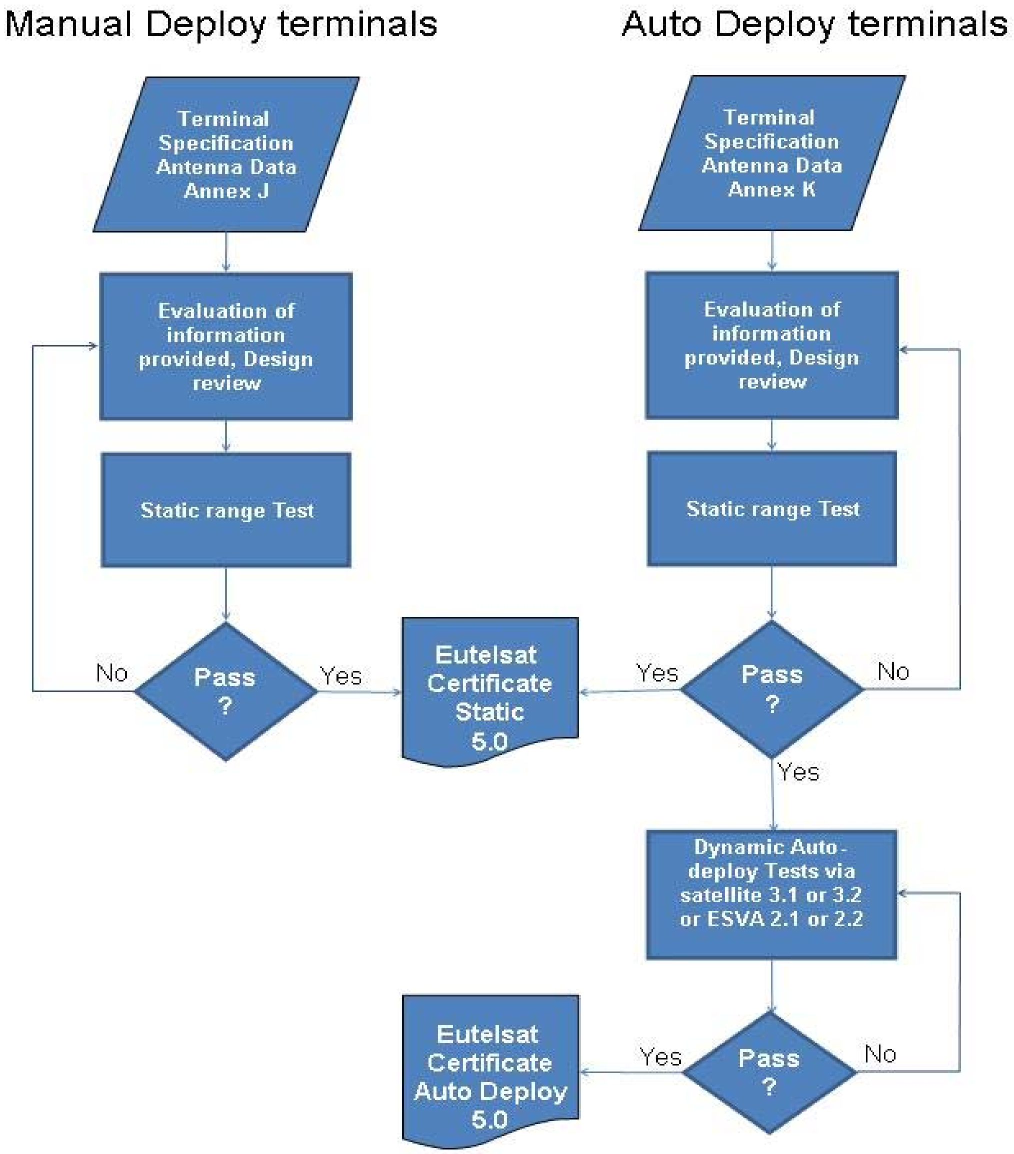
This handbook describes the Eutelsat S.A. characterization and approval conditions and relevant test requirements to verify radio electric and, if applicable, auto-pointing performance for manual and auto-deploy terminals for contribution services.

We understand by “auto-pointing” or “auto-deploy” terminal, a system which automatically deploys, and accurately points, its antenna towards a designated target satellite in Azimuth, Elevation and Polarization.

Apart of the initial satellite selection, the auto-pointing process shall not require any intervention of an operator at any time.

Pointing shall be such that beam pointing accuracy and cross-polarization isolation are within the specified values (EESS 502 refers). However automatic pointing shall not exempt the antenna’s operator to contact the Eutelsat Control Centre prior to any transmission, as per the ESOG Vol.1 Module 140.

1.1. Flow Chart Antenna Approval Process



1.2. Manual Deploy Terminal Information

In order to obtain the Eutelsat S.A. “characterization” of the manual-deploy terminals, and prior to the performance of the tests outlined in the following chapters, it is necessary to provide Eutelsat S.A. with precise information on the characteristics of the terminal.

This data is essential to start the project. Eutelsat S.A. will inform the manufacturer in due course if the data are compliant with the requirements.

The production processes of reflector, sub reflector (if applicable), feed subsystem and other antenna parts must ensure the continuous repeatability of the RF performance of the antenna. Re-use of antennas originally conceived for VSAT systems is not recommended, as the low cost associated production processes cannot guarantee constant RF performance. Moreover VSAT antennas are originally conceived for fixed application and not for mobile and frequent deploy processes.

The characterization tests for manual-deploy terminals consist in assessing the antenna radiation patterns and transmit and receive gains (see Annex A).

These “static” tests can be performed either via satellite or on a test range (recommended) which characteristics should be in line with the list of Annex M.

1.3. Auto-Deploy Terminal Information

In order to obtain the Eutelsat S.A. “characterization” of the auto-deploy terminals and prior to the performance of the tests outlined in the following chapters, it is necessary to provide Eutelsat S.A. with precise information on the characteristics of the terminal.

This data is essential to start the project. Eutelsat S.A. will inform the manufacturer in due course if the data are compliant with the requirements.

The production processes of reflector, sub reflector (if applicable), feed subsystem and other antenna parts must ensure the continuous repeatability of the RF performance of the antenna. Re-use of antennas originally conceived for VSAT systems is not recommended, as the low cost associated production processes cannot guarantee constant RF performance. Moreover VSAT antennas are originally conceived for fixed application and not for mobile and frequent deploy processes.

The characterization tests for auto-deploy terminals consist in assessing the antenna radiation patterns, transmit and receive gains (see Annex A) and the auto-deploy performance (see Annex B).

The antenna radiation patterns and gains tests (”static” tests) can be performed either via satellite or on a test range (recommended).

The “auto-deploy” performance tests have to be performed via satellite. In case of an auto-deploy terminal located in a test range site, it is recommended to perform some of the auto-deploy tests on the test range, for a higher precision of results.

2. STATIC TESTS

The list of the “static” tests to be performed is described in Annex A.
In order to qualify for the Eutelsat S.A. characterization, tests have to be successfully performed on a test range, see Annex M. Should a test range not be available, tests could be performed via satellite, but uniquely for a preliminary assessment of the RF performance of the terminal (para 2.2) The outcome of these tests will not lead to a Eutelsat S.A. characterization, for which tests results from a test range are required.

The performance of static tests on a test range presents a number of advantages with respect to the satellite tests:

- Accurate measurement of the transmit and receive Gains with the method of the standard gain Horn comparison,
- Possibility to slew the antenna through the positioner of the test range,
- Accurate measurement of the co-polar and cross-polar patterns with a predetermined step size (typically equal or less than 0.1°),
- Possibility to measure co-polar and cross-polar patterns at more than one frequency,
- High purity of the cross-polarization discrimination of the source antenna with consequently more reliable XPD results,
- Possibility to perform 2D contour plots (raster scans) of the co-polar pattern and of the cross-polarization discrimination at the -1 dB or pointing error contours.

2.1. Test Procedures at a Test Range

2.1.1. On Site Design Review and Additional Requirements

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.

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

It is recommended that the test range be equipped with a mechanical workshop, in particular to build the adaptation plate(s) between the bases of the auto-deploy terminal and the positioner of the test range.

To gain time, it is strongly recommended that the manufacturer of the auto-deploy terminal sends in advance of the tests (at least two weeks) to the test range operator a detail of its terminal, including dimensions, weights, electrical interfaces and the mechanical interface at which the terminal will be fixed on the positioner of the test range.

The manufacturer shall ensure, if applicable, that all motors and gears are properly braked, to guarantee stability of the system.

In case it was necessary to move the terminal (e.g.to rotate the polarization), the manufacturer shall provide the terminal controller and associated power supply.

2.1.2. Static Tests

The test range will be inspected and possible sources of reflections identified (trees, cranes, towers, etc for Azimuth plane measurements and ground reflections for Elevation plane measurements).

The way of presenting the test results will be reviewed and the operator of the test range will perform all necessary adaptations to the Eutelsat S.A. requirements.

The list of mandatory tests to be performed, as per Annex A, will be reviewed, their feasibility verified. Any amendments to the test plan shall be decided in agreement between the test range operator, the manufacturer and the Eutelsat S.A. representative(s).

Terminals not orienting along the geostationary orbit arc

For non circular antennas, the higher the ratio of the antenna's dimensions on the two principal planes, the higher the expected impairment of the sidelobes peaks when the terminal is operated at slanted angles with respect to the GSO arc.

To protect adjacent satellites from interference emanating from antennas that do not rotate around their axis to orient themselves along the geostationary orbit arc, it is necessary to perform additional tests with the antenna rotated by angles to be defined (e.g. 30°), to assess the sidelobes patterns in these non principal planes.

In case that the antenna could not be positioned at a slanted angle on the test range, a contour plot (raster scanning) of the co-polar sidelobes patterns within a region to be defined (e.g. + 4°) should be discussed and agreed instead.

2.2. Tests via Satellite

2.2.1. Location of the tests

With the exception of terminals for operations on EUTELSAT KA-SAT 9A, there are no specific recommendations for the location of the terminal other than visibility of the satellite geostationary arc.

In case of operations on EUTELSAT KA-SAT 9A, the location of the tests has to be studied on a case by case, to ensure that the ERS (Eutelsat S.A. Reference Station) will be able to receive the signals transmitted from the SUT.

2.2.2. On Site Design Review

Tests via satellite are reserved uniquely to motorized terminals.
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 tests which will be performed, in line with Annex A.

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 terminal to be tested will be inspected and the operator will explain its main features and functions.

The operator of the 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 beams tools, digital inclinometer, a white board target).

2.2.3. EUTELSAT KA-SAT 9A Auto-deploy terminals

In case of terminals for operations on EUTELSAT KA-SAT 9A, the SUT must transmit from a location within a Spot that is received by the ERS, for verification of the copolar sidelobes patterns and Gain. For the additional verification of the cross-polar sidelobes patterns, a transportable ERS may be needed, and both SUT and ERS should be located in a suitable intersection of Spots LHCP and RHCP using the same frequency band.

As the BUC (TRIA) of the EUTELSAT KA-SAT 9A SUTs may not be enabled for transmission of CW carriers, it is necessary to use a special adapter made by the manufacturer of the TRIA, with access to the OMT ports. This adapter is unique and has to be requested in loan well in advance to Eutelsat S.A., the System Integration Team.

3. 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). The tests on the cross-polarization discrimination at the -1 dB contour of the main beam (or 9-points box) can be performed on a test range and is recommended in order to achieve more accurate results.

3.1. 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.

3.1.1. 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.

3.1.2. 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, see Section 2.1.3, specifically tailored to verify the auto-deploy performance.

3.1.3. 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,
- External positioner encoders (see section 3.2).

If the SUT is mounted on an external positioner of the test range, the Azimuth and Elevation readouts of the test range will be used throughout the tests, if possible. SUT and Eutelsat S.A. representative will discuss which readout should be utilized for the polarization angle.

If the SUT is using its own positioner, the Eutelsat S.A. representative and SUT's operator discuss the resolvers' resolution and decide whether they are sufficient for the scope of the tests. In case they were not, the laser beam method (see Annex E) will be used.

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.

Step 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.

EUTELSAT KA-SAT 9A specific check list

The following additional check list is specific to auto-deploy terminals for operations on EUTELSAT KA-SAT 9A:

- ☐ The SUT must transmit from a location receivable by the ERS, with the same polarization, for verification of the Azimuth and Elevation pointing errors,
- ☐ Availability of the special adapter to make possible the transmission of CW carrier,
- ☐ Availability of a carrier (Gateway carrier, DVB from a Hub, SCPC) which the terminal will use in order to achieve the auto-pointing process.

Step 2 For reflectors with petals, assemble the reflector under control of the Eutelsat S.A. representative.

Step 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.

Step 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 C1 of Annex C and in table D2 of Annex D the relevant test parameters and SUT configuration.

Step 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.

Step 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.

Step 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 D1 of Annex D the value of MAZ and MEIRP.

Step 8 Cease transmission and stow the antenna.

Step 9 Repeat Steps 3 and 4.

Step 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 D2 of Annex D 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 D1 of Annex D the value of MPOL and MXPD.

Step 11 MEASUREMENT OF THE 9 POINTS XPD BOX AFTER AUTOMATIC POINTING

This step needs to be performed for auto-deploy terminals operating with either linear or circular polarized signals. Not necessary if cross-polarization measurements are performed on a test range, cfr. Para. 3.2.

The XPD is evaluated within a cone centred 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.

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 D3.1 and D3.2 of Annex D the corresponding measured XPD values.

Step 12 Cease transmission and stow the auto-deploy terminal.

For antennas with petals, disassemble the antenna.

Step 13 Repeat tests 2 to 11 for the other polarization.

Step 14 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.

Step 15 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.

Step 16 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 Annex D.

3.1.4. Ancillary Tests and Verifications

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

3.1.4.1 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 D4 of Annex D the values of AAZ, AEL and APOL. Calculate the arithmetic average and the standard deviation.

3.1.4.2 Wind deflection

The wind deflection will be primarily assessed by reviewing the data provided by the manufacturer of the auto-deploy terminal, based on either wind tunnel tests, application of direct loads to the reflector and feedboom to simulate axial load, yaw and pitch or finite elements analysis.

A possible on site test to prove the deflection of the beam because of wind is to operate a helix plane engine at different positions and rotational speeds to simulate the wind effect and measure the corresponding deflection in conjunction with the ERS.

3.1.4.3 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 E), 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.

3.1.4.4 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 2.4 and by iterations determine at which Eb/No the auto-deploy terminal is still capable of performing the auto- deploy function correctly.

3.1.4.5 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.

3.2. Auto-Deploy Tests at the Test Range

Tests shall be limited normally to the cross-polar discrimination of the auto-deploy terminal.

Tests whereby the source antenna is used to simulate a satellite signal are not recommended because auto-deploy terminals are normally designed for pointing to the geostationary orbit only and even if the parameters of the auto-deploy software may be modified to allow pointing anywhere, the obtained results may not be representative of a real case.

Tests whereby the optimization of the pointing of the auto-deploy terminal is performed (once the terminal has pointed to the satellite), by using the positioner of the test range and its encoders readouts would be feasible uniquely in the case that it would be possible to make the test range's and the SUT's elevation planes perfectly coincident. This is the case of Azimuth over Elevation over Azimuth positioners.

In this case, tests of section 3.1.3 shall be repeated by using the encoders of the test range rather than the encoders of the SUT.

Due to the physical limitations which are normally encountered in a test range, tests should take place primarily on fly away auto-deploy terminals; testing of vehicle mounted auto-deploy terminals will need a preliminary feasibility study, in particular to account for the possibility to disassembling the auto-deploy terminal from the vehicle without altering its physical and electrical characteristics.

While the SUT is installed on the positioner of the test range, the auto-deploy functions of the terminal must be fully operational, i.e. there must be a means of maintaining the connection between the ACU, the terminal controller and the antenna.

Tests of the cross polarization discrimination over the satellite may be subject to an uncertainty due to the way the polarization of the satellite combines with the polarization of the antenna.

In the following a possible approach to measure the cross polarization discrimination by using the source antenna of the test range is described.

The scope of the test is to measure the cross polarization discrimination within the contour of the main beam, by measuring either contour plots (raster scanning) or the 9 points cross-polarization box.

3.2.1. Cross-polarization measurements: Linear Polarization

Step 1 SUT enables the auto-deploy function over the targeted satellite.

On successful completion of the auto-deploy process, confirm that the SUT is correctly pointed on the satellite and with the correct polarization, by verifying reception of the test carrier from ERS.

Record the SUT's AAZ, AEL, APOL.

Step 2 SUT transmits a carrier at a pre-determined frequency and in co-operation with the ERS optimizes AZ, EL and POL and determine MAZ, MEL and MPOL as described in section 3.1.3, by using either the SUT's encoders or the laser beam method.

Determine the ∆AZ, ∆EL, ∆POL by calculating the differences between the auto and the manual (optimized by the ERS) pointing.

Step 3 Move the auto-deploy terminal on the positioner of the test range, auto-deploy the terminal, ensure that all antenna tracking functions are disabled and peak it (including the polarization) manually to the source of the test range.

Step 4 Move the polarizer of the SUT by ∆POL or move the polarizer of the source antenna by - ∆POL, whichever is the most accurate.

Step 5 Perform a contour plot (raster scanning) of the co-polar and cross-polar radiation pattern of the SUT at the same pre-determined frequency of Step 2. If it is not possible to perform a contour plot, measure the 9 points cross polarization discrimination as described in section 3.1.3 and note the angular values for each of the points.

Step 6 By superposing co-polar and cross-polar contour plots, evaluate the SUT's cross-polarization discrimination, with reference to the -1 dB contour of the main lobe.

Step 7 Repeat steps 1 to 6 for the other polarization.

NOTE: In case that the ∆AZ= AAZ-MAZ and/or ∆EL=AEL-MEL were greater than the angles corresponding to the -1 dB contour of the main lobe, the cross-polar discrimination shall be evaluated taking into account the overall de-pointing angle rather than the angles corresponding to the -1 dB contour.

3.2.2. Cross-polarization measurements: Circular Polarization

Step 1 SUT enables the auto-deploy function over the targeted satellite.
On successful completion of the auto-deploy process, confirm that the SUT is correctly pointed on the satellite and with the correct polarization, by verifying reception of the test carrier from ERS.
Record the SUT's AAZ, AEL.

Step 2 SUT transmits a carrier at a pre-determined frequency and in co-operation with the ERS optimizes AZ and EL and determine MAZ, MEL as described in section 3.1.3, by using either the SUT's encoders or the laser beam method).
Determine the ∆AZ, ∆EL by calculating the differences between the auto and the manual (optimized by the ERS) pointing.

Step 3 Move the auto-deploy terminal on the positioner of the test range, auto-deploy the terminal, ensure that all antenna tracking functions are disabled and peak it manually to the source of the test range.

Step 4 Perform a contour plot (raster scanning) of the co-polar and cross-polar radiation pattern of the SUT at the same pre-determined frequency of Step 2. If it is not possible to perform a contour plot, measure the 9 points cross polarization discrimination as described in section 3.1.3 and note the angular values for each of the points.

Step 5 If it possible to perform a contour plot, by superposing co-polar and cross-polar contour plots, evaluate the SUT's cross-polarization discrimination, with reference to the -1 dB contour of the main lobe.

Step 6 Repeat steps 1 to 5 for the other polarization.

NOTE: In case that the ∆AZ= AAZ-MAZ and/or ∆EL=AEL-MEL were greater than the angles corresponding to the -1 dB contour of the main lobe, the cross-polar discrimination shall be evaluated taking into account the overall de-pointing angle rather than the angles corresponding to the -1 dB contour.

4. MANUAL AND AUTO-DEPLOY TERMINALS OPERATIONS

4.1. Eutelsat S.A. System Discipline

a) All Manual and Auto-deploy terminal Earth Station operators should be able to communicate and follow instructions given to them by the Eutelsat S.A. CSC (Communications Control Centre).

b) Each RF Carrier Activation and De-Activation must only be done under the CSC control.

c) Pre-Transmission Line-up (PTLU) is mandatory for stations accessing the satellite for the first time or making any change to transmission parameters or equipment settings.

d) In case of deviations from Nominal Operational Status any instruction given by the CSC (e.g. to increase/reduce EIRP or eliminate cross-polar interference) to restore parameters to nominal must be implemented immediately. Any formal requests (e.g. SOPN – System Operating Notice) must be given appropriate attention.

e) For in station maintenance or tests, antenna should be depointed from the satellite (if possible) and HPA output or antenna feed input should be monitored to ensure no spurious transmissions occurs.

4.2. Eutelsat S.A. Interference Management

a) All uplink Earth Station operators should be able to communicate and follow instructions given to them by Eutelsat S.A. CSC.

b) If interference is detected, the Eutelsat S.A. CSC will immediately take steps to eliminate it by its localisation and request for ceasing the transmission from the station creating interference.

c) For the station creating interference problems a support in the identification of the source of the problem by Eutelsat S.A. CSC and other Eutelsat S.A. Auto-deploy terminal staff to the operator could be provided.

5. EUTELSAT S.A. CERTIFICATES

Upon completion of the tests and verifications described in the above section, Eutelsat S.A. will study the available data and results.

If all are in compliance with the required performance and operational objectives, Eutelsat S.A. will determine the transmit maximum authorized eirp density of the manual or auto-deploy terminal and the associated operational limitations, if any.

The summary sheet of the static and auto-deploy performance characteristics will be published on the Eutelsat S.A. Corporate Web, under the following links:

http://www.eutelsat.com/satellites/pdf/RF_Characterisation.pdf

http://www.eutelsat.com/satellites/pdf/RF_Characterisation_Tooway.pdf

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

The certificate will uniquely refer to terminals of the model stated in the summary sheet and using the equipment and software configuration which was tested and certified.

Any change in the equipment or software will require a new process of certification.

In order to ensure that the certified performance will not be subject to changes, Eutelsat S.A. will reserve the right to re-test the manual or auto-deploy terminal at a date which will be jointly agreed with the manufacturer of the terminal.

Annex A Manual and Auto-deploy terminal "Static" tests performance summary

The following list outlines the recommended tests to be performed for manual and auto-deploy terminal, for each frequency band, at a test range.

In case of non availability of a test range, tests via satellite can be exceptionally performed instead. The tests to be performed in this case will be a subset of the tests below, to be agreed on a case-by case basis with the Eutelsat S.A. earth station approval office.

For terminals not orienting along the geostationary orbit arc, additional tests are recommended, see 2.1.

C-Band

- Swept frequency measurement of the Tx and Rx Gains (or selected frequencies values if this function is not available at the test range),
- Swept frequency measurement of the Tx cross polarization @ boresight,
- Measurement of the Azimuth and Elevation radiation patterns for both polarizations (LHCP and RHCP), at three transmit frequencies (5.85, 6.135, 6.425 GHz) for the direct polarization and corresponding cross polarization; all radiation pattern measurements shall cover at least an angle of ±30° (Azimuth) and ±6° (Elevation),
- Measurement of the Azimuth and Elevation radiation patterns for both polarizations (LHCP and RHCP), at three receive frequencies (3.60, 3.90, 4.20 GHz), for the direct and corresponding cross polarization; all radiation pattern measurements shall cover at least an angle of ±30° (Azimuth) and ±6° (Elevation),
- For the Transmit mid-band frequency 6.135 GHz), a complete radiation pattern will be measured (co- and cross-polarization) in the whole Azimuth angle (±180°) as well as a contour plots (raster scanning) of the cross-polar radiation pattern (or 9 points XPD box if the raster function is not available),
- Swept frequency measurement of the on-axis cross polarization discrimination.

KU-Band and Ka-Band Linear Polarization

- Swept frequency measurement of the Tx and Rx Gains (or selected frequencies values if this function is not available at the test range),
- Swept frequency measurement of the Tx cross polarization @ boresight,
- Measurement of the Azimuth and Elevation radiation patterns for both polarizations (H and V), at four transmit frequencies (13.75, 14.00, 14.25, 14.50 GHz) for the direct polarization and corresponding cross polarization; all radiation pattern measurements shall cover at least an angle of ±30° (Azimuth) and ±6° (Elevation),
- Measurement of the Azimuth radiation patterns with the polarization rotated by +/- 20° for both polarizations (H and V), at four transmit frequencies (13.75, 14.00, 14.25, 14.50 GHz) for the direct polarization and corresponding cross polarization; all radiation pattern measurements shall cover at least an angle of ±9°,

- Measurement of the Azimuth and Elevation radiation patterns for both polarizations (H and V), at three receive frequencies (10.70 or 10.95, 11.70, 12.75 GHz), for the direct and corresponding cross polarization; all radiation pattern measurements shall cover at least an angle of ±30° (Azimuth) and ±6° (Elevation),
- For the Transmit mid-band frequency 14.25 GHz), a complete radiation pattern will be measured (co- and cross-polarization) in the whole Azimuth angle (±180°) as well as a contour plots (raster scanning)of the cross-polar radiation pattern (or 9+4 points if the raster function is not available),
- Frequency swept of the on-axis cross polarization discrimination.

Ka-Band Circular Polarization

- Swept frequency measurement of the Tx and Rx Gains (or selected frequencies values if this function is not available at the test range),
- Swept frequency measurement of the Tx cross polarization @ boresight,
- Measurement of the Azimuth and Elevation radiation patterns for both polarizations (LHCP and RHCP), at three transmit frequencies (29.50, 29.75, 30.00 GHz) for the direct polarization and corresponding cross polarization; all radiation pattern measurements shall cover at least an angle of ±30° (Azimuth) and ±6° (Elevation),
- Measurement of the Azimuth and Elevation radiation patterns for both polarizations (LHCP and RHCP), at three receive frequencies (19.70, 19.95, 20.20 GHz), for the direct and corresponding cross polarization; all radiation pattern measurements shall cover at least an angle of ±30° (Azimuth) and ±6° (Elevation),
- For the Transmit mid-band frequency 29.75 GHz), a complete radiation pattern will be measured (co- and cross-polarization) in the whole Azimuth angle (±180°) as well as a contour plots (raster scanning)of the cross-polar radiation pattern (or 9+4 points if the raster function is not available),
- Frequency swept of the on-axis cross polarization discrimination.

Annex B Auto-deploy terminal "Auto-Deploy" tests performance summary

The following list outlines the recommended tests to be performed for auto-deploy terminals, for each frequency band:

C-Band and Ka-Band Circular Polarization

- Measurement of the Tx Gain (in auto-deploy mode and after manual optimization of Azimuth and Elevation) for both LHCP and RHCP,
- Measurement of the cross-polarization discrimination (9 points XPD box), in auto-deploy mode and after manual optimization of Azimuth and Elevation,
- Measurement of the pointing error (Azimuth, Elevation) for both LHCP and RHCP and for different positions of the auto-deploy terminal with respect to the satellite,
- Assessment of the repeatability of the pointing process,
- Assessment of the pointing error with tilt conditions with respect to the ground of the auto-deploy terminal,
- Ancillary tests (Wind deflection, backlash, rain fade).

Ku-Band and Ka-Band Linear Polarization

- Measurement of the Tx Gain (in auto-deploy mode and after manual optimization of Azimuth and Elevation) for both Horizontal and Vertical Polarizations,
- Measurement of the cross-polarization discrimination (9 points XPD box), in auto-deploy mode and after manual optimization of Azimuth, Elevation and Polarization,
- Measurement of the pointing error (Azimuth, Elevation, Polarization) for both Horizontal and Vertical Polarizations and for different positions of the auto-deploy terminal with respect to the satellite,
- Assessment of the repeatability of the pointing process,
- Assessment of the pointing error with tilt conditions with respect to the ground of the auto-deploy terminal,
- Ancillary tests (Wind deflection, backlash, rain fade).

Annex C Test Record for Auto-Deploy Terminals

Table C1

Earth Station Name/Code		
Antenna	Manufacturer	
	Designation/Type	
	Diameter	
	Tx Gain as per Manufacturer [dBi] @ frequency	
	Rx Gain as per Manufacturer [dBi] @ frequency	
Terminal	Integrator	
	Designation/Type	
Feed	Designation/Type	
	2-port/4-port	
Positioner	Manufacturer	
	Designation/Type	
ACU	Manufacturer	
	Designation/Type	
Auto-pointing Routine	Manufacturer	
	Designation/Type/Software version	
Location of Auto-pointing routine	ACU/Station Controller	
Modem	Manufacturer	
	Designation/Type	
BUC	Manufacturer	
	Designation/Type/Rating	
LNB	Manufacturer	
	Designation/Type	
Acquisition Method		
Photos (compulsory)		
Notes		
Date/Record compiled by		

Annex D Auto-Deploy Results Summary Sheets

Table D1 – Summary of Auto-Deploy Tests Results Steps 1-10

Satellite Identification Orbital Location	**Frequency Up/Down [GHz]**	**Date/Place:**	**Weather SUT/ERS**

Test Conf N°/ Pol **(***)**	AAZ [Deg]	AEL [Deg]	APOL [Deg]	AEIRP [dBW]	AXPD [dB]	MAZ [Deg]	MEL [Deg]	MPOL (*) [Deg]	MEIRP [dBW]	MXPD [dB]	∆AZ,∆EL, ∆POL (**) [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 D2 – Notes on the Test Configurations of Table D1

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 D3. – 1 - 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 D3.2 - Additional 4 Points-box AXPD (auto-deploy XPD) results for Terminal

Test N°	Polarization (***)	1 (AZ+)	2 (AZ-)	3 (EL+)	4 (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

TABLE D4 Auto-Deploy Pointing Repeatability for Terminal

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

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

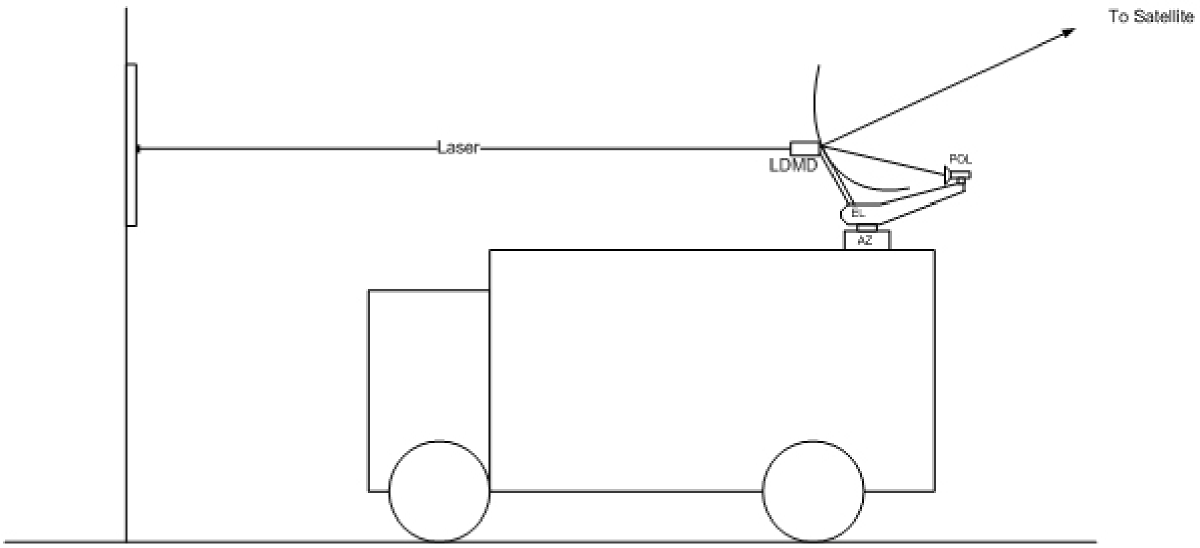
(***) Specify if X/Y or Y/X for linear polarization; LHCP/RHCP or RHCP/LHCP for circular polarization

Troubleshooting Check List

- ☐ The signal where the terminal shall lock is visible on the monitoring equipment (e.g. spectrum analyser),
- ☐ 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.

Annex E Laser beam method procedure

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



Example of an installation of a laser pointer on the back frame of a auto-deploy terminal

The laser beam tool used should be fixed to the back frame of the antenna in such a way to have it in the center. The target (e.g. a white board) should be aligned as parallel as possible to the antenna back frame, when the antenna is peaked to the satellite, i.e. its center, left and right borders should be at the same distance with respect to a horizontal line parallel to the target and passing through the center of the antenna back structure.

For the alignment of the target it is recommended to use an auxiliary laser tool with capabilities of measuring distances, while the main one remains fixed on the auto-deploy terminal.

If δ is the angular error, Δ is the corresponding error distance measured on the target, d is the distance between the rotation axis of the antenna and the target, the following relationships applies:

$\delta = \arcsin(\Delta/d)$

$\Delta = d * \sin\delta$

As an example, if the distance to the target be 6 meters this would result in a step size of approx 1 cm for 0.1° of antenna movement.

It is recommended to fix on the white board a plasticized sheet of paper with a grid of 3 mm squares, three squares would represent a 0.1° error in the suggested above set up.

Static tests

Step 1 Auto-deploy the terminal and optimize its peaking in co-operation with the ERS.

Step 2 Adjust with an auxiliary laser beam and an inclinometer, the position of the target wrt to the auto-deploy terminal, to ensure that its center is aligned with the main laser beam and that the target is parallel to a plane passing through the back frame of the antenna.

Mark on the target the position of the laser beam.

Disable all satellite tracking functions and under co-ordination of the ERS and the Eutelsat S.A. representative, drive the antenna Azimuth Right in steps of 2.5° away from the peak, up to ~20°. Mark each position of the laser beam on the whiteboard.

Drive back the antenna Azimuth left until the beam is in the peak position.

Drive the antenna Azimuth left in steps of 2.5° away from the peak, up to ~-20°. Mark each position of the laser beam on the whiteboard.

Step 3 Repeat step 2 for the elevation. Alternatively the readout of a digital inclinometer can be used to determine the points at 2.5° apart each other.

Step 4 The whiteboard will now have a template which will be used to ensure the optimum co-ordination between the ERS and SUT.

Step 5 Cross-polarization discrimination (9 points XPD box)

In case of pointing errors it might be difficult for the ERS to direct the SUT through this figure; therefore a “template” of the originally drawn XPD figure at the target shall be used to follow these 9 points.

Step 5.1 With the co-ordination of the ERS, point the antenna manually to the satellite, optimize it and write down azimuth, elevation and polarization angles.

Step 5.2 Adjust the target so as to have the laser beam in its center.

Step 5.3 De-point the antenna sequentially by 0.5° in azimuth and elevation. Mark each position of the laser pointer to get the azimuth and elevation axis drawn at the target. Additionally two points shall be marked indicating the minimum step size (e.g. 0.1°).

Step 5.4 Point the antenna again the antenna manually to the satellite.

Measure the XPD according ESOG 130 section 7 and mark each point of the 9 point figure at the target.

Ideally the 9 points should be inscribed in a square - in case of a symmetric dish.

Step 5.5 Draw the 9 points to a transparent paper (overhead paper) to get a “template”.

Step 5.6 Let the terminal deploy automatically, mark the laser beam position and write down azimuth, elevation and polarization angle.

Step 5.7 Run the 9 points XPD test. In case of pointing error it might be helpful to attach the “template” accordingly (bore sight, azimuth and elevation axis) to the whiteboard to visualize “where you are”.

Repeat steps 4.6 and 4.7 several times and then get the arithmetic average of the obtained error values.

Determination of the Auto-Deploy Pointing error with the laser beam method

Step 1 Auto-deploy the terminal and optimize its peaking in co-operation with the ERS.

Adjust with an auxiliary laser beam and an inclinometer the position of the target wrt to the antenna, to ensure that its center is aligned with the main laser beam and that the target is parallel to a plane passing through the back frame of the antenna.

Step 2 Mark on the target the position of the laser beam.

Step 3 In co-operation with the ERS, slew the antenna in Azimuth until the ERS will determine the optimum point maximizing the value received at ERS. Mark on the target the corresponding position of the laser beam.

Repeat for Elevation.

Step 4 Calculate through the formula (1) the Azimuth and Elevation pointing error.

Determination of the Auto-Deploy pointing repeatability

Step 1 Auto-deploy the terminal and optimize its peaking in co-operation with the ERS.

Step 2 Adjust with an auxiliary laser beam and an inclinometer the position of the target wrt to the antenna, to ensure that its center is aligned with the main laser beam and that the target is parallel to a plane passing through the back frame of the antenna.

Mark on the target the position of the laser beam.

Step 3 Repeat Step 1 and without moving the target, mark the new position of the laser beam.

Step 4 Calculate through the formula (1) the pointing error wrt the first measurement.

Step 5 Repeat steps 3 and 4 and make an arithmetic average of the results.

Annex F ESVA Questionnaire

FROM :

Test Nr ..../......

N°. of pages including this one :_________________

TO

Preparation of Forthcoming ESVA

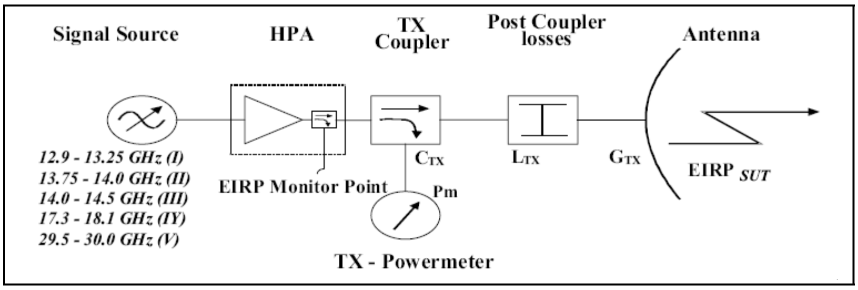
1) GUARANTEE

This is to re-confirm that __________________________________ earth station, appropriate test equipment and staff **will be ready** for the ESVA test planned for ________________________________.

ESOG Vol.I, Module 130 is available at the station under test Applicable www links: http://www.eutelsat.com/satellites/4_5_1_3.html or http://www.eutelsat.com/satellites/pdf/esog130.pdf

2) E/S PARAMETERS

3)



Unless stated otherwise, antenna diagrams will be normalized to typical antenna gain (e.g.: corresponding to 65% efficiency at Ku-Band test frequencies). If applicable, please indicate appropriate reference gain:

____

____

Will EIRP calibration be performed via monitor points applicable to forthcoming operations ?

Yes ☐
No ☐

TX Chain Designation			
TX Coupling Factor			
Post Coupler Loss			

3) **E/S CONFIGURATION**

Feed Type
2-Port ☐

Polarisation
Linear ☐

Geostationary Visibility
From ________° - ________°
(Geostationary Longitude)

Usable Frequency Range for ESVA
Up-Link
________- ________GHz

Test Equipment Type

Signal Source ________________

Power Meter ________________

Analyzer ________________

Antenna Slew Speed

Azimuth: ________________ °/s
Elevation: ________________ °/s

Polarization Plane Adjustment Range

+ / -:________________ °

4) **OPERATIONS**

	Test Manager	*Contact during ESVA*	**Contact details for transmission of final test report and ESVA invoicing ***
Name			
Contact (phone/fax/ e-mail)			

**** ESVA charges for EUTELSAT E/S are 3000€ for up to 10hrs testing plus 600€ for each additional hour.***

Receive pattern is attached Yes ☐ No ☐ **Earth station block diagram is attached** Yes ☐ No ☐

A copy of the receive pattern (e.g.: measured following antenna alignment) would be much appreciated.

5) **REMARKS** *{ Please indicate Latitude and Longitude in case of transportable station }*

____

____

SIGNATURE: ________________ Date:

Annex G Polarization skew of the Eutelsat S.A. satellites using dual linear polarization

GENERAL

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 are inclined by an angle with respect to the equatorial plane. This angle is referenced as the polarization skew.

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

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

If the pointing and polarization alignment software of a auto-deploy terminal falling in the categories above did not take duly into account this value of skew, 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.

VALUE OF THE SKEW OF THE EUTELSAT S.A. SATELLITES

The reference X-polarization 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 is defined as that polarization whose plane is orthogonal to the X-polarization plane and the reference vector defined above.

In other words the skew of the Eutelsat S.A. 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 skew of the Eutelsat S.A. satellites is +183.535°, clock-wise, from anywhere on the meridian corresponding to the orbital location of the satellite.

There are six satellites of the Eutelsat S.A. fleet using linear polarization which make exception.

These are:

- SESAT2,
- EUTELSAT 5 West A,
- EXPRESS A3,
- TELSTAR 12 for which the skew is 0.0 °,
- TELECOM 2 C and TELECOM 2 D
  for which the skew is -22°, when looking at the satellite from the earth.

EUTELSAT S.A. SATELLITES USING DUAL CIRCULAR POLARIZATION

To provide additional guidance to the development of automatic pointing and polarization alignment systems of antennas, it must be noted that Eutelsat S.A. operates part of the payload capacity of the following satellites:

- EUTELSAT 5 West A,
- EUTELSAT 36A
  in dual circular polarization,
- part of the payload capacity of:TELSTAR 12
  in left hand circular polarization ,
- the whole capacity of EUTELSAT KA-SAT 9A 9A
  in dual circular polarization.

Annex H Application form for Manual/Auto-Deploy Terminal Characterization

To: Earth Station Approval Office

Ref: .... Date: ....
From: ....
....

This is to request a Eutelsat S.A. characterization of the
☐ RF performance
☐ Auto-deploy performance

Based on procedures as described in ESOG Volume II, Module 260 for the following terminal:
(insert antenna/equipment details)

The anticipated number of production units will be .... per year/total.

Technical details of a complete unit and the proposed tests including test procedures are attached for your information.
It is suggested that all testing is to be undertaken at:
from: .... to: ....

Full Company details:
Name: ....
Address:...
....
....
Telephone: .... Facsimile: ....
E-mail: ....
Responsible Company Official:..

Signature:..

Attachments (whichever applies):

Manual-Deploy Terminal Technical Information
Auto-Deploy Terminal Technical Information
Auto-deploy performance and requirements

Annex I Summary of the EESS radio electric performance requirements

This Annex details a list of the radio electric performance requirements for obtaining the Eutelsat S.A. characterization. For a full detail of the requirements, refer to the Eutelsat S.A. EESS 502 standards (standard M) and to the Nomenclature M-x.

Manual and auto deploy terminals

a) Sidelobe patterns

Meet the Eutelsat S.A. masks (valid for C-, Ku-, Ka-band), in both Tx and Rx side:

$29 - 25 \log_{10}\theta$ dBi for $\alpha^* < \theta \leq 7°$

$+8$ dBi for $7° < \theta \leq 9.2°$

$32 - 25 \log_{10}\theta$ dBi for $9.2° < \theta \leq 48°$

-10 dBi for $48° < \theta$

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).

Any individual peak shall not exceed those envelopes by more than 6 dB when θ is greater than 9.2° and by more than 3 dB when θ is equal to or smaller than 9.2°.

For antennas aligning along the Geostationary arc, the masks applicable on the Elevation plane may be increased by 3 dB.

b) Cross-polarization discrimination

For Ku-band and Ka-band (linear polarization) operations:

Cross-polarization discrimination should be at least 25 dB within the -1 dB contour of the main lobe for low rating HPAs and 30 dB for medium rating HPAs.

For C-band operations:

Cross-polarization discrimination should be at least 20 dB within the -1 dB contour of the main lobe for low rating HPAs and 27 dB otherwise.

For Ka-band (circular polarization) operations:

Cross-polarization discrimination should be at least 20 dB within the -1 dB contour of the main lobe for low rating HPAs and 25 dB for medium rating HPAs.

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

c) Maximum authorized eirp density.

The maximum authorized eirp density at the satellite reference contour will be calculated by Eutelsat S.A. on the basis of either the maximum co-polar sidelobe peaks levels or the cross-polarization discrimination, whichever yields the lowest value.

If the eirp density values are calculated from the peaks, Eutelsat S.A. will consider the peaks from an angle $\alpha = 100\lambda/D$, where D is the antenna diameter and λ is the carrier wavelength. This formula is valid as long as $1 < \alpha < 1.5$. If the formula yields values outside this range of validity, α is set to either 1° or 1.5°, depending on which is the nearest, except when orbital separation of the adjacent satellite is greater than 2.5°. In this case, this formula is valid as long as $1 < \alpha < 2°$ and if the formula yields values outside this range of validity, α is set to either 1° or 2°, depending on which is the nearest.

Auto-deploy terminals

In addition to the requirements above, the following pointing error requirements will need to be fulfilled:

d) The maximum pointing error in Azimuth and Elevation shall be < 0.2°. For antennas tracking the satellite, some tolerance may apply on the maximum pointing error.

e) Polarization error should be less than typically 1° (for linear polarization only).

Annex J Manual-Deploy Terminal Technical Information

This Annex details the information which the manufacturer shall provide to Eutelsat S.A. in conjunction with the Application form for Manual/Auto-Deploy Terminal Characterization.

MANUAL-DEPLOY TERMINAL DATA SHEET

ANTENNA PARTS

- Antenna manufacturer/model,
- Feed manufacturer/model,
- OMT manufacturer/model,
- Feedboom manufacturer/model,
- Back structure manufacturer/model,
- If applicable, describe all parts which have been added to the original antenna between the OMT and the feedhorn (feed cover, waveguide adapters etc).

ANTENNA PHYSICAL CHARACTERISTICS

- Diameter (for non circular antennas major and minor axis),
- Type of geometry (Prime focus, Gregorian, cassegrain, planar…),
- Type of feed (mode matched 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 (petals, solid etc),
- Sub reflector material (if applicable).

ANTENNA MANUFACTURING

- Describe the manufacturing processes of the reflector(s),
- Describe the manufacturing processes of the feedhorn and OMT.

ANTENNA RF CHARACTERISTICS

- Transmit frequencies of operations,
- Receive frequencies of operations,
- Polarization (linear, circular),
- Tx and Rx Gains,
- G/T.

TERMINAL MOTION (IF APPLICABLE)

- 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°,
- Fine pointing description (if no motorization is available)
- 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
- Terminal expected backlash,
- Maximum operating tilt of the antenna,

TRANSMITTER

- Manufacturer/model and number,
- Type of transmitters (TWTA, SSPA etc),
- Transmitter rating,
- Post HPA losses.

MODEM(S)

- Manufacturer/model.

MONITORING SYSTEMS

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

INSTALLATION AND OPERATIONS HANDBOOK

Annex K Auto-Deploy Terminal Technical Information

This Annex details the information which the manufacturer shall provide to Eutelsat S.A. in conjunction with the Application form for Manual/Auto-Deploy Terminal Characterization.

AUTO-DEPLOY TERMINAL DATA SHEET

ANTENNA PARTS

- Antenna manufacturer/model,
- Feed manufacturer/model,
- OMT manufacturer/model,
- Feedboom manufacturer/model,
- Back structure manufacturer/model,
- If applicable describe all parts which have been added to the original antenna between the OMT and the feedhorn (feed cover, waveguide adapters etc).

ANTENNA PHYSICAL CHARACTERISTICS

- Diameter (for non circular antennas major and minor axis),
- Type of geometry (Prime focus, Gregorian, cassegrain, planar…),
- Type of feed (mode matched etc),
- If mode matched feed is used describe how the feed alignment is verified,
- Reflector material (SMC, metallic, carbon fibre, glass fibre etc),
- Reflector built (petals, solid etc),
- Sub reflector material (if applicable),

ANTENNA MANUFACTURING

- Describe the manufacturing processes of the reflector(s),
- Describe the manufacturing processes of the feedhorn and OMT.

ANTENNA RF CHARACTERISTICS

- Transmit frequencies of operations,
- Receive frequencies of operations,
- Polarization (linear, circular),
- Tx and Rx Gains,
- G/T.

AUTO-DEPLOY TERMINAL INTEGRATION

- System integrator,
- Model,

- Describe the inspections and measurements on reception of every auto-deploy terminal subcomponents: reflector, sub reflector if applicable, feed horn, OMT, back structure, struts, cover, motors, encoders, GPS, compass etc.,
- Describe the changes to the mount which have been implemented,
- Describe how the original antenna is integrated with the motors and the hosting platform,
- Provide the expected distances between predetermined points on the feed, reflector and sub reflector (if applicable) and the accepted tolerances,
- Describe the verifications performed on the antenna geometry to ensure that the original optics is maintained and expected tolerances,
- Describe the auto-deploy terminal commissioning,
- Quality control and assurance processes,
- Total weight of the auto-deploy terminal.

AUTO-DEPLOY TERMINAL SUB-SYSTEMS

- ACU manufacturer and model,
- Positioner manufacturer and model,
- Auto-deploy terminal's controller manufacturer and model,
- Auto-deploy controller software vendor, designation and version number,
- Location of the auto-deploy routine,
- Motors' manufacturer, model, type and number of them.

AUTO-DEPLOY TERMINAL 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,

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 optimisation 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 optimised by calculation. Describe satellite skew look up tables, see Annex G. It applies for linear polarized antennas only,
- Transmission enable procedures (describe).

TRANSMITTER

- Manufacturer/model and number,
- Type of transmitters (TWTA, SSPA etc),
- Transmitter rating,
- Post HPA losses.

MODEM(S)

- Manufacturer/model.

MONITORING SYSTEMS

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

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).

INSTALLATION AND OPERATIONS HANDBOOK

Annex L Auto-deploy operational requirements

This Annex contains a check list of the operational requirements specific to the auto-deploy terminal which shall be complied with. In case one or more of the requirements were not fulfilled, Eutelsat S.A. will decide on a case by case basis if the characterization tests can still be performed albeit with a limited scope.

ESVA SLEW SPEED

For ESVA tests it is recommended that the target slew speed should be of 0.1°/sec, for achieving high precision results. Higher slew speed (e.g. up to 0.5°/sec) could still be acceptable, but may lead to less accuracy in the end results. In case of slew speeds superior to 0.5°/sec, the manufacturer may implement an ad hoc temporary device to interface with the terminal positioner. Eutelsat S.A. would reserve the right to decide if auto-deploy terminals with slew speeds superior to 0.5°/sec will be eligible for testing.

MANUAL SLEW SPEED

The minimum step for the step-by-step slew should be 0.1° or smaller to ensure the correct evaluation of the pointing error.

CW CARRIER TRANSMISSION

For the performance of the tests, the auto-deploy terminal will transmit a CW carrier, the manufacturer shall ensure that the modem has the capability of being operated in this mode. In case of EUTELSAT KA-SAT 9A auto-deploy terminals, it may not be normally possible to enable the BUC (TRIA) of the SUT for transmission of CW carriers. It is then necessary to use a special adapter made available by the manufacturer of the TRIA, with access to the OMT ports. This adapter is unique and has to be requested in loan well in advance to Eutelsat S.A., the System Integration Group.

AUTO-DEPLOY DISABLE

It is necessary that the auto-deploy and any form of tracking be manually disabled in order to assess the pointing error of the auto-deploy terminal.

TRANSMISSION ENABLE

There must be no ways for the operator of the auto-deploy terminal to enable transmission prior to the completion of the auto-deploy process.

JACKS

Use of jacks/tools to stabilise the vehicle/fly-away.

Annex M Test Range Characteristics

Prior to deciding on the suitability of a given test range, it is necessary to assess its capabilities, namely the following elements shall be considered:

1. A description of the range facility,
2. Dimensions and characteristics of the source antenna(s) and source signal generating equipment,
3. A description of the means of operation of the transmitting end of the range and of the receiving end of the range,
4. Summary of the dynamic range and accuracy of gain, pattern, and polarization discrimination measurements (and/or axial ratio, as appropriate),
5. Description and results of any periodic re-characterization of the test range, due to changes such as equipment calibration, or changes in foliage, buildings, or ground surface near the path,
6. Description of the range characterization, including the measurement technique used the results of those measurements and a summary description of the results. The tests should cover any relevant frequencies of operation that are used for the characterization of the auto-deploy terminal,
7. Description of the way the test results will be presented; it is recommended that the values of the sidelobes pattern peaks with respect to the Eutelsat S.A. masks and the values of the XPDs at the - 1 dB contour or pointing error of the main lobe be calculated automatically and presented in the report,
8. Any relevant measurement data should be included, such as:
   - Dimensions of quiet zone (typically should be > $2D^2/\lambda$ where D is the diameter of the antenna under test and λ the lower wavelength to be tested),
   - Polarization discrimination, across the frequency band of interest, of all source feeds used,
   - Description of any shortcomings, limitations, interference or reflections inherent on the test range that may cause anomalies in antenna measurement data.

Annex N Glossary

AAZ, AEL, APOL, AXPD, AEIRP

represent the values of azimuth, elevation, polarization angle, XPD (Cross-Polarization Discrimination) and EIRP of the auto-deploy terminal achieved when deploying the antenna automatically.

MAZ, MEL, MPOL, MXPD, MEIRP

represent the values of azimuth, elevation, polarization angle, XPD (Cross-Polarization Discrimination) and EIRP of the auto-deploy terminal achieved after a manual optimisation of the pointing.

∆AZ,∆EL, ∆POL

Are the pointing errors in Azimuth, Elevation and Polarization respectively. They are given by the differences AAZ-MAZ, AEL-MEL and APOL-MPOL respectively.

Application form for Manual/Auto-Deploy Terminal Characterization

The applicant shall fill in and send to Eutelsat S.A. a relevant request as per Annex H.

The applicant shall ensure that the unit to be tested is "typical" and representative of the units operating in the field.

Once the terminal registered in the Eutelsat S.A. database, the operator will receive an earth station code, usually with a temporary validity, to allow the performance of the verification tests via satellite.

Approval to access the Eutelsat S.A. space segment

It is delivered by the Eutelsat S.A. earth station office upon review of the Earth Station Application received from the manufacturer. It implies the assignment of a Eutelsat S.A. earth station code.

Auto-deploy terminal

It implies

- C or Ku or Ka band operations,
- Intended for operation on geostationary (non-inclined) satellites,
- Automatically deploys and points its antenna towards a designated target satellite.

Includes fly-aways, or vehicle mounted earth stations with motorized platforms (deploys and points automatically).

It does not include for the purpose of this book, “Satcom-On-The-Move” terminals, i.e. terminals that in addition to deploy and point functions have full tracking capabilities (e.g. earth stations on vessels, aircrafts, trains, moving vehicles).

"Auto-deploy" performance characterization

It consists in evaluating the terminal pointing error and its repeatability for different satellites and operating conditions.

Contour plots

Also referred as raster scanning. It is a 2D representation of either the copolar or cross-polar radiation patterns. It allows to determine the sidelobes levels in planes other than the principal ones, as well as the XPD performance at the -1dB contour of the main beam or within the antenna pointing angle error.

EIRP

Equivalent Isotropic Radiated Power.

ERS

Eutelsat S.A. Reference Station. It will be in charge of the ESVA co-ordination and performance.

ESOG

Eutelsat S.A. Systems Operations Guide.

ESVA

Earth Station Verification and Assistance.

For a detailed description of the ESVA tests, refer to ESOG Vol 1 Module 130, available on the Eutelsat S.A. Web at the following link:
http://www.eutelsat.com/satellites/pdf/esog130.pdf

Eutelsat S.A. earth station access and approval procedures

See ESOG vol.1 Book 110
http://www.eutelsat.com/satellites/pdf/esog110.pdf

Eutelsat S.A. earth station approval services
The email of the contact is esapproval@eutelsat.fr

Eutelsat S.A. Earth Station Code

An alphanumerical code univocally assigned to a given earth station. Ex.: ITA-457 for mobile terminals.

Eutelsat S.A. standards

EESS (Eutelsat S.A. Earth Station Specification) 502 – Standard M (available on request by emailing to esapproval@eutelsat.fr or via the Eutelsat S.A. Extranet) details the mandatory requirements a terminal must comply to access the Eutelsat S.A. space segment.

List of Eutelsat S.A. approved equipment

If the terminal is compliant with the EESS 502 standards, Eutelsat S.A. may decide to publish on-line a summary of the RF characteristics of the terminal in the list of the Eutelsat S.A. approved equipment:
http://www.eutelsat.com/satellites/4_5_1_5.html

It consists of several books:

- Earth Station Antennas & VSATs (Eutelsat S.A. Characterization),
- Auto-pointing Antennas,
- Earth Stations on Vessels,
- Type approved Antennas, VSATs & VSAT Outdoor Units.

Once inserted in this list, Eutelsat S.A. Operators will be able to register terminals of the same model and obtaining the authorization to access the Eutelsat S.A. space segment without the need for further full verification testing, unless otherwise decided by Eutelsat S.A., for operational reasons.

Manual-deploy terminal

It implies:

C or Ku or Ka band operations,

Intended for operation on geostationary (non-inclined) satellites,

It is manually operated to point towards a designated target satellite,

Includes fly-aways with and without motorized platforms.

Power balance

The ERS and SUT transmit a CW carrier via satellite at about 100 KHz apart. ERS adjusts its transmit eirp to be at the same level of the carrier from SUT. Knowing the G/T of the satellite for the ERS and the SUT and knowing the ERS eirp from previous calibrations, the power balance is a way of assessing the eirp transmitted by SUT.

Registration of terminals

When tests require an access to the Eutelsat S.A. satellites, terminals need to be registered with the Eutelsat S.A. earth station approval services. This is not necessary for terminals to be tested uniquely on a test range.

The registration can only be performed on-line via the Eutelsat S.A. Extranet https://services.eutelsat.fr This earth station registration link is login and password protected.

“Static” characterization of a terminal

It consists in verifying the RF radio electric performance of the terminal and their compliance with the Eutelsat S.A. EESS standards, in particular the Antenna Sidelobe patterns and polarization and the compliance with the off-axis eirp density emission constraints.

SUT

Station Under Test.

Test Range

It is a facility, either outdoor or indoor, where the RF “static” performance of the terminal can be measured by using a source antenna and moving the terminal through a precision positioned. See Annex M.

User Login and Password codes

In case of a new user, the applicant shall register his company details in order to obtain the login and password codes, by accessing to the following link: http://www.eutelsat.com/deploy_DAOW

XPD

Cross-polarization discrimination.

4 points XPD box

Corresponds to the XPD at the -1 dB contour of the main lobe on the Azimuth (left and right) and Elevation (up and down) planes.

9 points XPD box

Refer to ESOG Vol 1 Module 130, available on the Eutelsat S.A. Web at the following link:
http://www.eutelsat.com/satellites/pdf/esog130.pdf - Chapter 7.

EUTELSAT S.A. OPERATIONS CONTACT POINTS

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