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**Volume II - ESOG Module 230 - Issue 2.1**  
**VSAT HANDBOOK**  
30 July 2008

# EUTELSAT<sub>S.A.</sub>

## SYSTEMS OPERATIONS GUIDE

ESOG      Module 230

VSAT HANDBOOK

Issue 2.1

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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>

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# 1. INTRODUCTION

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The purpose of this VSAT Handbook is to provide pointing and alignment guidelines to assist in the installation and commissioning of terminals in VSAT networks via Eutelsat S.A. satellites and to ensure that performance objectives are being met.

This handbook assumes that the network's Hub station has already been put into operation following the procedures for standard SMS carriers in ESOG Module 220.

Prior to accessing the satellite, any VSAT network must have obtained Eutelsat S.A. Approval to Access the Space Segment in accordance with ESOG Module 110.

Some important preparatory issues for conducting successful testing are presented below:

- a. Test Plan, Test Schedule and Instructions:** Prior to the commencement of any satellite transmission the Earth station/VSAT Operator shall have received the detailed line-up test schedule containing all necessary technical/operational parameters and other special instructions.
- b. CSC Coordination Circuit:** Prior to the first satellite access of the first VSATs of any newly installed VSAT network or the activation of additional in-bound carriers or capacity for an existing network, the Hub station must establish communications to the Eutelsat S.A. CSC in Paris, as detailed in the ESOG Module 140. The telex, facsimile and telephone numbers are as indicated in the table of contact numbers attached to each ESOG module.

Test results shall be summarised at the end of each month or quarter, combined with the VSAT registration information and made available to Eutelsat S.A. by mail, fax, or any other commercially available data system when requested.

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## 2. INITIAL TERMINAL INSTALLATION AND ALIGNMENT

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Operators are requested to begin the installation and initial pointing and alignment of their VSAT terminals according to their supplier instructions. A suggested procedure to assist VSAT Operators is as follows:

- Step 1: Check azimuth, elevation and polarisation angle calculations.
  - Step 2: Check magnetic variation figure for VSAT site to give correct magnetic azimuth bearing.
  - Step 3: Accurately set antenna pointing and feed polarisation offset.
  - Step 4: Verify the frequency of the on-board satellite beacon or another RF carrier (e.g. the outbound from Hub). If a spectrum analyser is available, accurately calculate the down converted frequency that you will be viewing on it. Remember that some LNBS (Low Noise Block) down-converters may have fairly unstable local oscillators and this must be taken into account when setting the spectrum analyser span/division and resolution bandwidth.
- NOTE:** The on-board beacon is visible from any point within Eutelsat S.A. satellite beam coverage.
- Step 5: Once all these values are determined and the antenna is pre-pointed, begin a slow antenna sweep in azimuth each side of the calculated azimuth and repeat in small (0.5°) elevation increments. Carefully peak antenna pointing once the beacon / RF carrier is detected.

Operators should then begin the final alignment of the subject terminal, before proceeding to system tests including hub control over the terminal.

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## 3. FINAL TERMINAL ALIGNMENT

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For each VSAT alignment it is necessary to optimise as much as possible its cross-polar performance. For this purpose one or more Test Slot(s) as needed, with free cross-polar can be provided by Eutelsat S.A. on demand. Eutelsat S.A. will provide this slot(s) on a best effort basis on the understanding that this slot(s) is preemptible at any time for operational/commercial reasons. A typical slot may be 45 kHz wide.

Two methods are recommended for final alignment of VSAT terminals.

The first one utilises a central site, such as the Hub, to monitor the co-polar and cross-polar components of the signal from the VSAT under test, using a good quality spectrum analyser. The cross-polar component of the VSAT under test is measured by means of:

- a) a four-port antenna Hub, or
- b) a dedicated monitoring earth station with a good quality antenna (preferably with a XPD value of better than 35 dB) and LNB, previously aligned on the opposite polarisation to that of the carrier(s) from the VSAT(s) being aligned.

This is the preferred method for pointing and aligning terminals in large VSAT networks, as only one high quality spectrum analyser is required. (Note that a second spectrum analyser would facilitate the process as both the co-polar and cross-polar could be monitored simultaneously, and this would also avoid having to switch a single analyser between the different output ports or feeds). A step by step procedure is given in §3.1 below.

The second method requires the use of a spectrum analyser at each VSAT site. This is believed to be more applicable to VSAT networks with a limited number of remote terminals and a limited number of installation teams, as not many spectrum analysers would be required. A step by step procedure is given in §3.2 below. This method requires a RF carrier that can be received by the VSAT being aligned. It can be either an existing carrier with free cross-polar or alternatively a carrier uplinked by the Hub in a preassigned test slot as previously mentioned.

For a qualitative analysis on the accuracy of spectrum analyser measurements see Annex A.

### 3.1. Method A: Alignment using a Central Site

#### Test Description:

This is the preferred method for pointing and aligning terminals in large VSAT networks.

It requires the support of a cooperating earth station (normally the network Hub) where a spectrum analyser with predetermined characteristics (which must be of good quality, e.g. -140 dBm/Hz noise floor) will be available to monitor both co-polar and cross-polar components radiated by the VSAT under test.

**Test Procedure:**

The following is the procedure to be employed:

- Step 1: A telephone contact is established between the VSAT being aligned and the central monitoring site or Hub. This contact must be maintained at all times.
- Step 2: The VSAT radiates a continuous unmodulated carrier in the pre-provided test slot in order to ensure good measurement accuracy achieved on the spectrum analyser. In case the VSAT under test cannot radiate this type of carrier, it is suggested to use test Method B in § 3.2 below.
- Step 3: The central site monitors the test slot to detect the presence of the carrier originating from the VSAT. If the central site does not detect and confirm the carrier in the assigned transponder and/or if the communications link between the VSAT under test and the central site fails, the VSAT under test shall:

+++++ immediately CEASE, transmissions +++++

The VSAT under test shall again verify its set -up on:

- correct satellite acquisition
- polarisation plane alignment
- transmit frequency

re-commencing with Step 1.

- Step 4: Under control of the central site, adjust carefully the antenna in azimuth and elevation to achieve maximum receive level of the co-polar signal on the spectrum analyser at the central site. Ensure that the instruments sweep bandwidth and resolution bandwidth is optimised. (As an example of spectrum analyser settings, choose a resolution bandwidth in the order of 10 KHz, a video bandwidth in the order of 1 KHz and a frequency span in the order of 1 MHz.)
- Step 5: Adjust carefully the polariser (or feed) in clockwise and counter clockwise direction until the maximum receive signal is obtained. Mark the antenna and polariser (or feed) positions and note the signal level value.
- Step 6: In the case of a four-port antenna Hub remove the spectrum analyser from the co-polar port and connect the instrument to the cross-polarisation output port of the feed system without changing the previous frequency, sweep bandwidth and resolution bandwidth settings. In the case of a dedicated monitoring antenna remove the spectrum analyser from the output port of the Hub's feed system and connect it to that of the monitoring antenna.
- (Note that a second spectrum analyser would facilitate the process as both the co-polar and cross-polar could be monitored simultaneously, and this would also avoid having to switch a single analyser between the different output ports or feeds.)
- Step 7: Re-adjust the instruments sweep bandwidth and resolution bandwidth until the cross-polar component of the VSAT signal can be clearly measured on the spectrum analysers screen.
- Step 8: Under control of the central site adjust very carefully the VSAT polariser (or feed) in clockwise and counter clockwise direction until minimum cross-polar signal level has been reached. Mark position and this signal level value. Also note the maximum signal levels obtained clockwise and counter-clockwise to this setting.

Feed system cross-polarisation optimisation (also called "Nulling") has been achieved when the polariser (or feed) has been adjusted and set to the minimum cross-polar signal value.

**Note A:** If the received cross-polar signal is still too high then adjust carefully the antenna in azimuth and elevation, within its 3 dB beamwidth, to minimise the carrier received at the spectrum analyser and then repeat steps 7 and 8.

Step 9: At the VSAT terminal compare the polariser (or feed) setting obtained in maximising the co-polar with that obtained in minimising the cross-polarisation (Step 8). It should be the same. In the case of a small difference the VSAT should be aligned at the setting corresponding to the cross-polarisation minimum obtained in Step 8. Important differences in the two settings may indicate problems in the antenna mount (e.g. de-focusing of the feed).

Step 10: Adjust carefully the antenna in azimuth to ensure that the azimuth (and, when necessary elevation) setting is still the same as that of the maximised co-polar signal. If it is not then Steps 4 to 9 should be repeated.

**Note B:** For offset front feed antennas the cross-pol null exists only in azimuth, so there is no requirement to adjust in elevation.

### 3.2. Method B: Alignment Using Spectrum Analysers at each VSAT

#### Test Description:

This method is believed to be more appropriate for pointing and aligning terminals in relatively small VSAT networks.

It requires a spectrum analyser (which must be of good quality, e.g. -140 dBm/Hz noise floor) to be available at each VSAT as it is being installed, thus it could be applied to networks with a small number of installation teams.

#### Test Procedure:

The following is the procedure to be employed:

Step 1: Connect the spectrum analyser to the output port of the antenna feed system of the VSAT under test. RF access should be available at the outdoor unit. Adjust the spectrum analyser and feed to receive a predetermined satellite carrier in the polarisation where the VSAT will operate. This carrier's corresponding slot in the opposite polarisation should be signal-free, in order to enable the cross-polar nulling detailed below. (As an example of spectrum analyser settings, choose a resolution bandwidth in the order of 10 KHz, a video bandwidth in the order of 1 kHz and a frequency span in the order of 1 MHz.)

Step 2: Adjust carefully the antenna in azimuth and elevation to maximise the satellite carrier received on the spectrum analyser.

Step 3: Adjust carefully the polariser (or feed) in clockwise and counter-clockwise direction until the received signal is maximised. Mark the antenna and polariser (or feed) positions.

Step 4: Rotate the feed system by 90° clockwise or counter-clockwise without changing the previous frequency, sweep bandwidth and resolution bandwidth settings.

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- Step 5: Re-adjust if necessary the input sensitivity of the spectrum analyser until the received satellite carrier can be detected (a line amplifier may be required for spectrum analysers with a noise floor above -140 dBm/Hz).
- Step 6: Adjust carefully the polariser (or feed) in clockwise and counter-clockwise direction until minimising the satellite carrier. Mark the feed position and note this signal level value. Also note the maximum signal levels obtained clockwise and counter-clockwise to this setting.
- Note A** If the received signal is still too high with respect to the expected cross-polar performance of the antenna being aligned, then adjust carefully the antenna in azimuth and elevation if necessary to minimise the carrier received at the spectrum analyser and then repeat steps 5 and 6.
- Step 7: Rotate the feed by exactly 90° counter-clockwise or clockwise i.e. in the opposite sense of Step 4.
- Step 8: The feed position should now correspond to that obtained in maximising the co-polar (Steps 2 and 3). In the case of a small difference the VSAT should be aligned at the setting obtained in Step 7. Important differences in the two settings may indicate problems in the antenna mount (e.g. de-focusing of the feed).
- Step 9: Adjust carefully the antenna in azimuth to ensure that the azimuth (and when necessary, elevation) setting is still the same as that of the maximised co-polar signal. If it is not then steps 4 to 8 should be repeated.
- Note B** For offset front feed antennas the cross-pol null exists only in azimuth, so there is no requirement to adjust in elevation.

## **4. TERMINAL AND NETWORK TESTING**

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For each newly installed VSAT operators are requested to perform a minimum set of system tests including hub control over the remote terminal. These tests should be conducted according to the VSAT supplier instructions.

Each terminal should also conform to ETSI requirements (Refer to ETSI 300 160 and 300 161), including those for control channel messages from the Hub.

In addition as a general Eutelsat S.A. requirement it should be demonstrated that the terminal can be at any time forced to cease transmission by the Hub, and also that when the Hub outbound carrier is removed the transmitting VSATs automatically respond by ceasing their transmissions.

## Annex A - Spectrum Analyser Measurements of VSAT Signals

### A- General Information

Spectrum analysers are capable of detecting and measuring very low level signals provided that a large difference can be obtained between the resolution bandwidth (RBW) setting and the bandwidth of the carrier being measured. For example, a measurement advantage of 30 dB could be obtained if a RBW of 45 Hz was used while measuring an unmodulated continuous carrier signal with a 45 kHz bandwidth.

VSAT terminals often have unstable (and inexpensive) transmit oscillators and it may be necessary to increase the RBW to take account of this thus losing some of the advantage.

### B- Measurement of the cross-polar component of a signal

It may be difficult to measure the cross-polar component of a signal especially if it is uplinked at a relatively low EIRP from a VSAT (i.e. being measured at the central site), or alternatively being received on a VSAT with low G/T and cross-polar discrimination.

A qualitative analysis is given below:

#### Input data:

Satellite:	EUTELSAT II-F4
Transponder:	44
Downlink coverage:	East coverage, medium gain
Transmit Station:	Located at 39 dBW contour
Receive station:	Located at -0.5 dB/K contour
Carrier 3 dB bandwidth:	45 kHz.

The contribution into the cross-polarisation is calculated for three isolations:

- 25.5 dB**, corresponding to a signal transmitted from an antenna with  $CPI_{\text{uplink antenna}} = 35$  dB (Standard S spec.), and assuming  $CPI_{\text{sat}} = 33$  dB, and a pol. plane alignment error of 1 deg, and
- 22.1 dB**, corresponding to a signal transmitted from an antenna with  $CPI_{\text{uplink antenna}} = 25$  dB (Standard M spec.), and assuming  $CPI_{\text{sat}} = 33$  dB, and a pol. plane alignment error of 1 deg, and
- 18.2 dB**, corresponding to a signal transmitted from an antenna with  $CPI_{\text{uplink antenna}} = 20$  dB, and assuming  $CPI_{\text{sat}} = 33$  dB, and a pol. plane alignment error of 1 deg.

Five different receive earth station G/T values are also assumed:

G/T	Approximate Antenna Diameter
27 dB/K	3.7 m
25 dB/K	2.4 m
22 dB/K	1.8 m
19 dB/K	1.2 m
17 dB/K	0.9 m

Finally three different Transmit EIRP levels are assumed, 45 dBW, 42 dBW and 38 dBW:

Transmit EIRP (dBW)	Earth Station Receive G/T (dB/K)	C/N (dB)	C/N in cross-pol for an isolation of		
			25.5 (dB)	22.1 (dB)	18.2 (dB)
45	27 dB/K	9.6	-15.9	-12.5	-8.6
45	25 dB/K	6.3	-19.2	-15.8	-11.9
45	22 dB/K	4.4	-21.1	-17.7	-13.8
45	19 dB/K	1.5	-24	-20.6	-16.7
45	17 dB/K	-0.5	-26	-22.6	-18.7
42	27 dB/K	6.1	-19.4	-16	-12.1
42	25 dB/K	3.3	-22.2	-18.8	-14.9
42	22 dB/K	-0.5	-26	-22.6	-18.7
42	19 dB/K	-1.5	-27	-23.6	-19.7
42	17 dB/K	-3.5	-29	-25.6	-21.7
38	27 dB/K	2.1	-27.6	-24.2	-20.3
38	25 dB/K	-0.7	-26.2	-22.8	-18.9
38	22 dB/K	-2.6	-28.1	-24.7	-20.8
38	19 dB/K	-5.5	-31	-27.6	-23.7
38	17 dB/K	-7.5	-33	-29.6	-25.7

## EUTELSAT S.A. OPERATIONS CONTACT POINTS

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