EUTELSAT S.A.

Systems Operations Guide

ESOG
Volume II

SATELLITE MULTI SERVICE (SMS) HANDBOOK

Issue 2.0, 01-07-2004

Module 220

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SYSTEMS OPERATIONS GUIDE

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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 System Management and Policy aspects and is therefore primarily of interest to personnel engaged in these matters.

Volume II is of direct concern to earth station staff who are directly involved in system operations, i.e. the initial line-up of satellite links between earth stations and the commissioning of earth stations for Eutelsat S.A. services. The modules that 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, 06-09-2004

OVERVIEW ESOG MODULES

VOLUME I

EUTELSAT S.A. SYSTEM MANAGEMENT AND POLICIES

VOLUME II

EUTELSAT S.A. SYSTEMS OPERATIONS AND PROCEDURES

1. INTRODUCTION

The purpose of this SMS Handbook is to outline the requirements for commissioning digital SMS services via Eutelsat S.A. satellites and to ensure that performance objectives are being met. This ESOG Module also includes all necessary tests required to confirm that interactive VSAT networks utilising the digital SMS capacity meet minimum requirements on compatibility with overall system integrity.

The strategy for testing satisfies the different needs of the networks (CLOSED and OPEN) that utilise the digital SMS capacity (including IDC):

Digital SMS Open Network: The open network is characterised by a set of commonly adopted performance requirements and specifications in order to guarantee compatibility between all user equipments. The tests relating to the introduction of this type of network are all mandatory in order to ensure compatibility with the network and to confirm that the common performance objectives are being achieved.

Digital SMS Closed Network: The closed network may use a variety of other performance characteristics not specified in the SMS System Specification to allow users the maximum flexibility to meet any other particular requirements. Therefore the mandatory tests, while identical to the open network tests, are limited in number to ensuring that the parameters which may potentially cause interference to other services are verified.
The balance of the tests are described as "recommended only" and, whilst Eutelsat S.A. does not insist that these tests are completed (because there are not any commonly adopted performance characteristics and objectives), Eutelsat S.A. strongly recommends that they are effected prior to the commencement of the initial service.

Following the above, and to ensure interference-free access to the space segment while confirming the expected quality performance, a minimum set of tests has been established that is applicable to any digital SMS user either in the closed or open network environment. An overview of these tests is given in Table 1.a below:

ESOG §	Test	PTLU	FLU
2.1	Carrier EIRP, centre frequency and RF bandwidth	X	X
2.2	HPA output spectrum of transmit stations	X	X
2.3	Additional tests for interactive VSAT terminals	X	X
3.1	C/N versus BER performance at the RX e/s		X
3.2	BER Continuity test		X
3.3	Data polarity check		X

Table 1.a: Carrier Line-Up Tests

As can be seen from the table, a Full Line-Up (FLU) consists of the complete set of tests, while a Pre-Transmission Line-Up (PTLU) comprises only a subset of the test programme.

In principle, the testing programme is identical for both networks. However, in the case of the Open Network, all the tests are MANDATORY whereas in the Closed Network only those which ensure the protection of other satellite services are. This results in a utilisation of the two different groups of tests in the following manner:

	PTLU	FLU
Open Network:	mandatory	mandatory
Closed Network:	mandatory	recommended

The implementation of the balance of the tests in the closed network environment are strongly recommended to ensure satisfactory operations. However, as a minimum requirement to protect other users Eutelsat S.A. must insist that the mandatory test procedures are completed satisfactory.

Upon satisfactory completion of the mandatory tests, the earth station operator can assume that Authorisation to Operate as indicated in ESOG Module 110 §3.2 has been granted for the earth station concerned.

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

2. MANDATORY PRE-TRANSMISSION LINE-UP TESTS (PTLU)

The tests given in this chapter are mandatory for both the closed and open network of the digital SMS services.

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 transmissions 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 ANY satellite access the earth 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.
c. **Finding a Satellite:** A simple procedure is given in Annex 1 to this Module to assist SMS Earth Stations/VSAT Operators finding the desired Eutelsat S.A. satellite.
d. **Polarisation Alignment:** A procedure to assist Earth Station/VSAT Operators to align the earth station plane of polarization is described in Annex 2 to this Module.

Test results shall be made available to Eutelsat S.A. by mail, fax, telex or any other commercially available data system when requested. Annex 6 to this Module includes the format for the test report.

2.1. Carrier EIRP, Centre Frequency, C/N and RF Bandwidth

Purpose of Test: To establish the nominal up-link and down-link EIRPs of the carrier under test and to measure the centre frequency, C/N and RF bandwidth.

Performance Objective: The:
- Carrier Centre Frequency
- EIRP
- C/N
- RF Bandwidth

shall conform to the expected values as provided in the Line-Up Test Plan/Schedule.

Test Equipment:
- Spectrum Analyser
- RF Frequency Counter
- Camera/Plotter

Test Procedure:

NOTE: This test should be conducted under clear sky conditions at both the transmit and receive earth stations. Polarisation plane alignment must have been performed prior to any carrier activation (see procedure in Annex 2).

Step 1: Access Coordination: The earth station under test shall ascertain by means of a spectrum analyser that the satellite is free of any activated carrier in the bandwidth and polarization which the earth station plans to illuminate. The earth station under test must establish and maintain contact with the Eutelsat S.A. CSC throughout the following steps.

Step 2: Space Segment Access: Under the control of the Eutelsat S.A. CSC, transmit the energy dispersed carrier at an EIRP of no more than 30 dBW into the allocated transponder at the assigned frequency.

Step 4: Frequency Verification: The Eutelsat S.A. CSC will check and record the correct downlink frequency and confirm compliance with the Transmission Plan. If the Eutelsat S.A. CSC does not detect and confirm the carrier in the assigned transponder and/or if the communications link between the earth station under test and the CSC fails, the earth station under test shall:

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

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

- correct satellite acquisition
- polarization plane alignment
- transmit frequency

commencing with Step 1.

Step 5: Transmit EIRP: Under the control of the Eutelsat S.A. CSC, the transmit earth station gradually increases the EIRP of the assigned carrier.

Step 6: EIRP and Crosspolar Isolation: The Eutelsat S.A. CSC will check and record the corresponding downlink level and confirm that the crosspolar component of the carrier under test is satisfactory and that no interference to other services exists.

Step 7: Space Segment Access Authorisation: Upon successful completion of Steps 1-7 the transmitting earth station will be authorised by the Eutelsat S.A. CSC to proceed with further line-up testing.

NOTE: Removal of carriers: When transmit carriers are removed the Eutelsat S.A. CSC must be immediately advised and any carrier re-activation is subject to authorisation by the Eutelsat S.A. CSC. Carriers must be removed immediately if required to do so by the Eutelsat S.A. CSC.

Step 8: Measurement of Carrier-to-Noise Power Density Ratio (C_o/N_o). At the receive earth station:

a) Display the carrier spectrum from the receive IF on the spectrum analyser.
b) Adjust the sweep bandwidth to allow the carrier width to be 20 to 30 percent of the horizontal display.
c) Ensure that the resolution filter bandwidth in use is less than 20% of the signal bandwidth. For example, a 10 kHz filter would be suitable for an 70 kHz carrier.
d) Adjust the instrument's step attenuator to place the peak of the carrier on some convenient horizontal reference line with the vertical scale set to 1 or 2 dB per division.
e) Use as much video filtering as practical to limit the uncertainty in the average level. Note the attenuator setting.

Step 9: Measurement of Noise Power

a) Decrease the spectrum analyser attenuator setting to move the signal up.
b) Continue until the noise level is brought up to the same horizontal reference mark as was used for the carrier.
c) Note the attenuator setting at this point.

Step 10: Calculation of C_o/N_o: Take the difference in the attenuator settings noted in Steps 8 and 9 This is the $(C_o + N_o)/N_o$ ratio of the spectral densities. Correct the measured value $(C_o + N_o)/N_o$ to C_o/N_o using the Table in Annex 4.

Step 11: If Step 10 above does not provide the expected results, the Eutelsat S.A. CSC will then decide whether or not the Transmit stations EIRP requires adjustment to obtain the expected C/N.

Step12: Upon successful completion of Step 11, the transmit earth station shall record the analyser display reading and the corresponding earth station EIRP. This level should be maintained from now on unless instructed by the Eutelsat S.A. CSC to change.

Step13: Without radiating the unmodulated carrier to the satellite the transmit earth station will measure its own carriers centre frequency. Record the result for the test report.

Step 14: The transmit earth station should now re-radiate the modulated carrier to the satellite. The Eutelsat S.A. CSC will then measure the bandwidth occupied by the carrier within the 10 dB points of its spectrum.

2.2. HPA Output Spectrum of T_X Station at Nominal EIRP

Purpose of Test: To characterise the transmit spectrum at the HPA output after all filtering and to ensure it meets the performance objectives before other tests are conducted. The carrier's spectrum requirements are to be met when the carrier is transmitted at its nominal EIRP level as established during the previous test.

Performance Objective: The actual transmitted RF spectrum shall be within the limits of the mask given in Figures A3. of Annex 3. The transmission rate (R) used in the mask calculation shall be the satellite links transmission rate (i.e. after FEC coding).

Test Equipment:

- Spectrum Analyser
- X-Y Plotter or Camera

Test Procedure:

NOTE: The receive earth station is not required to participate in this test.

Step 1: At the transmit earth station, connect the modulator IF output to the input of the spectrum analyser.

Step 2: Adjust the spectrum analyser setting to a span of approximately 3 times the allocated bandwidth and display the signal spectrum at the centre frequency. Use a resolution filter bandwidth less than the signal bandwidth. The instrument should be set to an average responding display with enough video filtering to reduce the noise to less than 0.25 dB p-p. The vertical scale should be set to 10 dB per division.

Step 3: Measure the actual signal bandwidth at the -10 dB points and record the result, photograph or plot the spectrum.

Step 4: Disconnect the spectrum analyser and reconnect the modulator output to the transmit system.

Step 5: Connect the spectrum analyser to the HPA output test point at RF, after all filtering.

Step 6: Set up the spectrum analyser at the carrier frequency as described in Step 2.

Step 7: Compare the spectrum with the mask in Figure A3 of Annex 3. Measure the level at the appropriate points, e.g.: $\pm$0.5MABW (maximum allocated bandwidth) in the case of closed network carriers.

Step 8: Record the results for inclusion into the test report telex and forward the hard copy separately to Eutelsat S.A. If this test is satisfactorily, continue with the next test.

2.3. Additional tests for VSAT Hub/Terminal Stations

NOTE: Prior the proceeding with the following tests the Hub Station must have completed the PTLU tests in the previous paragraphs 2.1 - 2.2. The following tests apply to the initial setting up of interactive VSAT networks.

Purpose of Test: To ensure that transmitting VSAT terminals cease transmission at any time, WHEN required for operational reasons.

Performance Objective: When the Hub outbound carrier is removed, Transmitting VSATs must automatically respond by ceasing their transmissions.

Test Coordination: Immediately prior to the commencement of and throughout the tests the HUB station must establish and maintain direct contact with the Eutelsat S.A. CSC.

Test Procedures:

Step 1 Perform a system start up with at least one remote VSAT on each inbound carrier.

Step 2 At the Eutelsat S.A. CSC, confirm adherence to the agreed Transmission Plan for the system under test.

Step 3 Upon request by the Eutelsat S.A. CSC at the HUB station cease transmission of the out bound carrier.

Step 4 At the Eutelsat S.A. CSC, confirm the remote VSAT terminal ceases to transmit so that no inbound carrier is being radiated.

3. ADDITIONAL FULL LINE-UP TESTS (FLU)

The tests presented in this chapter form, together with the (mandatory) PTLU tests given in Chapter 2, the Full Transmission Line-up. These additional tests are mandatory for the Open Network and recommended for the Closed Networks.

Upon completion, the test results shall be made available to Eutelsat S.A. by mail, fax, telex or any other commercially available data system when requested. Annex 6 to this Module includes the format for the test report.

3.1. C/N versus BER Performance at the Receive Earth Station

Purpose of Test: To record the C_O/N_O and BER performance curve at the receiving earth station by varying the transmit up-link EIRP, in order to reduce the C_O/N_O from nominal in defined steps until sufficient reliable non-zero BER data points are measured to characterise the carrier performance taking into account actual transmission parameters, actual earth station G/T and the demodulation threshold performance.

Test Equipment:
- Spectrum Analyser
- BER Test Set

Test Procedure:

NOTE: This test should only be conducted under clear sky conditions.

Step 1: The carrier under test shall be radiated with the nominal EIRP as established during Test No. 2.1, with the Eutelsat S.A. CSC and/or the receive station confirming the corresponding down-link level and C_O/N_O, before proceeding with the test.

Step 2: At the transmit earth station, connect the BER generator to the modulator input or, if FEC is used, to the FEC encoder input. At the receive earth station, connect the BER receiver to the demodulator output or to the FEC decoder output, if FEC is used. At both earth stations, set the pattern mode switch on the BER test set to a Pseudo Random Bit Sequence (PRBS) for a pattern conforming to the bit rate of the carrier under test:

e.g. 2^{11} - 1 for 64 kbit/s or 2^{15} - 1 for 2 MBit/s

Step 3: At the transmit and receive earth station set, the BER test set according to the manufacturers instructions. The receive earth station records the number of errors over the test period as given below and computes the BER.

Customers bit rate	Approximate Measurement Time
64 kbit/s	60 minutes
128 kbit/s	30 minutes or 2500 errors
256 kbit/s	20 minutes whichever occurs
1920 kbit/s	20 minutes first

Step 4: At the transmit earth station, decrease the EIRP in defined steps (e.g. nominal EIRP -3 dB; -4 dB etc.), and at the receive station measure the BER as prescribed in Step 3. Repeat this process until the receive earth stations modem continuously loses synchronisation. Record for each step, the C_o/N_o, the corresponding up-link EIRP, test period, BER and weather conditions for inclusion in the test report.

Step 5: Increase the transmit earth station's EIRP in increments of 0.3 to 0.5 dB until the receive modem regains sync.

Step 6: Measure and record the C_o/N_o up-link EIRP and BER.

Step 7: Repeat Step 5 through 6 until at least three non-zero BER readings are obtained. Record the BER, EIRP and C_o/N_o. Repeat Step 5 and 6 until a BER reading better than 10^{-6} is obtained.

Step 8: Upon completion of Step 7 above, the transmit earth station shall restore the nominal EIRP as established under Test 2.1.

3.2. BER Continuity Test

Purpose of Test: To validate the BER performance of the satellite radio link between the transmit and the receive earth stations over a 24 hour test period. The test will be conducted under nominal link conditions.

Test Equipment: BER Test Set

Test Procedure:

Step 1: The carrier under test should be radiated with the nominal EIRP and corresponding $(C_o + N_o)/N_o$ as established during Test 2.1.

Step 2: At the transmit earth station, connect the BER generator to the modulator input or, if FEC is used, to the FEC encoder input. At the receive earth station, connect the BER receiver to the demodulator output or to the FEC decoder output, if FEC is used. At both earth stations, set the pattern mode switch on the BER test set to a PSEUDO random bit sequence (PRBS) for a pattern conforming to the bit rate of the carrier under test:

e.g. 2^{11} - 1 for 64 kbit/s or 2^{15} - 1 for 2 MBit/s

Step 3: At the transmit and receive earth station, set the BER test set according to the manufacturers instructions and record, at the receive earth station, the number of errors over convenient test intervals throughout the next 24 hours, and compute the BER.

3.3. Data Polarity Check

Purpose of Test: To verify the correct polarity transmission of data signals between the transmit and receive earth station.

Test Equipment: BER Test Set

Test Procedure:

Step 1: Connect the BER test set to the modem at both the transmit and the receive earth station.

Step 2: At the transmit earth station, an "all zeros" data pattern will be transmitted.

Step 3: If an "all zeros" data pattern is received, the receive earth station's polarity is correct, otherwise a polarity inversion has occurred.

Step 4: Record whether or not the polarity is correct on the test report.

NOTE: Upon completion of this test, forward final test report with all results of the Full Line-Up (FLU) to Eutelsat S.A. For the format of the test report, refer to Annex 6 of this ESOG Module.

4. SMS SYSTEM OPERATION

Digital satellite links in the Eutelsat S.A. SCPC/SMS System are operated on a multiple access basis through common satellite transponders. Any deviation from the parameters initially established can cause degradation of some or all of the digital satellite links being operated through a particular transponder. For this reason, great care should be exercised to keep all system parameters within the specified limits to ensure that degradation of service due to mutual interference does not occur.

Day-to-day operations concerning network maintenance, including such matters as EIRP adjustments and RF network carriers transmission scheduling, will be controlled by the Eutelsat S.A. CSC.

The Network Control Centres (NCCs) shall address all communications, on operation of its earth stations under their responsibilities to the Eutelsat S.A. CSC.

Any temporary deviation from the established parameters considered necessary for operational, maintenance or other reasons requires the prior approval of the Eutelsat S.A. CSC.

Interruption of satellite communication links should be strictly limited to emergencies and routine maintenance causing interruptions should be avoided.

Normal in-station, off-line, routine maintenance of earth station equipment together with checks of operating links should be sufficient to maintain the system in proper operating condition.

Although earth station operators are fully aware of the importance of maintaining their earth stations in optimum operational condition, Eutelsat S.A. stresses the importance of basic precautions at all earth stations and to the system as a whole.

4.1. Reactivation of Digital Satellite Link following an Outage

Following an outage of a digital satellite radio link where the transmit carrier has failed or has been removed, reactivation shall take place in accordance with the following procedure:

a) Prior to reactivation, the NCC of the transmitting earth station advises the Eutelsat S.A. CSC of the carrier(s) to be reactivated.
b) The reactivated carrier will be measured by the Eutelsat S.A. CSC or by alternative monitoring facilities in frequency and power.
c) Following the satisfactory reactivation of the carrier, the NCCs of the receiving earth station(s) will advise the Eutelsat S.A. CSC and NCC of the transmitting earth station that the link is back in service.

4.2. Supervision of Operational Parameters

The most important parameters to supervise with utmost precaution are:

a) Transmit EIRP: Carrier must never be activated without direct control of the Eutelsat S.A. CSC and they should be maintained at the power within the specified limits.

b) Transmit Frequency: The centre frequency of any carrier may not differ from its specified value.

c) Antenna Movement: Transmit carriers should always have their power removed before moving an antenna away from the satellite. In order to avoid variations in down-link EIRP and in crosspolar isolation, particular care should be exercised to keep the tracking accuracy of the antenna within appropriate limits.

d) Transmit Polarisation Isolation: Correct polarisation plane alignment must be maintained at all times.

4.3. Trouble Shooting

The Eutelsat S.A. CSC can assist earth station in locating problems either within the satellite link or the earth station.

In the case where satellite links are interfered with by other RF emissions earth station operators should refer to ESOG Module 140, §9: "Interference Reporting".

Annex A - Finding a Satellite

Step 1: Check azimuth, elevation and polarisation angle calculations.

Step 2: Check magnetic variation figure for earth station 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 existing or temporary RF carrier. Calculate the down converted frequency accurately that you will be viewing on the spectrum analyser. Remember that many LNB's (Low Noise Block down-converters) have fairly inaccurate DRO local oscillators (+/- 2 MHz is common) and this must be taken into account when setting the spectrum analyser span/division and resolution bandwidth.

Step 5: If using the on-board satellite beacon, its level is very low and it linearly polarised. Hence, the position of the feed will affect the beacon level. Also, ensure that the spectrum analysers sweep bandwidth and resolution bandwidth is optimized or the beacon will be impossible to see.

NOTE: The on-board beacon is visible from any point within Eutelsat S.A. satellite beam coverage.

Step 6: 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 is detected.

Step 7: If a temporary RF carrier is being used, it can also be used to peak the polariser. Because of the response of the feed, it is better to "null out" the marker and then rotate back 90° trying to peak directly. If a temporary marker had been used, it is valuable to use the spectrum analyser to find the satellites on-board beacon to double-check, that you are pointed to the desired Eutelsat S.A. satellite.

Annex B - Earth Station Polarization Plane Adjustment

Upon acquisition of the desired satellite (see Annex 1), the following procedure should be employed to optimise the earth station's polarisation plane:

Step 1: Connect the spectrum analyser to the X-polarisation output port of the antenna feed system.

Step 2: Adjust the spectrum analyser to receive the satellites beacon frequency.

Step 3: Gauge carefully the antenna in azimuth (AZ) and elevation (EL) to achieve maximum satellite beacon level on the spectrum analysers screen.

Step 4: When the satellite beacon is shown on the spectrum analysers screen ensure that the instruments sweep bandwidth and resolution bandwidth is optimised.

Step 5: Gauge carefully the polariser (or feed) in clockwise and counter clockwise direction until maximum receive beacon level is optimised. Mark the antenna and polariser (or feed) positions and note the beacon level value.

NOTE: Observe the moderate changes in beacon receive level while gauging the antenna and polariser (or feed) around the maximum beacon level readings.

Step 6: Remove the spectrum analyser from the X-polarisation port and connect the instrument to the Y-polarisation output port of the feed system without changing the previous frequency, sweep bandwidth and resolution bandwidth settings.

Step 7: Re-adjust the instruments sweep bandwidth and resolution bandwidth until the cross-polar component of the beacon level can be clearly measured on the spectrum analysers screen.

NOTE: Observe the very low receive level of the satellite beacon which is to be used for gauging the polariser (or feed) to achieve minimum overall cross-polarisation discrimination.

Step 8: Gauge very carefully the polariser (or feed) in clockwise and counter clockwise direction until minimum beacon level has been reached. Mark position and this beacon level value.

NOTE: Observe the very fast changes in receive beacon level when gauging very slowly the polariser (or feed), in counter clockwise direction, through the minimum beacon level reading on the spectrum analyser screen.

Feed system cross-polarisation optimisation (also called "Nulling") has been achieved when the polariser (or feed) has been adjusted and set to minimum satellite beacon receive level in Y-polarisation.

Minimum receive beacon level in Y-polarisation should normally correspond to maximum receive beacon level in X-polarisation at the same setting of the polariser (or feed).

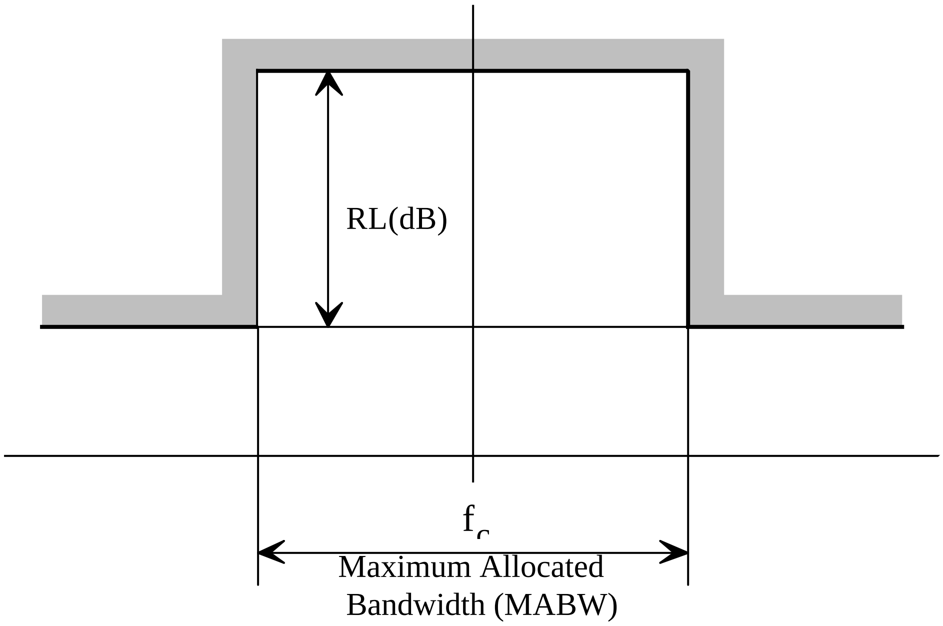
Step 9: Compare the polariser (or feed) setting in X-polarisation with the polariser setting achieved in Y-polarisation (Step 8). It should be the same.

Step 10: Polarisation discrimination has now been optimised on-site.

N.B: Should the Beacon Signal not be available then any other signal radiated from the satellite may be utilise for the above purpose.

Annex C - Spectrum Masks for SMS Carriers

Figure A1: Mask for SMS Services



For the SMS Network, the mask is referenced to the Maximum Allocated Bandwidth.

Normally the Maximum Allocated Bandwidth is defined in order to protect two neighbouring carriers of any type. If however two "similar" carriers are put adjacent to each other, values lower than usual might be allocated.

The Maximum Allocated Bandwidth is determined from the Transmit Symbol Rate (TSR), usually by applying a Filter Roll-off Coefficient of 40 %. The Transmit Symbol Rate in its turn depends on the Transmission Rate (R), and the modulation applied.
The value for RL (Relative Level) depends on the TSR and on the allocated Reference Carrier EIRPo (i.e. the EIRP allocated for a transmit earth station located in the satellite reference contour of -0.5 dB/K for EUTELSAT II and of 0 dB/K for Hot Bird and W satellites); both values, TSR and EIRPo are stated in the Eutelsat S.A. Transmission Plans.
The formulae to calculate RL are:

RL = EIRPo - 10 log10 (TSR) - 36 dB	for: TSR < 4 Msymb/s
RL = EIRPo - 42 dB	for: 4 Msymb/s < TSR < 12.5 Msymb/s
RL = EIRPo - 10 log10 (TSR) - 31 dB	for: TSR >12.5 Msymb/s

with TSR expressed in **Msymb/s.**

Annex D - Theory of C/N Spectrum Analyser Measurement

A convenient method of measuring carrier-to-noise density ratio (C/N_o) uses a spectrum analyser. Good results can be obtained if care is taken in operation of the instrument. The spectrum analyser measurement can be converted to a carrier-to-noise density ratio (C/N_o) by the method described below. A modulated QPSK transmission that uses a scrambler has a spectral density (C_o) at its centre frequency that is a function of the total carrier power and the transmission rate. This can be expressed as :

$$C_o = C - 10 \log (R/2) \quad \text{dBW/Hz} \quad (1)$$

where :	C_o	=	Spectral Density	dBW/Hz
	C	=	Carrier Power	dBW
	R	=	Transmission Rate	bit/s

An alternate form of the same expression is:

$$C_o = C + 3 - 10 \log (R) \quad \text{dBW/Hz} \quad (2)$$

A spectrum analyser using a resolution bandwidth that is less than the signal bandwidth will measure the carrier power spectral density. When a PSK signal is measured in the presence of noise, the spectrum analyser will display the ratio of the carrier spectral density and the noise spectral density. Since the ratio is of two spectral densities, the value will be independent of the actual noise bandwidth of the spectrum analyser resolution filter. Therefore, it is not necessary to know either the noise bandwidth or the log converter RMS correction factor to correctly measure the ratio of two spectral densities.

The ratio of the carrier spectral density and the noise spectral density (which the spectrum analyser measures) is actually a $(C_o+N_o)/N_o$ ratio. The correction factors given in the table on the next page must be used to give the actual C_o/N_o ratio.

$\frac{(C_0 + N_0)}{N_0}$ (dB)	Correction Factor (dB)	$\frac{C_0}{N_0}$ (dB)
3.0	- 3.02	0.0
3.5	- 2.57	0.9
4.0	- 2.20	1.8
4.5	- 1.90	2.6
5.0	- 1.65	3.3
5.5	- 1.44	4.1
6.0	- 1.26	4.7
6.5	- 1.10	5.4
7.0	- 0.97	6.0
7.5	- 0.85	6.6
8.0	- 0.75	7.2
8.5	- 0.66	7.8
9.0	- 0.58	8.4
9.5	- 0.52	9.0
10.0	- 0.46	9.5
11.0	- 0.36	10.6
12.0	- 0.28	11.7
13.0	- 0.22	12.8
14.0	- 0.18	13.8
15.0	- 0.14	14.9
16.0	- 0.11	15.9
17.0	- 0.09	16.9
18.0	- 0.07	17.9
19.0	- 0.06	18.9
20.0	- 0.04	20.0

C_0/N_0 Conversion Table

The C_0/N_0 ratio thus obtained can easily be converted into the common units used to measure signal-to-noise ratios through the following derivation :

C_0	=	$C + 3 - 10 \log (R)$	dBW/Hz	(2)
C	=	$C_0 - 3 + 10 \log (R)$	dBW	(3)
C/N_0	=	$C - N_0$	dB/Hz	(4)
C/N_0	=	$C_0 - 3 + 10 \log (R) - N_0$	dB/Hz	(5)
C/N_0	=	$C_0/N_0 - 3 + 10 \log (R)$	dB/Hz	(6)

Annex E - Relationship Between C/N, $(C_o+N_o)/N_o$ and E_b/N_o

AE.1 C/N_o: Carrier-To-Noise Spectral Density Ratio

The carrier-to-noise spectral density ratio is an "artificial" measure of signal-to-noise ratio. It is artificial in the sense that it implies that it is possible to measure noise power in a filter having a noise bandwidth of 1 Hertz. Real measurements made with actual filters of wider bandwidth must be converted to express the C/N_o. The carrier-to-noise spectral density is a useful measure, as it expresses satellite link performance in terms that are independent of the measuring method. The "artificial" measure can be related to a realisable measurement as:

$C/N_o = C/N + 10 \log (B)$ dB/Hz (1)

Where: C/N is the measured ratio using a filter of bandwidth B Hertz.

It has been assumed that the QPSK signal will occupy a bandwidth equal to 0.6R, where R is the actual transmission rate. This bandwidth, (0.6R), is used to calculate the signal's C/N:

C/N_o	$= C/N + 10 \log (0.6R)$	dB/Hz	(2)
C/N	$= C/N_o - 10 \log (0.6\ R)$	dB	(3)
C/N	$= C/N_o + 2.2 - 10 \log (R)$	dB	(4)

This relation for C/N is only valid for a filter bandwidth equal to the occupied bandwidth of the QPSK signal. It is important to use the actual transmission rate for R.

AE.2 E_b/N_o: Energy Per Bit/Noise Power Per Hertz

The E_b/N_o is commonly used to evaluate the performance of digital modems. It is defined by the general formula as:

$E_b/N_o = C/N_o - 10 \log (\text{data rate})$ dB (5)

where:

E_b	= Energy Per Bit (referred to the data rate)	dBW/Hz
N_o	= Noise Spectral Density	dBW/Hz
C	= Carrier Power	dBW

The data rate in bits per second could be the symbol rate, transmission rate, composite rate or information rate. The E_b/N_o is then referred to the chosen data rate, and it is important to bear that in mind when using the E_b/N_o in any calculations.

Just as a C/N measurement has no real significance without a definition of the measurement bandwidth, E_b/N_o must be carefully specified in terms of the data rate associated with the value. Modems having built-in codecs are typically specified by the manufacturer in terms of the uncoded or input composite data rate E_b/N_o.

The composite data rate is the sum of the information rate and the overhead (OH) bit rate and does not include any bits for forward error correction (FEC).

The composite rate E_b/N_o is defined as follows:

$$E_{bc}/N_o = C/N_o - 10 \log (IR + OH) \qquad (6)$$

where :
IR = information rate (bits/sec)
OH = overhead (bits/sec)

When FEC is used, the "Transmission Rate (R)" is generated by the addition of forward error correction (FEC) information to the uncoded composite rate . The transmission rate is the product of the composite rate and the inverse of the FEC coding rate.

The transmission rate E_b/N_o is defined as follows:

$$E_{bt}/N_o = C/N_o - 10 \log (R) \qquad (7)$$

where: R = transmission ratebits/sec

Thus, the transmission rate of a Rate 3/4 system will be 1.333 (i.e. 4/3) times the composite rate and the transmission rate E_b/N_o will be 1.25 dB (10 log 4/3) less than the composite rate E_b/N_o, for Rate 3/4 FEC.

The transmission rate of a Rate 1/2 system will be 2 times the composite rate. Therefore, the transmission rate E_b/N_o will be 3 dB (10 log 2) less than the composite rate E_b/N_o for Rate 1/2 FEC.
The transmission rate E_b/N_o has particular relevance to spectrum analyser C_o/N_o measurements. For QPSK, the transmission rate E_b/N_o is 3 dB less than the spectrum analysers C_o/N_o. The relationship between C/N_o, C_o/N_o, E_b/N_o and C/N is shown in the following.

AE.3 C_o/N_o, C/N_o, E_b/N_o and C/N

$C/N_o = C - N_o$		dB/Hz	(8)
$C_o = C + 3 - 10 \log (R)$		dBW/Hz	(8a)
$C = C_o - 3 + 10 \log (R)$		dBW	(9)
$C - N_o = C_o - 3 + 10 \log (R) - N_o$		dB/Hz	(10)
$C/N_o = C_o/N_o - 3 + 10 \log (R)$		dB/Hz	(11)
E_{bt}/N_o[1] $= C/N_o - 10 \log (R)$		dB	(7)
Ebt/N_o[1] $= C/N_o - 3 + 10 \log (R) - 10 \log (R)$		dB	(12)
E_{bt}/N_o[1] $= C/N_o - 3$		dB	(13)
E_{bc}/N_o[2] $= C/N_o - 1.75$	(for rate 3/4 FEC)	dB	(14)
E_{bc}/N_o[2] $= C/N_o$	(for rate 1/2 FEC)	dB	(15)

finally, for the C/N in the QPSK occupied bandwidth:

$C/N = C/N_o + 2.2 - 10 \log (R)$	dB	(4)
$C/N = C_o/N_o - 3 + 10 \log (R) + 2.2 - 10 \log (R)$	dB	(16)
$C/N = C_o/N_o - 0.8$	dB	(17)

To reiterate, C_o/N_o is the ratio of carrier to noise spectral density obtained from the spectrum analyser measurement after correction for the $(C_o + N_o)/N_o$ difference. In all cases, R is the actual transmission rate.

$C_o/N_o = C/N_o + 3 - 10 \log (R)$		dB	(11)
$C_o/N_o = E_{bt}/N_o + 3$		dB	(13)
$C_o/N_o = E_{bc}/N_o + 1.75$	for Rate 3/4 FEC	dB	(14)
$C_o/N_o = E_{bc}/N_o$	for Rate 1/2 FEC	dB	(15)
$C_o/N_o = C/N + 0.8$		dB	(18)

NOTE 1: E_{bt}/N_o relates to the transmission rate R.

NOTE 2: E_{bc}/N_o relates to the composite data rate.

Annex F - Format for SMS PTLU/FLU Test Result Report

The next pages give the format of the Test Result Report, to be sent to the CSC upon completion of the line-up testing.

Facsimile and telex addresses of the CSC are given in the list of Operational Contact Points in the back of every ESOG Module.

To : Eutelsat S.A. CSC, Paris

From : ....
(originating earth station)

Copy : ....
(participating earth station(s))

Eutelsat REF : ....
(reference of Eutelsat S.A. Test Plan)

Reference : ....
(reference of reporting entity)

Subject : ....
(subject of Eutelsat S.A. Test Plan)

A. General Information

A.1 Earth station under test : ....
(Eutelsat S.A. e/s code)

A.2 Date and time (utc) of test : ....

....
(actual period of time when testing was conducted)

A.3 Prevailing weather conditions at earth station under test: : ....

A.4 Test conducted by : ....
(name of test manager)

B. Transmit Link Results

B.1	Test 2.1 Carrier transmit frequency and EIRP		
B.1.1	RF carrier frequency	:	MHz
B.1.2	Carrier transmit power reading (only applicable for single carrier)	:	dBm
B.1.3	Corresponding EIRP	:	dBw
B.2	Test 2.2 HPA Output Spectrum		
B.2.1	10 dB bandwidth at IF	:	MHz
B.2.2	10 dB bandwidth at RF	:	MHz
B.2.3	Spectral level at + 0.35 R	:	dBC
B.2.4	Spectral level at - 0.35 R	:	dBC
B.2.5	Spectral level at + 0.5 R or MABW	:	dBC
B.2.6	Spectral level at - 0.5 R or MABW	:	dBC
B.2.7	HPA output meets mask	: Yes / No	
B.2.8	Spectrum plot to be enclosed	: Yes / No	
B.3	Test 2.3 Additional Test for Interactive VSAT Systems		
B.3.1	VSAT System (EUTELSAT Network Code)	:	
B.3.2	Date and Time (UTC) of test	:	
B.3.3	Compliance with Performance Objective	: Yes / No	

C. Receive Link Results

C.1 Test 3.1 Carrier-to-Noise Ratio

C.1.1 $(C_o + N_o)/N_o$ reading : .... dB

C.1.2 Calculated $C_o + N_o$: .... dB

C.1.3 C/N : .... dB

C.1.4 Carrier down link level at CSC : .... dBW

C.1.5 Test 3.2 $(C_o/N_o)/N_o$ versus BER Performance

EIRP at TX Earth Station (dBW)	$(C_o + N_o)/N_o$ at Rx Earth Station (dBW)	BER
Nominal EIRP		
- 3 dB		
- 4 dB		
- 5 dB		
- 6 dB		
- n dB (Sync Loss)		

C.1.6 Spectrum Analyser Type

Resolution Bandwidth : .... kHz

D. Nominal Link Performance

D.1 Test 3.2 BER Continuity Test

D.1.1 Start of Test (Date, Time UTC) : ....

D.1.2 End of Test (Date, Time UTC) : ....

D.1.3 BER : ....

D.1.4 Conclusion : ....

D.2 Test 3.3 Compatibility Test

D.2.1 Data polarity correct : Yes / No

D.3 Type of modem at earth station under test (Manufacturer, Type) : ....
....

D.4 Remarks : ....
....
....
....

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