EUTELSAT S.A.

Systems Operations Guide

ESOG

Volume I

EARTH STATION VERIFICATION AND ASSISTANCE (ESVA)

Module 130

Issue 2.0

EUTELSAT
SYSTEMS OPERATIONS GUIDE

ESOG Module 130

EARTH STATION VERIFICATION AND ASSISTANCE (ESVA)

Issue 2.0 25-07-2000

FOREWORD

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

The ESOG in its final form will consist 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 services. The modules that are contained in this Volume relate to the services provided via EUTELSAT satellites.

Regarding Issue 2.0 of Module 130:

In view to the previous issue 1.1 (and DRAFT issue 2), this version includes the following enhancements:

1. Antennae without angular readout (para. 8.2.2)

2. More details of EUTELSAT beacons (Annex E)

3. Measurement guidelines for spurious radiation (Annex G)

Annex F has been updated and minor editorial changes were made to other chapters.

The ESOG can now be obtained, apart from the printed version, in Acrobat format from the EUTELSAT Internet server:

http://www.eutelsat.com/Satellite information/Technical & operational docs/Uplinking & Satcom Services/EUTELSAT Systems Operation Guide (ESOG).

Paris, 25-07-2000

OVERVIEW ESOG MODULES

VOLUME I

EUTELSAT S.A. SYSTEM MANAGEMENT AND POLICIES

VOLUME II

EUTELSAT S.A. SYSTEMS OPERATIONS AND PROCEDURES

1. INTRODUCTION

EUTELSAT approval procedures require the submission of technical earth station data to demonstrate compliance with the relevant specifications (ESOG Vol. I, Module 100 and Module 110 refer).

In general, this can be achieved by the following means:

- EUTELSAT ESVA facilities.
- Non-EUTELSAT facilities such as:
    - test range, boresight tower, radiostar etc.,
    - other satellite systems.
- Some combination of these facilities.

The purpose of conducting verification tests is to prove that the earth station and/or associated equipment will comply in all respects with the mandatory performance characteristics as set forth in the relevant specifications.

Verification testing involving the use of a EUTELSAT satellite shall be conducted in cooperation with the EUTELSAT ESVA facility and/or a qualified corresponding earth station, under the direction of the EUTELSAT CSC.

ESVA testing, which is an efficient and inexpensive alternative to most other methods, may be required upon request from EUTELSAT or the earth station owner. The ESVA testing may generally be required:

- for new earth stations prior to commencement of service,
- for existing earth stations after major modifications (especially of the RF front end).

Typical parameters which can be measured using a EUTELSAT satellite and are included in the standard program presented in this Module are:

- earth station EIRP,
- transmit gain,
- transmit sidelobes,
- transmit polarisation isolation,
- receive gain,
- G/T,
- receive polarisation isolation,
- receive sidelobe patterns.

The above measurements are generally conducted between an EUTELSAT reference station and a distant earth station under test via the EUTELSAT space segment. This enables testing of a given station at it’s true, operational configuration. For small earth stations (aperture <2 m), such as VSAT or SNG terminals, which are furnished with manual antenna pointing, the pattern measurements may be very time consuming and inaccurate if conducted from a remote site. Such stations may therefore be tested at Rambouillet, where an antenna slewing facility is available.

Presently, EUTELSAT Reference Stations (ERS) for ESVA are ETS1A and ETS1B stations at Rambouillet (France), the TMS-1/4 station at Redu (Belgium), UKI-GHY-008 at Goonhilly (UK) and AUT-AFL-005 at Aflenz (Austria).

2. ESVA REQUIREMENTS

This section includes the conditions which ensure smooth implementation of ESVA, namely:

- prevention of interference to existing traffic,
- consistency of measurement results,
- efficient coordination of testing.

The rules given hereafter apply to **all** ESVA activities including full scale ESVA programmes or parts of it and repetitions.

2.1. Earth Station Preparation

The correct function of all relevant earth station equipment must be verified by preliminary in-station testing. Thus avoiding delay of ESVA and interference to existing traffic during the initial space segment access. As far as possible, the in-station test shall prove compliance of the equipment with the EUTELSAT specification. Additional parameters which are required for ESVA such as:

- antenna slew speed for azimuth and elevation,
- power meter coupling factor and post coupler loss for each TX chain,
- receive coupling factor and receive feed loss if applicable

shall be measured during the preparational phase and results shall be communicated to EUTELSAT.

Before the commencement of the ESVA, the SUT must be already configured for the forthcoming measurements (Figure 4.1 refers). The station shall acquire and track the satellite foreseen for testing and the equipment shall be set to parameters defined in the EUTELSAT test plan.

To eliminate eventual problems at this stage, it is strongly recommended to perform a G/T and a receive sidelobe pattern test, using the satellite beacon.

2.2. Test Coordination

Planning of ESVA activities is based on the initial request for ESVA forwarded by the relevant telecommunications entity (i.e. Signatory or DATE). For new earth stations, this request is made by completion of paragraph 6 of the "APPLICATION FOR APPROVAL TO ACCESS THE EUTELSAT SPACE SEGMENT" (ESOG Module 110, Annex 1). The format of Annex 1 to this Module may be used for already approved stations.

An advance notice of normally 4 weeks prior to the tentative ESVA date, should be given to ensure smooth implementation. EUTELSAT issues a test plan which includes the confirmation of the availability of the ESVA facility (i.e. space segment and reference station). It must be born in mind that due to operational needs, the test plan may be subject to changes at any time on short notice. The test plan contains the time schedule, technical and geographical parameters, contact points and notes required for preparation and execution of the subject test.

Immediately after conclusion of testing, the EUTELSAT Reference Station transmits a provisional test report to the test manager of the station under test. This provisional report provides a summary of all test results. All data is subject to confirmation by EUTELSAT who will issue the final test report usually within 4 weeks following test conclusion.

This final report comprises results and parameters in detail and, will be forwarded to the relevant telecommunications entity who initially requested the subject ESVA.

2.3. Space Segment Access

Prior to commencement of **any** test programme, the Station Under Test (SUT) must contact the EUTELSAT Reference Station (ERS). The reference station will then coordinate with the EUTELSAT CSC the forthcoming test activities. The reference station must obtain the approval of the CSC for space segment access before the start of testing and report to the CSC when testing is terminated or in case of significant interruptions.

Furthermore, each space segment access by a station under test must be endorsed by the EUTELSAT Reference Station. When transmitting, the Station Under Test must maintain contact with the reference station during ALL times. In particular, the SUT must ensure permanent presence of staff at the phone to guarantee instant reaction on ERS directives. If the communication link fails, the Station Under Test must immediately **CEASE** transmissions and attempt to re-establish contact with the reference station. It is therefore essential, that suitable telephone equipment be available and accessible at all relevant sites (e.g.: antenna hub, control room etc.) throughout testing. The appropriate phone(s) must be authorized for international connections and shall preferably be equipped with a loudspeaker. The detailed procedures compulsory to each space segment access are prescribed in paragraph 4.1 of this document.

2.4. Weather Conditions

Atmospherical attenuation and wind may considerably degrade the accuracy of measurements. It is therefore preferable to conduct ESVA testing during clear sky conditions where light windspeeds are not exceeded. If, due to operational needs, testing has to be performed during deteriorated weather conditions, special consideration will be given to evaluation of results. In case of discrepancies, partial or complete repetition of the test programme will be agreed.

2.5. Antenna Alignment

All ESVA tests are based on the perfect initial alignment of the antenna under test. Great care must be taken by the Station Under Test when optimizing the antenna pointing i.e. peaking.

Peaking must be performed initially, i.e. prior to testing,

1. after each antenna movement (e.g. during G/T, antenna sidelobe measurements etc...),

2. after interruption of the test programme,

3. before each measurement during transmissions via satellites in inclined orbit.

The Station Under Test must ensure that optimized pointing is achieved during all measurements. On request, the reference station will provide assistance and guide the Station Under Test.

2.6. Check List

Completion of the following check-list by the Station Under Test, before the start of an ESVA activity will prevent delays.

- ☐ Earth Station equipment functions compliant to specifications
  - ☐ Antenna, drive and tracking system
  - ☐ HPA
  - ☐ LNA (LNB, LNC)
  - ☐ Up and Down-Converters
  - ☐ Station control and waveguide switching
  - ☐ TX chains have been checked for spurious emissions
- ☐ Test equipment is available, calibrated and warm-up period respected
  - ☐ RF synthesizer (frequency drift measured)
  - ☐ RF power meter (auto-zero, calibration factor set)
  - ☐ Spectrum Analyser (calibration procedure completed)
  - ☐ Plotter (connected, calibrated)
- ☐ TX power meter coupling factors and post coupler losses measured for each TX-chain, results sent to EUTELSAT
- ☐ Antenna slew speed measured for azimuth and elevation, results sent to EUTELSAT
- ☐ Satellite as per test plan acquired, antenna pointing optimized (peaking)
- ☐ Polarization alignment optimized
- ☐ Appropriate means for communication during the test are available

–and optional:

- ☐ G/T and antenna RX-pattern measured via satellite beacon

3. TEST EQUIPMENT

The measurement equipment which must be available at the Station Under Test during ESVA, is summarized hereafter. Prior to the start of ESVA, the station operator shall ensure that all test equipment:

- functions correctly,
- warm-up periods are respected,
- calibration procedures have been carried out correctly.

For completion of test records, the test equipment types shall be reported to EUTELSAT.

3.1. RF Power Meter

The RF power meter is required for the measurement of the transmit power and calibration of the station EIRP. At SUT equipped for pilot injection, the power meter is furthermore required for measurement of the pilot level. Generally, the dynamic range of the power sensor should be dimensioned to include the full range of transmit power required during operations and ESVA. Before measurements, the operator shall set the appropriate calibration factor and execute an "Auto-Zero" cycle to ensure accurate results.

Examples[1]: Hewlett Packard 435B; 436A; 437A; 438A
Hewlett Packard EPM 442A
Rhode & Schwarz NRVS
Gigatronix 8541, 8542
Marconi RF Power Meter 6960B

3.2. RF Spectrum Analyser

The spectrum analyser is required for execution of the space segment access test, the measurement of the G/T ratio and the antenna receive sidelobe pattern. Furthermore, it is used for monitoring of the receive frequency range and the HPA output. To facilitate the G/T measurement, it is preferable to use an analyser which permits a direct noise level readout (noise marker). The RF and IF frequency bands of the station under test should be covered by the analyser.

Examples[1]: Hewlett Packard 8566 A/B
Hewlett Packard 8562 A
Wandel & Goltermann SNA-23
Ronde & Schwarz FSEM or FSEK series
Ronde & Schwarz FSIQ 26 or FSP30
Aritsu MS 2802A

A suitable plotter/recorder is necessary for documentation of the antenna pattern test results.

3.3. Signal Source

For the assessment of transmit parameters, a stable signal source is required at the station under test. To prevent interference when testing is conducted via transponders bearing traffic, to obtain a maximum dynamic range and accuracy, the frequency drift, residual modulation and level variation must be kept at a minimum.

The short term frequency drift measured at RF level (e.g. 14 GHz), should be less than 10 Hz per 30 minutes (typical figure: 5 x 10^{-10}/day ageing rate). Therefore, a synthesized source is required for generation of the test signal. Alternatives like the operational modulator require prior endorsement by EUTELSAT and should be considered only in exceptional case:

Examples[1]: Hewlett Packard 8672 A
Hewlett Packard 8673 A
Hewlett Packard 8341 B
Rhode & Schwarz SMP22

1. *The test equipment list is not exhaustive. Alternative test sets e.g. of other manufacturers may be suitable to accomplish ESVA testing*

4. SPACE SEGMENT ACCESS TEST

4.1. Test Objectives

1. To ensure the correct alignment with parameters prescribed in the EUTELSAT test plan.

2. To prevent any interference to existing services.

3. To evaluate basic carrier parameters as frequency drift and EIRP fluctuation in order to estimate possible impairments to test results and to adapt instrument settings at ERS accordingly.

4.2. Principle

Initially, the ERS transmits a marker carrier which shall be identified by the SUT to prove correct pointing. Upon authorization by the ERS, the SUT transmits at low EIRP. The ERS will check value and fluctuation of carrier level and frequency.

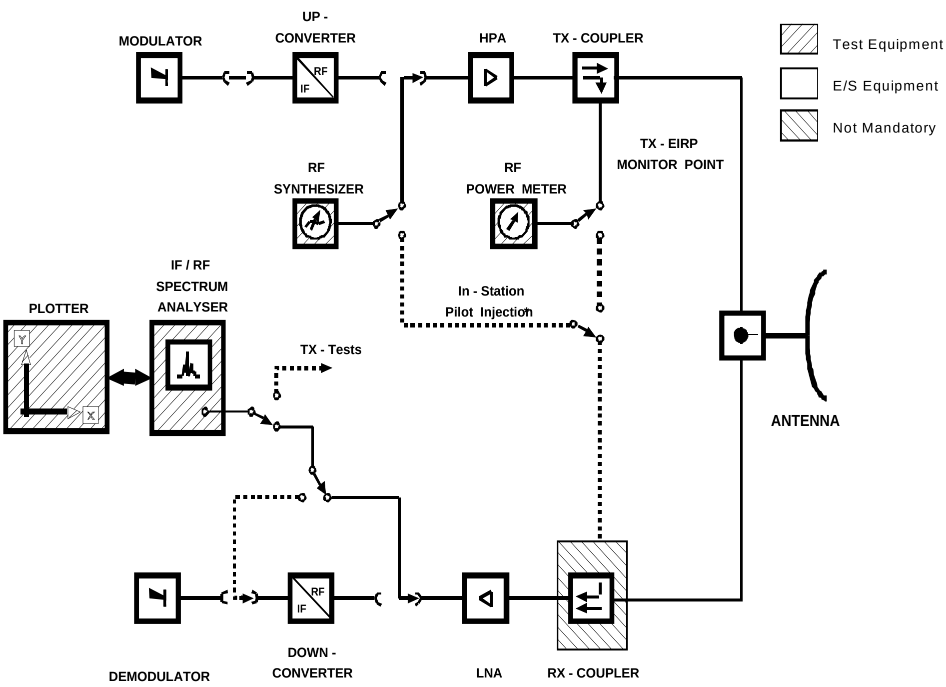

Figure 4.1 : SUT Configuration during ESVA

4.3. Step-by-Step Procedure

A. Acquisition of Satellite

Step 1: Upon successful completion of the independent in-station tests as described under para. 2.1 above and **PRIOR** to the transmission of **ANY** signal, the SUT shall identify, acquire and track the specified satellite.

Step 2: SUT set the polarization angle according to the parameter provided in the EUTELSAT test plan. For further optimization, SUT shall monitor the cross-polar component of the satellite beacon signal. The, SUT shall slowly rotate the polarization plane until the level reaches a minimum.

Note: Where this procedure is not applicable (e.g. for transmission on X polarization from SUT equipped with a 2-port feed), another suitable signal on the satellite may be used.

B. Access Coordination

Step 3: Immediately prior to the scheduled commencement of ESVA (i.e. ~ 5 minutes) the SUT shall establish and maintain phone contact with ERS. SUT shall communicate sky and wind conditions and information on all details which may impair testing.

Step 4: ERS ensure that the allocated frequency range is free of traffic.

Step 5: ERS shall contact the EUTELSAT CSC to obtain authorization for space segment access. If required, CSC arrange for change of satellite configuration on request of ERS.

Step 6: In accordance with parameters of the EUTELSAT test plan, ERS transmit a marker carrier.

Step 7: On request of ERS, SUT monitor the allocated down-link frequency range. SUT reconfirm presence of the marker carrier to ERS.

Step 8: ERS double-checks identification of marker carrier by SUT. Proceed to Step 9 only if identification is affirmative.

C. Transmission by SUT

Step 9: Under direction of the ERS, SUT transmit a carrier at the assigned frequency and EIRP. (The initial EIRP is in general in the order of 50 dBW and it must never exceed 55 dBW).

Note: The SUT must **<u>CEASE</u>** transmissions immediately if the communications link to the ERS fails or if the presence of staff at the SUT phone is interrupted. This rule applies to this and all following tests where the SUT transmits.

Step 10: SUT notify the ERS of the activation of its carrier.

Step 11: If the ERS does not detect the carrier under test within the allocated frequency range, the SUT shall CEASE transmissions. The SUT shall again verify its set-up on:

- correct satellite acquisition,
- polarization plane alignment,
- transmit frequency and
- transmit EIRP

and return to Step 8.

Step 12: ERS check carrier frequency, EIRP and polarization and request corrections if necessary.

Step 13: SUT monitor the receive level of its own transmitted carrier. ERS request SUT to slew SUT antenna first in azimuth and then in elevation to reconfirm correct pointing.

Step 14: SUT report TX power meter reading to ERS and maintain frequency setting throughout following tests.

Step 15: ERS monitor short term (~ 10 minutes) fluctuation of frequency and EIRP of carrier under test.

4.4. Example for Spectrum Analyser Setting

Reference level	: As applicable
Attenuator	: As applicable
Scale	: 1 dB/Division
Centre frequency	: SUT down-link frequency as per test plan (11 or 12 GHz range)
Span	: 200 Hz
Resolution bandwidth	: Auto
Video bandwidth	: Auto
Video averaging	: OFF
Sweep time	: Auto
Marker noise	: OFF
D-Marker	: OFF
Trace	: Clear write A Max. Hold B
Display line	: OFF

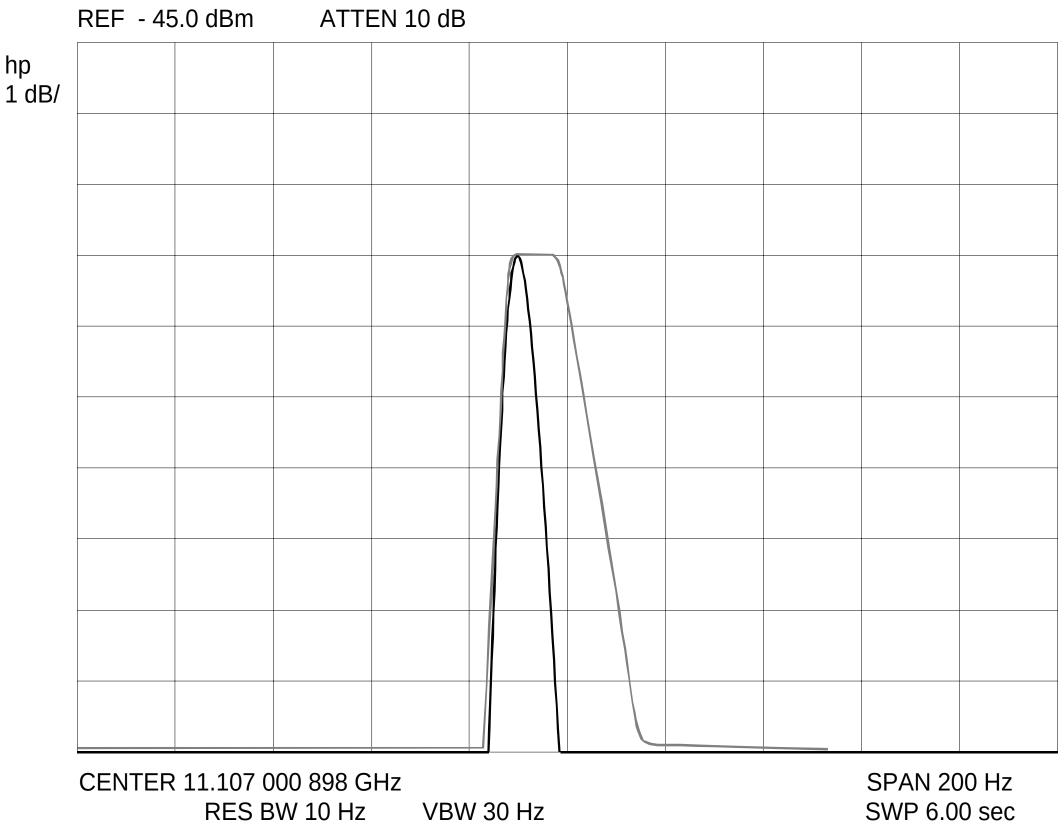

Figure 4.2 : Spectrum Analyser Display at ERS during Space Segment Access Test (Verification of frequency stability)

5. POLARIZATION ALIGNMENT

5.1. Test Objectives

To accomplish optimum alignment of the polarization plane of the SUT antenna with the receive antenna of the satellite, in order to guaranty accurate ESVA measurement results.

For SUT equipped with 4-port feed, to evaluate orthogonality of transmit polarization planes (X and Y).

5.2. Principle

The SUT transmits a carrier via the co-polar channel while the ERS monitors the residual carrier level in the cross-polar channel. Under control of the ERS, the SUT slowly rotates its polarization plane. The ERS records the variation of the cross-polar level and guides the SUT to the angular position where the minimum level is detected (nulling).

The following configurations must be considered:

1. the down-link frequency bands of the co-polar and cross-polar channel are different.

2. The down-link frequency bands are identical but the co-polar satellite channel is switched OFF.

3. The down-link frequency bands are identical and the co-polar channel is ON:

   a) The co-polar channel is set to minimum gain and the cross-polar channel is set to maximum gain.

   b) Gain settings of one or both channels may not be changed.

To avoid influence caused by the down-link, the polarization alignment is performed in configuration 1) or 2) above. The ERS will apply additional precautions in the evaluation of recorded data in case of configurations 3).

For SUT equipped with a 4-port feed, and in order to verify the orthogonality, the alignment procedure is executed via both polarizations (X and Y). The angle indications for the optimum positions are read for X and Y polarization and then compared.

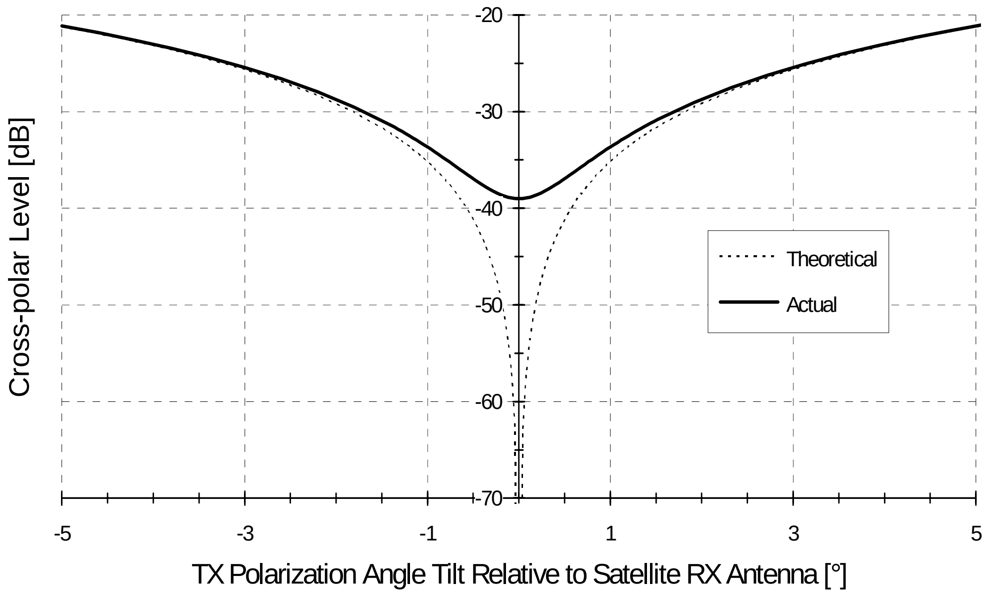

Figure 5.1 : Cross-polar Signal Level as Function of Polarization Plane Alignment

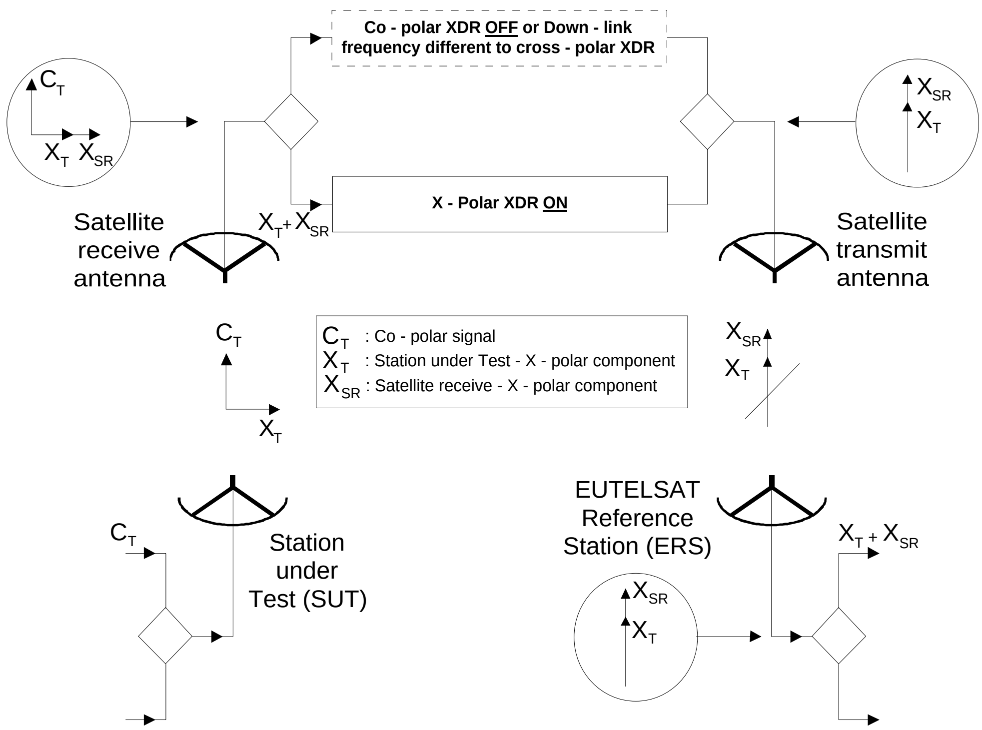

Figure 5.2 : Schematic Representation of Polarization Alignment

5.3. Step-by-Step Procedure

Step 1: If required, CSC arrange for change of satellite configuration on request of ERS.

Step 2: SUT set antenna tracking system to manual mode.

Step 3: Under direction of ERS, SUT transmit a carrier at the frequency as established during the Satellite Access Test and set the EIRP as per test plan.

Step 4: ERS record the level of the cross-polar component of the carrier under test.

Step 5: In coordination with the ERS, SUT rotate slowly the polarization plane in the following way:

1. Rotate towards the anti-clockwise limit. (e.g.: –5° relative to start position).

2. Rotate via the optimum to the clockwise limit. (e.g.: +5° relative to start position).

Note: Values of angles are positive if the rotation is clockwise as seen from the earth station towards the satellite.

Step 6: ERS guide SUT to acquire the optimum position (i.e. where polarization plane of SUT and satellite receive antenna match and a minimum in cross-polar level is observed).

Step 7: SUT secure feed position. ERS verify that the optimum is maintained.

Step 8: SUT report the polarization angle indication to the ERS. If the SUT is not equipped with indicators, the feed position shall be marked.

5.4. Example for Spectrum Analyser Setting

Reference level	: As applicable
Attenuator	: As applicable
Scale	: 5 dB/Division
Centre frequency	: SUT down-link frequency as per test plan (11 or 12 GHz range)
Span	: 0 Hz
Resolution bandwidth	: 100 Hz
Video bandwidth	: 3 Hz
Sweep time	: 100 s or as appropriate
Marker noise	: OFF
Δ-Marker	: Disabled
Trace	: Clear write A
Display line	: Set to minimum

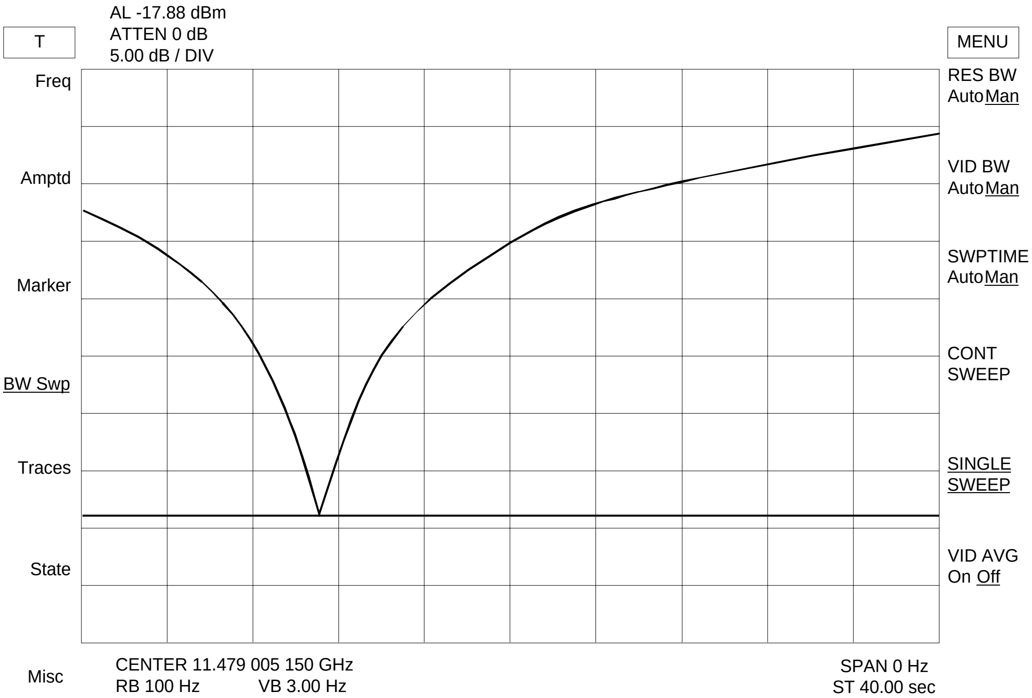

Figure 5.3 : Spectrum Analyser Display during Polarization Plane Alignment

6. EIRP (INCLUDING TRANSMIT GAIN)

6.1. Test Objectives

1. To reconfirm the SUT EIRP calibration prior to commencement of operations.
2. To assess the linearity of the EIRP indication at the SUT.
3. To evaluate the transmit gain of the antenna at the SUT.
4. To measure the maximum EIRP capability of the SUT.

6.2. Principle

6.2.1. Power Balance

The EIRP measurement is based on the up-link power balance technique where the EIRP of the SUT is compared against an accurately calibrated EIRP radiated from the ERS. Corrections for the satellite antenna receive gain (off-axis loss), path loss and atmospherical loss due to the distant location of both stations are applied to obtain the value of the SUT EIRP. To minimize the influence of amplitude-frequency response of the satellite transponder and ERS, the difference of carrier frequencies of SUT and ERS is small (generally < 100 kHz). Carrier levels of both SUT and ERS are equal or differ by no more than 0.2 dB to avoid inaccuracies due to the non-linearity of the satellite TWT.

The following formula applies:

$$EIRP_{SUT} = EIRP_{ERS} + (L_{oa,SUT} - L_{oa,ERS}) + (L_{at,SUT} - L_{at,ERS}) + (l_{fs,SUT} - L_{fs,ERS}) - \Delta \quad (1)$$

where:

where:	L_{oa}	: Off-axis Loss	[dB]
	L_{fs}	: Free space Loss	[dB]
	L_{at}	: Atmospheric Loss	[dB]
	Δ	: Small difference between EIRP of carriers	[dB]

Δ is positive when: $EIRP_{SUT} < EIRP_{ERS}$

Δ is small when: $|\Delta| < 0.2$ dB

L_{at} is measured at the ERS by radiometer during the test. For SUT where no radiometer is available, 0.3 dB shall be assumed for clear sky conditions.

The values of free-space loss (L_{fs}) and off-axis loss (L_{oa}) will be indicated in the relevant EUTELSAT test plan.

6.2.2. EIRP Calibration

At power balance condition, the SUT reads the transmit power meter. This value which corresponds to a (now) accurately known EIRP, shall be noted and used as reference for future operations.

In cases where the power reading during operations will not be derived from the same test point, it is essential to include the operational test point in the calibration procedure.

6.2.3. Linearity of EIRP Indication

EIRP calibration is repeated at several (e.g. 4) different EIRP levels. The range shall include the future operational EIRP of the SUT. It shall thus provide a reliable base for determination of any EIRP value required during forthcoming SUT operations.

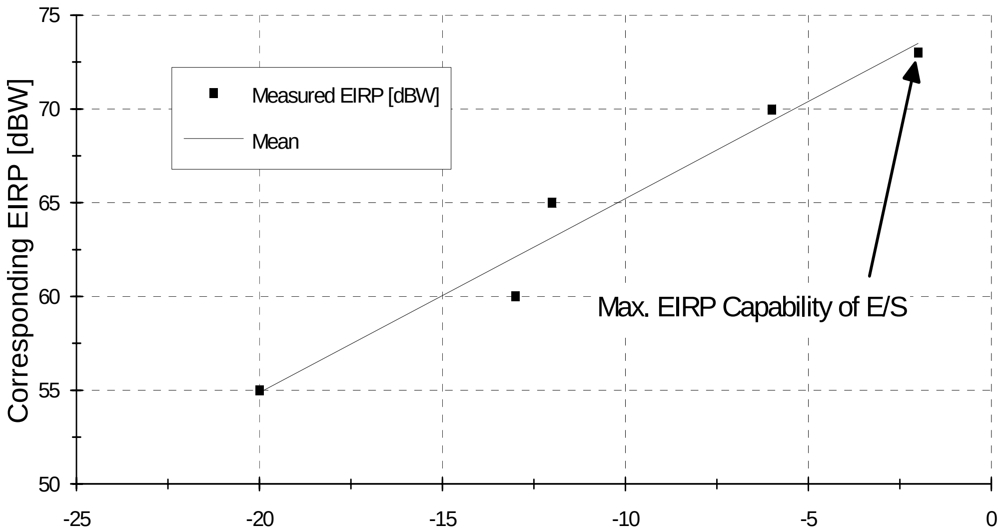

Figure 6.1 : Linearity of TX Power Indication

6.2.4. Transmit Gain

At known station EIRP the antenna TX gain of the SUT may be calculated. During ESVA preparation, TX power meter coupling factor and loss between TX coupler and antenna flange (or interface where antenna gain is defined) have to be obtained by in-station measurements.

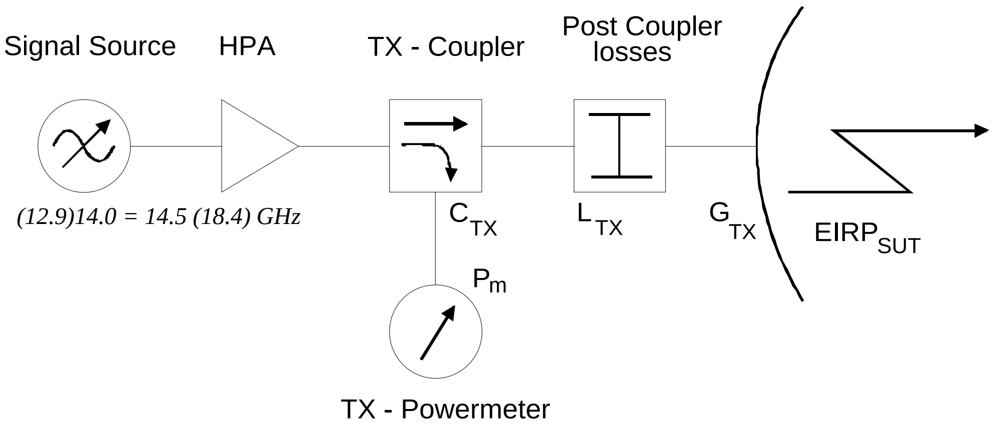

Figure 6.2 : Schematic Diagram of SUT TX-Chain

Using the value of $EIRP_{SUT}$ from equation (1) above, the TX gain is given by:

$$G_{TX} = EIRP_{SUT} - P_m + 30 - C_{TX} + L_{TX} \qquad (2)$$

where:	P_m	: T_x power meter reading	[dBm]
	C_{TX}	: T_x coupling factor	[dB]
	L_{TX}	: Post coupler Losses	[dB]
	30	: Conversion dBW ⇒ dBm	[dB]

To appreciate the measurement result, it is compared to the expected value which may be computed as follows:

$$G = 10\mathrm{Log}_{10}\left(\eta \cdot a \cdot b \cdot \left(\frac{\pi \cdot f}{c}\right)^2\right) \qquad (3)$$

where:	G	: Antenna gain	[dBi]
	η	: Efficiency (assumed at 0.65)	[1]
	a, b	: Major, minor axis of antenna reflector aperture	[m]
	f	: Frequency	[Hz]
	c	: Speed of light (i.e 3 x 10^8)	[m/s]

6.2.5. Maximum EIRP Capability of SUT

Under close control of the ERS, the SUT increases its TX EIRP to the maximum value defined as per test plan or until the saturation of the SUT HPA, which ever is reached first. If applicable, 2 HPAs and phase combiner shall be used during this test. The ERS conducts a power balance and logs the maximum EIRP capability of the SUT as reference for EUTELSAT records.

6.3. Step-by-Step Procedure

A. Preparation

Step 1: SUT forward the following information to EUTELSAT prior to commencement of ESVA:

- Type of feed (2-port, 4-port).
- No of TX-chains.
- Coupling factor (C_{TX}) for each TX chain.
- Post coupling Loss (L_{TX}) for each TX chain.

Step 2: SUT set appropriate calibration factor of TX power meter and conduct an "Auto ZERO" cycle.

B. Power Balance

Step 3: If required, CSC arrange for change of transponder gain setting on request of ERS. ERS transmits the reference carrier at the frequency and EIRP as specified by the ESVA test plan.

Step 4: SUT adjust the EIRP setting to obtain the value specified in the ESVA test plan. Under the direction of the ERS, SUT commence transmission at the frequency established during the Satellite Access Test.

Step 5: If necessary, SUT adjust the EIRP under control of ERS to balance the reference carrier. The difference in level of both carriers as monitored by the ERS shall not exceed 0.2 dB.

Step 6: ERS confirm balance condition.

Step 7: SUT read the TX power meter and report the value to ERS.

C. Linearity

Step 8: If required by the test plan, ERS increase the EIRP of the reference carrier. Under control of ERS, SUT increase the EIRP of the carrier under test.

Step 9: Repeat Steps 5 through 7 for each EIRP level to be calibrated.

Note: In general the EIRP calibration is performed for the following levels:

1. Start EIRP.

2. Start EIRP – 5 dB.

3. Start EIRP – 10 dB.

4. Start EIRP – 15 dB.

The start EIRP is specified in the ESVA test plan.

D. Maximum EIRP Capability

Step 10: Carry out this step only if required by the ESVA test plan, otherwise proceed to Step 12.

Step 11: Under close control of the ERS, SUT increase slowly the EIRP. The increase shall in no case exceed the limits given in the ESVA test plan to avoid interference to traffic or over saturation of the transponder. Below the specified limits, the SUT EIRP may be increased until the SUT HPA or in case of phase combiner, the two SUT HPAs are saturated. SUT report the TX power reading to ERS. If the SUT Tx chain is equipped with several couplers, the calibration is performed using the coupler which is the nearest to the antenna feed. For cross-reference, at least 1 measurement shall be performed for each Tx chain using another coupler(s) (e.g. HPA RF power meter).

Step 12: If the SUT EIRP capability is superior to the limit stated as per test plan, the ERS will request to commute the SUT TX-chain to dummy load and/or to de-point the SUT antenna far off the geostationary arc. Then, the SUT increases its power to its maximum. The corresponding powermeter reading is communicated to the ERS, which will compute the maximum SUT EIRP capability. The SUT reduces its EIRP to the nominal level and ceases transmissions. To proceed with testing, the SUT re-acquires the satellite as previously defined.

Step 13: From the results of the previous power balance, ERS evaluate the maximum EIRP capability of the SUT and the SUT antenna TX gain, and if available, other power indications (e.g. output-power display of HPA).

6.4. Example for Spectrum Analyser Settings

Reference level	: As applicable
Attenuator	: As applicable
Scale	: 1 dB/Division
Centre frequency	: SUT down-link frequency as per test plan (11 or 12 GHz range)
Span	: 200 kHz
Resolution bandwidth	: 30 kHz
Video bandwidth	: Auto
Video average	: 20
Sweep time	: Auto
Marker noise	: OFF
Marker	: Peak search
Δ-Marker	: Δ-peak search
Trace	: Clear write A
Display line	: OFF

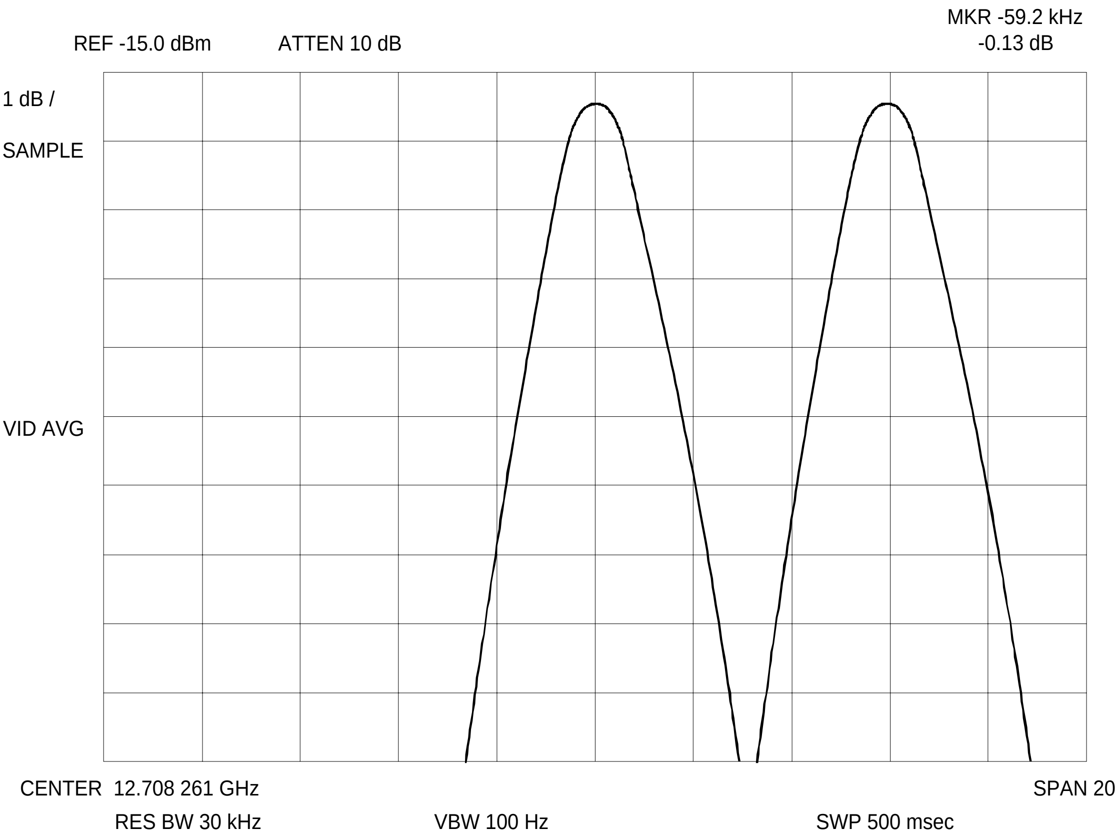

Figure 6.3 : Spectrum Analyser Display during Power Balance

7. TRANSMIT POLARIZATION DISCRIMINATION

7.1. Objectives

To measure the transmit polarization isolation of the Station Under Test at optimized TX polarization alignment. The measurement is carried out at boresight and at 8 samples within the 1 dB contour of the co-polar antenna TX pattern.

In case of non-orthogonal polarization planes, the operational XPD will be lower than measured during ESVA.

7.2. Principle

To measure the EIRP of the SUT, a power balance is carried out via the co-polar channel. Then, the ERS transmits a reference carrier (e.g. 20, 30 or 40 dB below the co-polar level) via the cross-polar transponder. From the difference in level of the reference carrier and the cross-polar component of the carrier under test, the transmit XPD of the SUT is computed. Then in order to verify the performance within the co-polar -1 dB TX contour, the SUT antenna is depointed in azimuth and elevation as described in the figure below

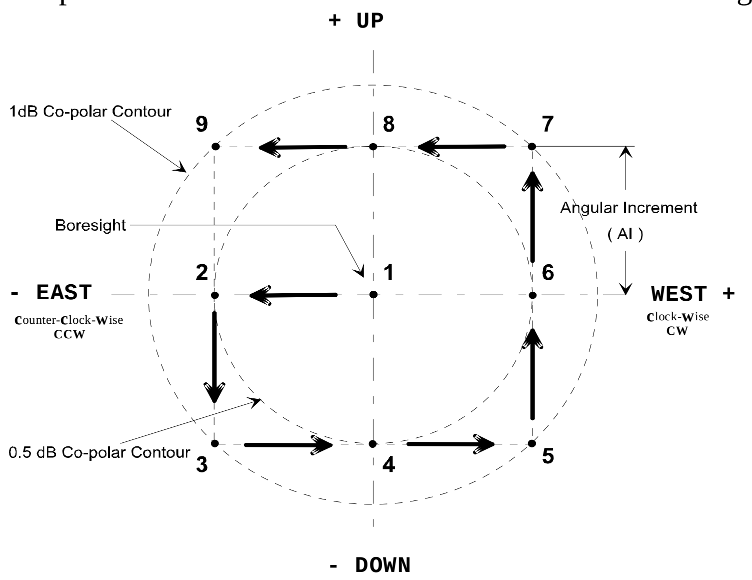

Figure 7.1 : Antenna Depointing Sequence during XPD Measurements

The angular increment for antennas with circular aperture may be estimated by the following expression:

$$AI = \frac{3.978}{d \cdot f} \qquad (1)$$

where: d: Antenna diameter [m]
f: Frequency [GHz]
(Ref.: CCIR Handbook on Satellite Communications).

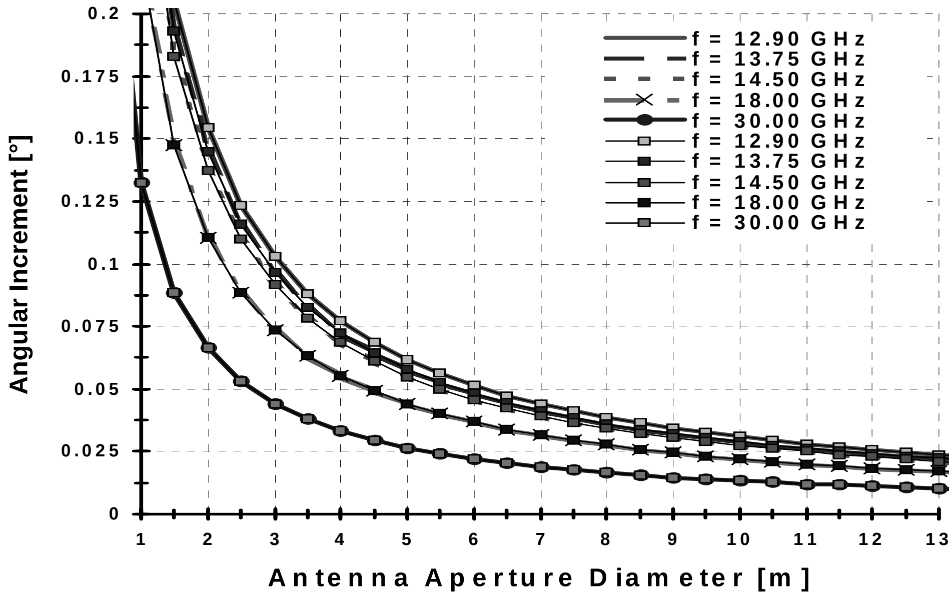

Figure 7.2 : Angular Increment (AI) for TX-XPD Measurements

While the SUT is depointing its antenna, the ERS monitors the variation of the co-polar carrier level and guides the SUT through the defined measurement pattern.

Nine measurements of the difference between the cross-polar component of the carrier under test and the cross-polar reference carrier are taken. Then the test configuration is reversed (i.e. the cross-polar channel becomes co-polar, etc...) and the measuring sequence is repeated. A correction for differences in the up-link off-axis loss between co-polar and cross-polar channel is applied and the XPD of the SUT is computed.

$$XPD = C_{SUT} - X_{SUT} \qquad (2)$$

$$XPD = (C_{ERS} - X_{ERS}) - L_{OA/ERS/C} + L_{OA/ERS/X} + L_{OA/SUT/C} - L_{OA/SUT/X} - D_C + D_X \qquad (3)$$

$(C_{ERS} - X_{ERS})$:	Difference in EIRP of co-polar and cross-polar reference carrier	[dB]
D_C :	Difference between co-polar reference carrier and co-polar carrier under test	[dB]
D_X :	Difference between cross-polar reference carrier and cross-polar component of carrier under test	[dB]
L_{OA} :	Off axis-Loss	[dB]

Index SUT: Station Under Test
Index ERS: EUTELSAT Reference Station
Index C: Co-polar
Index X: Cross-polar

Note: D_C, D_X is positive if the level of the reference is greater than the level of the signal under test.

In case of a perfect power balance via the co-polar channel (i.e. $D_C = 0$ at boresight), the values of D_C are as follows:

Point Nr.	D_C [dB]
1	0
2, 4, 6, 8	0.5
3, 5, 7, 9	1

Table 7.1: Variation of co-polar carrier level during depointing sequence

To eliminate inaccuracies due to the non-perfect XPD performance of the down-link (i.e. satellite transmit antennas, ERS antenna), measurements require one of the following configurations:

a) the down-link frequency bands of co-polar and cross-polar channel are different.

b) the frequency bands are identical but the co-polar channel is switched OFF.

c) the down-link frequency bands are identical and the co-polar channel is ON. The co-polar channel is set to minimum gain and the cross-polar channel is set to maximum gain. In this case the ERS will apply additional precautions in the evaluation of results.

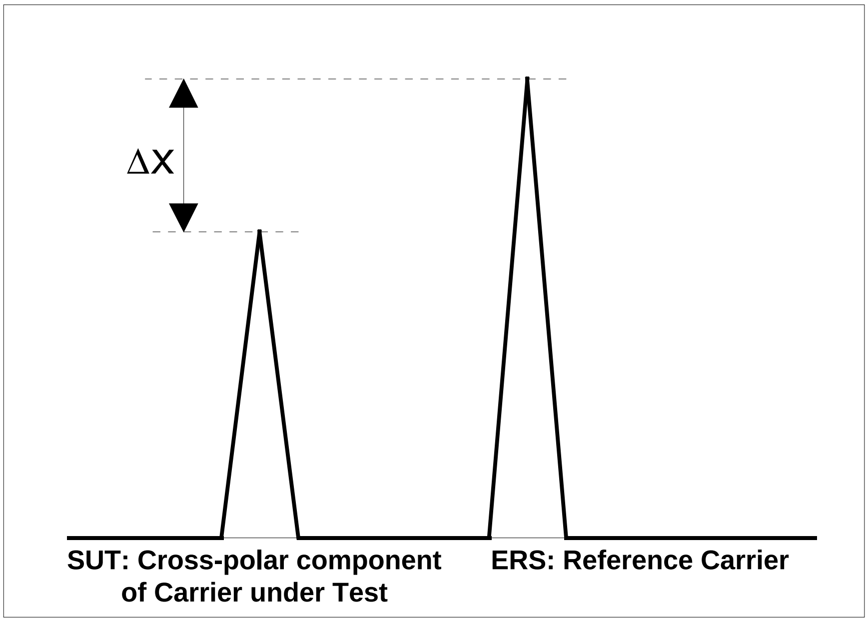

Figure 7.3 : Carrier Configuration during XPD Measurements

7.3. Step-by-Step Procedure

Step 1: CSC arrange for change of satellite configuration (gain settings, channelized section ON/OFF) on request of ERS.

Step 2: ERS transmit the reference carrier via the co-polar channel at the frequency and EIRP as specified in the EUTELSAT test plan.

Step 3: SUT adjust the EIRP setting to obtain the value specified in the EUTELSAT test plan. Under direction of the ERS, SUT commence transmission at the frequency established during the satellite access test.

Step 4: If necessary, SUT adjust the EIRP under control of ERS to balance the reference carrier.

Step 5: ERS confirm balance condition.

Step 6: ERS transmit the reference carrier via the cross-polar channel at EIRP (generally 20 ... 40 dB below co-polar) and frequency as specified in the EUTELSAT test plan.

Step 7: ERS measure the difference in level between the reference carrier and the cross-polar component of the carrier under test.
ERS compute the value of the TX-XPD of the SUT.

Step 8: In coordination with the ERS, SUT move the antenna off-boresight according to Figure 7.1. The angular increment (AI) is given in the EUTELSAT test plan. ERS monitor the variation of the co-polar level of the carrier under test. If necessary, guide the SUT to the required antenna positions.

Step 9: Repeat Step 7.

Step 10: Repeat Steps 8 and 9 for the remaining points.

7.4. Example for Spectrum Analyser Settings

Co-polar Signal:

Reference level	: As applicable
Attenuator	: As applicable
Scale	: 1 dB/Division
Centre frequency	: SUT down-link frequency as per test plan (11 or 12 GHz range)
Span	: 200 kHz
Resolution bandwidth	: 10 kHz
Video bandwidth	: 3 kHz
Video average	: ON (10 samples)
Sweep time	: Auto
Marker noise	: OFF
∆-Marker	: ON (Marker peak search at boresight)
Trace	: Clear write A
Display line	: ON (Set to level at boresight)

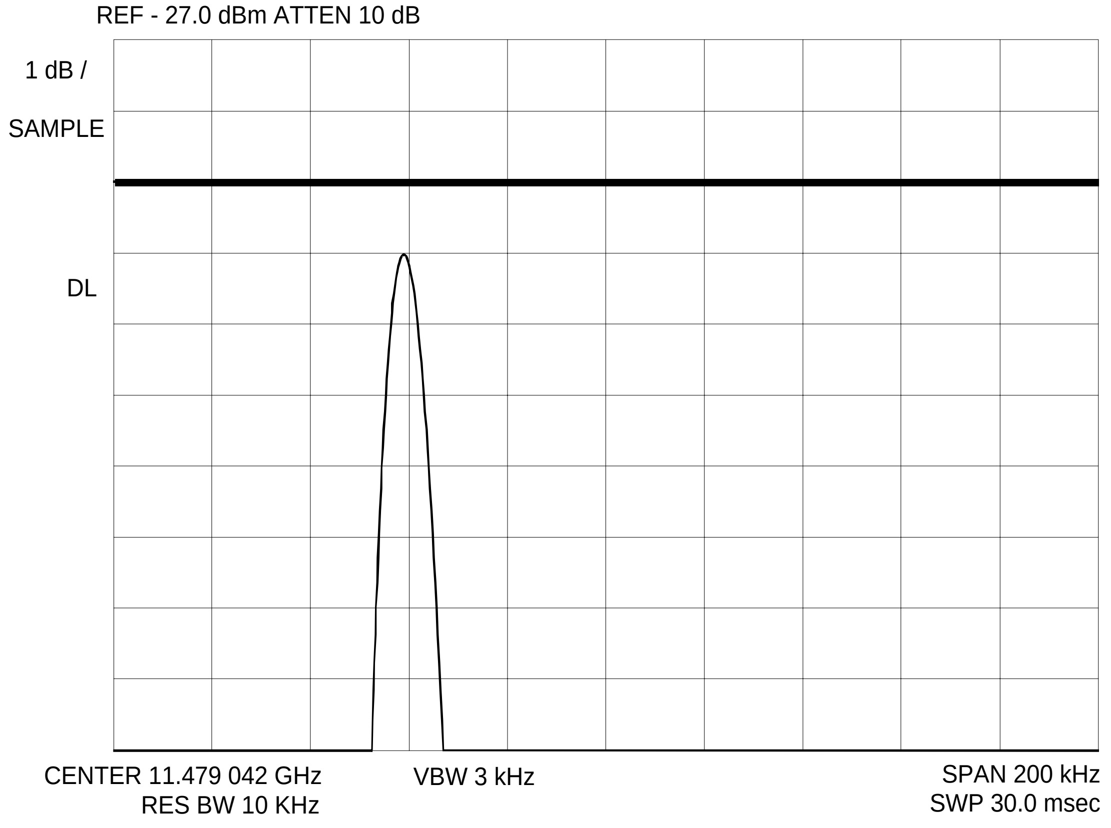

Figure 7.4 : Spectrum Analyser Display during TX-XPD Measurement (Co-polar Signal)

Cross-polar Signal:

Reference level	: As applicable
Attenuator	: As applicable
Scale	: 5 dB/Division
Centre frequency	: Centre between down-link frequencies of SUT and ERS (11 or 12 GHz range)
Span	: As applicable
Resolution bandwidth	: As applicable
Video bandwidth	: As applicable
Video average	: ON (10 samples)
Sweep time	: Auto
Marker noise	: OFF
Δ-Marker	: ON (Marker set to ERS carrier, Δ-Marker to SUT cross-polar signal)
Trace	: Clear write A
Display line	: OFF

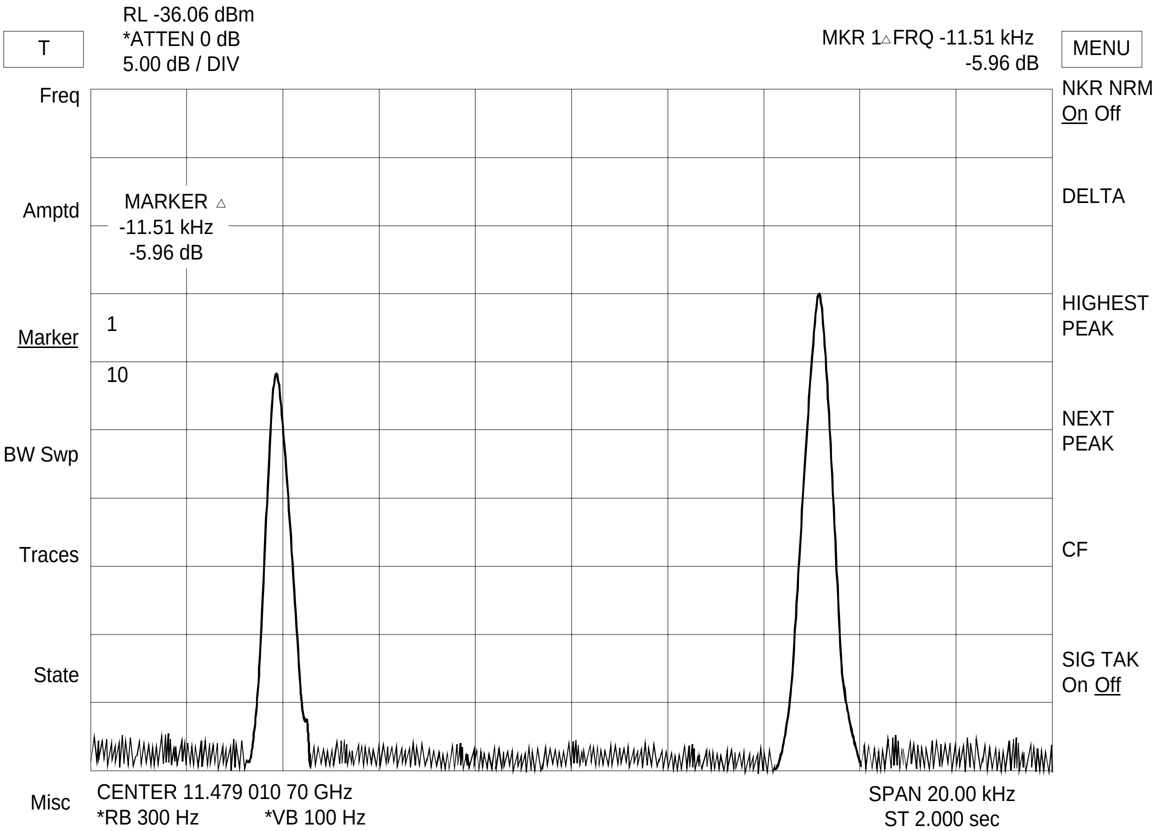

Figure 7.5 : Spectrum Analyser Display during TX-XPD Measurement (Cross-polar Signal)

8. TRANSMIT SIDELOBES

8.1. Test Objectives

To record the co- and cross-polar radiation diagrams of the antenna of the station under test, the result shall enable EUTELSAT to determine the maximum permissible EIRP limits of the SUT.

8.2. Principle

8.2.1. General

While transmitting a carrier the SUT slews its antenna in azimuth or elevation and communicates continuously the antenna position readout to the ERS. The ERS records the level of the co- and cross-polar component of the received carrier. Prior to the antenna measurement the ERS performs a calibration to compensate inaccuracies which may be caused by non-linearity of the satellite transponder or the ERS RX chain. The ERS processes angular information, calibration data and the recorded level to produce the antenna pattern. For azimuth cuts, the following correction is applied to compute the true angle from the azimuth readout.

$$\sin(Az'/2) = \sin(Az/2) \cdot \cos(El) \qquad (1)$$

Where: Az' : Real angle from boresight.
Az : Azimuth as read from encoders.
El : Elevation under which the test is performed.

To facilitate the evaluation the following envelope is given in Figure 8.2.

Co-polar:	$G = (29 - 25 \log_{10}(\Theta))$ dBi	1° <	Θ	< 7°
	G = +8 dBi	7° <	Θ	< 9.2°
	$G = (32 - 25 \log_{10}(\Theta))$ dBi	9.2° <	Θ	< 48°
	G = −10 dBi	48° <	Θ	
Cross-polar:	$G = (19 - 25 \log_{10}(\Theta))$ dBi	1° <	Θ	< 7°
	G = -2 dBi	7° <	Θ	< 20°

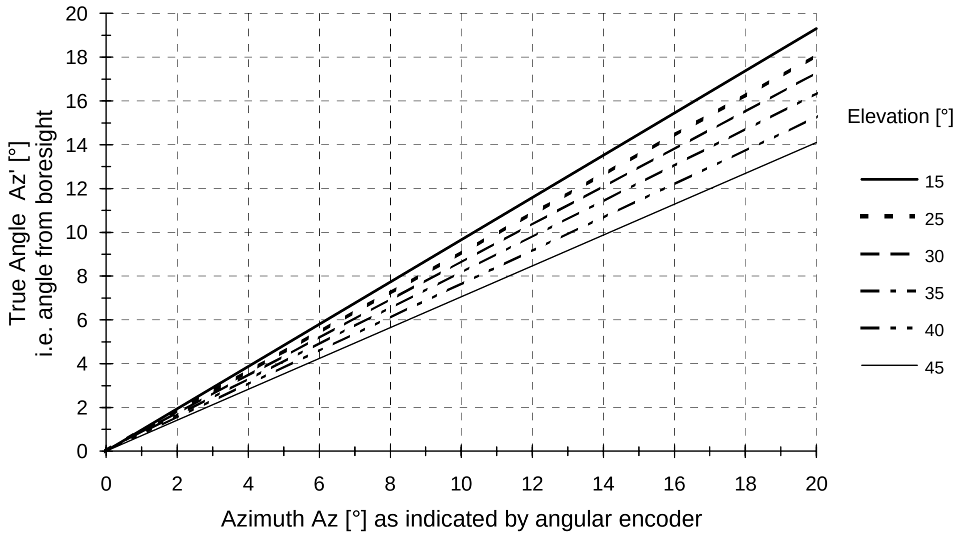

Figure 8.1 : True Angle (Az') as Function of Azimuth (Az)

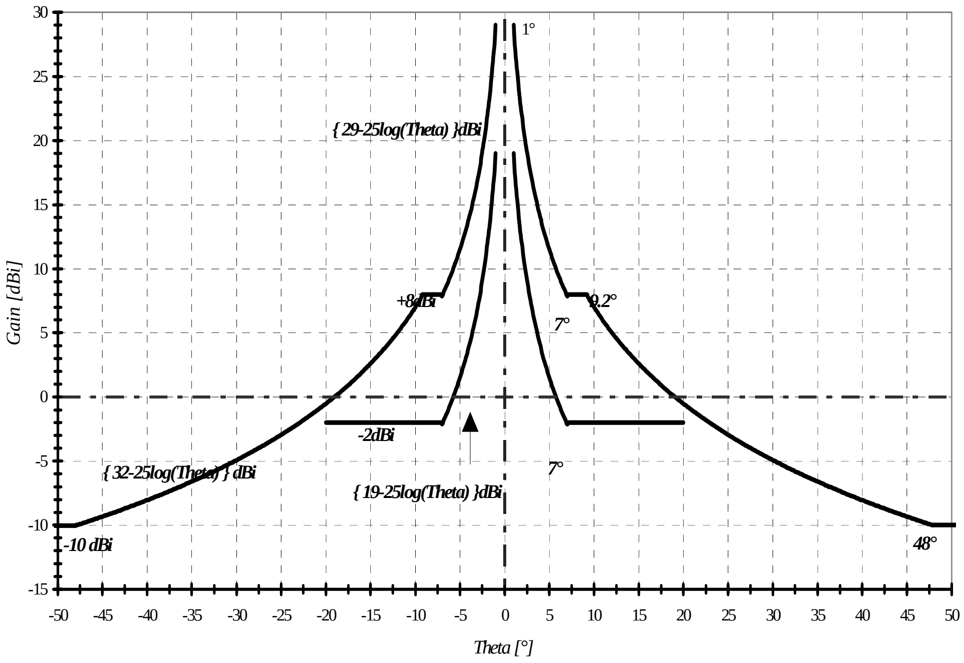

Figure 8.2 : Envelope for Co-polar TX Sidelobe Pattern

8.2.2. Antennae without Angular Readout

Sidelobe measurements for antennae that are not equipped with a pointing angle display are carried out following the same procedures as apply for standard configurations. However, the earth station operator must establish angular graduations for the azimuth and elevation axis. For elevation, this is normally achieved by placing a precise inclinometer on a convenient spot of the antenna structure. Figure 8.3 shows a simple implementation of an azimuth scale. Both azimuth and elevation scales need not be calibrated in absolute readings but they must provide sufficient resolution to allow the SUT operator to clearly indicate “marks” at each degree of antenna movement.

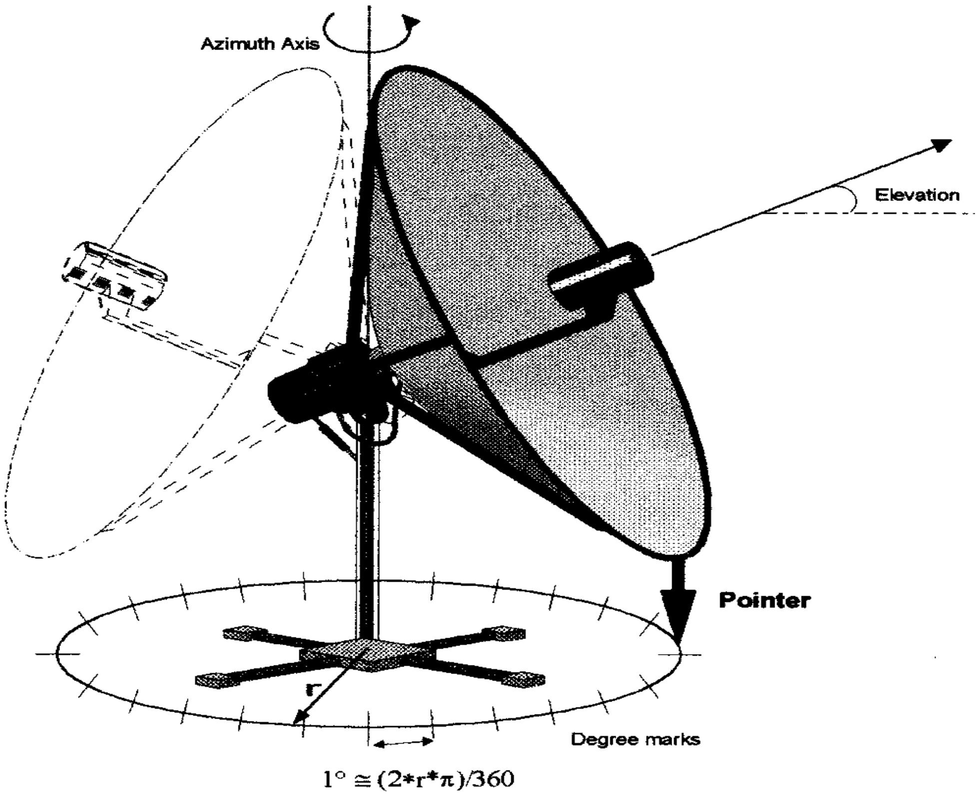

Figure 8.3 : Schematic presentation of Earth Station Set-up for Azimuth Read-out

8.3. Step-by-Step Procedure

This procedure is applicable to earth stations equipped with motorized antenna drives.

A. Preparation

Step 1: During ESVA preparation, prior to commencement of testing, SUT investigate the slew speed for azimuth and elevation antenna movement and forward the values to EUTELSAT. An antenna slew speed suitable for pattern measurements is in the order of 0.1° per second. If various settings are available (e.g. SLOW and FAST), all speeds should be communicated to EUTELSAT. If these parameters are not provided by the station manufacturer, the slew speed should be measured by the method described hereafter (Steps 1.1 through 1.9).

No signals shall be transmitted during this part of the test.

No signals shall be transmitted during this part of the test.

Step 1.1: Acquire the beacon of the satellite specified in the test plan. Optimize the antenna pointing for maximum receive signal level.

Step 1.2: Move the antenna in azimuth 5° counter-clockwise.

Step 1.3: Measure the time of the azimuth movement from –5° via beamcentre to +5° (i.e. clockwise antenna motion from East to West). Calculate the azimuth slew speed in degrees per second.

Step 1.4: For motorized antennas which are not equipped with angular encoders, Steps 1.1 through 1.3 shall be repeated at least 3 times and results shall be averaged.

Step 1.5: Repeat Step 1.1.

Step 1.6: Move the antenna in elevation 5° down.

Step 1.7: Measure the time of the elevation movement from –5° via beamcentre to +5° (i.e. ascending antenna motion). Calculate the elevation slew speed in degrees per second.

Step 1.8: If applicable, repeat Step 1.4.

Step 1.9: Report results prior to commencement of ESVA to the EUTELSAT System Verification Test Section.

B. Power Balance

Step 2: If required, CSC arrange for change of transponder gain setting on request of ERS. ERS transmit the reference carrier at the frequency and EIRP as specified in the EUTELSAT test plan.

Step 3: ERS perform a calibration of the satellite loop by recording the ERS carrier for an EIRP range of 60 dB below the initial value in 10 dB steps. Proceed with step 6 if co-polar patterns only are recorded.

Step 4: ERS transmit the reference carrier via the cross-polar channel at EIRP (generally 20.40 dB below co-polar) and frequency as specified in the EUTELSAT test plan.

Step 5: ERS measure the difference in level between the reference carrier and the cross-polar component of the carrier under test. ERS compute the cross-polar antenna gain of the SUT.

Step 6: SUT adjust the EIRP setting to obtain the value specified in the EUTELSAT test plan. Under direction of the ERS, SUT commence transmission at the frequency established during the satellite access test.

Step 7: If necessary, SUT adjust the EIRP under control of ERS to balance the reference carrier.

Step 8: ERS confirm balance condition.

Step 9: ERS cease transmission of the reference carrier.

C. Azimuth Pattern

Step 10: Considering the outcome of the Satellite Access Test, ERS optimize spectrum analyser settings for reception of the SUT carrier.

Step 11: Upon request by the ERS, SUT interrupt transmission for a short interval. ERS proceed with optimization of analyse settings. SUT activate carrier on request of ERS.

Step 12: Under direction of the ERS, SUT move the antenna starting from boresight to +1° clockwise (i.e. to the West). ERS verify the antenna slew speed.

Step 13: In close coordination with the ERS (Figure 8.4 refers), SUT move the antenna to the "counter clockwise" limit (i.e.: from the start position via boresight to the East). The value of the East limit (e.g. –25° off beamcentre) is stated in the test plan. ERS record the pattern.

Step 14: SUT switch off the carrier and return to boresight. Under the direction of the ERS, SUT recommence transmission and optimise antenna pointing for maximum receive level. SUT cease transmission if no further antenna measurements follows.

Step 15: Repeat Steps 10 through 12 for the "clockwise" antenna movement, i.e. from –1° via boresight to the West limit (e.g. +25° off beamcentre).

D. Elevation Pattern

Step 16: Under direction of the ERS, SUT move the antenna starting from boresight to +1° up in elevation. ERS verify the antenna slew speed.

Step 17: In close coordination with the ERS (Figure 8.4 refers), SUT move the antenna to the "lower" limit (i.e. from start position via boresight down). The value of the lower limit is stated in the test plan (e.g. –15° off beamcentre). ERS record the pattern.

Step 18: SUT switch off the carrier and return to boresight. Under direction of the ERS, SUT recommence transmission and optimize antenna pointing for maximum receive level. SUT cease transmission if no further antenna measurements follow.

Step 19: Repeat Steps 14 through 16 for the ascending antenna movement, i.e. from –1° via boresight to the "upper" limit (e.g. +15° off beamcentre).

Step 20: ERS process measurement data and produce plots of co-polar azimuth and elevation antenna TX diagrams including the appropriate masks.

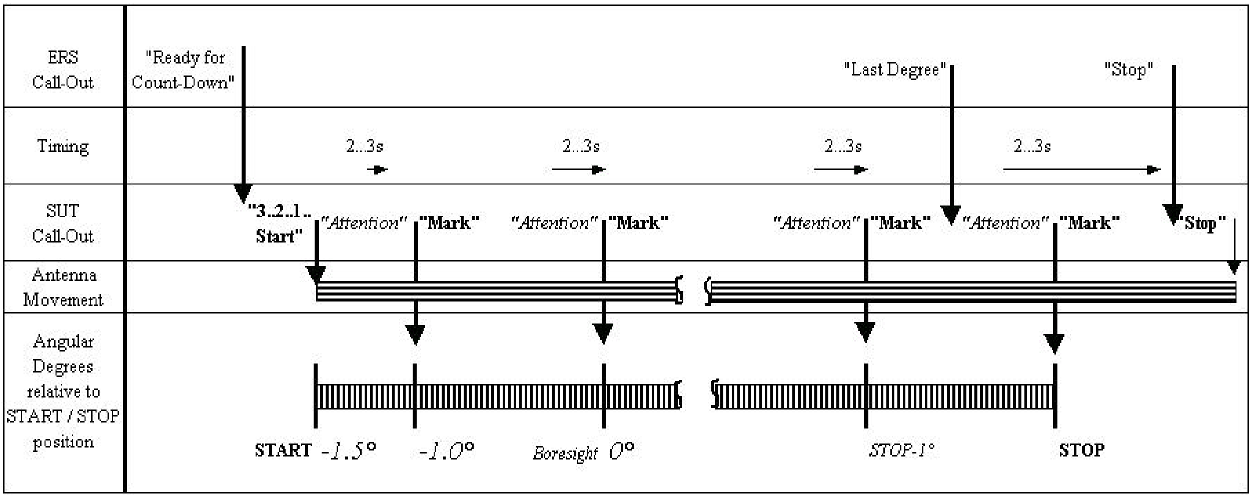

Figure 8.4 : Coordination Scheme during Antenna Pattern Measurements

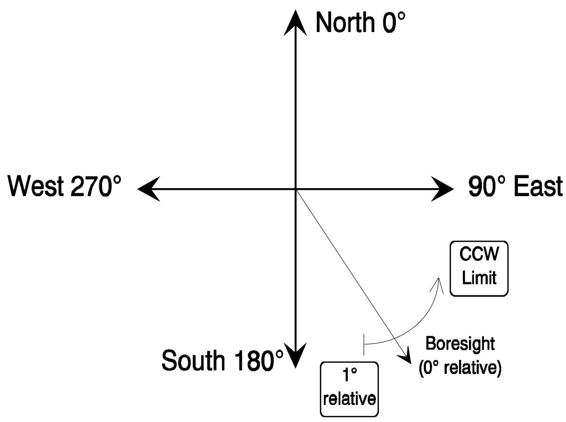

Figure 8.5 : Terminology for Azimuth Antenna Movement

Cut Nr.	Azimuth/Elevation	Antenna Movement	Direction
1	Az	+1° to CCW limit	Towards East
2	Az	-1° to CW limit	Towards West
3	El	+1° to lower limit	Down
4	El	-1° to upper limit	Up
CW: Clockwise		CCW: Counter-clockwise	

Table 8.1: Summary of Antenna Pattern Measurement

Note: Relative azimuth angles are not corrected for non-orthogonality. They are therefore equivalent to angular encoder readout at the earth station.

Note: The SUT shall drive its antenna to a start position which is offset by 0.5° to 1.0° (depending on slew speed) to the actual commencement of the recorded diagram.

8.4. Example for Spectrum Analyser Settings

Reference level	: As applicable
Attenuator	: 0 dB
Scale	: 10 dB/Division
Centre frequency	: SUT down-link frequency as per test plan (11 or 12 GHz range)
Span	: 0 Hz
Resolution bandwidth	: 30 Hz (or 10 Hz)
Video bandwidth	: 1 Hz
Sweep time	: According to antenna slew speed e.g. 500 sec.
Marker noise	: OFF
D-Marker	: OFF
Trace	: Clear write
Display line	: Position to noise floor

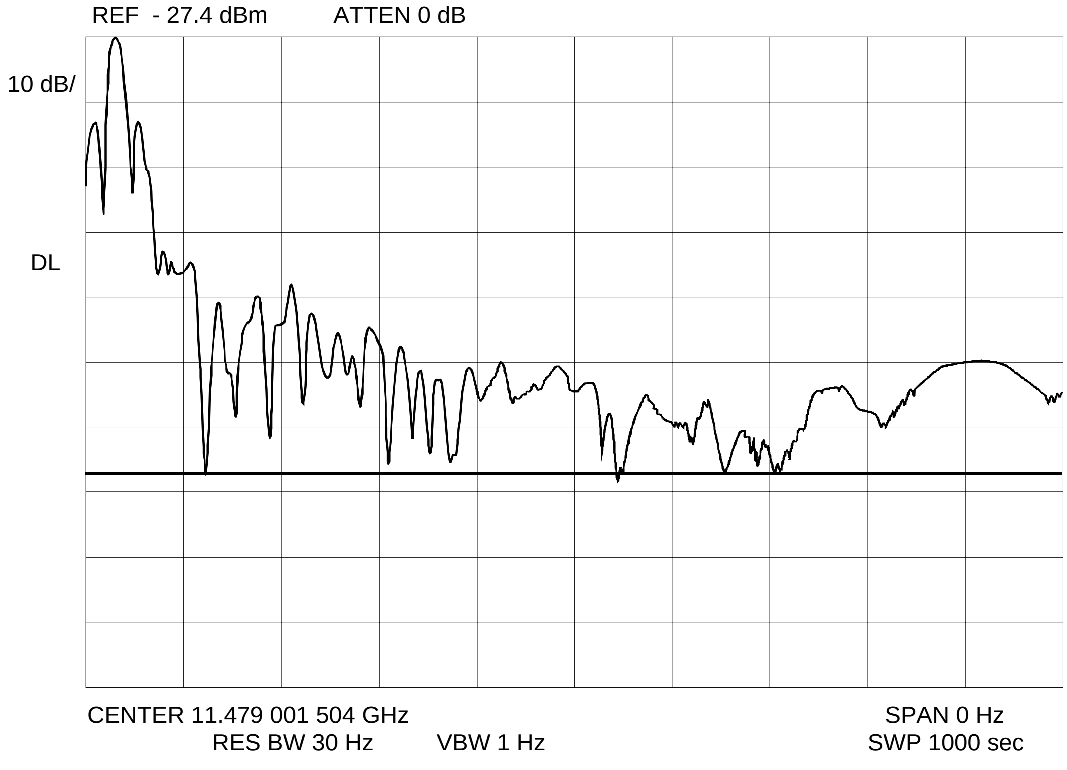

Figure 8.6 : Spectrum Analyser Display during Antenna Pattern Measurement

9. G/T

9.1. Test Objectives

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

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

9.2. Principle

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

$$G/T_{SUT} = L_{fs,SUT} + L_{at,SUT} + B + K - EIRP_{SAT/SUT} + R \qquad (1)$$

$$R = 10\ Log_{10}\,(10^{(P_C - P_N)/10} - 1) \qquad (2)$$

if: $P_C - P_N > 20,$ (3)

the expression (2) may be simplified to

$$R = P_C - P_N \qquad (4)$$

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

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

f = frequency (Hz)
d = distance (m)
c = 299792458 (m/s)

L_{at}	: Athmospheric attenuation at SUT	[dB]
B	: Equivalent noise bandwidth	[dBHz]
K	: Boltzmann's constant:	
	$(1.38051 \cdot 10^{-23}$ Ws/K $\cong -228.60$ dBWs/K)	[dBWs/K]
$EIRP_{SAT/SUT}$	: Satellite EIRP towards SUT	[dBW]
P_C	: Carrier level (C + N)	[dBm]
P_N	: Noise level (N)	[dBm]
R	: Power ratio $\left(\frac{C+N}{N}\right)$	[dB]

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

	11 GHz range:	0.20 dB
	12 GHz range:	0.25 dB

Note: For spectrum analyser measurements, (3) must be valid at resolution bandwidth even if readout is normalized to 1 Hz.

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

$$EIRP_{SAT/SUT} = EIRP_{SAT/ERS} + L_{OA/ERS} - L_{OA/SUT} \qquad (5)$$

where:

$EIRP_{SAT/ERS}$	: Satellite EIRP towards ERS	[dBW]
$L_{OA/ERS}$	: Off-axis loss towards ERS	[dB]
$L_{OA/SUT}$	: Off-axis loss towards SUT	[dB]

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

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

1. Translation from resolution bandwidth to noise bandwidth: ....–0.8 dB

2. Combined correction for detector characteristics and logarithmic shaping: ....+2.5 dB

The total typical correction is therefore: **.............................+1.7 dB**.

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

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

9.3. Step-by-Step Procedure

A. Transmission of Reference Carrier

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

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

B. Measurement of Carrier Level

Step 2: ERS measure the satellite EIRP of the reference carrier and compute the corresponding EIRP towards the SUT.

Step 3: With the antenna at boresight, SUT measure the reference carrier level at RF and IF interfaces. For beacon measurements, the applicable resolution bandwidth shall be agreed between ERS and SUT. (Figure 9.1 through 9.2). SUT report the value to the ERS.

C. Measurement of Noise Level

Step 4: At a small frequency offset (e.g. 100 kHz), SUT measure the noise level.

Step 5: SUT move the antenna off to the satellite, preferably in azimuth by at least 5°. While slewing the antenna, SUT monitor the noise level. The antenna movement may be stopped when the noise level does no longer decrease.

Step 6: SUT terminate the spectrum analyser input and read the noise level.
Report the value to the ERS.

Step 7: SUT connect the spectrum analyser to the RF interface. With identical settings of Steps 5, 6 above, SUT measure the noise level (Figure 9.3). SUT reports the value to the ERS.

Step 8: Repeat Step 7 with the analyser connected to the IF interface.

D. Evaluation

Step 9: If applicable, SUT report the relevant correction factors and the bandwidth to ERS. SUT return the antenna to boresight.

Step 10: ERS communicate value of the satellite EIRP to SUT and calculate the value of the G/T.

9.4. Example for Spectrum Analyser Settings

Measurement of Carrier Level (Note: ERS may advice to apply different settings)

Reference level	: Equal to level of reference carrier
Attenuator	: 0 dB
Scale	: 10 dB/Division
Centre frequency	: ERS down-link frequency as per test plan (11 or 12 GHz or IF range)
Span	: 500 kHz
Resolution bandwidth	: 10 kHz
Video bandwidth	: 100 Hz
Video average	: ON (10 samples)
Sweep time	: Auto (1.5s)
Marker noise	: OFF
Δ-Marker	: OFF, Marker peak search
Trace	: Clear write A
Display line	: OFF

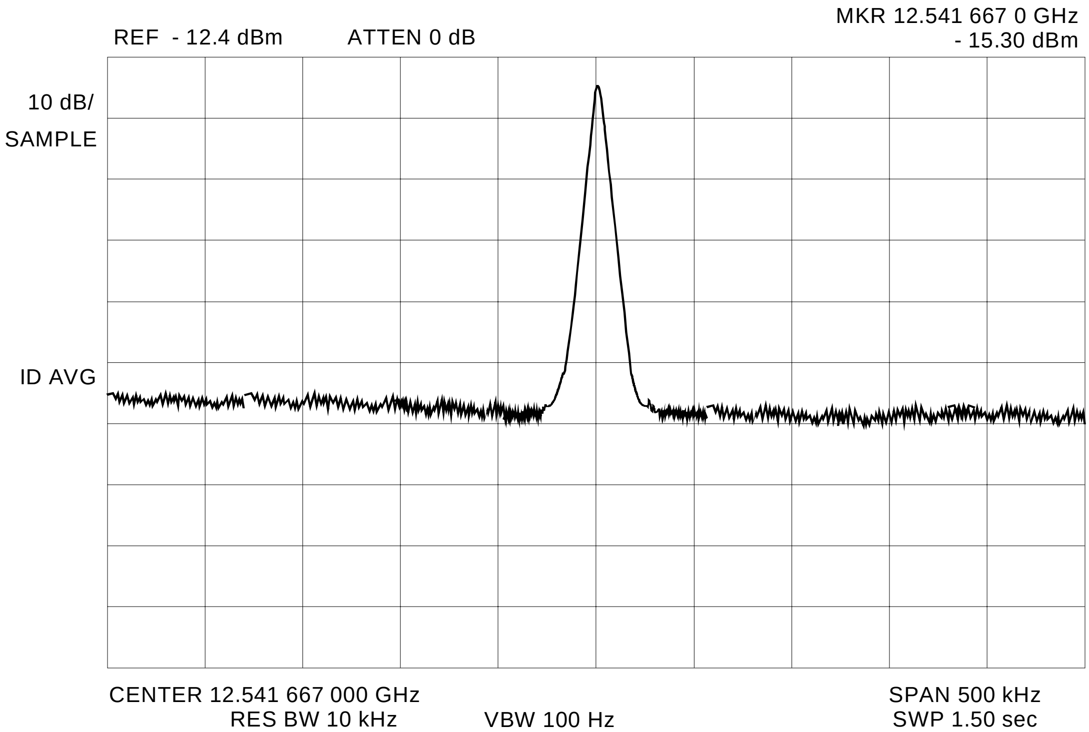

Figure 9.1 : Spectrum Analyser Display during G/T Measurement (Carrier Level)

Measurement of Beacon Level (Note: ERS may advice to apply different settings)

Reference level	: Equal to beacon level
Attenuator	: 0 dB (or different value as appropriate for given test point)
Scale	: 5 dB/Division
Centre frequency	: Beacon frequency as per test plan (11 or 12 GHz or IF range)
Span	: 500 kHz
Resolution bandwidth	: 10 kHz
Video bandwidth	: 100 Hz
Video average	: ON (10 samples)
Sweep time	: Auto (1.5s)
Marker noise	: OFF
Δ-Marker	: OFF, Marker peak search
Trace	: Clear write A
Display line	: OFF

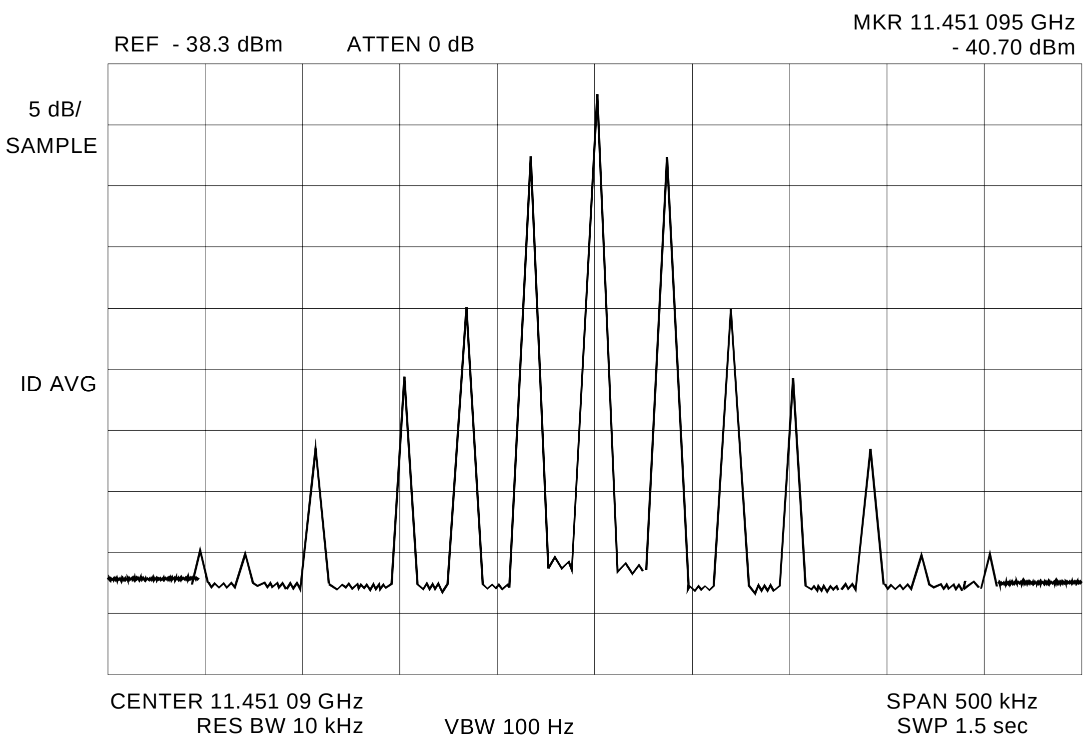

Figure 9.2 : Spectrum Analyser Display during G/T Measurement (Beacon Level)

Measurement of Noise Level (Note: ERS may advice to apply different settings)

Reference level	: 0.... 5 dB above noise floor
Attenuator	: 0 dB (or different value as appropriate for given test point)
Scale	: 10 dB/Division
Centre frequency	: 200 kHz below carrier/beacon frequency (11 or 12 GHz or IF range)
Span	: 500 kHz
Resolution bandwidth	: 10 kHz
Video bandwidth	: 100 Hz
Video average	: ON (10 samples)
Sweep time	: Auto (1.5s)
Marker noise	: ON
Δ-Marker	: OFF
Trace	: Clear write A
Display line	: OFF

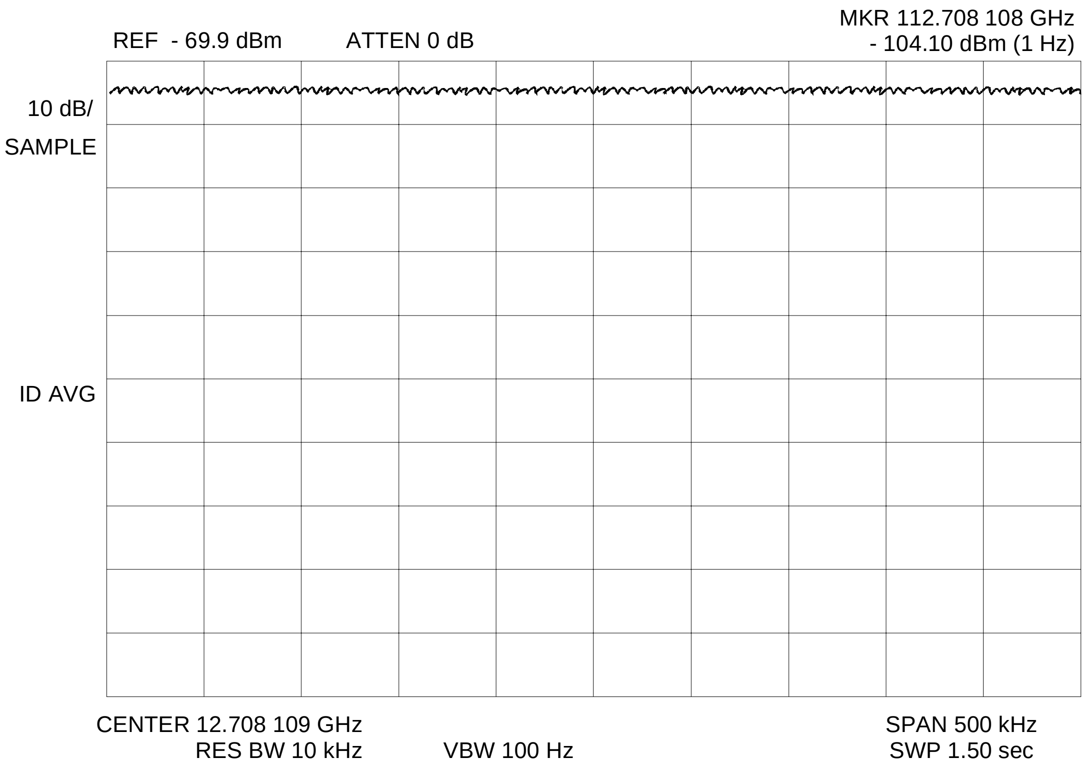

Figure 9.3 : Spectrum Analyser Display during G/T Measurement (Noise Level)

Note: The above (para. 9.4) are generally applicable if the spectrum analyser is connected to an LNA output. The attenuator setting to 0 dB may be inappropriate in case of connection to the output of a down-convertor, line-amplifier, etc. In any case, the carrier level indicated must be independent of the attenuation setting, i.e.:when changing the attenuator no change of carrier level should be observed.

10. RECEIVE POLARIZATION DISCRIMINATION

10.1. Objectives

To measure the receive polarization isolation of the station under test at optimized TX polarization alignment. The measurement is carried out at boresight and at 8 samples within the 1 dB contour of the co-polar antenna RX pattern.

Although, the measurement is not mandatory, it is recommended and it will provide additional aspects for the evaluation of the overall antenna performance.

10.2. Principle

The ERS transmits a carrier via an EUTELSAT satellite and maintains a constant flux. Then at optimum TX polarization alignment (paragraph 5 refers), the Station Under Test measures the co-polar and the cross-polar component of the reference carrier by comparison to an injected signal. From the difference in level, the RX-XPD of the SUT is computed. To eliminate inaccuracies due to the up-link (i.e. ERS, TX-XPD, satellite RX-XPD), the cross-polar satellite channel must be switched OFF or configured to a different down-link frequency band (e.g.: measurement at 11 GHz, cross-polar channel down-link at 12 GHz).

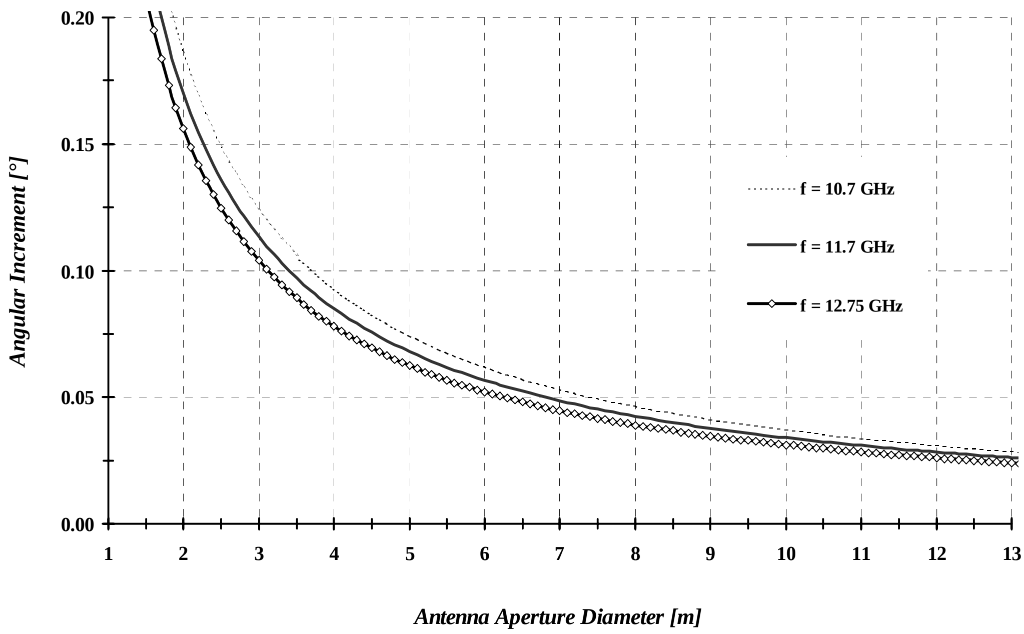

Figure 10.1 : Angular Increment (AI) for RX-XPD Measurements

To verify the performance of the SUT antenna within the co-polar -1 dB RX contour, the SUT antenna is depointed in azimuth and elevation as described in Figure 7.1 and the measurement is conducted at each point (boresight and 8 samples). The angular increment (AI) may be estimated by formula (1) of paragraph 7.2.

To ensure accurate positioning of the antenna, a SUT equipped with a 4-port feed monitors the variation of the co-polar RX level of the reference carrier. For SUT equipped with a 2-port feed, the reference carrier shall be transmitted via X polarization (i.e. received via Y polarization). Hence, the SUT measures the cross-polar component of the reference carrier and monitors the variation of the satellite beacon level via the same (X) polarization.

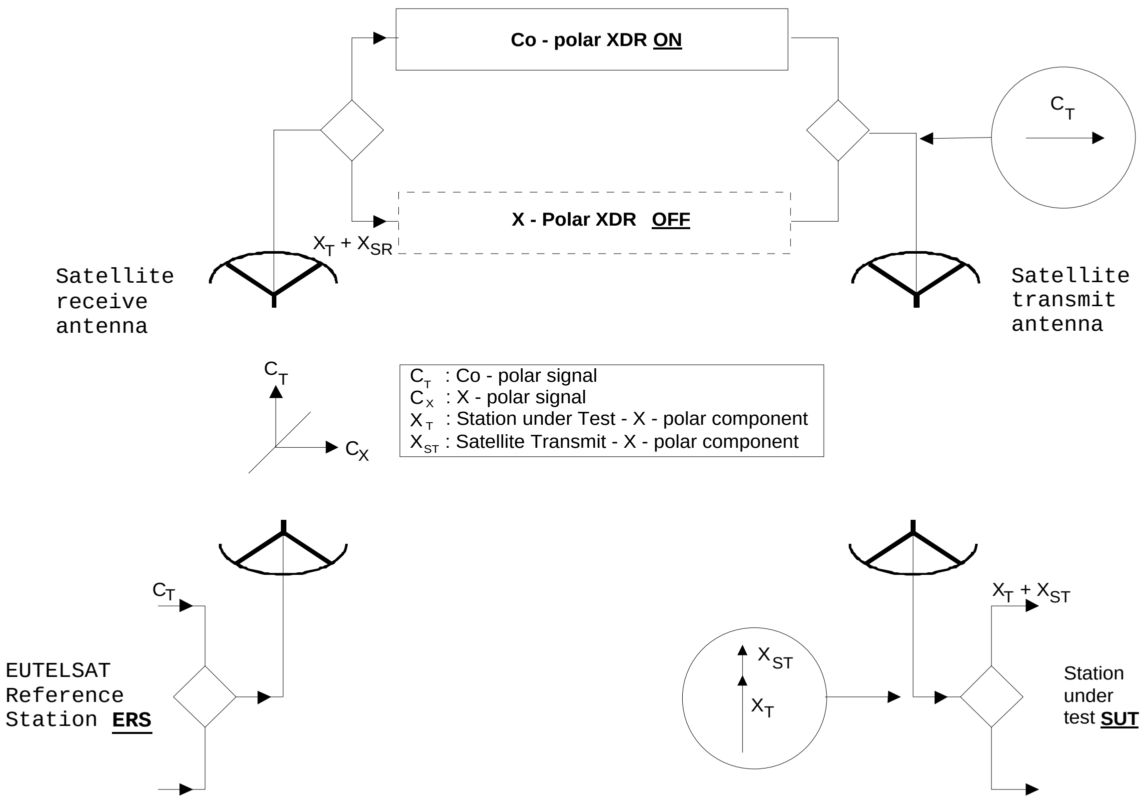

Figure 10.2 : Schematic Representation of the RX-XPD Measurement

10.3. Step-by-Step Procedure

Note: Optimum TX-polarization alignment must be assured prior to this test. For SUT equipped with a 4-port feed the alignment of para. 4.2 remains unchanged and commutation from X to Y polarization is done by switching.

Note: For SUT equipped with a 2-port feed, the optimum polarization alignment must be established for the Y-plane. If this has not been accomplished, test 4.2 must be repeated prior to the following measurements.

Step 1: During ESVA preparation and prior to commencement of ESVA testing, SUT check the linearity of the RX-chain(s) as follows:

A test signal at stable amplitude and frequency (i.e. the in-station pilot) is injected at the input of the LNA. By means of a microwave attenuator, the pilot level is reduced in 10 dB steps and the corresponding power levels displayed on the spectrum analyser are recorded. This establishes a reference scale and a check of the linearity of the RX-chain(s) including the analyser display.

Step 2: SUT equipped with 2-port feed proceed with Step 5.

Step 3: SUT inject the pilot into one of the RX chains and measure its level.

Step 4: Under consideration of differences in the RX coupling factors, inject the same pilot level into the second RX chain and measure the difference relative to the value obtained in Step 3 above. The result is the correction factor (i.e. the RX gain difference) for the following RX-XPD measurements.

Step 5: If required, CSC arranges for change of satellite configuration on request of ERS.

Step 6: ERS transmit the reference carrier at frequency and EIRP as specified in the EUTELSAT test plan.

Note: If the SUT is equipped with a 2-port feed, the test plan shall provide a channel with X polarization in up-link and Y polarization in down-link.

Step 7: SUT receive the co-polar component of the reference carrier. Set the pilot frequency close to the RX-frequency of the reference carrier (e.g. $f_{PILOT} = f_{REF}$ — 200 Hz).

Step 8: ERS transmit the reference carrier via the co-polar channel at the frequency and EIRP as specified in the EUTELSAT test plan.
SUT equipped with 4-port feed proceed with Step 10.

Step 9: SUT rotate the antenna feed by 90° and ensure that this position corresponds to the optimum TX polarization alignment established during test 4.2 (compare angular readout and/or marks on feed).
SUT equipped with 2-port feed proceed with Step 11.

Step 10: SUT switch to orthogonal channel.

Step 11: SUT lock to the cross-polar component of the reference carrier and measure the difference in level between the pilot and the cross-polar component of the reference carrier. If necessary, apply a correction (Step 3 above) and determine the XPD.

Step 12: SUT lock to the co-polar component of the reference carrier (the satellite beacon for SUT equipped with 2-port feed). Move the antenna off boresight according to Figure 7.1. While moving the antenna, SUT monitor the variation of the RX level and control the movement accordingly, (Table 7.1 refers).

Step 13: Repeat Steps 11 and 12 for each point of the sequence described in Figure 7.1.

Step 14: SUT report results to EUTELSAT.

10.4. Example for Spectrum Analyser Settings

Co-polar Reception

Reference level	: As applicable
Attenuator	: 0 dB
Scale	: 5 dB or 10 dB/Division
Centre frequency	: ERS down-link frequency as per test plan (11 or 12 GHz range)
Span	: 2 kHz
Resolution bandwidth	: 30 Hz
Video bandwidth	: 30 Hz
Video average	: OFF
Sweep time	: Auto
Marker noise	: OFF
Δ-Marker	: activated
Trace	: Max. Hold A
Display line	: OFF

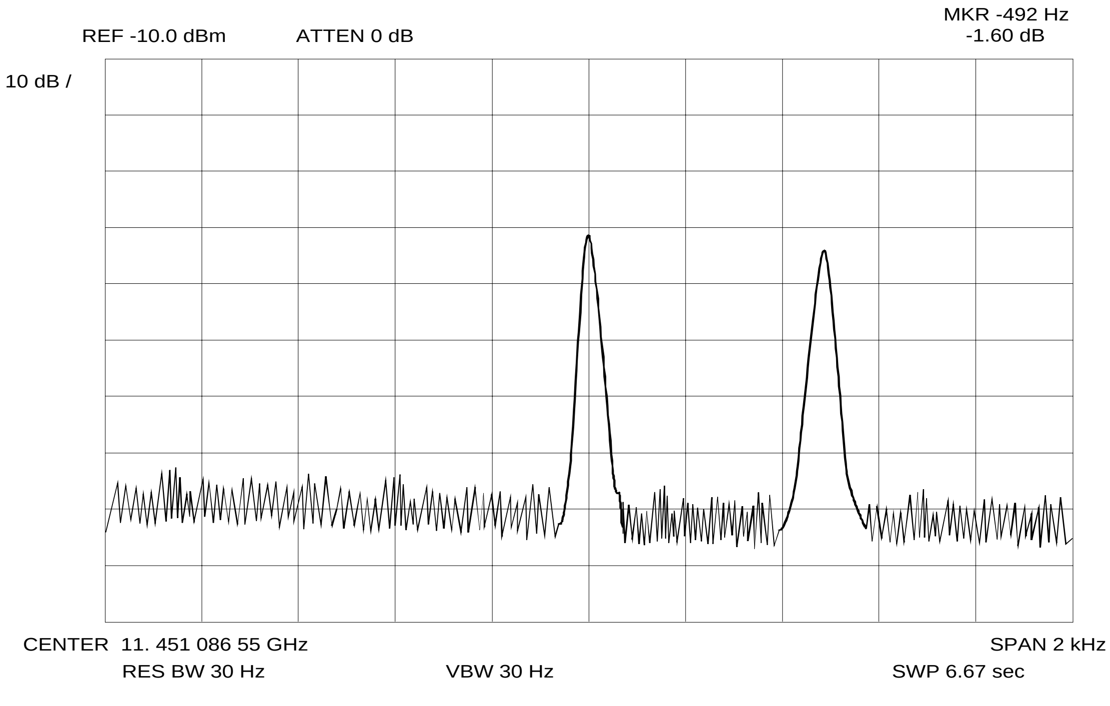

Figure 10.3 : Spectrum Analyser Display during RX-XPD Measurement Co-polar Reception

Cross Polar Reception

Reference level	: As applicable
Attenuator	: 0 dB
Scale	: 5 dB or 10 dB/Division
Centre frequency	: ERS down-link frequency as per test plan (11 or 12 GHz range)
Span	: 2 kHz
Resolution bandwidth	: 30 Hz
Video bandwidth	: 30 Hz
Video average	: OFF
Sweep time	: Auto
Marker noise	: OFF
Δ-Marker	: activated
Trace	: Max. Hold A
Display line	: OFF

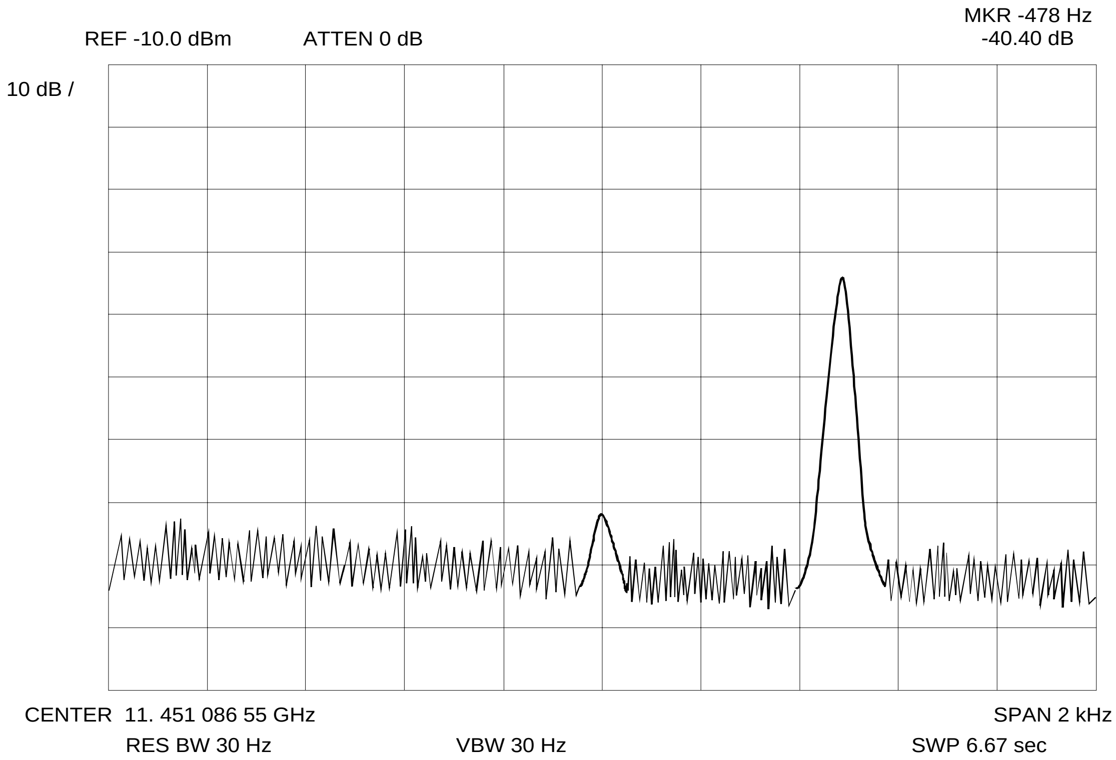

Figure 10.4 : Spectrum Analyser Display during RX-XPD Measurement X-pol Reception

11. RECEIVE SIDELOBES (INCLUDING RECEIVE GAIN)

11.1. Test Objectives

To record the receive antenna diagram of the station under test. Although the measurement is not mandatory, it is recommended and it will provide additional aspects for the evaluation of the overall antenna performance.

11.2. Principle

11.2.1. Antenna Pattern

The ERS transmits a carrier via an EUTELSAT satellite and maintains a constant flux. Alternatively, the station under test may lock to a satellite beacon signal. Then, the station under test records the receive level as function of the slewing angle in azimuth and elevation. Due to the non-orthogonality of the rotational axes, the azimuth angle is corrected according to formula 1 of paragraph 8.2. For evaluation of the antenna performance, the envelope of Figure 8.1 is applied.

11.2.2. Receive Gain

If the station under test is equipped with a receive coupler, the antenna receive gain may be calculated at known satellite EIRP. During ESVA preparation, the values of the RX coupling factor and the loss between the RX coupler and the antenna flange (or interface where the antenna gain is defined) have to be obtained by in-station measurement.

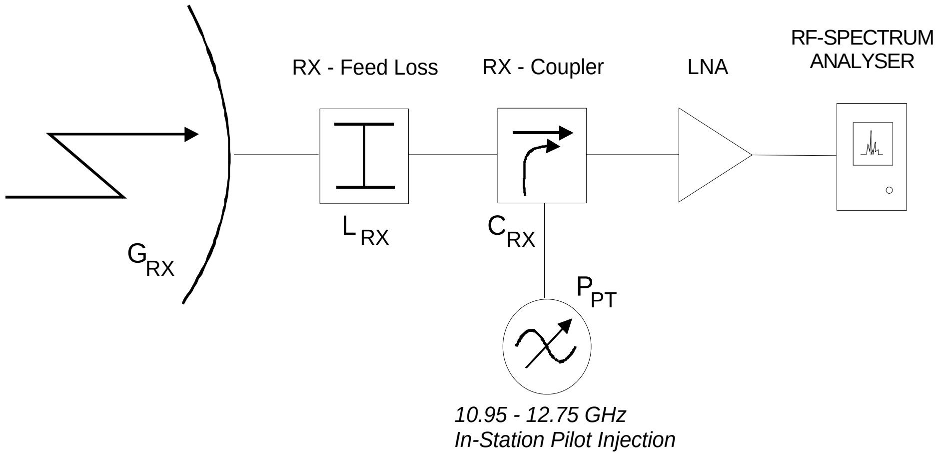

Figure 11.1 : Block Diagram of SUT RX-Chain

At known satellite EIRP, the RX gain is given by:

$$G_{RX} = P_{Pt} + L_{RX} - C_{RX} - (EIRP_{SAT/SUT} - L_{fs/SUT} - L_{at/SUT} + 30) \quad (1)$$

where:

G_{RX}	: Antenna receive gain of SUT	[dBi]
L_{RX}	: RX feed Loss	[dB]
P_{Pt}	: Level of in-station pilot at injection point	[dBm]
C_{RX}	: RX coupling factor	[dB]
$EIRP_{SAT/SUT}$	: Satellite EIRP towards SUT	[dBm]
$L_{fs/SUT}$	: Free space loss towards SUT	[dB]
$L_{at/SUT}$	: Athmospheric loss for reception at SUT	[dB]
30	: Conversion dBW $\Rightarrow$ dBm	[dB]

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

$$EIRP_{SAT/SUT} = EIRP_{SAT/ERS} + L_{OA/ERS} - L_{OA/SUT} \quad (2)$$

where:

$EIRP_{SAT/ERS}$	: Satellite EIRP towards ERS	[dBW]
$L_{OA/ERS}$	: Off-axis loss towards ERS	[dB]
$L_{OA/SUT}$	: Off-axis loss towards SUT	[dB]

To appreciate the measurement results, the theoretical expected value of the receive gain may be calculated according to (3) of para. 6.2.4.

11.3. Step-by-Step Procedure

A. Transmission of Reference Carrier

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

Note: Disregard Step 1 if the antenna measurement is performed by the satellite beacon.

B. Calibration of Receive Chain

Step 2: With the SUT antenna at boresight, SUT adjust the spectrum analyser and confirm linearity of receive and test equipment.
If the SUT is not equipped with a receive coupler go to Step 6.

Step 3: Verification of linearity may be achieved by injection of a in-station pilot via a coupler prior to the LNA input. The pilot level shall be equal to the received carrier at frequency which is approximately 10 kHz apart.

Step 4: SUT communicate receive coupling factor and receive feed loss to ERS. ERS evaluate satellite EIRP towards SUT and calculate antenna receive gain.

Step 5: SUT report the in-station pilot level at the LNA output and reduce the pilot in 10 dB steps from relative 0 dB to –50 dB.

C. Azimuth Pattern

Step 6: SUT remove the in-station pilot and lock to the reference carrier. Except for the centre frequency, all analyser settings must remain unchanged from Step 5.

Step 7: SUT move the antenna counter clockwise (i.e. to the East) in azimuth until the receive level is in the order of the noise floor (e.g. to –20°).

Step 8: While recording the receive level, SUT slew the antenna in azimuth via boresight to the corresponding clockwise (i.e. West) position (e.g. +20°).

Step 9: SUT slew the antenna to beam centre and optimize pointing for maximum receive level.

D. Elevation Pattern

Step 10: SUT descend the antenna in elevation until the receive level is in order of the noise floor (e.g. –15°).

Step 11: While recording the receive level, SUT rise the antenna in elevation via boresight to the corresponding upper position (e.g. +15°).

Step 12: SUT slew the antenna to beamcentre and optimize pointing for maximum receive level.

Step 13: SUT process measurement data and produce plots of the co-polar azimuth and elevation antenna receive diagrams including the appropriate envelopes.

Step 14: SUT inform ERS of measurement conclusion and forward results to EUTELSAT.

11.4. Example for Spectrum Analyser Settings

Reference level	: As applicable
Attenuator	: 0 dB
Scale	: 10 dB/Division
Centre frequency	: SUT down-link frequency as per test plan (11 or 12 GHz range)
Span	: 0 Hz
Resolution bandwidth	: 30 Hz (or 10 Hz)
Video bandwidth	: 1 Hz
Sweep time	: According to antenna slew speed e.g. 500 sec.
Marker noise	: OFF
Δ-Marker	: OFF
Trace	: Clear write
Display line	: Position to noise floor

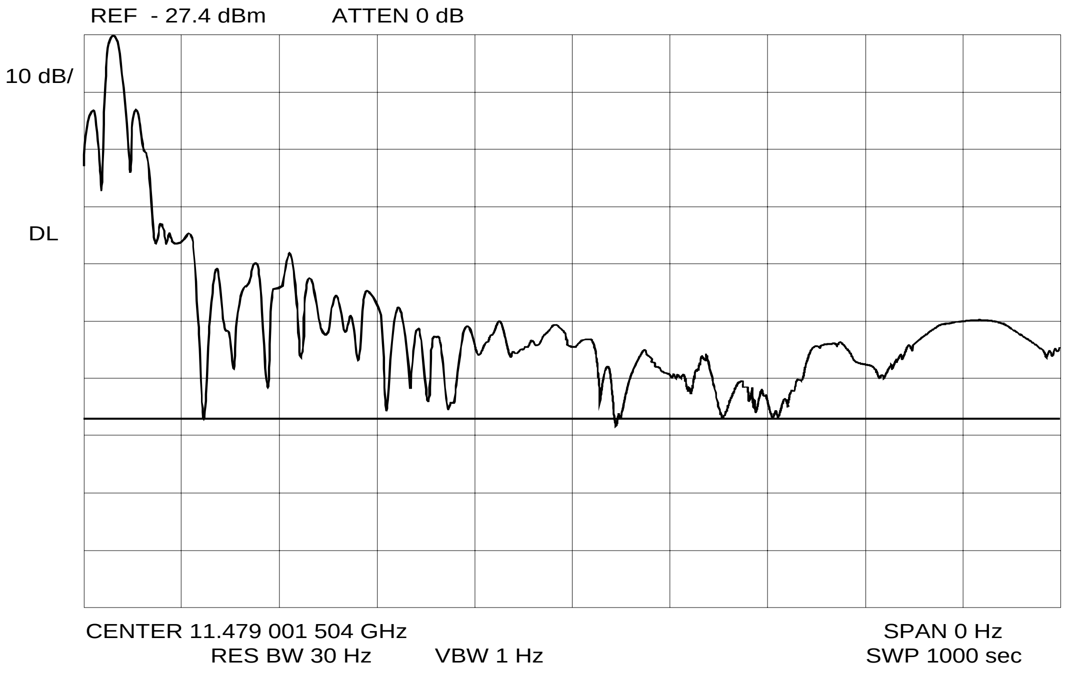

Figure 11.2 : Spectrum Analyser Display during Antenna Pattern Measurement

Annex A. Request for ESVA Format

The form on the next page should be used to require ESVA for an existing earth station. After completion, it should be sent to the address indicated in Annex D of this Module.

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From: ______________________________________
____
____

FACSIMILE / E-MAIL TRANSMISSION
N°. of pages including this one : 1

To : EUTELSAT
System Verification Test Section

Fax : + 33 1 5398 3741 E-mail: fschurig@eutelsat.fr
kbadalov@eutelsat.fr

ESVA Request for a EUTELSAT Approved Earth Station

1. EARTH STATION UNDER TEST

EUTELSAT Earth Station Verification Assistance (ESVA) is hereby requested for the following station:

1.1. **Earth Station Name: ....**

1.2. **EUTELSAT Code: ....**

2. ESVA TEST PROGRAMME

2.1. **Tests to be conducted ☑ :**

a) Earth Station EIRP ☐

b) Transmit Frequency ☐

c) Polarization Alignment ☐

d) Transmit Polarization Isolation ☐

e) Earth Station G / T ☐

f) TX Sidelobe Pattern ☐

g) RX Sidelobe Pattern ☐

h) Other (describe on separate page) ☐

2.2. **Requested period :**

a) Earliest start:___ / ___ / ___

b) Finished before:___ / ___ / ___

3. REMARKS

....
....
....

SIGNATURE : .... **DATE** : ....

☑ indicate as appropriate

Annex B. Questionnaire

The form on the next page is used to provide EUTELSAT with specific data relevant to any forthcoming ESVA or Earth Station Test activity. This information is required to ensure smooth implementation of measurements and is normally not part of the EUTELSAT Earth Station database. With submission of the completed form, the station operator re-confirms and guarantees his adequate preparation and readiness for test activities.

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FROM : ____
____
____

TO: EUTELSAT - Division 10
System Verification Test Section **Fax: + 33 (1) 53 98 37 41**

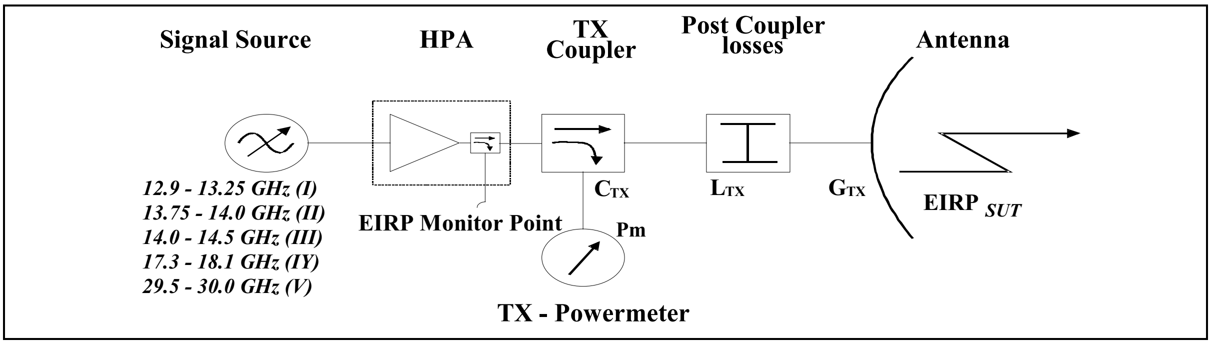
FACSIMILE TRANSMISSION
Total N°. of Pages:

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.

2) E/S PARAMETERS



Are there other EIRP monitor points which may be used during following line-up and / or operations ? ☒
Yes ☐ **No** ☐ If "☒ YES", please state details on a separate sheet.

TX Chain Designation			
TX Coupling Factor C_{TX} [dB]			
Post Coupler Loss L_{TX} [dB]			

3) E/S CONFIGURATION

Feed Type ☒ 2-port ☐ 4-port ☐

Phase Combiner ☒ Yes ☐ No ☐

Antenna Positioning ☒ Electrical ☐ Manual ☐

Number of LNA/B/C(s) :______________________
LNANoise Temperature :____________________**°K**

Number of HPA(s): __________

Test Equipment Type

Signal Source ______________________________
Power Meter ______________________________
Analyzer ______________________________

Antenna Slew Speed

Freq. Stab. __________ Hz/min.
Az. __________ °/s
El. __________ °/s

4) OPERATIONS

	Test Manager	Contact during ESVA
Name		
Phone		
Fax		

Earth station block diagram is attached ☒ Yes ☐ No ☐

5) REMARKS

____
____
____

SIGNATURE : ____________________ Date : ________________

Annex C. List of Abbreviations

AI	Angular Increment
C/N	Carrier to Noise Ratio
CCIR	International Radio Consultative Committee (Comité Consultatif International de Radiocommunications)
CCW	Counter-Clockwise
CSC	EUTELSAT Communications System Control Centre
CW	Clockwise
CW	Continuous Wave (clean carrier)
DATE	Duly Authorized Telecommunications Entity
E/S	Earth Station
EIRP	Equivalent Isotropic Radiated Power
ERS	EUTELSAT Reference Station
ESA	European Space Agency
ESOG	EUTELSAT System Operations Guide
ESVA	Earth Station Verification Assistance
ETS 1A	EUTELSAT Test Station (ERS at Rambouillet)
ETS 1B	EUTELSAT Test Station (ERS at Rambouillet)
EUTELSAT	European Telecommunications Satellite Organization
G/T	Gain to Equivalent Noise Temperature Ratio
HPA	High Power Amplifier
IF	Intermediate Frequency
IPFD	Input Flux Density
LNA	Low Noise Amplifier
LNB	Low Noise Block Converter
LNC	Low Noise Converter
RF	Radio Frequency
RX	Receive
SUT	Station Under Test
TMS	Test and Monitoring Station (ERS at Redu/Belgium)
TX	Transmit
UTC	Universal Time Coordinate (previously GMT i.e. Greenwich Mean Time)
XDR	Transponder
XPD	Cross-Polarization Discrimination

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Annex D. ESVA Contact Points

Planning and Coordination	EUTELSAT System Verification Test Section 70, rue Balard 75502 PARIS Cedex
Phone +33.1.53.98.48.25 +33.1.53.98.49.76	Fax +33.1.53.98.37.41
ESVA Reference Station	ETS 1A and 1B, Rambouillet, FRANCE
Phone +33.1.34.85.97.17 +33.1.53.98.44.09	Fax +33.1.34.84.20.34
ESVA Reference Station	TMS1/4, Redu, BELGIUM
Phone +32.6122.9553 +32.6122.9511	Fax +32.6122.9544
ESVA Reference Station	AUT-AFL-005 Aflenz, AUSTRIA
Phone +43.3863.2181.0 +43.3863.2181.235	Fax +43.3863.2630 E-mail znk.efa.wien@telekom.at
ESVA Reference Station	UKI-GHY-008 Goonhilly, UK
Phone + 44.1872.325452/7 + 44.1872.325447 (day only)	Fax +44.1872.325509
Space Segment Access	EUTELSAT - CSC, Paris, FRANCE
Phone +33.1.53983411 +33.1.53983443	Fax +33.1.53 98 33 33 E-mail csc@eutelsat.fr

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Annex E. EUTELSAT Beacons

1. Beacon Data Sheet

2. Examples for Beacon Coverage areas

2.1) W2, 12 GHz Beacon

2.2) W2, Global Beacon

2.3) EUTELSAT II-F4, 11 GHz Beacon

2.4) EUTELSAT II-F4, 12 GHz Beacon

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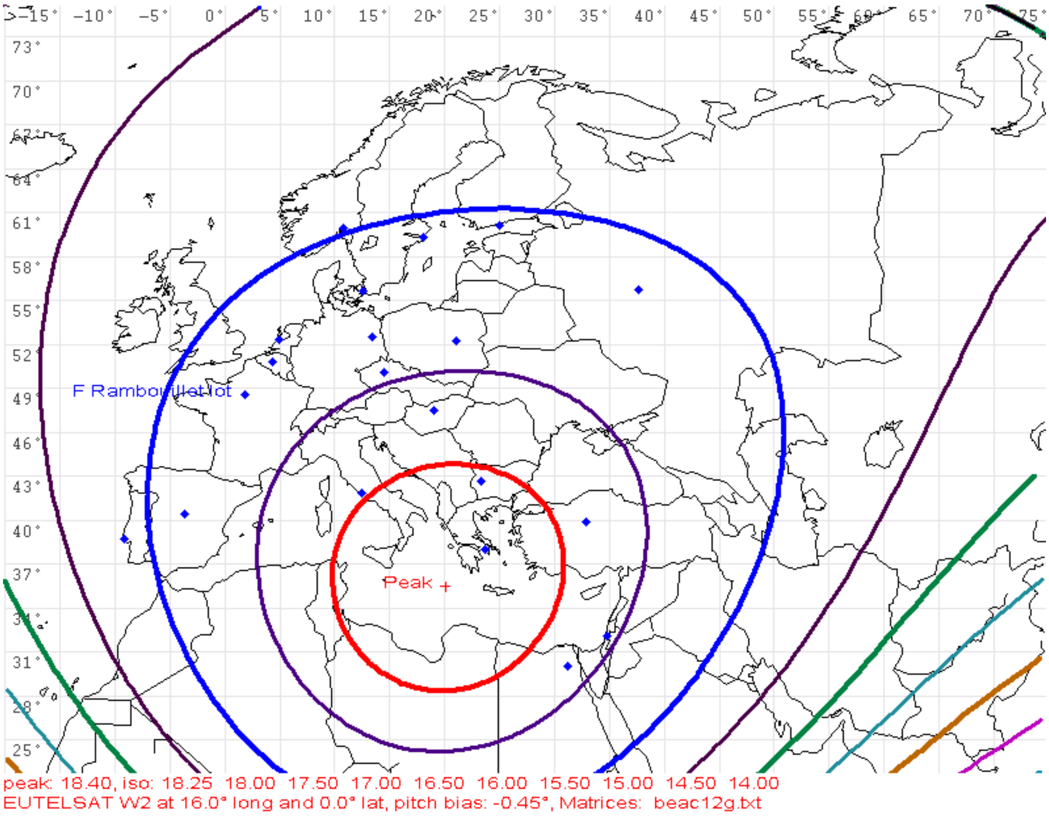
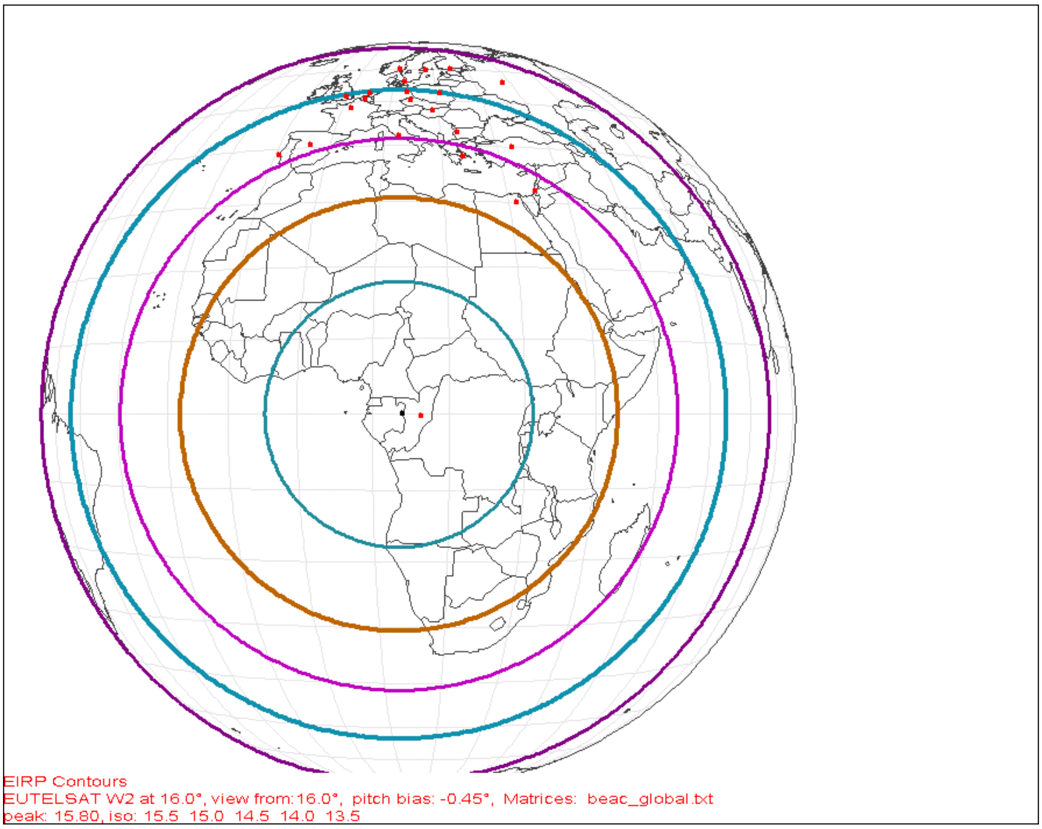
1) Beacon Data Sheet **Status: 07/00**

Satellite	Orbital Position	Beacon Frequency [MHz]									Operational Beacon EIRP towards Beam Centre [dBW]					
		X (Horizontal) Polarization								Y Polarization						
		11 GHz				12 GHz			KA-Band		11 GHz			12 GHz		KA-Band
		operational	spare	global	steerable	operational		spare		operational	operational	spare	global	X-Pol	Y-Pol	X-Pol
I-F4	25.5° E	11 449.650	-	-	-	-	-				17.18	-	-	-	-	-
I-F5	14.8° W	11 448.950	-	-	-	-	-				17.08	-	-	-	-	-
II-F1	48.0° E	11 451.091	11 451.830	-	-	12 541.667	-	-	-	-	15.55	15.50	-	14.15	-	-
II-F2	12.5° W	11 451.091	11 450.350	-	-	12 541.667	-	-	-	-	12.35	15.50	-	12.95	-	-
II-F3	35.9° E	11 451.830	11 452.570	-	-	12 541.667	-	-	-	-	14.47	15.70	-	15.17	-	-
II-F4	10.0° E	11 451.091	11 452.570	-	-	12 541.667	-	-	-	-	14.53	16.60	-	15.03	-	-
Hot Bird™ 1	13.0° E	11 449.610	11 450.350	-	-	-	-				13.17	15.40	-			
Hot Bird™ 2	13.0° E	11 702.200	11 703.400	-	-	-	-				13.37	13.40	-			
Hot Bird™ 3	13.0° E	11 702.800	11 704.000	-	-	12 500.000	-	-	-	-	11.67	13.00	-	15.57	-	-
Hot Bird™ 4	13.0° E	11 704.600	11 705.800	-	-	-	-				12.67	14.20	-			
Hot Bird™ 5	13.0° E	11 701.000	11 699.800	-	-	-	-				12.47	14.00	-			
Hot Bird™ 6	13.0° E	11 700.400	11 701.600	-	-	-	-	-	19 701.000	-	-	-	-	-	-	-
W1	10.0° E	11 450.500	11 451.000	-	-	12 500.250	-	12 749.750								
W2	16.0° E	11 698.000	11 699.200	11 199.000	-	12 501.000	-	-	-	-	17.07	17.10	16.15	18.87	-	-
W3	7.0 E	11 698.600	11 699.800	11 199.500	-	12 501.000	-	-	-	-	-	-	15.85	18.49	-	-
W4	36.0°E	11 706.850	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EUROBIRD™	28.5° E	11 452.570	11 451.091	-	11 200.000	12 501.000	-	-	-	-	-	-	-	-	-	-
ATLANTIC BIRD™	12.5° W	11 703.400	11 704.600	-	-	12 500.150	12 749.850	-	-	-	-	-	-	-	-	-
SESAT	36.0°E	11 450.350	11 451.091	-	11 199.500	12 501.000	-	-	-	-	-	-	-	-	-	-
TELECOM 2A	8.0° W	-	-	-	-	12 502.500	-	12 501.500	-	12 500.500	-	-	-	25.32	16.57	-
TELECOM 2D	8.0° W	11 450.500	-	-	-	-	-	-	-	11 452.500	-	-	-	-	-	-
TELSTAR 12	14.8° W	11 450.500	11 451.000	-	-	-	-	-	-	-	-	-	-	-	-	-
DFS-2 KOPERNIKUS	28.5° E	-	-	-	-	-	-	-	19 701.750	11 452.700	-	-	-	-	-	-
EXPRESS 3A	11.0° W	-	-	-	-	-	-	-	-	11 400.000	-	-	-	-	-	-

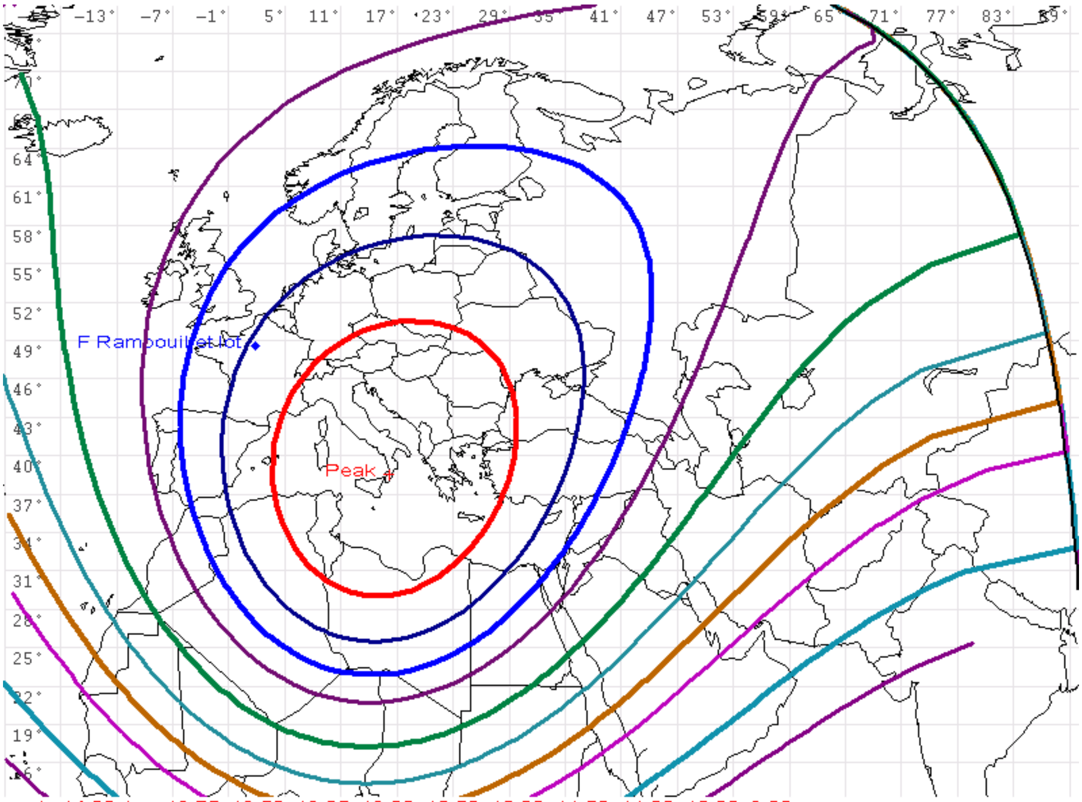
2.1) W2 at 16°E, 12 GHz Beacon Coverage



2.2) W2 at 16°E, Global Beacon Coverage



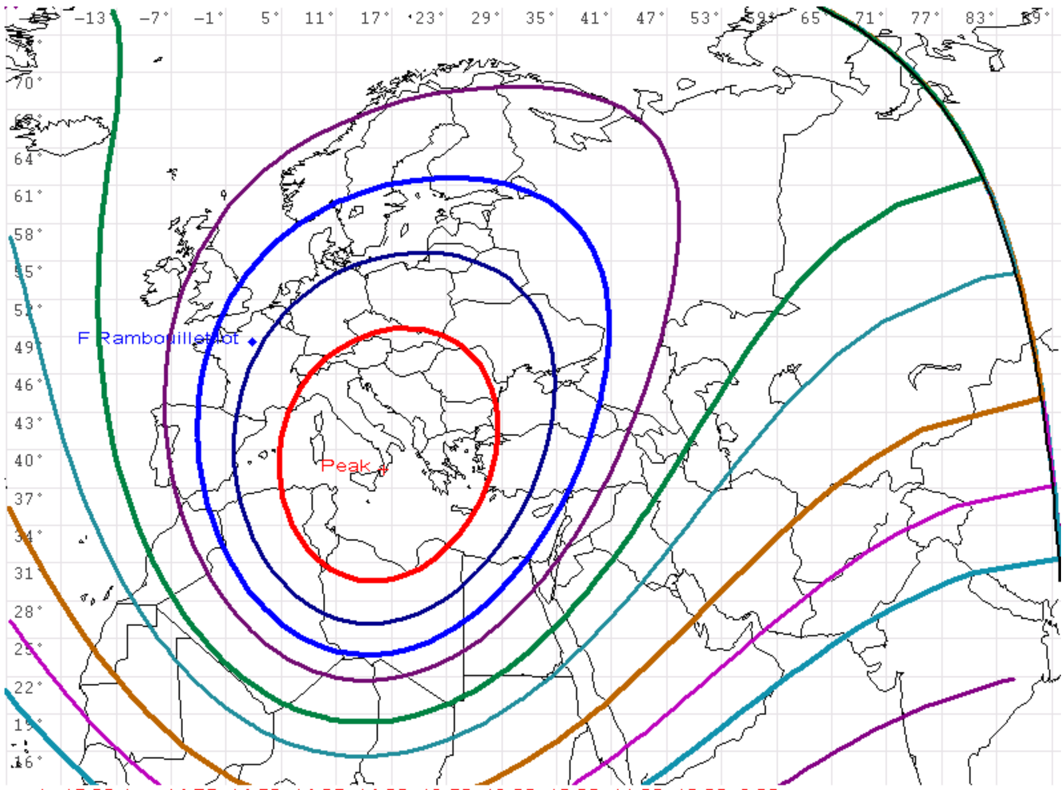
2.3) EUTELSAT II-F4 at 10°E, 11 GHz Beacon



peak: 14.00, iso: 13.75 13.50 13.25 13.00 12.50 12.00 11.50 11.00 10.00 9.00
EUTELSAT 2-F4 at 10.0° long and 0.0° lat, pitch bias: 1.04°, Matrices: Beacon_TM.txt

Remark: Values refer to the central spectral component (∃∅) of beacon signal

2.4) EUTELSAT II-F4 at 10°E, 12GHz Beacon Coverage



peak: 15.00, iso: 14.75 14.50 14.25 14.00 13.50 13.00 12.00 11.00 10.00 8.00
EUTELSAT 2-F4 at 10.0° long and 0.0° lat, pitch bias: 1.04°, Matrices: Beacon.txt

Annex F. Frequency Plans

The next pages show the transponder configurations and frequency plans for the following satellites:

- EUTELSAT-I
- EUTELSAT-II
- HOT BIRD™ 1....6
- EUTELSAT W1....W4
- SESAT
- EUROBIRD™
- ATLANTIC BIRD™
- TELECOM 2A and 2D
- DFS 2 - KOPERNIKUS
- TELSTAR 12
- EXPRESS 3A

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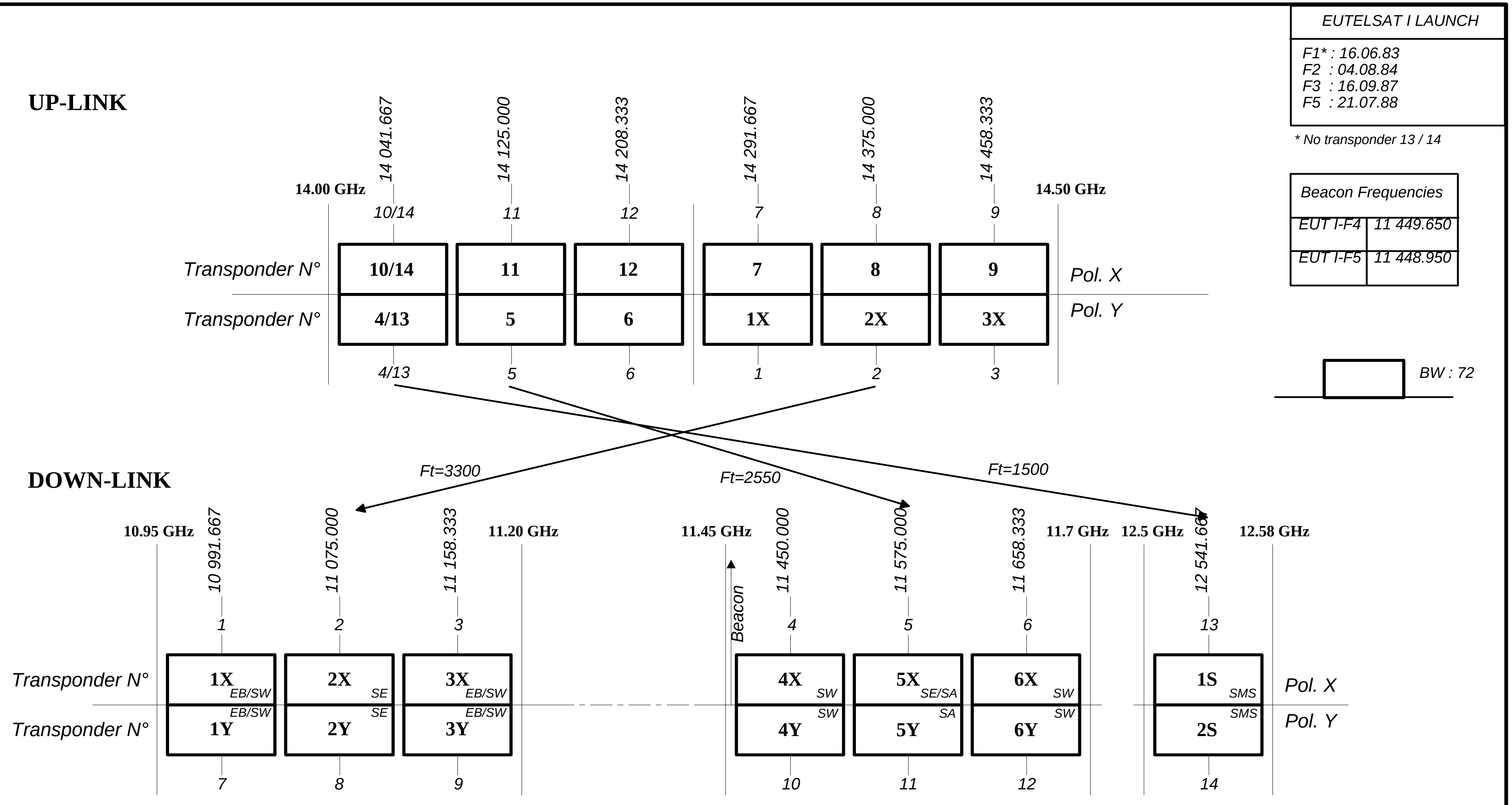
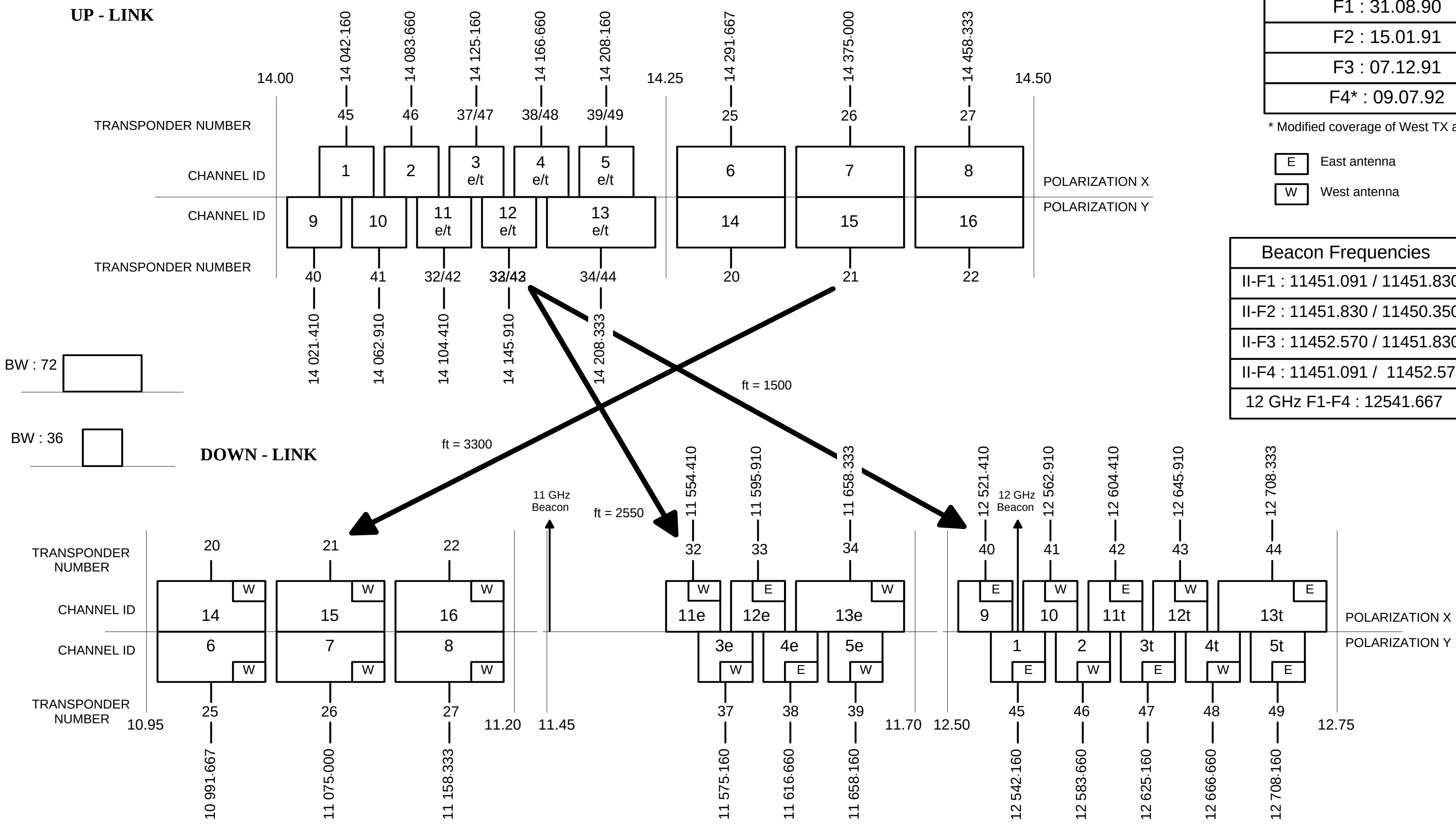


EUTELSAT I Transponder Frequency Plan
(Frequency in MHz)



EUTELSAT II LAUNCH
F1 : 31.08.90
F2 : 15.01.91
F3 : 07.12.91
F4* : 09.07.92

* Modified coverage of West TX antenna

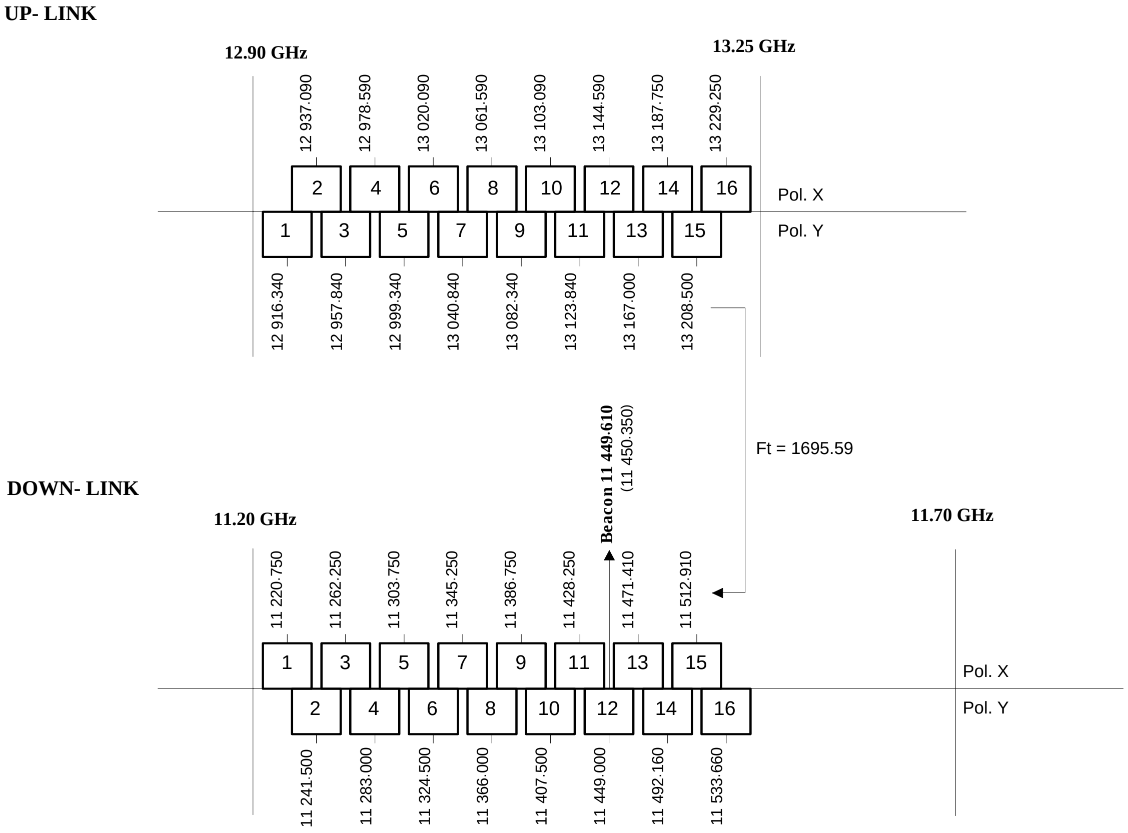
Beacon Frequencies
II-F1 : 11451.091 / 11451.830
II-F2 : 11451.830 / 11450.350
II-F3 : 11452.570 / 11451.830
II-F4 : 11451.091 / 11452.570
12 GHz F1-F4 : 12541.667

EUTELSAT II Frequency Plan

(Frequency in MHz)

SHU/98/012

HOT BIRD 1 launch :
29.03.95



Receive (up-link)	Antenna on Earth Panel
Superwide (dn-link)	Antenna on Earth Panel

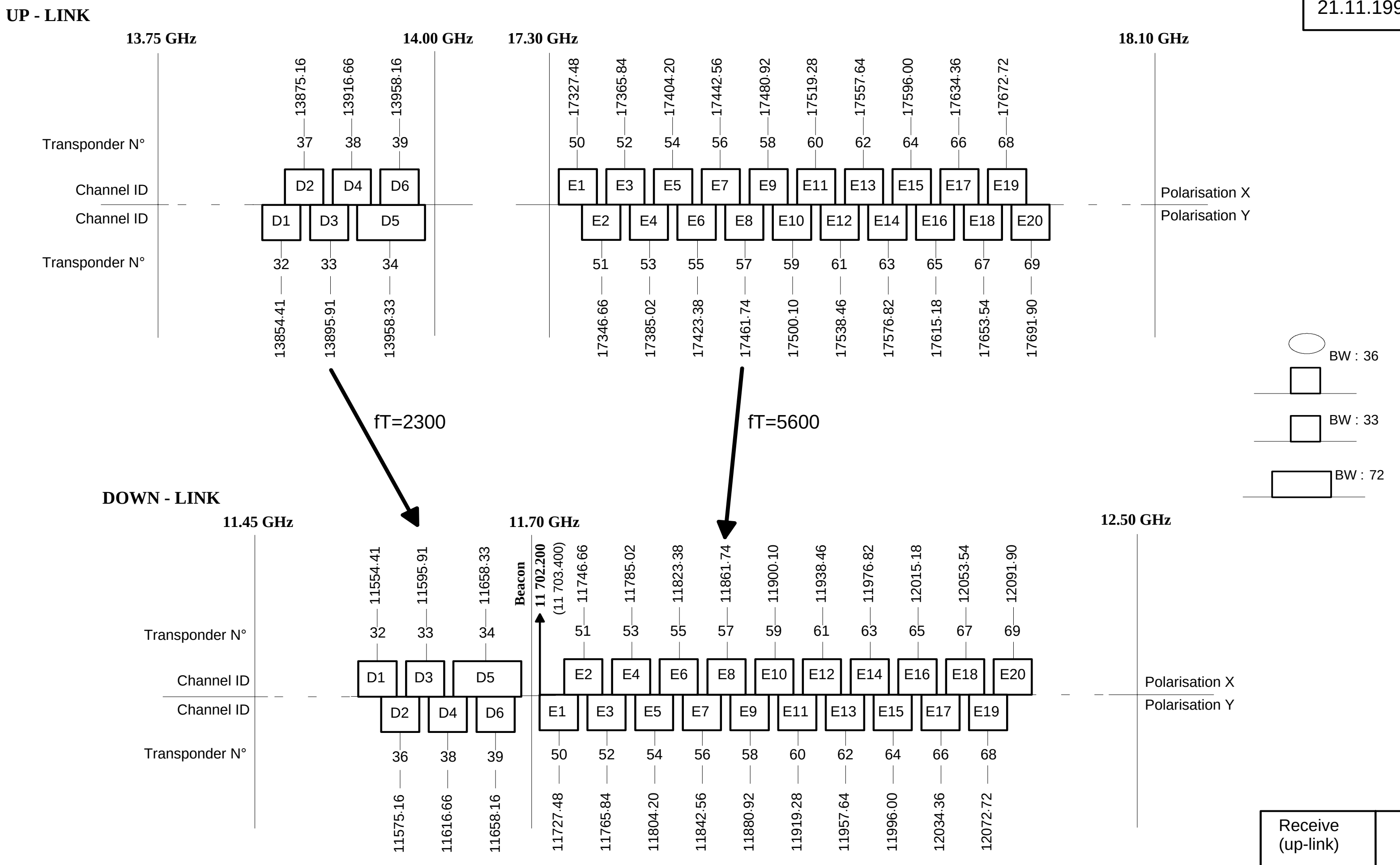
BW : 36

Hot Bird™ 1 Frequency Plan
(Frequency in MHz)

SHU/98/011

C1 Launch :

21.11.1996

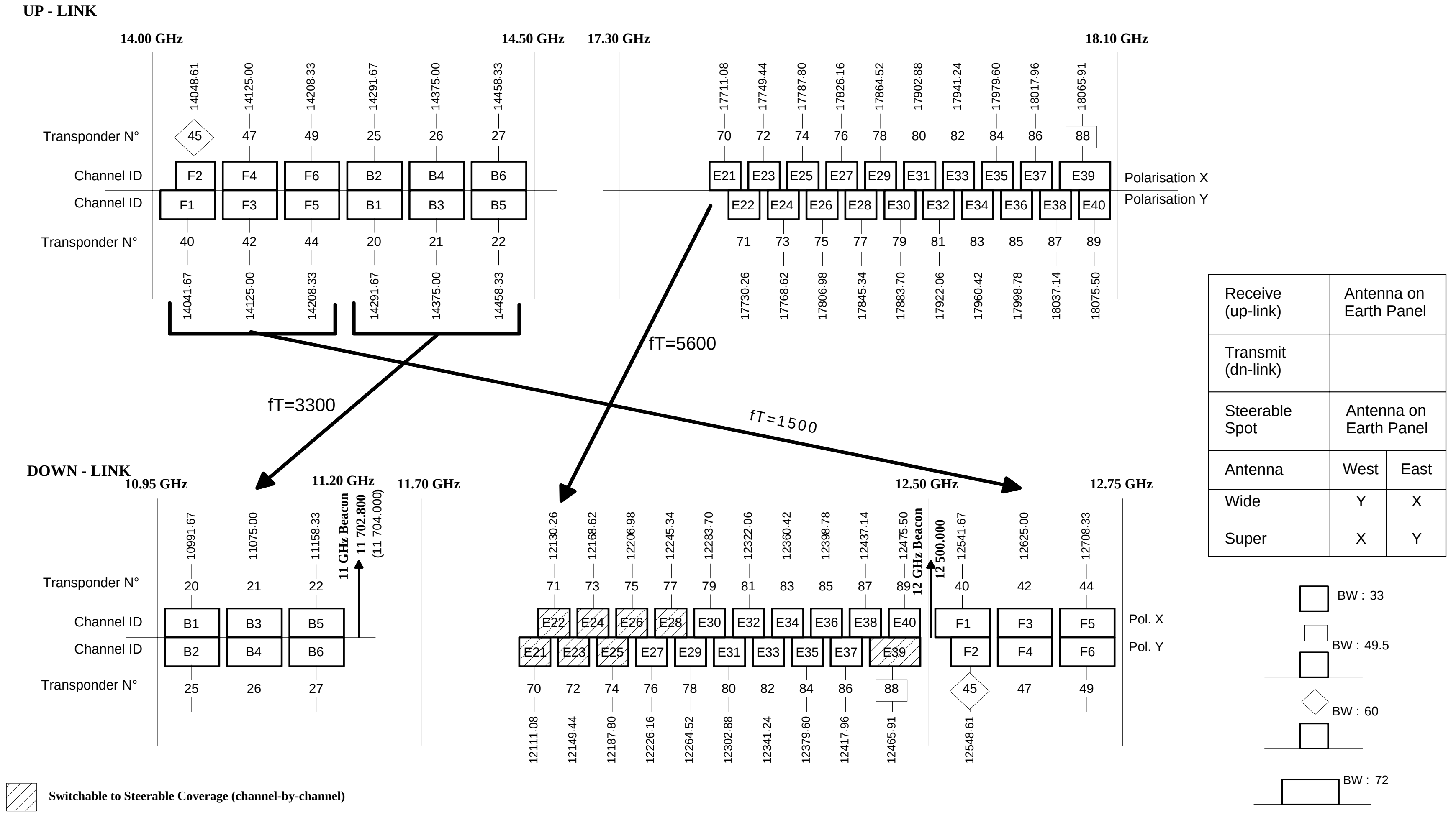


Receive (up-link)	Antenna on Earth Panel	
Transmit (dn-link)	Antenna West	East
Wide	Y	X
Super	X	Y

Hot Bird™ 2 Frequency Plan
(Frequency in MHz)

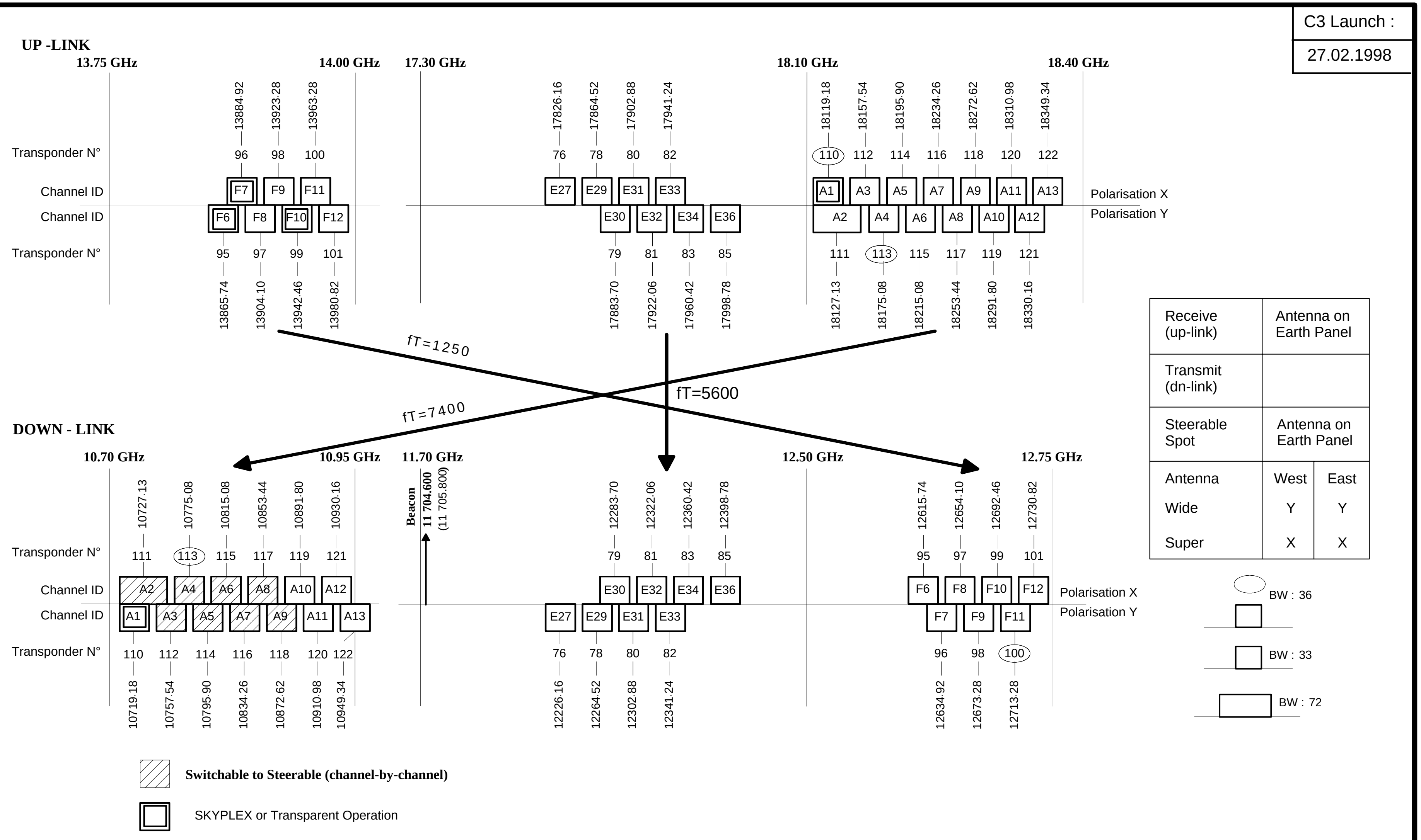
SHU/96/006

C2 Launch :
29/07/1996 :

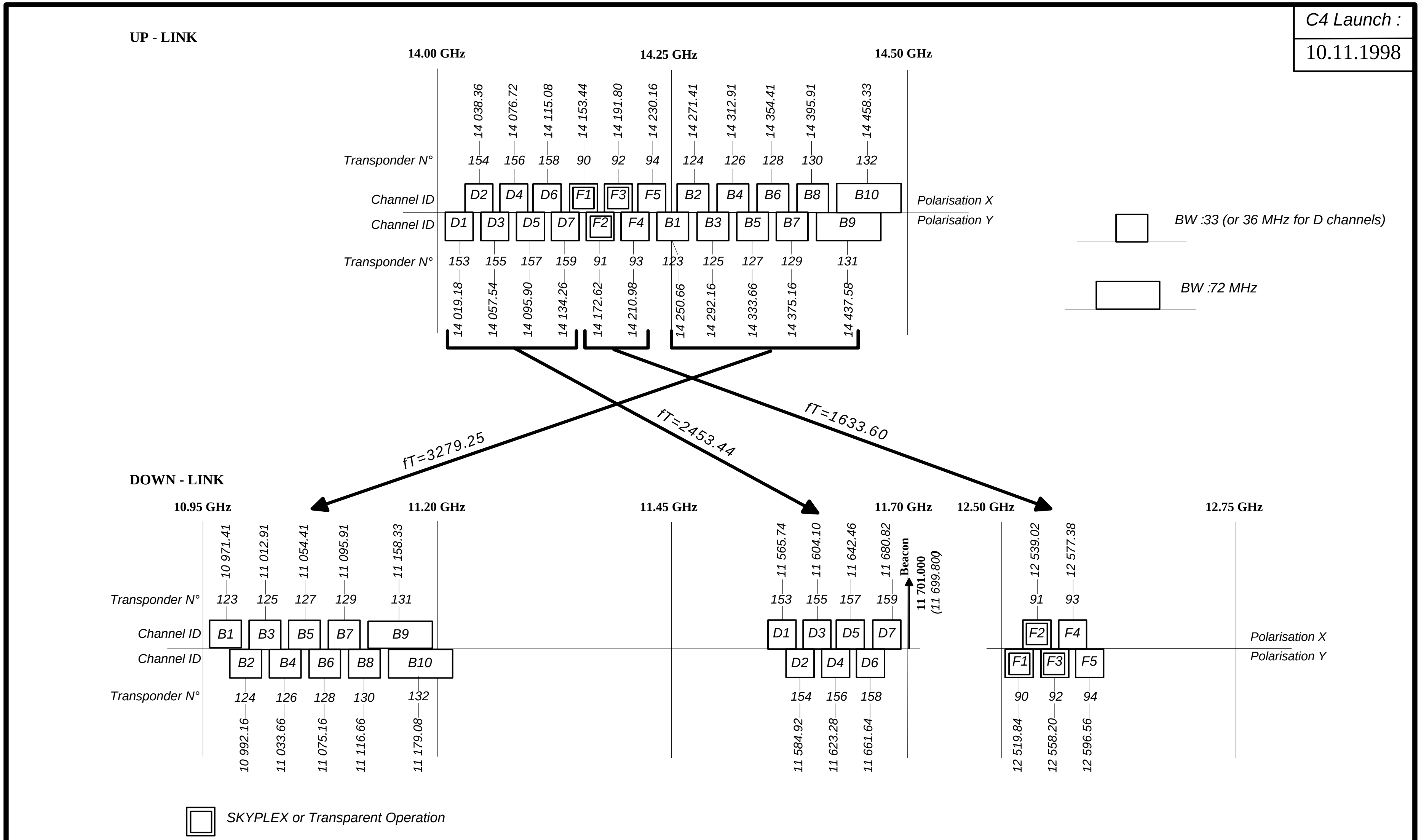


Hot Bird™ 3 Frequency Plan
(Frequency in MHz)

SHU/98/009

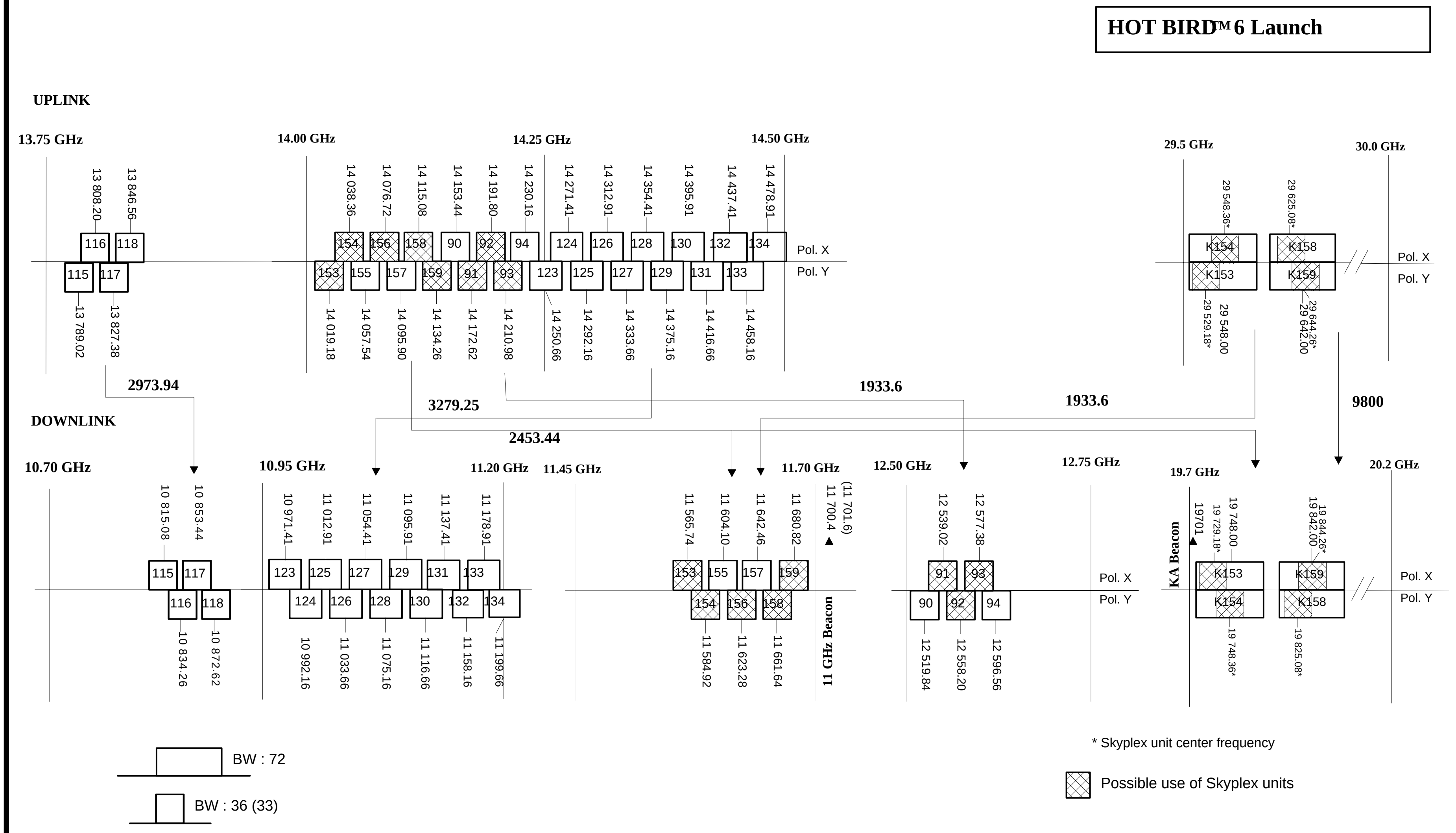


Hot Bird™ 4 Frequency Plan
(Frequency in MHz)

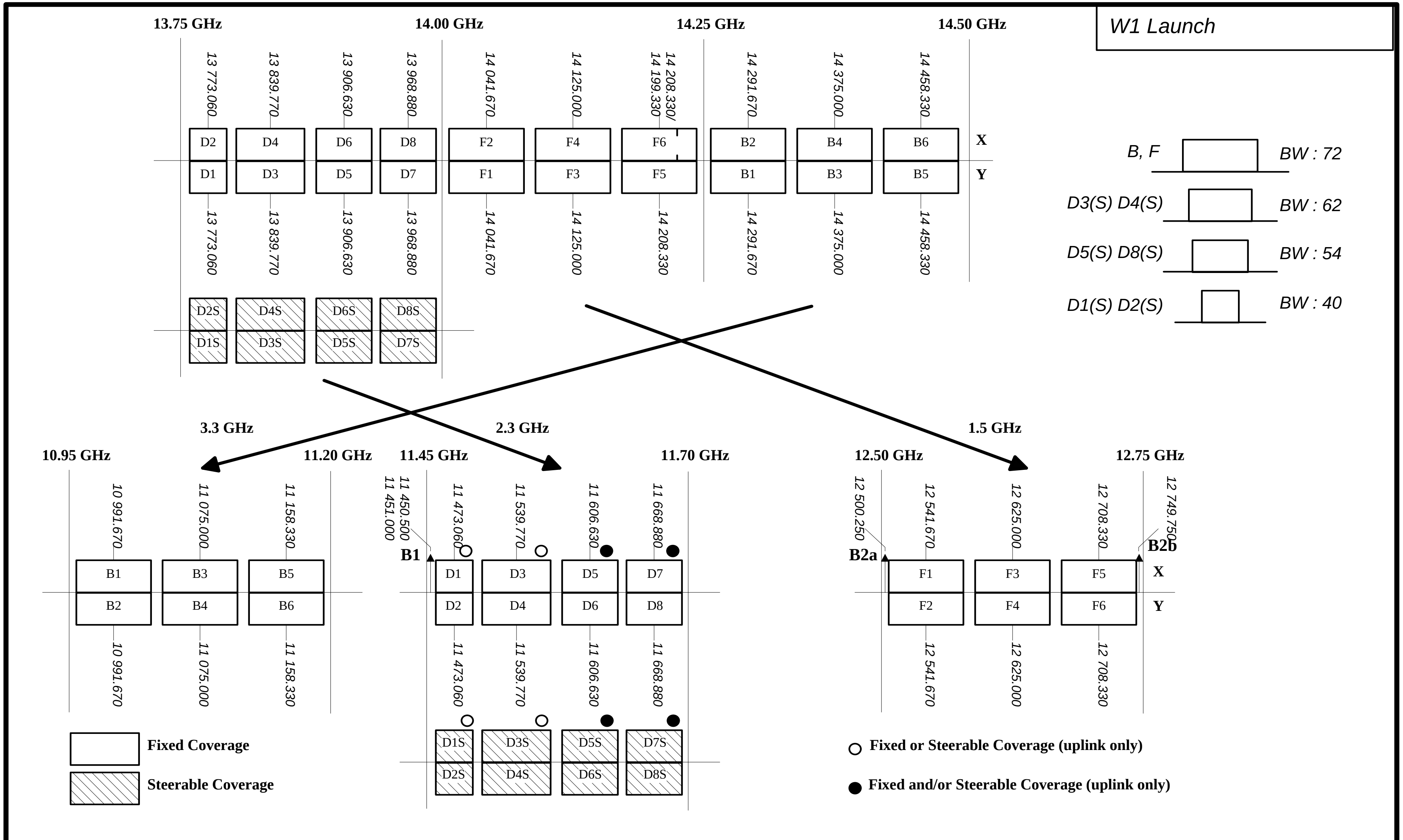


Hot Bird™ 5 Frequency Plan
(Frequency in MHz)

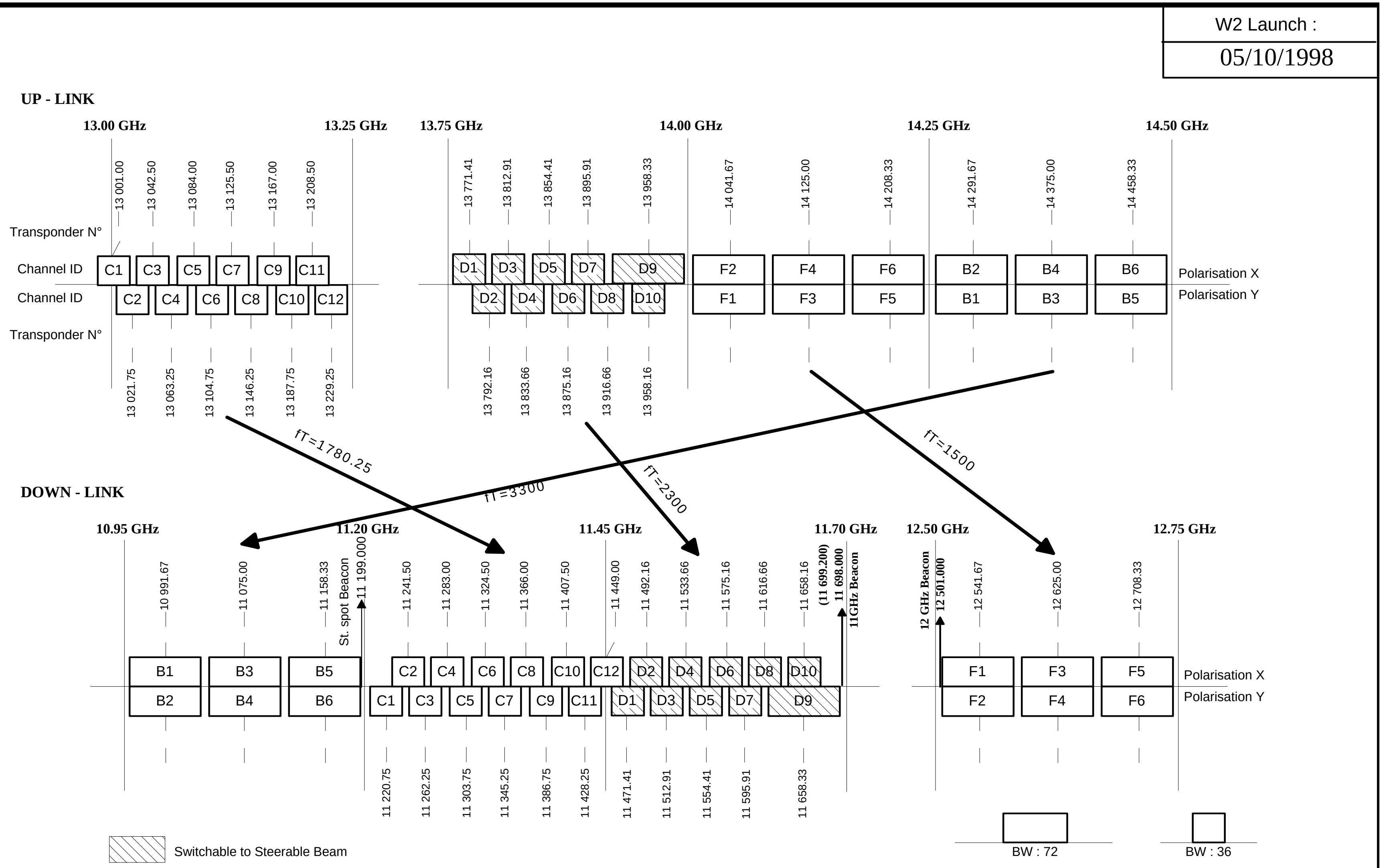
SHU/98/007



HOT BIRD™ 6 FREQUENCY PLAN
(Frequency in MHz)

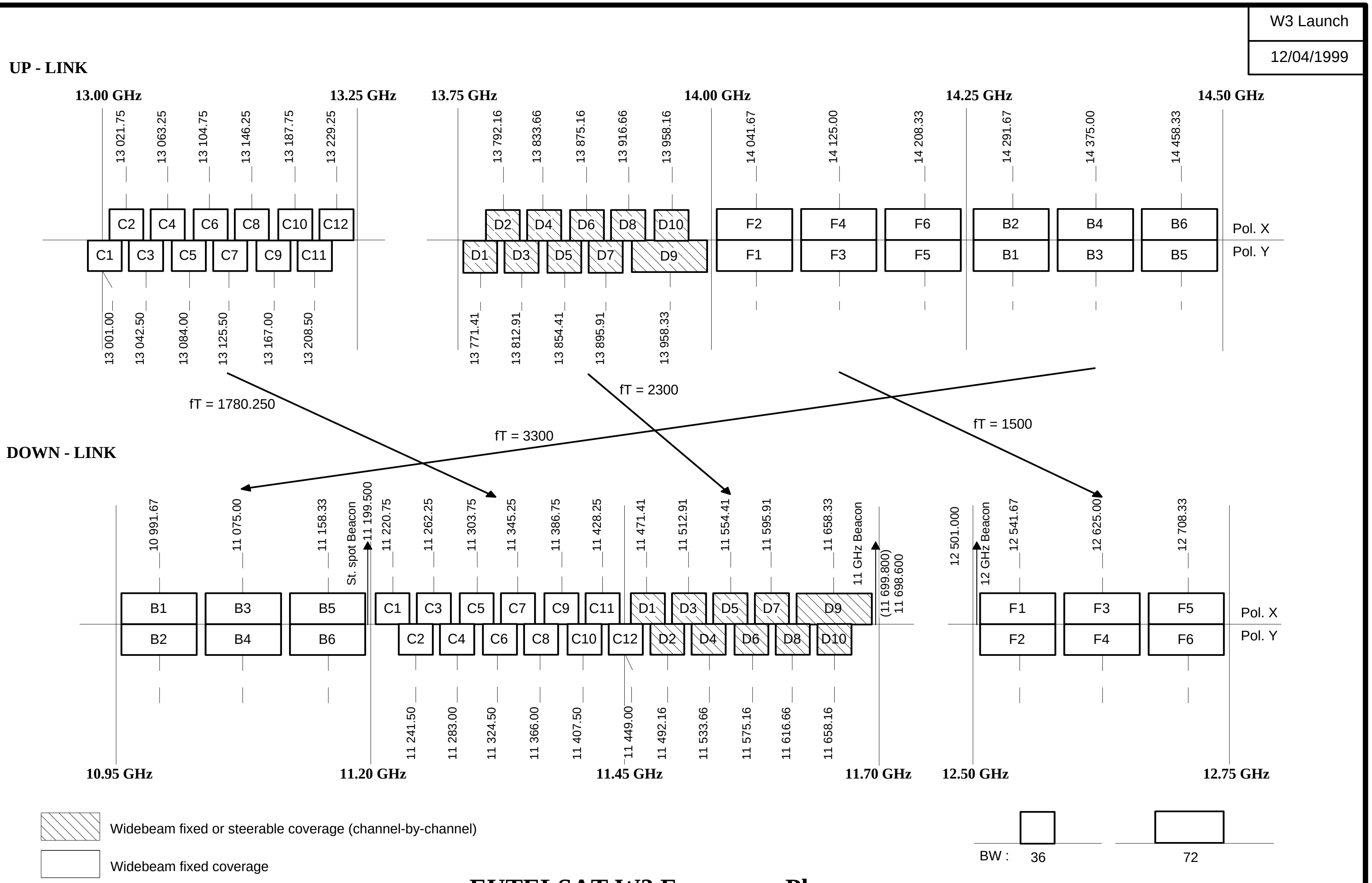


W1 FREQUENCY PLAN *(Former RESSAT)*
(Frequency in MHz)



EUTELSAT W2 Frequency Plan
(Frequency in MHz)

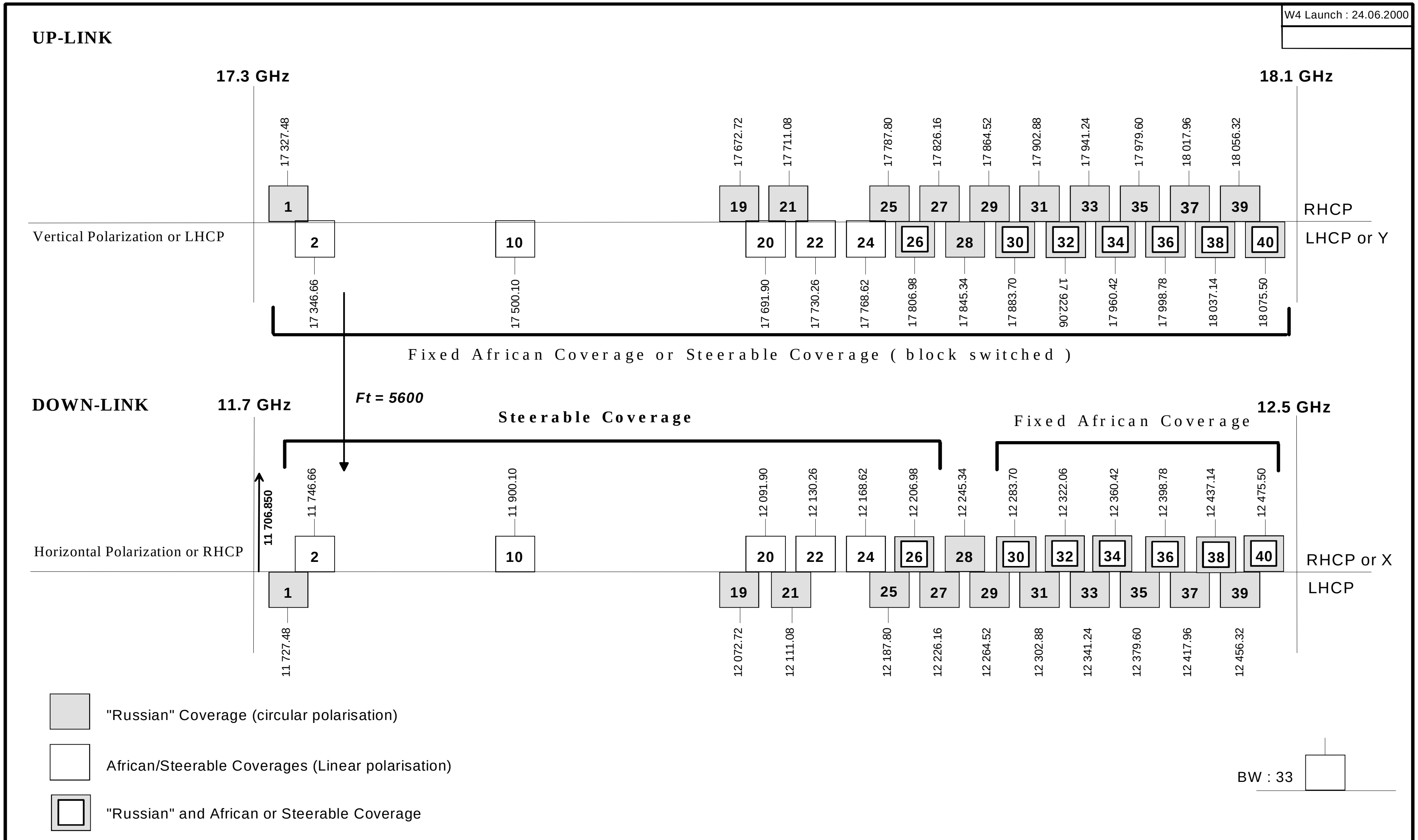
SHU/98/005



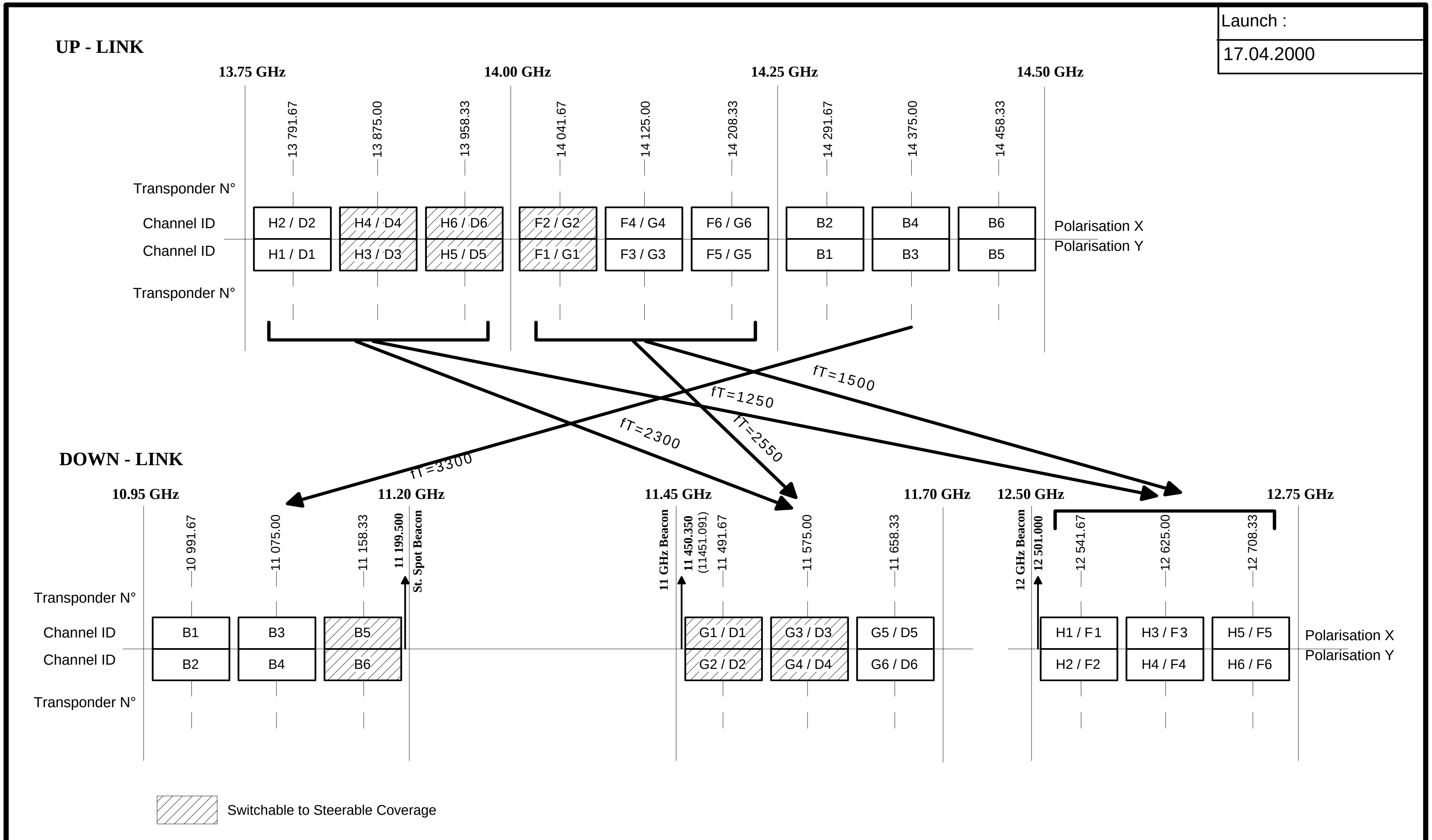
EUTELSAT W3 Frequency Plan

(Frequency in MHz)

SHU/98/003



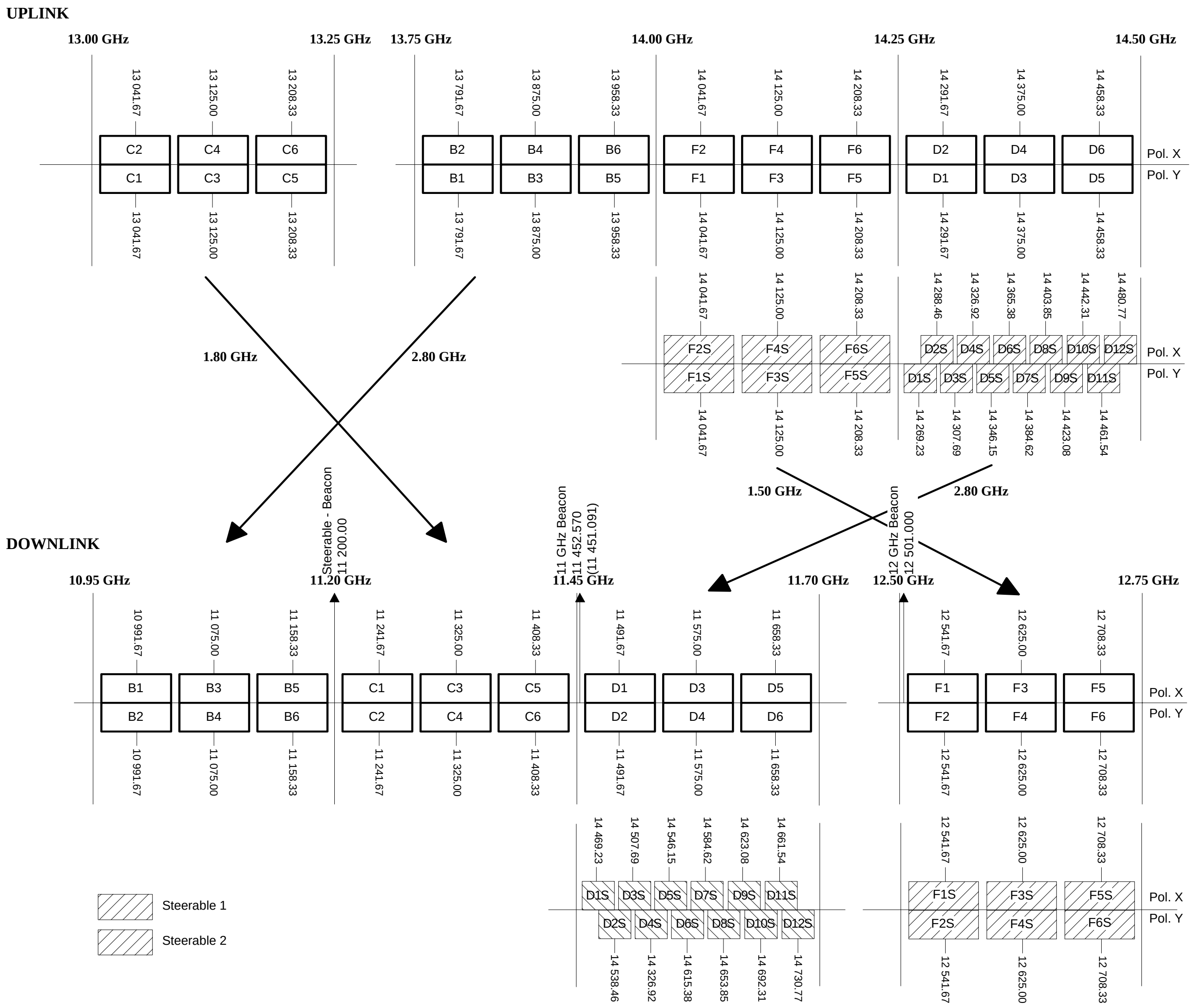
EUTELSAT W4 Frequency Plan
(Frequency in MHz)



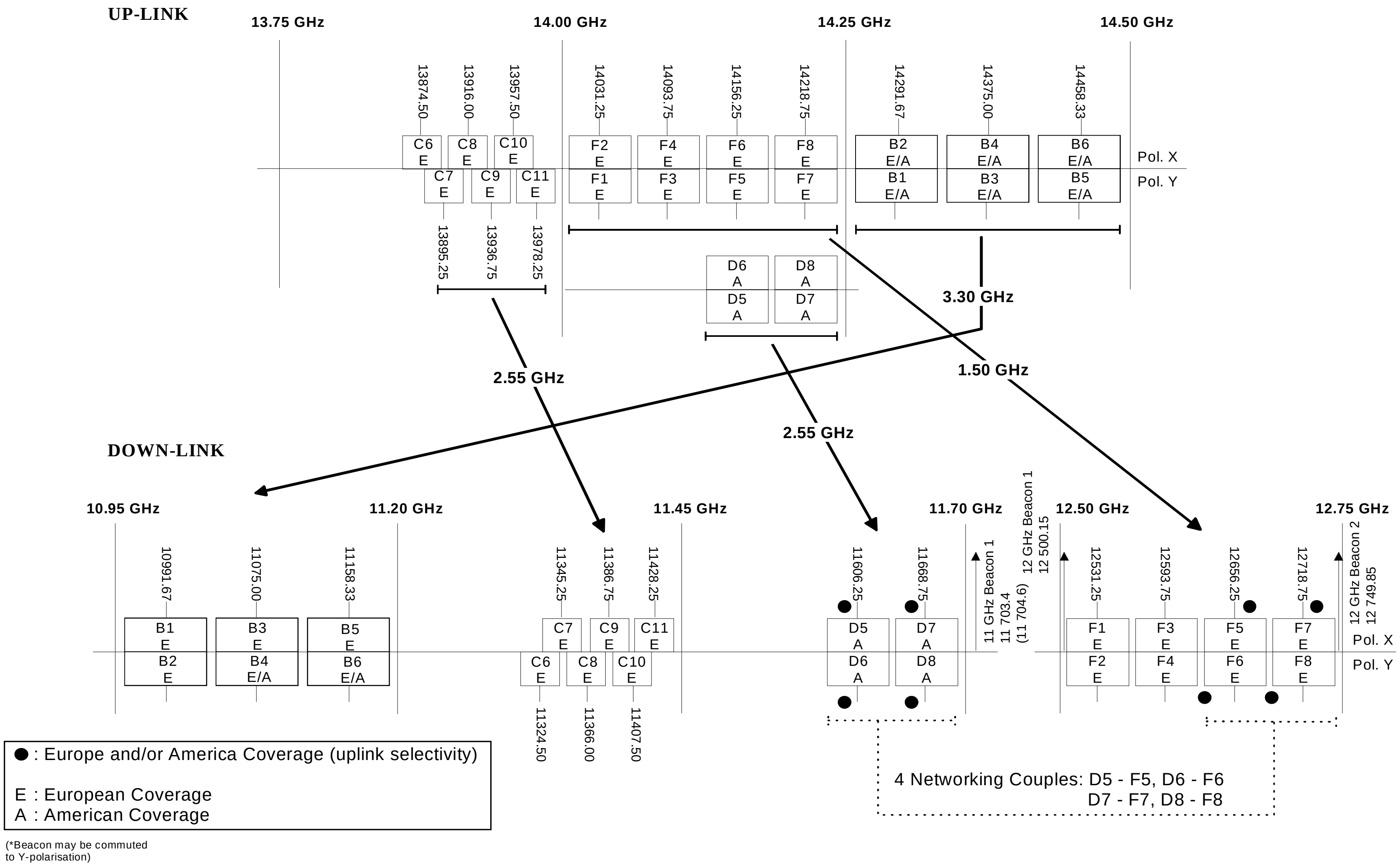
SESAT Frequency Plan (Frequency in MHz)

SHU/98/002

EUROBIRD Launch

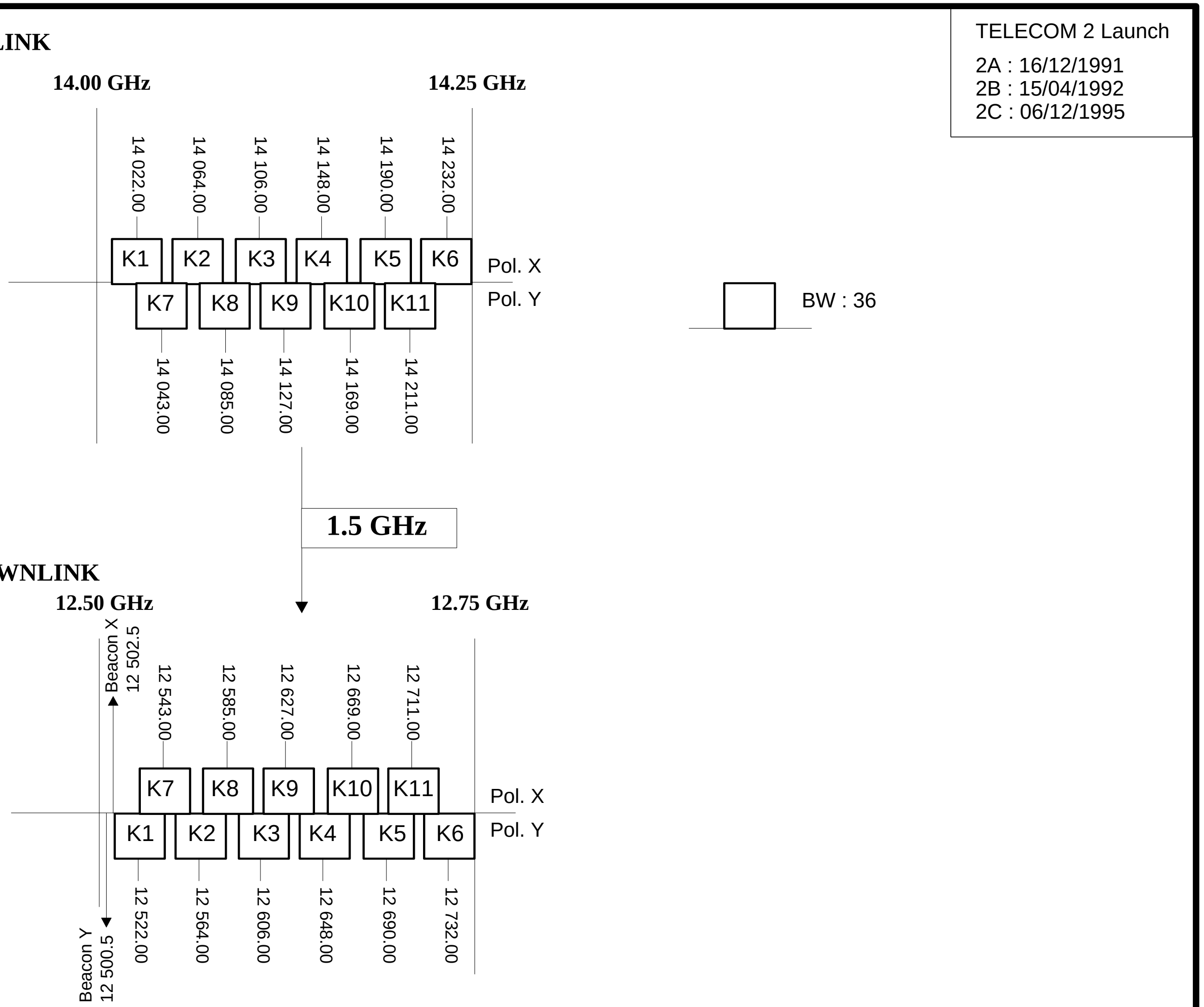


EUROBIRD™ FREQUENCY PLAN (Former W1RM)
(Frequency in MHz)



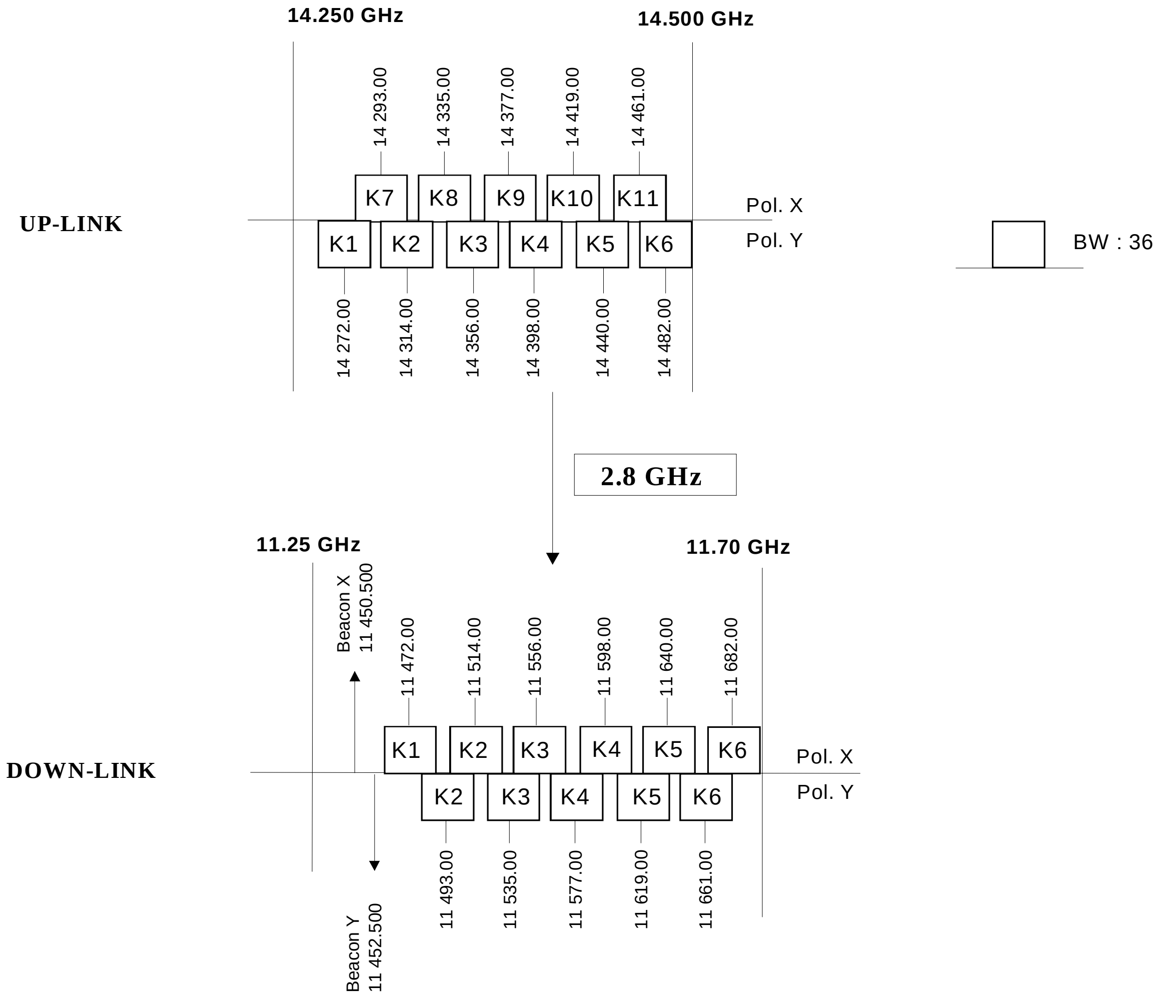
ATLANTIC BIRD™1 – FREQUENCY PLAN

(Frequency in MHz)

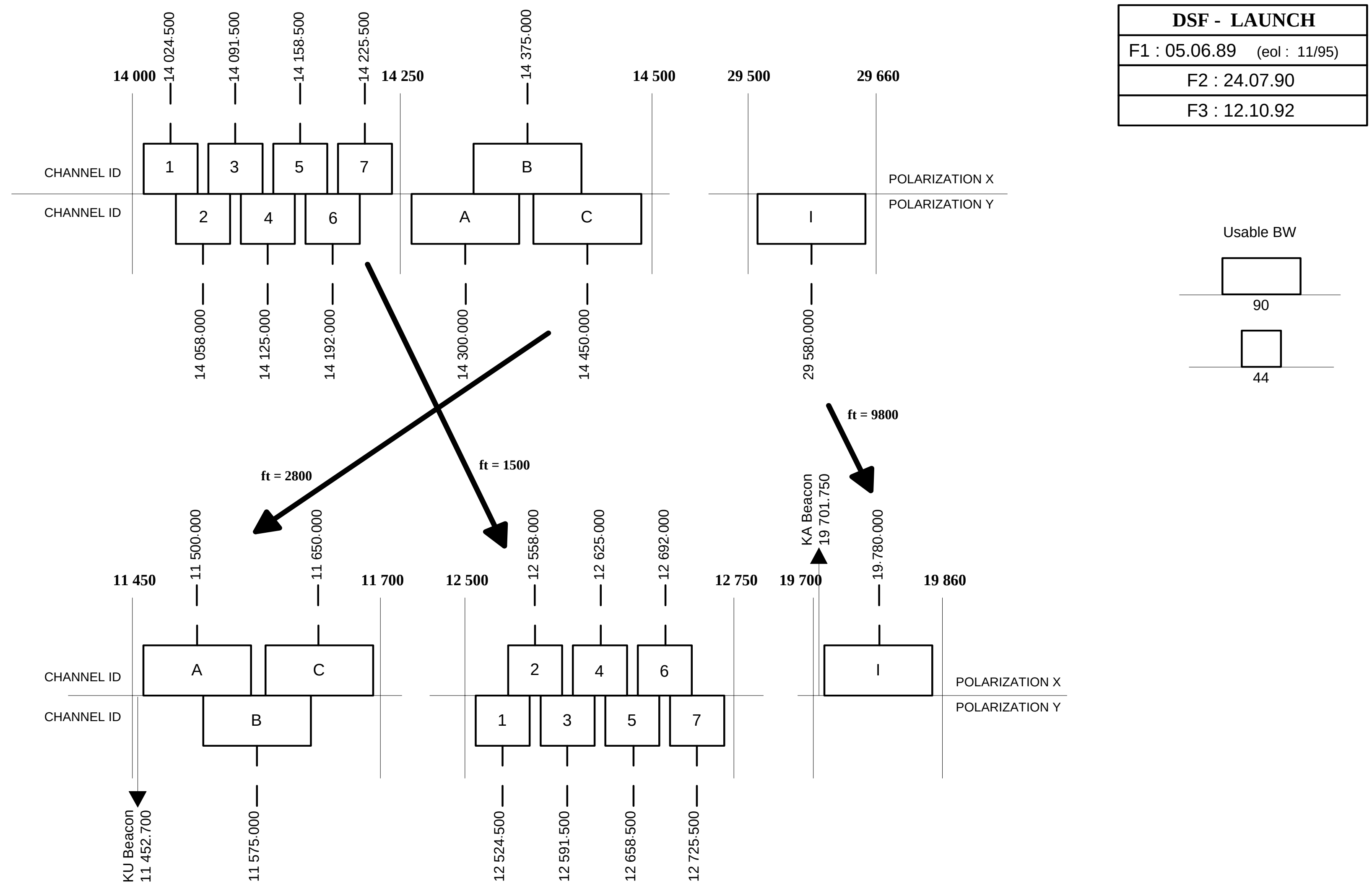


TELECOM 2 FREQUENCY PLAN (Ku-band channels)
(Frequency in MHz)

TELECOM 2 Launch
2D : 08/08/1996



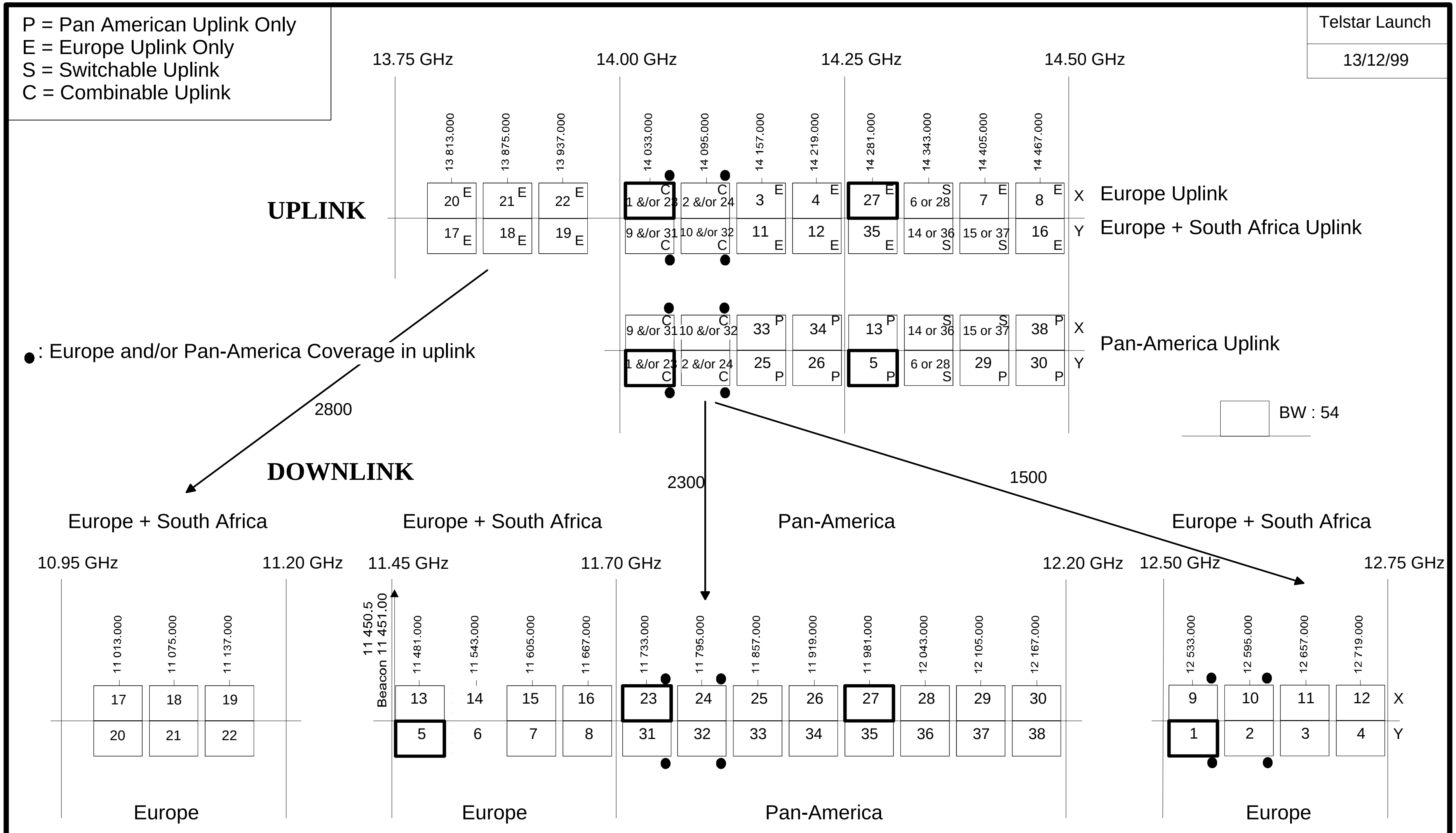
TELECOM 2D FREQUENCY PLAN (Ku-band channels)
(Frequency in MHz)



DFS 2 Kopernikus Frequency Plan

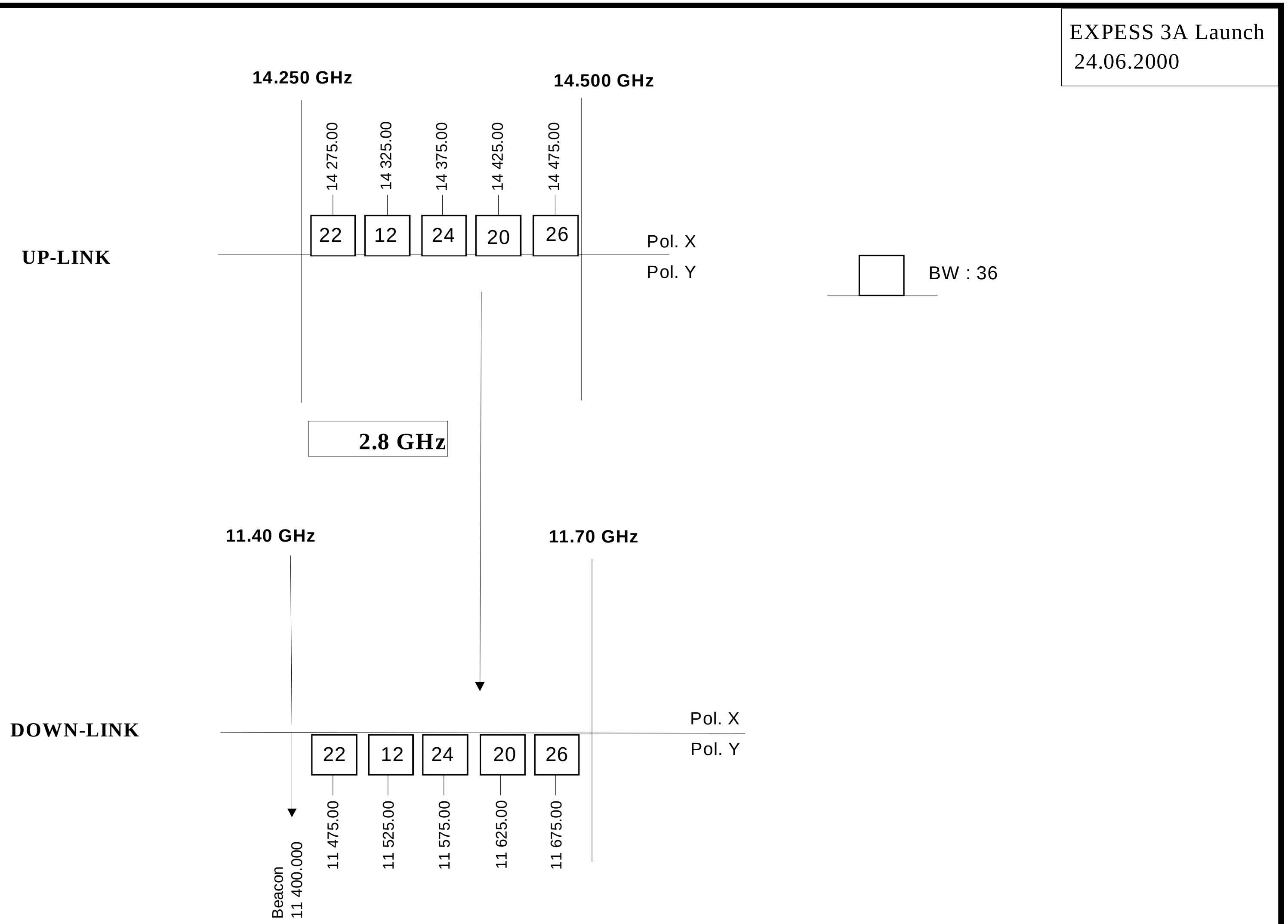
(Frequency in MHz)

SHU/98/012



Telstar 12 Frequency Plan
(Frequency in MHz)

pdftelstar.dsf



EXPRESS 3A FREQUENCY PLAN (Ku-band channels)
(Frequency in MHz)

Annex G. Measurement of Spurious Radiation

G.1. Test Objectives

- To confirm compliance with spurious radiation specifications.
- To prevent any interference to existing services.

G.2. Principle

The SUT transmits at nominal power to dummy load or clear sky (i.e. far off the geostationary arc) at operational configuration. Using a calibrated measurement point of the station transmit (TX) chain, the output signal is examined within a suitable frequency range for the presence of spurious and intermodulation products.
The following procedure is intended to provide sufficient indication of presence of spurious emissions. Further investigation (e.g.: zooming into the frequency band where a suspect spurious signal occurs) will be required if spurious signals are detected during this measurement.

G.3. Summary of Requirements

Although the specifications vary following E/S standard, a reasonably simple way to check compliance is to take spectrum analyser dumps of the frequency range of interest. It is however required that SUT provides at least a way to keep a copy of the trace (plotter, screen snapshot, computer file), copy which shall be forwarded (fax or e-mail) to ERS/EUTELSAT for evaluation.

Furthermore, the SUT shall record the relevant levels observed using the spectrum analyser marker functions.

EUTELSAT Specification	**E/S standard**	**Spurious excluding Intermodulation**				**Intermodulation Products**		**Spectral Sidelobes**	
		outside alloc. BW		inside alloc. BW					
		level (dBW)	meas BW (kHz)	level (dBW)	meas BW (kHz)	level (dBW)	meas BW (kHz)	level (dBW)	meas BW (kHz)
EESS 200	T-2	4	4	n.a.	n.a.	12	4		
EESS 203	I	4	4	TX carrier -50 dB	4	12	4		
EESS 400	L	4	4			7 12 42	4 4 12500	 12 42	 4 12500
EESS 500	S	4	4	TX carrier -50 dB					
EESS 502	M	4	4	TX carrier -50 dB		12		TX carrier -50 dB	

G.4. Test conditions:

- HPA to dummy load or antenna pointed to clear sky.
- Signal generated by the operational modulator, routed through the operational up-converter. (SUT in operational configuration).
- SUT HPAs to operate at standardized input back off.
- Test Equipment (S.A.) connected to a test point which has been calibrated during ESVA.
- HPA power set using a powermeter at the calibrated test point. (Use of the S.A. would be inaccurate since it is usually connected through an uncalibrated cable).

G.5. Potential Pitfalls:

Linearity of S.A. log amplifier, as a wide dynamic range is used.

Noise floor of S.A.: with the typical levels observed in most stations, this will not usually cause trouble.

Noise response of S.A log amplifier/detector: see point 1.9 below.

Long sweep time (15s) for 4kHz measurements: some brief events may be lost possible remedy: let at least 10 sweeps accumulate data in max. hold mode.

Limited 1000 or 400 points frequency resolution (4kHz measurements).

Position of the measurement point in the up-link chain (if an up-link bandpass filter is present).

SUT signal modulation may be incompatible with the above S.A. settings.

The actions to take here depend obviously upon the modulation spectral characteristics and are to be solved on a case by case basis.

G.6. Step-by-Step Procedure

Step 1: SUT switches to dummy load or depoints the antenna to cold sky (SUT to consider potential danger when commuting switches at high EIRP settings).

Step 2: SUT configures the signal path as for operational transmission, i.e.: The signal is generated by the operational modulator and routed through the operational upconverter. No modulation is applied (see test conditions below).

Step 3: SUT adjusts the EIRP to obtain the nominal transmit EIRP value, using the calibrated test point (see EIRP test). SUT records the EIRP and level readings.

Step 4: Keeping the HPA power constant, SUT substitutes the spectrum analyser cable to the power sensor and sets the spectrum analyser (refer to recommended settings below).

Step 5: SUT records the peak signal level on the analyser and deduces the cable loss (which should typically not exceed 5 dB).

Step 6: SUT sets the spectrum analyser following the guidelines of table 1.7.1 below then activates the max. hold mode. After at least 10 sweeps, SUT freezes (‘view’) and records the trace (plotter / printer).

Note: Assuming a 1000-point plot, each point represents a 500 kHz slice of the spectrum, which is 50 times larger than the resolution bandwidth. It is therefore recommended to zoom on visible spurious using a 10 MHz span, keeping same reference level, RBW and VBW.

Step 7: Maintaining the above analyser settings, the SUT disconnects the spectrum analyser and records the level of the noise floor.

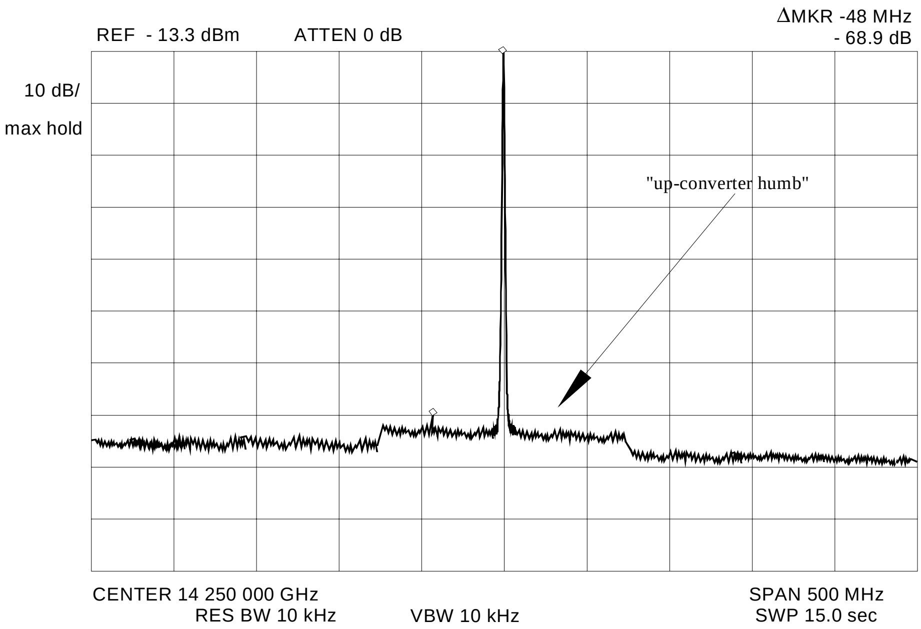
Step 8: As step 6 but SUT uses the settings defined by table 1.7.2 below (The required data accumulation time will exceed 2 minutes).

Step 9: SUT ceases transmission and forwards the results (copy of spectrum plots including corresponding EIRP levels of spurious signals and noise floor) to EUTELSAT and ERS.

G.7. Spectrum Analyser Settings:

Measurements for Detection of Spurious within 4 kHz Bandwidth:

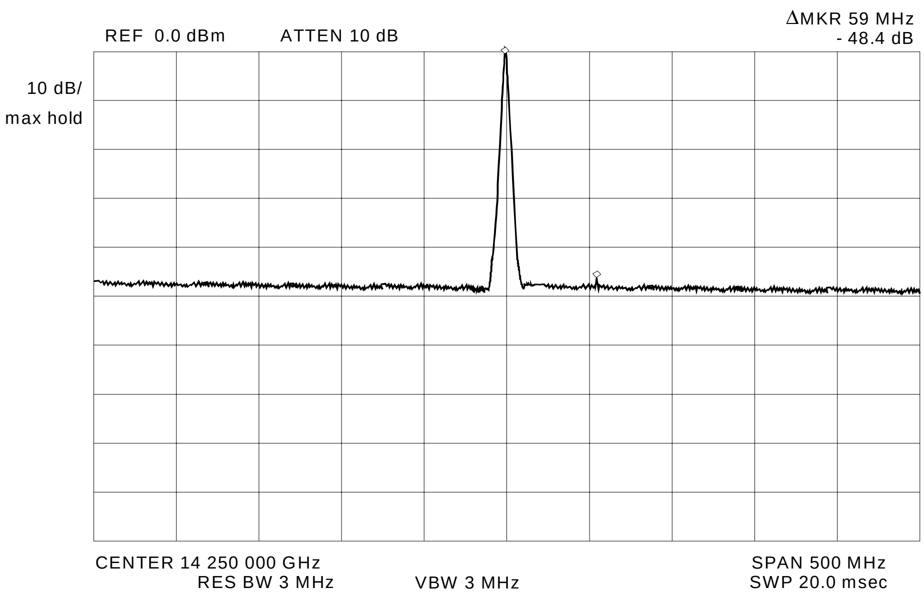
Frequency	: 14.25 GHz	(Centre of the transmit band of interest or SUT carrier frequency)
Span	: 500 MHz	
Resolution Bandwidth	: 10 kHz	(For HP S.A. equivalent Noise Bandwidth equals 10 x 1.2 = 12 kHz). See note*
Video Bandwidth	: 10 kHz	See note*
Sweep Time	: 15 sec	Automatic (coupled)
RF Attenuator	: 10 dB	(Depends on level at nominal power. To optimize the dynamic range, it is recommended to set the attenuator to 0dB at test points with low level)
Max. Ref level	: 0 dBm	(Depends on RF attenuation)
Max. hold	: On	
Max. hld noise	: -73 dBm	(With HP8566A/B and 10dB RF input attenuation. At 0dB input attenuation: -83)



* *Since the RBW is larger than the specified 4 kHz, noise-like spurious will have to be corrected, as they appear too high by about 4.77 dB (ratio of 12 kHz/4 kHz). Assuming 60 dBW nominal EIRP, the required dynamic range to read 4 dBW levels with a 10 dB noise margin is >66 dB. In the typical frequent case of a 0 dBm level at measurement point for 60 dBW, this requirement is satisfied (noise is at -73 dBm).*

Measurements for Detection of Spurious within 4 kHz Bandwidth:

Frequency	: 14.25 GHz	(Centre of the transmit band of interest or SUT carrier frequency)
Span	: 500 MHz	
Resolution Bandwidth	: 3 MHz	(For HP S.A. equivalent Noise Bandwidth equals 3x 1.2 = 3.6 MHz). See note*
Video Bandwidth	: 3 MHz	See note*
Sweep Time	: 20 ms	Automatic (coupled)
RF Attenuator	: 10 dB	(Depends on level at nominal power. To optimize the dynamic range, it is recommended to set the attenuator to 0dB at test points with low level)
Max. Ref level	: 0 dBm	(Depends on RF attenuation)
Max. hold	: On	
Max. hld noise	: -48 dBm	(With HP8566A/B and 10dB RF input attenuation. At 0dB input attenuation: -58)



* *Since the RBW is narrower than the specified 12.5 MHz, spurious which behave like noise will have to be corrected, as they appear too low by about 5.4 dB (ratio of 12.5 MHz/3.6 MHz). Assuming 60 dBW nominal EIRP, the required dynamic range to read 40 dBW levels with a 10 dB noise margin is >30 dB. In the typical frequent case of a 0 dBm level at measurement point for 60 dBW, this requirement is satisfied (noise level at -48 dBm).*

G.8. SUT Test Report:

- Level at the calibration point when HPA power has been set.
- Level at the powermeter probe and corresponding EIRP.
- Corresponding S.A level in the configuration used for measurement (with cable inserted) or S.A. connecting cable losses value in the frequency range.
- Spectrum analyser plots in max. hold mode with the above recommended settings.
- (Including values of RBW,VBW,Freq.,Span,Sweep time...).
- Level/frequency of the highest peaks observed (especially if the plot is a snapshot).
- Level at analyser noise floor.

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Annex H. Earth Station Alignment Verification

H.1. Objectives

a): To re-confirm:

- correct earth station alignment in azimuth elevation and polarization,
- correct setting of operational station EIRP and frequency.

b): To prevent any interference to existing traffic.

H.2. Principles

Initially, the earth **S**tation **U**nder **T**est (SUT) proceeds with transmission of its modulated operational carrier whereas the **E**UTELSAT **R**eference **S**tation (ERS) transmits a clean reference carrier. Upon authorization by the ERS, the SUT disables carrier modulation. The ERS verifies the SUT antenna pointing (azimuth, elevation, polarization) and, if necessary, guides the antenna under test to the optimized position.

The ERS verifies the SUT transmit frequency.

ERS and SUT carry out a power balance to establish the operational transmit EIRP as defined by the relevant EUTELSAT transmission plan.

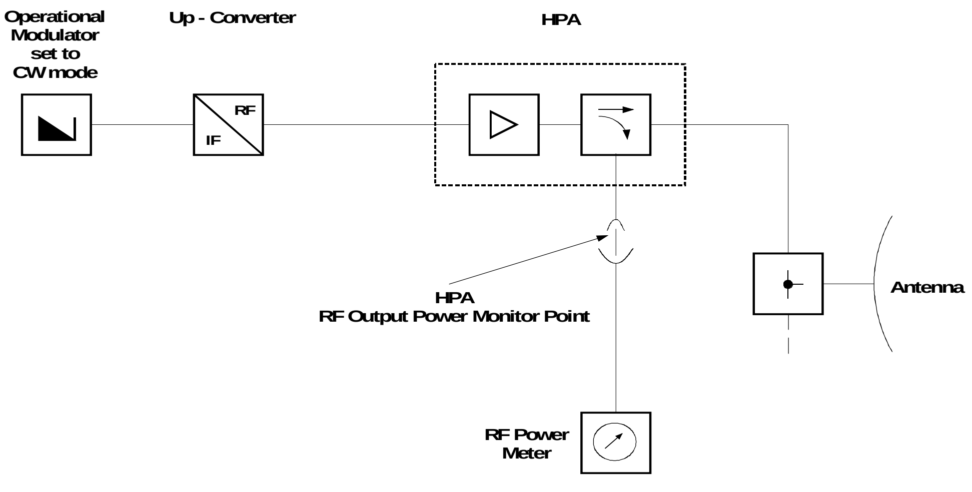

Figure H.1 : SUT TX Chain Configuration during Earth Station Alignment Verification (EAV)

H.3. Step-by-step procedure

H.3.1. Access Coordination

Step 1: Immediately prior to the scheduled commencement of EAV (i.e. ~ 5 minutes) the SUT shall establish and maintain phone contact with ERS. SUT shall communicate sky and wind conditions and information on all details which may impair testing.

Step 2: ERS ensure that the allocated frequency range (for the reference carrier) is free of traffic.

Step 3: ERS shall contact the EUTELSAT CSC to obtain authorization for space segment access and reconfirmation of actual gain setting.

Step 4: In accordance with parameters of the EUTELSAT test plan, ERS transmit the reference carrier.

H.3.2. Transmission by SUT

Step 5: Under direction of the ERS, SUT disable the modulation of the operational carrier at the assigned frequency and EIRP. The SUT CW - carrier shall be generated by the operational TX-chain with the modulator set to CW mode. SUT equipped with an automatic tracking system, shall disable auto-track mode.

Note: The SUT must CEASE transmissions immediately if the communications link to the ERS fails or if the presence of staff at the SUT phone is interrupted. This rule applies to this and all following tests where the SUT transmits.

Step 6: SUT report TX power meter reading to ERS. If available, SUT also report the applicable TX coupling factor and post coupler loss to the ERS.

Step 7: ERS take a plot of the spectrum and check carrier frequency, EIRP and polarization and request corrections if necessary.

Step 8: Under the direction of the ERS, SUT depoint its antenna first in azimuth and then in elevation. ERS record the corresponding variation of RX levels and guide the SUT to boresight. If applicable, SUT report azimuth and elevation readouts otherwise, SUT secure the antenna and mark appropriately the antenna position.

Step 9: Under the direction of the ERS, SUT rotate slowly the antenna feed. ERS advise on the sense of rotation.

Step 10: ERS guide the SUT to acquire the optimum position (i.e. where polarization plane of the SUT and satellite receive antenna match and a minimum in cross-polar level is observed).

Step 11: SUT secure feed position. ERS verify that the optimized position is maintained.

Step 12: SUT report the polarization angle indication of the ERS. If the SUT is not equipped with indicators, the feed position shall be marked.

Step 13: ERS monitor short term (~ 5 minutes) fluctuation of frequency and EIRP of carrier under test.

Step 14: Under the direction of the ERS, SUT adjust its EIRP to balance the reference carrier.

Step 15: ERS confirm balance condition.

Step 16: SUT read the TX power meter and report the value to the ERS. SUT record the reading of the transmit power meter and the corresponding station EIRP and maintain this EIRP at all times during operational transmissions, and carefully note this value for future transmissions as the nominal EIRP.

Step 17: SUT equipped with an automatic tracking system, shall enable auto-track mode.

Step 18: SUT enable carrier modulation.

Step 19: ERS take a plot of the spectrum.

Step 20: ERS cease transmissions.

Step 21: ERS advise the EUTELSAT CSC of test completion and request instructions for further proceedings.

Step 22: ERS forward CSC directions to the SUT (e.g. cessation of transmissions, start of IFLU, immediate commencement of traffic).

Step 23: ERS forward the completion report to EUTELSAT.

EUTELSAT S.A. OPERATIONS CONTACT POINTS

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ESVA	Voice: +33-1-53.98.48.25 +33-1-53.98.49.76
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MAILING ADDRESS	EUTELSAT S.A. 70, rue Balard F-75502 PARIS Cedex 15 FRANCE
EUTELSAT S.A. WEB on operational issues	"http://services.eutelsat.com" or "http://www.eutelsat.com/ Satellite information/Technical & operational docs/Uplinking & Satcom Services"

02-07-2001