5 m Ka Uplink Station - ESVA and Stability Test Results

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Abstract
This paper describes the ESVA and Stability Test Results conducted between October through December 2004 on the Ka Band Tx/Rx Uplink provided by Aersat to Skylogic-Eutelsat in Turin (Italy). The Aersat has been fully responsible for the Project implementation in conjunction with Antech.

The ESVA and Stability Test Results have been carried out on W3A satellite located at 7° East with the support of an ESVA Reference Station ERS located in Redu (supported by the monitoring station located in South Africa). The W3A satellite, besides to constitute the back-up to the Eutelsat W3 satellite for Ku bandwidth, is provided with Ka transponders (H transponders) for European coverage in cross-strapping with Ku transponders (J transponders) covering the south of Africa area[1].

Ka Satellite Coverage of W3A
The specified satellite network, which the Ka Uplink in Turin will operate with, will utilize for transmission from Europe to South of Africa the transponder H (operating in the Ka band from 27.50 GHz to 28.60 GHz in up-link from Europe and in Ku band from 12.50 GHz to 12.75 GHz in down-link to South of Africa) and for reception from South of Africa to Europe the transponder J (operating in the Ka band from 21.40 GHz to 21.65 GHz in down-link to Europe and in Ku band from 14,00 GHz to 14,25 GHz in up-link from South of Africa).

The Eutelsat W3A Ka band coverage on Europe is shown in Figure 1 and Figure 2 respectively for uplink and downlink. The Ku band coverage on South of Africa is shown in Figure 3. The W3A Frequency Plan is shown in Figure 4.

The Ka band Earth Station in Turin will operate on the following frequency bands:

a. Ka band Up-Link: 27.50 to 28.60 GHz;
b. Ka band Down-Link: 21.40 to 21.65 GHz.

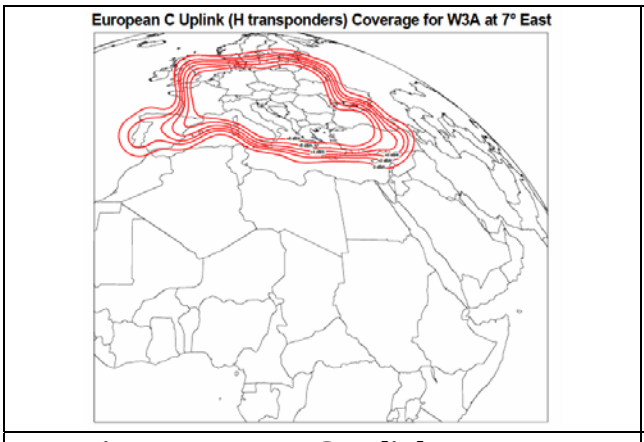

Figure 1 Europe C uplink coverage

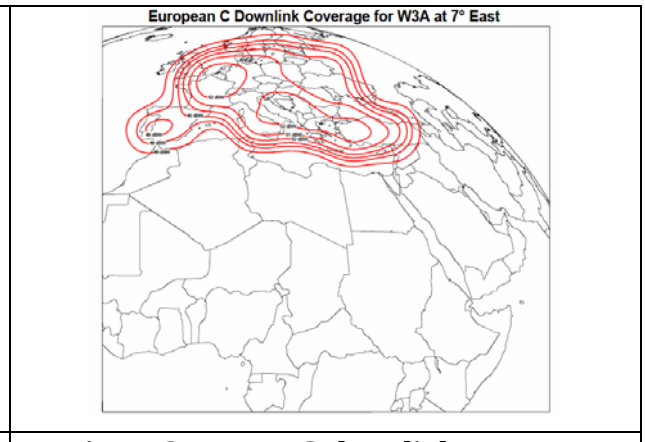

Figure 2 Europe C downlink coverage

[1] Recently the W3A has completely substituted the W3 which has been re-located at 21,5°E and renamed W6 by Eutelsat.

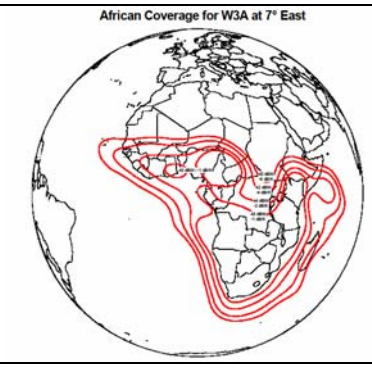

Figure 3 South of Africa UL/DL coverage

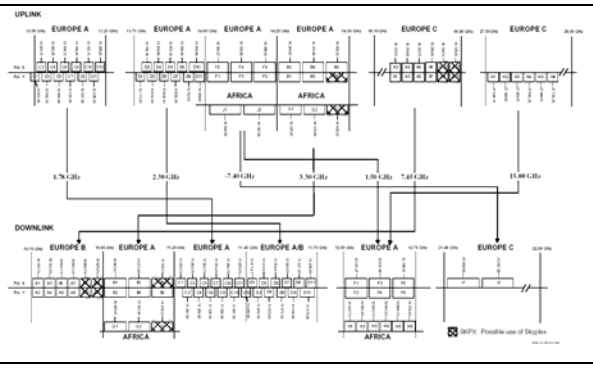

Figure 4 W3A Frequency Plan

Earth Station Configuration

The Earth Station block diagram is shown in Figure 5. The Ka Uplink photos are shown in Figure 6. The redundancy configuration is 1+1 either for Block Up Converters and TWTA subsystems in order to increase the earth station flexibility and availability during equipment failures.

Each TWTA is capable to transmit up to 210 W (rated power) being equipped with TWT's of 250 W. This configuration allows the simultaneous transmission of two carriers each one with an EIRP of 74 dBW. The 5m Antenna system is equipped with a Step Tracking System.

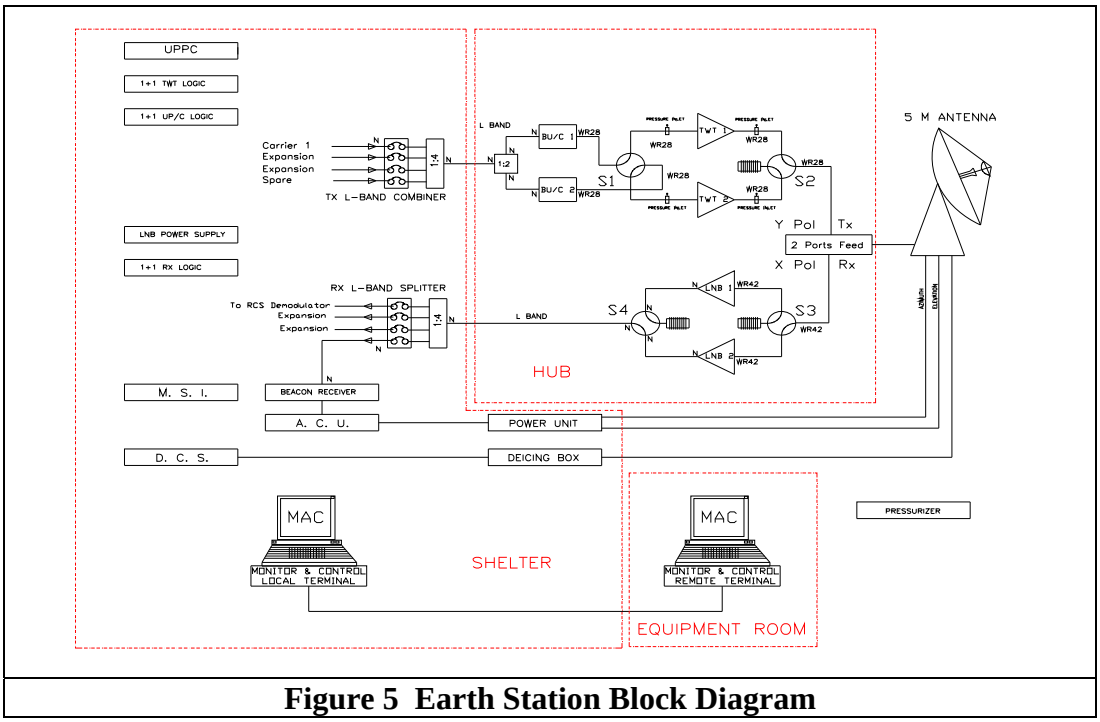

Figure 5 Earth Station Block Diagram

5m Ka Uplink Test Campaign

The Tests have been conducted since October through December 2004 in different phases, as follows:

- ESVA Tests
- Tracking Stability Tests
- EIRP Stability Tests
- Tx Gain Flatness
- Rx Gain Flatness
- Amplitude Stability RX
- Rms Surface Measurements

Figure 6 - Ka Uplink Pictures

ESVA Tests

The official ESVA tests between Turin (Station Under Test SUT) and Redu (ESVA Reference Station ERS) have been conducted on 22nd of October 2004. At the beginning of the ESVA tests the following parameters have been measured:

- Transmit Gain
- EIRP capability
- Receive Gain
- G/T

The Results are shown in Table 1 .

Immediately after, the Ka Uplink Transmit Patterns in Elevation and Azimuth have been recorded in the ESVA Reference Station ERS (Redu) while the Receive Patterns in Elevation and Azimuth have been recorded in the Station Under Test SUT (Turin) on the reception of a pilot from ERS. All the Tx and Rx Sidelobes have been found compliant with the EUTELSAT ESS400 Specifications for Ka band. The following figures show the obtained results:

- Transmit Pattern for Elevation (see Figure 7)
- Transmit Pattern for Azimuth (see Figure 8)
- Receive Patterns for Elevation (see Figure 9)
- Receive Patterns for Azimuth (see Figure 10)

Parameter	Value
❖ Antenna Reflector diameter	5 mt
❖ Polarization	dual linear (2 port feed)
❖ Frequency	21.40 - 21.65 GHz (RX Ka)
	27.50 - 28.60 GHz (TX Ka)
❖ **Gain Tx**	**60.65 dBi typical (@ 28.0 GHz)**
❖ **EIRP capability Tx Chain 1 - 2**	**78,2 dBW**
❖ **Gain Rx**	**58.4 dBi typical (@ 21.5 GHz)**
❖ **G/T**	**32.2 dB/°K @ 38.1° elevation**
❖ Loss between TWTA and Feed flange	1.3 dB

Table 1 5m Ka Antenna –RF Measured Performances

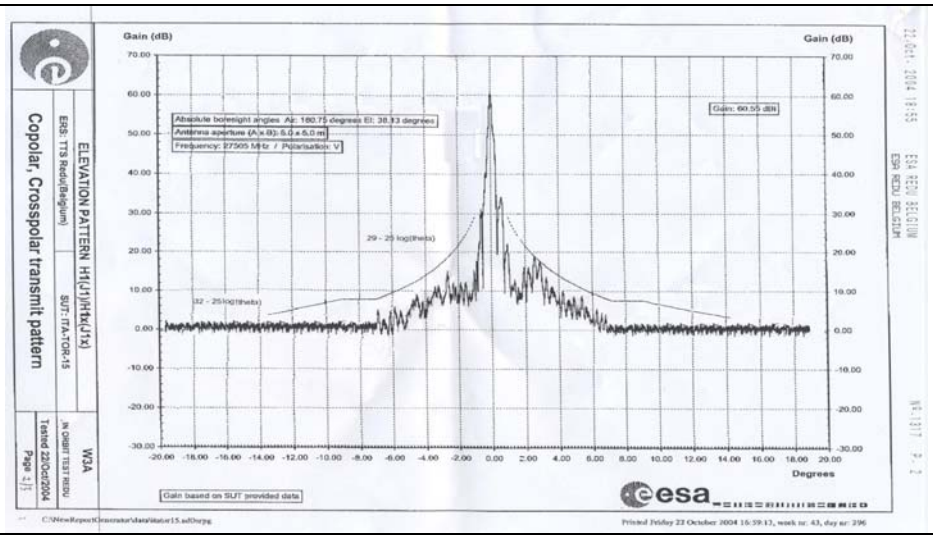

Figure 7 Ka Uplink Tx Patterns - Elevation

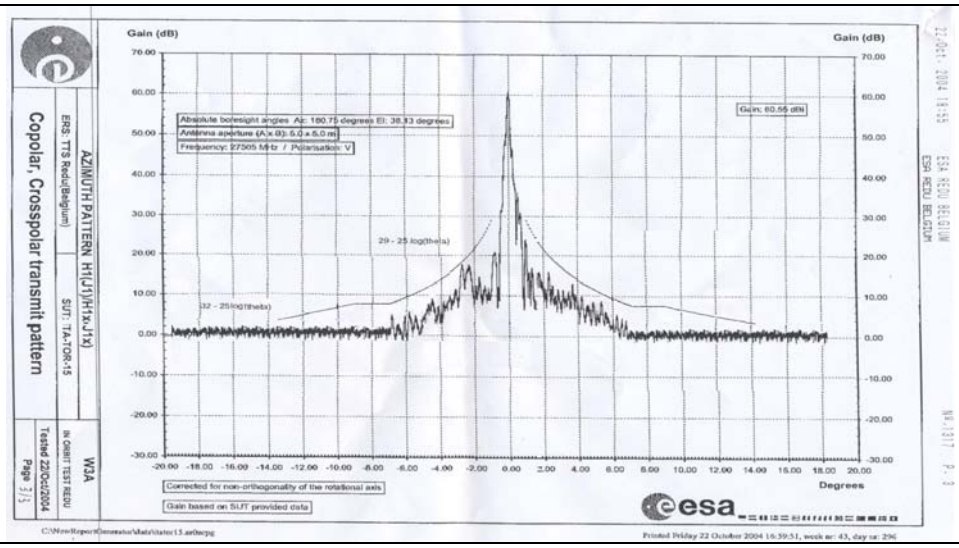

Figure 8 Ka Uplink Tx Patterns - Azimuth

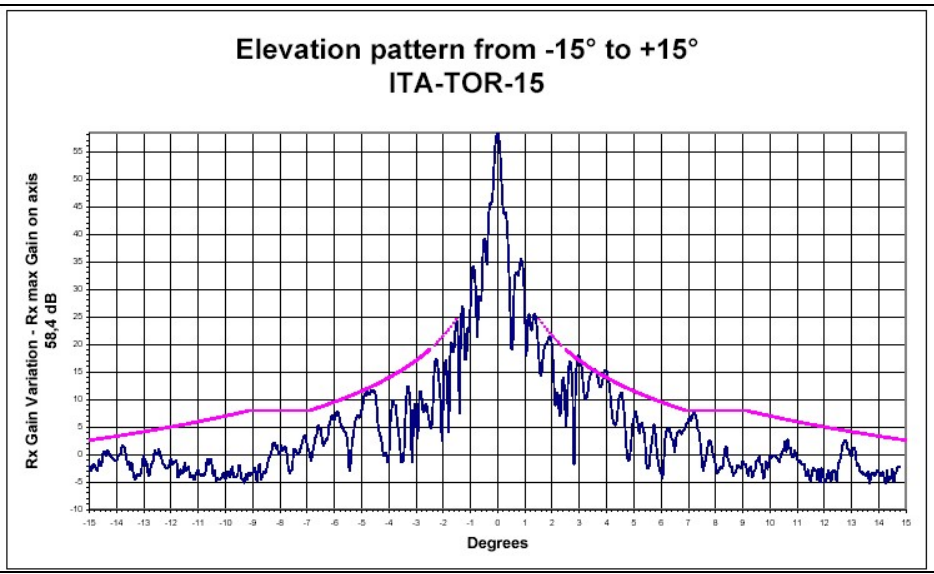

Figure 9 Ka Uplink Rx Patterns - Elevation

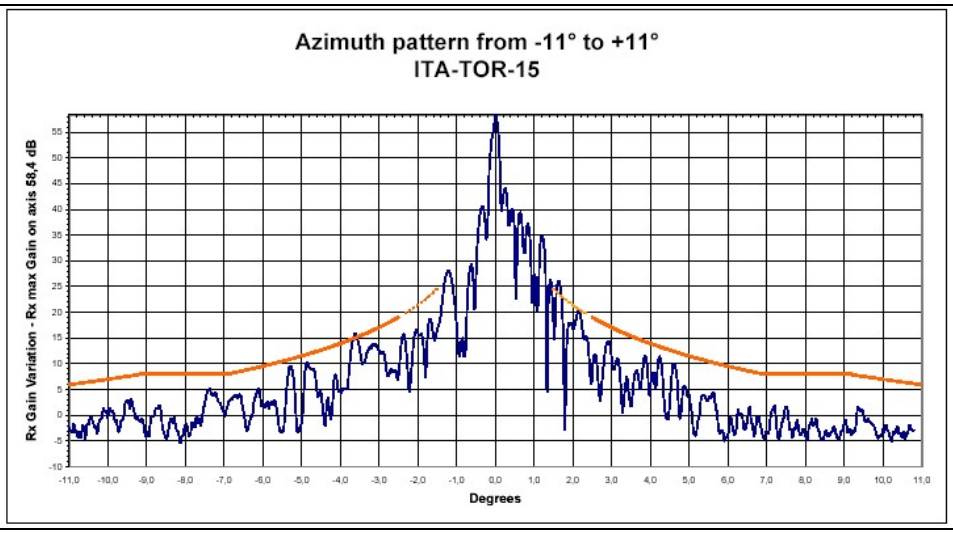

Figure 10 Ka Uplink Rx Patterns - Azimuth

Tracking Stability Tests

The Tracking Stability tests have been conducted on 3rd and 4th of December 2004 over 24 hours of continuous measurements. The test results provided the stability of the three main tracking parameters, as follows:

- Signal Strenght Stability
- Azimuth vs effemerides Stability
- Elevation vs effemerides Stability

The results are shown in Figure 11. The measured values are within the ranges and in compliance with the specified values shown in Table 2.

	EL degrees		Az Degrees
STATIC ERRORS			
TOTAL BIAS ERROR	0,01033		0,01167
TOTAL RANDOM STATIC ERROR	0,01378		0,01231
TOTAL (rms OF BIAS AND RANDOM)	0,01723		0,01696
SYSTEM ERROR (DEGREES rms)		0,02418	
Tx GAIN LOSS (dB)		0,35	
Rx GAIN LOSS (dB)		0,19	
TRACKING ERRORS			
TOTAL BIAS ERROR (PEAK)	0,027		0,027
TOTAL RANDOM ERROR (rms)	0,0064		0,0064
TOTAL AXIS ERROR (rms OF BIAS AND RANDOM)	0,0111		0,0111
SYSTEM ERROR (DEGREES rms)		0,0157	
Tx GAIN LOSS (dB)		0,15	
Rx GAIN LOSS (dB)		0,08	
TOTAL ERRORS			
Total Tx GAIN LOSS (dB)		**0,5**	
Total Rx GAIN LOSS (dB)		**0,3**	

Table 2 - 5m Ka Antenna – Pointing and Tracking System Features

EIRP Stability Tests

The EIRP Stability tests have been conducted over 25 days of continuous measurements (since 19th of December 2004 through 12th of January 2005) and the normalized results, monitored by the Eutelsat

NOC at the monitoring point (coupling factor 28,3 dB), are shown in Figure 12. The operational EIRP for 1 carrier transmission (74,0 dBW) has been set 4,2 dB's below the maximum EIRP capability of 78,2 dBW with the TWTA transmitting 40W at the Feed flange. The average measured value in 25 days has been 74,06 dBW.

There are few values under the nominal (maximum 8 dB's below the nominal value) which indicate the severe fading due to heavy rain.

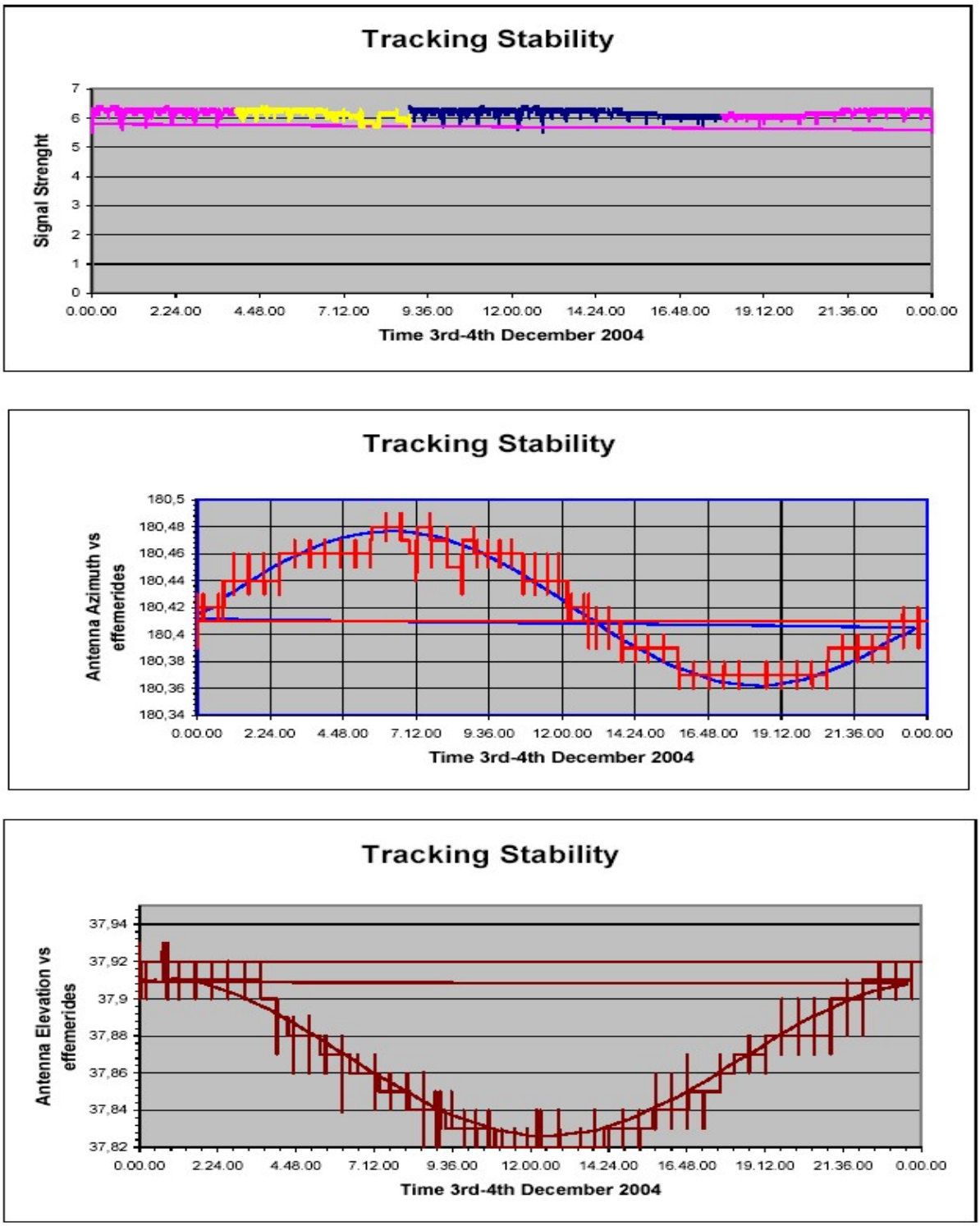

Figure 11 - Tracking Stability Test Results

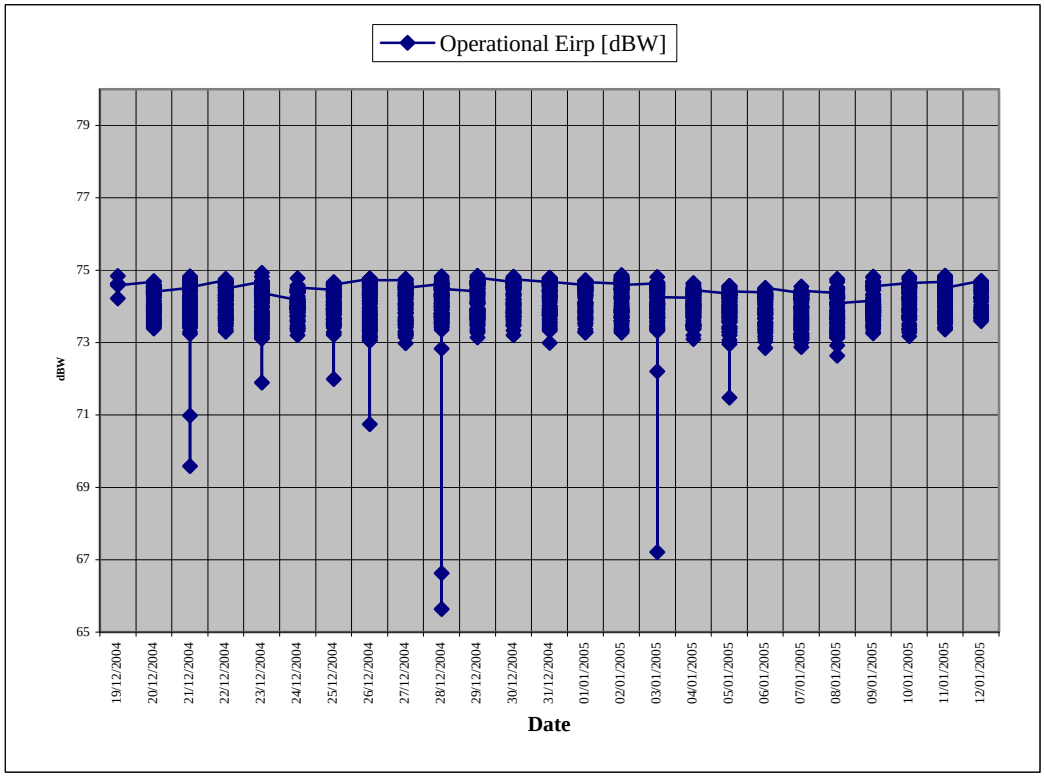

Figure 12 - EIRP Stability Test Results

TX Gain Flatness Tests

The Tx Gain Flatness Tests have been conducted at the end of November 2004 on all the four combinations of Tx Chains, including U/C and TWTA, over the operational bandwidth ranging between 27,5 upto 27,75 GHz. The Tests Results provided the specified flatness and these are shown in Figure 13.

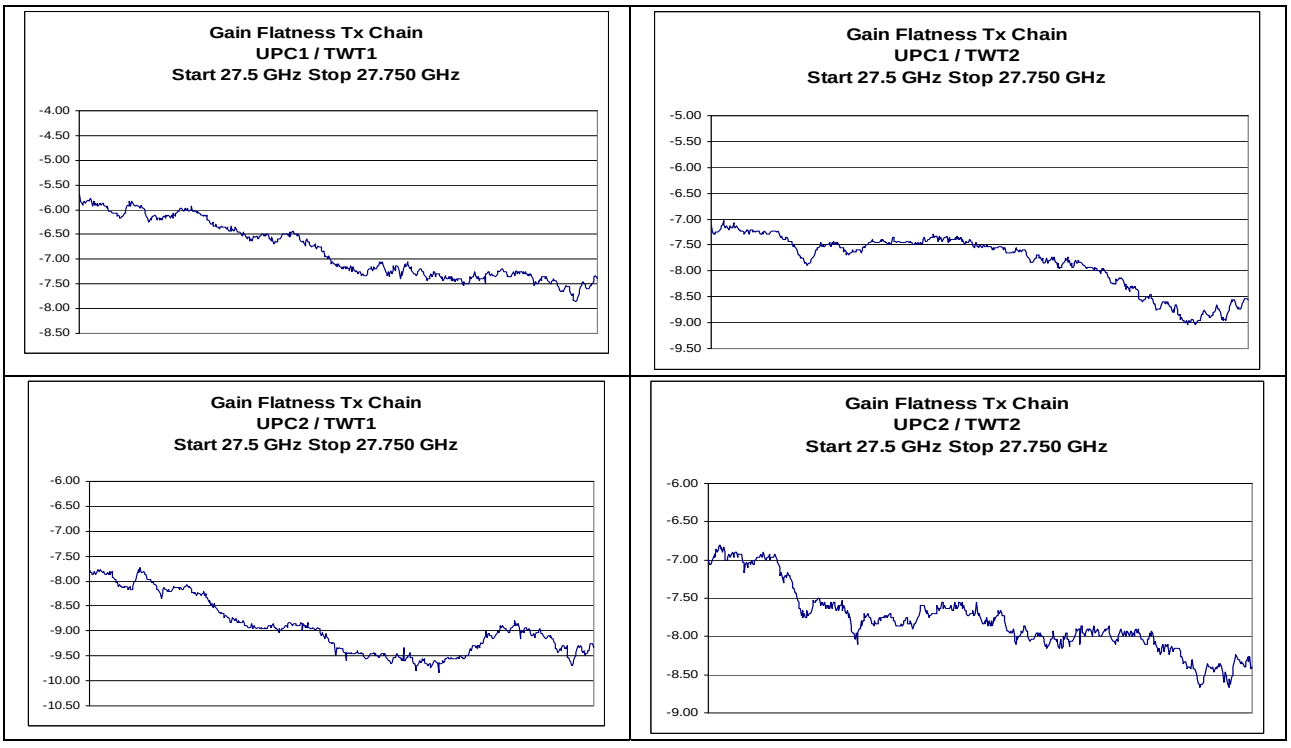

Figure 13 - Tx Chains Gain Flatness

RX Gain Flatness Tests

The Rx Gain Flatness Tests have been conducted at the end of November 2004 on both Rx Chains, including Low Noise Block Down Converter (LNBDC) at the LNBDC L band output ranging between 950 upto 1190 MHz. The Test Result for chain 1 is shown in Figure 14.

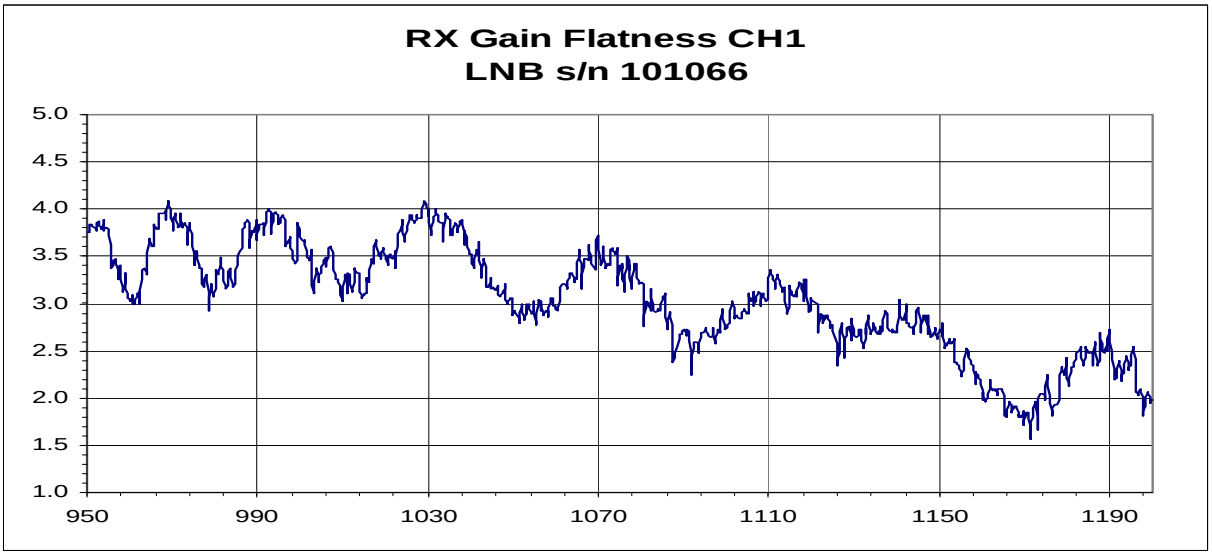

Figure 14 - Rx Chain Gain Flatness

Rx Amplitude Stability Tests

The Rx Amplitude Stability Tests have been conducted at the end of November 2004 on 24 hours of continuous recording. The test have been conducted injected a 28.0 GHz signal inside the LNBs and reading the L band variation in 24 hours. The Test Result is shown in Figure 15.

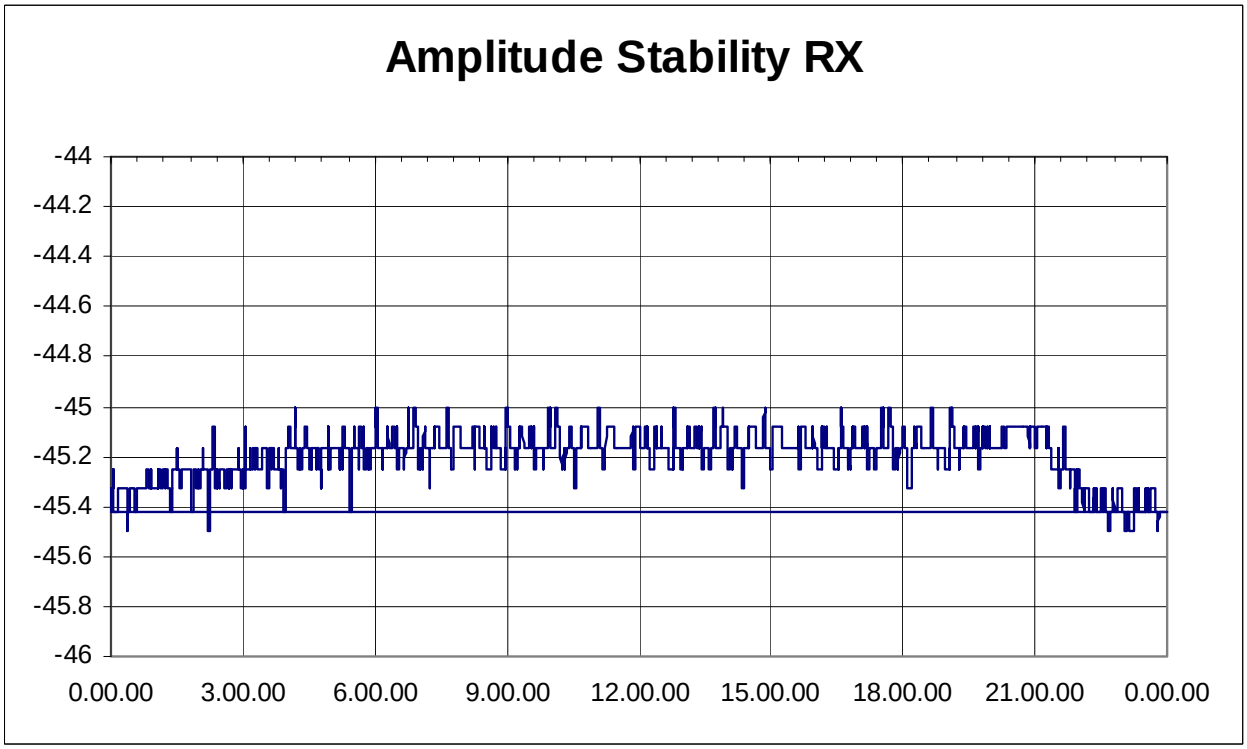

Figure 15 - Rx Amplitude Stability

RMS Surface Measurements

The RMS Surface Measurements have been conducted on site at the beginning of October 2004. The Results are summarized in Table 3.

Date	13/10/2004
Reflector UT	5 mt Antenna
Site	Turin
Antenna Elevation	38.14°
Required RMS (mm)	**0.300**
Measured RMS (mm)	**0.253**

Table 3 - 5m Ka Antenna – RMS Surface Measurements Summary

The measured result of 0,253 mm is the envelope of the measurements conducted with Digital Teodolite (LEICA TRCRM 1105 Plus) on ten 5 mt Reflector circles whose detailed results are shown Figure 16.

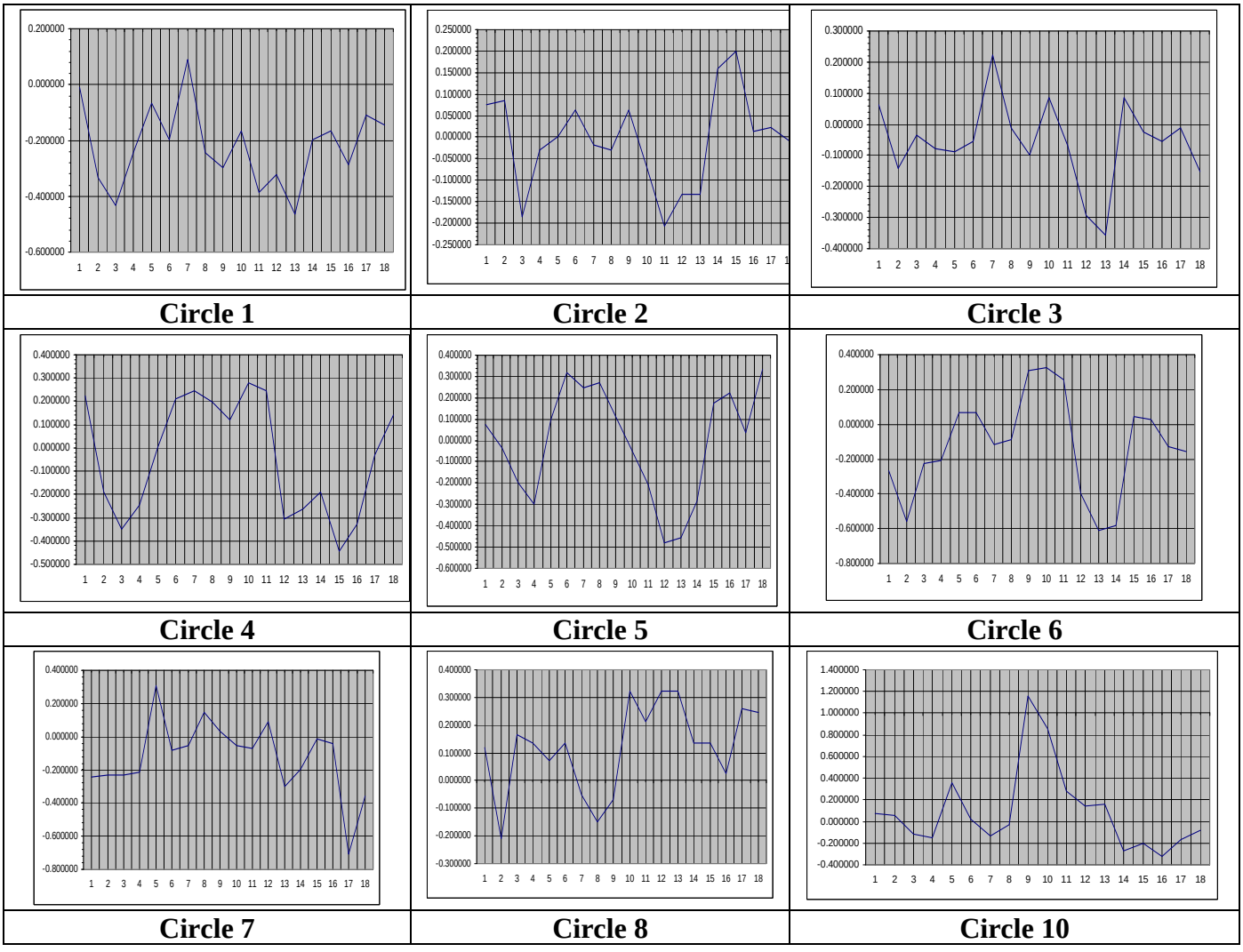

Figure 16 - RMS Surface Measurements with Digital Teodolite

Conclusion

The Skylogic Ka Uplink is in operation since the beginning of December 2004 providing Digital Services and Internet access to South Africa customers via the Skylogic facilities installed at the Turin Teleport. No major alarms have been encountered on this Ka Uplink at exception of some alarms on TWTA and Up Converter depending on the technology assessment of these new equipment operating in the Ka bandwidth. The availability of this Ka Uplink Earth Station is very closed to the 99,98 % of the time with an average BER of 10E-8.

This Uplink constitute the first operational application in Europe to carry out High Data Rate Services based on DVB RCS technology on a commercial transparent satellite equipped with Ka band payload. The implementation and testing of this reality has been successful completed demonstrating the mature state of art of the Ka band technology. Nevertheless it has to reminded the Skylogic effort in maintaining in operation the Ka Uplink jointly with DVB RCS Hub station granting high availability figures in consideration of the high transmitted bit rate of 34 Mbps.

Thanks have to be addressed to all the team (Aersat, Antech, Eutelsat, Sematron, Skylogic, Miteq, etc) which has got possible this technologically advanced reality in Ka bandwidth.

References

Ka Uplink Station for Skylogic - Design and E/S Engineering — 10^ Ka Conference – Vicenza October 2004