HELLAS- SAT 2 SATELLITE HANDBOOK

MARCH 2004

HELLAS- SAT 2 HANDBOOK

Module 100

SCOPE OF THE HANDBOOK

TABLE OF CONTENTS

1 INTRODUCTION

The HELLAS- SAT 2 Handbook provides a description of the Hellas- Sat 2 satellite system together with a short description of how the transponders may be employed for certain applications. It is addressed to service providers and potential users of the system with the aim to provide necessary information in order for them to visualize the capabilities of the system for the planning and implementation of satellite services.
However, depending on the case, the information and guidance provided cannot be considered as a specification but only as a reference tool.

2 MODULAR STRUCTURE

The HELLAS- SAT 2 Handbook consists of different series of modules which cover different subjects. The list of Modules is presented in the Annex to this module. The first digit of the Module's number indicates the series to which it belongs, while the other digits indicate the subcategories of the same Module

The 200 series provide a description of the satellite system and contain information concerning satellite transmit and receive coverages.

The 300 series cover different possible utilizations of transponders which are leased on a full-time basis. The Modules cover only the most frequently occurring transmission systems and the cases presented should not be considered as exhaustive. For transmission plans which are not covered by the 300 series, the lessee should contact HELLAS SAT.

Module 400 covers applications which are referred to Data Services. These applications employ VSAT topology with FDMA and /or TDMA structure which share the transponder resources in terms of bandwidth or power.

Module 500 covers the Temporary Transmissions, also referred to as "Occasional Use" whereby either a full transponder or a fraction thereof is leased for transmissions for a limited period of time. (e.g special events like football, short news at a given point of time etc)

3 USE OF THE HANDBOOK

The scope of the modular structure is to allow the user to limit his reading and focus only to material which is necessary for his particular application. Modules 100 and 200 should be consulted for all applications.

Annex 1 to Module 100

Module 100: General Overview
Introduction
Modular Structure
Use of the Handbook

Module 200: Hellas- Sat 2 Satellite
Introduction
General Characteristics
Frequencies and Polarization
Coverage maps
Payload Configuration
Beacons
Input Power Flux Density
TWTA Transfer Characteristics
Annexes

Module 201: Hellas- Sat 2 Coverage Maps
Introduction
Hellas- Sat 2 Satellite Coverages Description and Parameters
Hellas- Sat 2 Satellite Coverage Maps
Annexes

Module 300: Utilization of Leased Transponders
Leased Transponder Utilization Conditions
Leased Transponder Application

Module 301: Digital Carriers
Introduction
Coding
Quality Objectives
Filtering
Special Sidelobes

Module 302: Multiple Digital TV Carriers per Transponder
Introduction
Transponder operating conditions
  Satellite Input Power Flux Density and Operating I/O Back-offs
  Frequency Assignments
Interference
  Transmission Constraints

HELLAS- SAT 2 HANDBOOK
Module 200

HELLAS- SAT 2 Satellite

TABLE OF CONTENTS

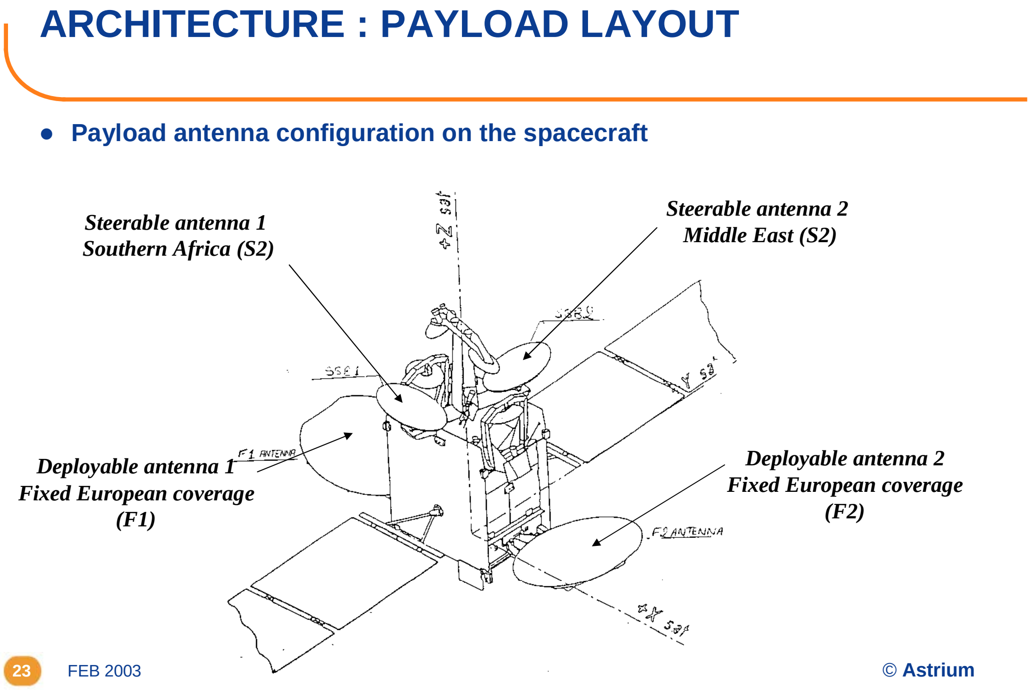
1 INTRODUCTION

This Module contains general information on the multi-region geostationary Hellas Sat satellite which is shown in schematic form in figure 1. It provides a description of the satellite and of its payload. The specified coverages are contained in the specific Module 201.

2 GENERAL CHARACTERISTICS

The Hellas- Sat 2 satellite is designed for a minimum operational lifetime of 15 years and its orbital position can be controlled within ±0.09º East/West and ± 0.05º North/South over at least 12 years. In order to enable the pointing of manually adjusted or program-tracked antennas, HELLAS SAT provides, on request, the data for orbit determination to the earth station operators. Up to thirty (30) transponders of 36 MHz bandwidth each, are available for simultaneous operation, in eclipse as well as in sunlight.

Reception and transmission take place via four dual polarized beam antennas. The two of them (F1 & F2) are fixed, with a 2.5m main reflector each and dual offset Gregorian configuration of single feed with numerically shaped main reflector to provide complex beam shape for efficient illumination of Europe, and part of Middle East and N. Africa. The other two antennas (S1&S2) also Gregorians, are steerable with a shaped parabolic reflector of 1.3m to provide spot coverage and can be pointed anywhere over the surface of the visible Earth.



ARCHITECTURE : PAYLOAD LAYOUT

- **Payload antenna configuration on the spacecraft**

Steerable antenna 1
Southern Africa (S2)

Steerable antenna 2
Middle East (S2)

Deployable antenna 1
Fixed European coverage
(F1)

Deployable antenna 2
Fixed European coverage
(F2)

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Figure 1: HELLAS SAT satellite in orbit (illustrative)

3 FREQUENCIES AND POLARIZATION

3.1 Frequencies

The frequencies and polarization arrangement of the Hellas-Sat 2 satellite transponders are shown in Figure 2 (page 6) whereas in Table 1(page 7) the transponder center frequencies are provided.

The fixed coverage antenna F1 receives signals in the band 13.75-14.00 GHz whilst the fixed coverage antenna F2 receives signals in the band 14.00-14.25 GHz. The steerable antenna S1 receives signals in the band of 13.75-14.00 GHz.
The steerable antenna S2 receives signals in the band 14.00-14.25 GHz on the horizontal uplink polarization and in band 14.00-14.50 GHz on the vertical uplink polarization. There are two types of receivers/downconverters.

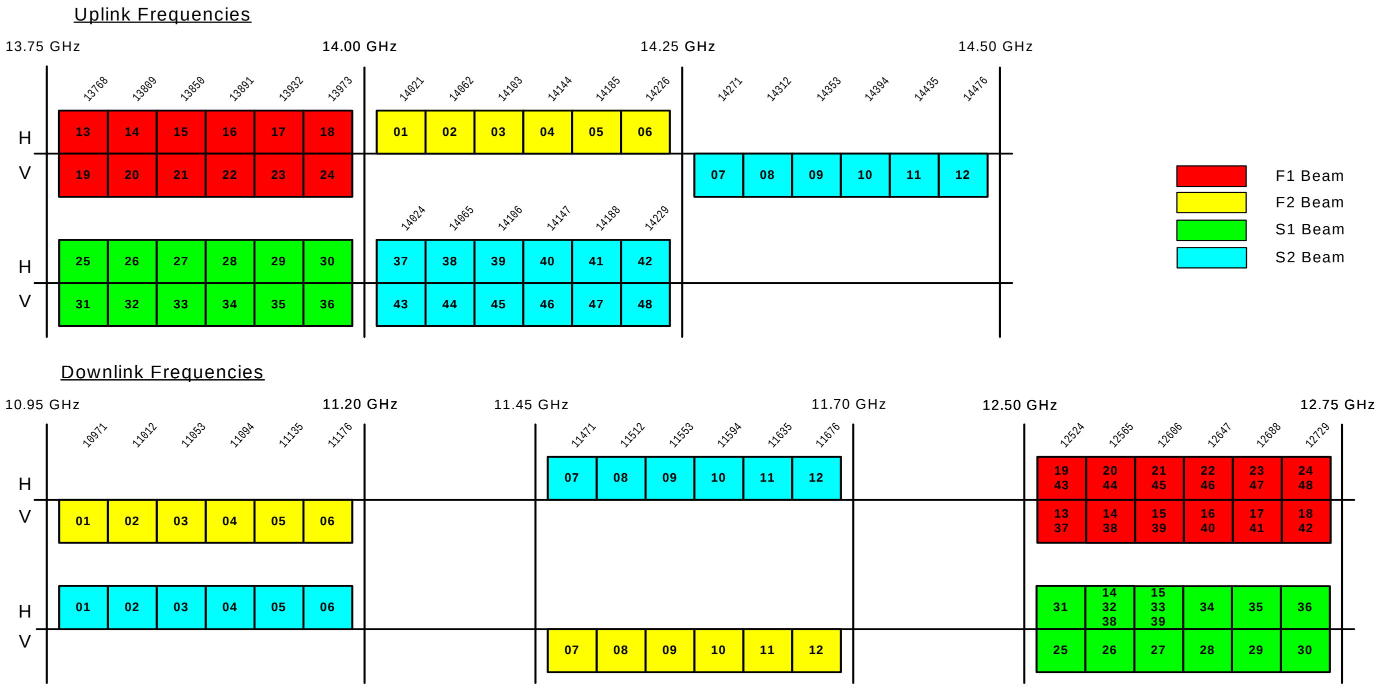
Type 1 receiver provides frequency translation of either uplink band 13.75-14.00 GHz or 14.00-14.25 GHz to downlink band 12.50-12.75 GHz using two switchable local oscillators(1.244GHz and 1.5GHz respectively). These receivers are connected in a 8/6 redundancy scheme.

Type 2 receiver provides frequency translation of uplink band 14.00 to 14.25GHz, to downlink band 10.95 to 11.20 GHz using a 3.050 GHz local oscillator.
These receivers are connected in a 2/1 redundancy scheme.

There are also two downconverter assemblies that provide frequency translation of the S2 uplink band 14.25-14.50 GHz to downlink band 11.45 to 11.70 GHz using a 2.8 GHz local oscillator and connected in a 2/1 redundancy scheme.
It is noted that, due to switching capabilities, channels 13-24(F1 antenna) or channels 37-48 (S2 antenna) may be downlinked in the band 12.50 to 12.75 GHz via the F1 antenna, selectable on a channel by channel basis. It is also possible to downlink S2 channels of the 14.25-14.50 GHz band via the F2 antenna in the 11.45-11.70 GHz band but in this case the F2 channels have to be downlinked via the S2 antenna in the 10.95-11.20 GHz band.

Moreover, there is the possibility to uplink in channels 14 and 15 of F1 and downlink in channels 32 and 33 of S1 on a channel basis thus connecting Europe with areas outside F1 coverage.

HELLAS-SAT Satellite Frequency Plan



Notes:

The downlink channels 01-06, 07-12 and 25-30 can be switched on channel by channel basis but cannot operate simultaneously more than 12. Switching will follow the block order (01,07,30), (02,08,29)...

Channels 37 up to 48 of beam S2 can be downlinked on a channel by channel basis

Channels 32,33 of S1 can be linked with channels 14,15 of beam F1 and/or channels 38,39 of beam S2

When beam F2 is downlinked in beam S2, then beam S2 has to be downlinked to beam F2

30 total transponders are active all the time

Transponder numbers are unique

Figure 2: Hellas-Sat 2 Frequency Plan

Transponder No	Uplink center frequency MHz	Downlink center frequency MHz
1	14021	10971
2	14062	11012
3	14103	11053
4	14144	11094
5	14185	11135
6	14226	11176
7	14271	11471
8	14312	11512
9	14353	11553
10	14394	11594
11	14435	11635
12	14476	11676
13,19,25,31	13768	12524
14,20,26,32	13809	12565
15,21,27,33	13850	12606
16,22,28,34	13891	12647
17,23,29,35	13932	12688
18,24,30,36	13973	12729
37,43	14024	12524
38,44	14065	12565
39,45	14106	12606
40,46	14147	12647
41,47	14188	12688
42,48	14229	12729

Table 1: Uplink and Downlink Transponders Center Frequencies

3.2 Polarization

The Hellas- Sat 2 satellite antennas can simultaneously transmit and receive on two orthogonal linear polarizations at the same frequency (dual polarization, frequency re-use).
The two orthogonal polarizations are denoted as H (Horizontal) and V (Vertical). The signals received on one polarization H or V, are transmitted on the orthogonal polarization V or H, respectively.
The receive antennas of the satellite have a polarization discrimination within the receive coverage area of at least 30 dB (25 dB specified value).
The polarization discrimination of the transmit antennas is at least 31 dB (25 dB specified value) within the transmit coverage.

4 COVERAGE MAPS

4.1 Receive Coverage

Hellas –Sat 2 satellite provides four antennas for reception. The fixed coverage F1 and F2 antennas differ only in the shaping of the main reflectors. In practice they provide almost the same coverage over Europe, N.Africa and Middle East.
Module 201 provides the receive coverage areas in terms of G/T contours for F1, F2, S1 and S2.
The steerable antennas S1 and S2 are pointed, as an example, to cover S.Africa and M.East/Eastern Europe region respectively. S1 and S2 are of identical design.

4.2 Transmit Coverage

Hellas- Sat 2 provides four antennas for transmission. The fixed transmit coverage of F1 and F2 as well as those of the S1 and S2 are presented in the Module 201 in terms of EIRP contours.

5 PAYLOAD CONFIGURATION

5.1 Channel selector description

The payload is capable of operating 30 transponders at the same time up to the end of satellite lifetime, 15 transponders on each of the -Y and +Y panels.
From the 30 transponders, there are 18 dedicated channels and 12 channels that are selectable from a choice of 18. The 18 dedicated downlink channels comprise :

- 12 channels on the F1 coverage area (6 on horizontal and 6 on vertical downlink polarization)
- 6 channels on the S1 coverage area (horizontal downlink polarization)

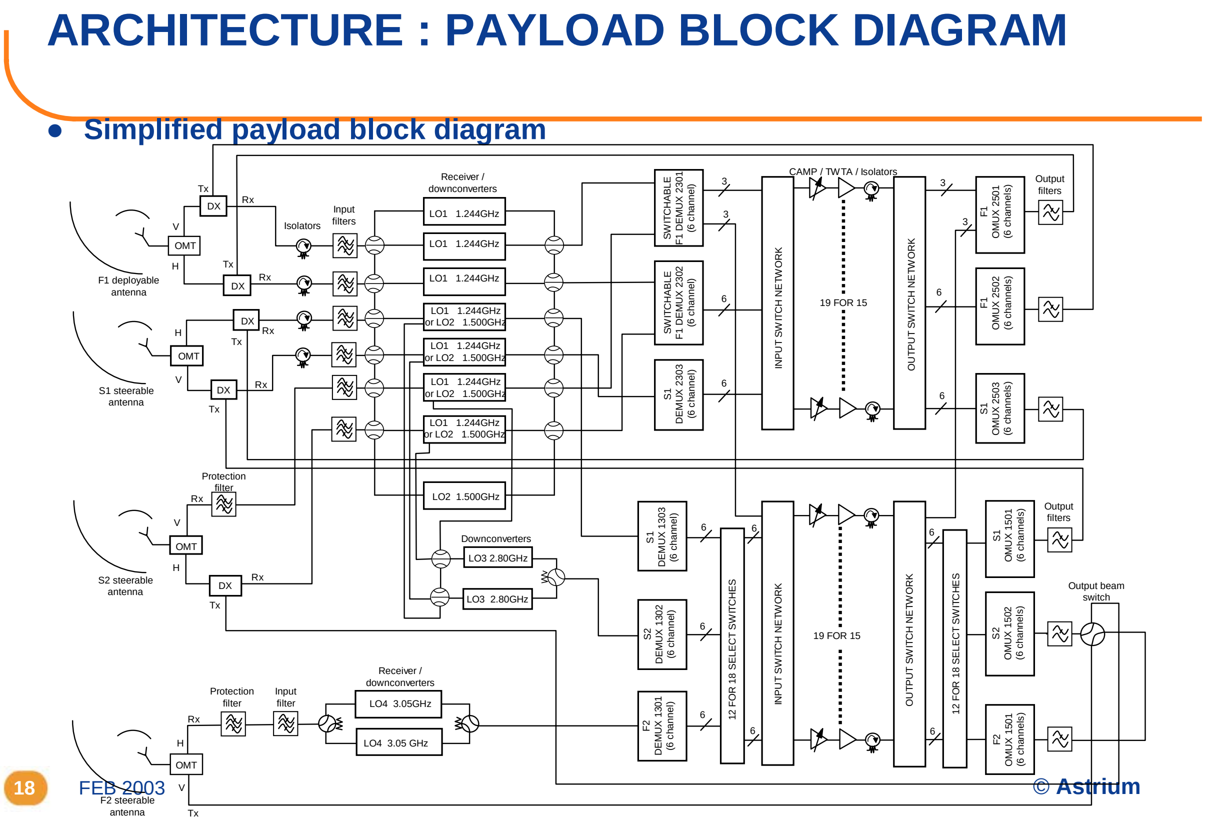
The 12 remaining channels are selectable from the following 18 channels :

- 6 channels from F2 (vertical downlink polarization)
- 6 channels from S1 (vertical downlink polarization)
- 6 channels from S2 (horizontal downlink polarization)

The 18 for 12 channel selectivity criteria are summarized below :

- Any 2 from 3 ; channels F2H6, S1H25, S2V12
- Any 2 from 3 ; channels F2H5, S1H26, S2V11
- Any 2 from 3 ; channels F2H4, S1H27, S2V10
- Any 2 from 3 ; channels F2H3, S1H28, S2V9
- Any 2 from 3 ; channels F2H2, S1H29, S2V8
- Any 2 from 3 ; channels F2H1, S1H30, S2V7

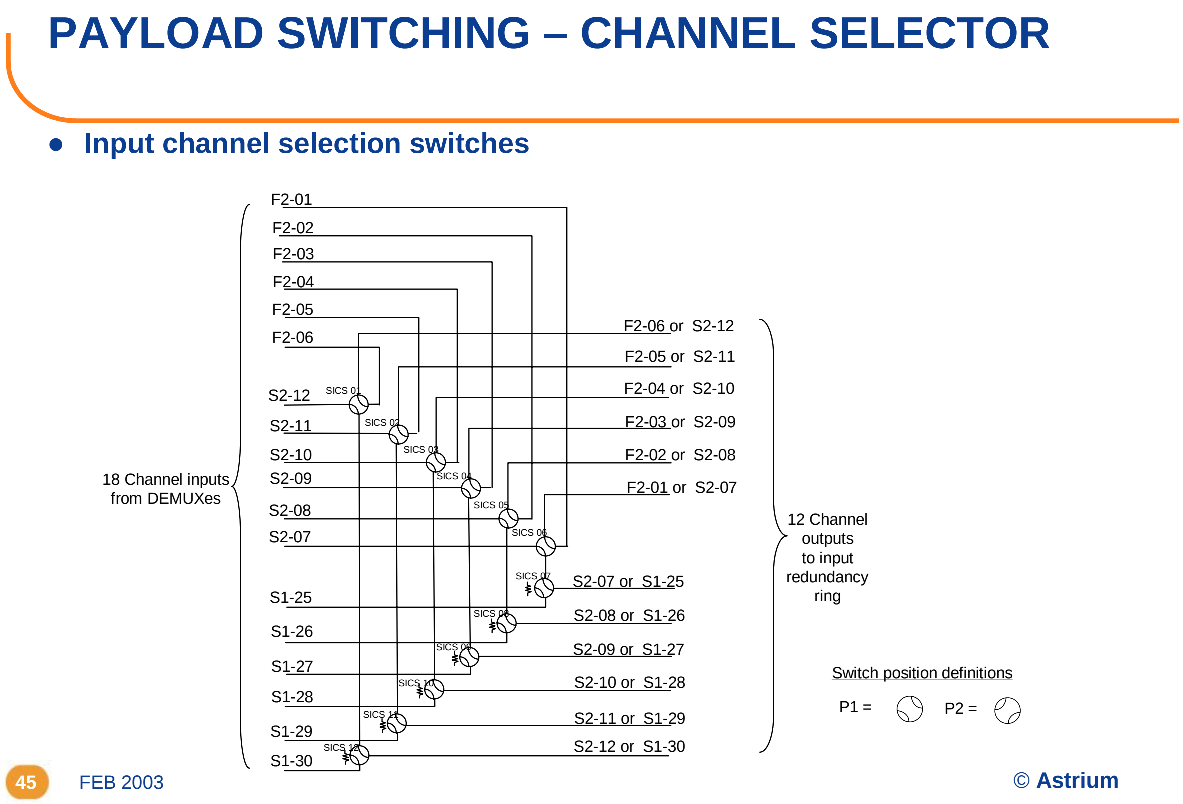
In addition to above, there is the possibility either to downlink channel 14 and/or 15 of F1 in the S1 beam or downlink channels 38 and/or 39 of the S2 in the S1 beam.
The beam/channel selection is done by means of ground commands.
The uplink and downlink center frequencies of each transponder are listed in Table 1(p.7).
The simplified payload block diagram is shown in Figure 3 (page 10).
Figures 4 and 5 (pages 11,12) provide respectively the input/output channel selection configuration for above channels combined in OMUXes on –Y panel.
The channels are routed to the TWTAs on the +Y and –Y panels using a unique switch matrix. The switch matrix for the TWTAs mounted on the +Y panel comprises an input redundancy ring and an output redundancy ring. The switch matrix for TWTAs mounted on the –Y panel comprises an input channel selector, an input redundancy ring, an output redundancy ring and an output channel selector.



ARCHITECTURE : PAYLOAD BLOCK DIAGRAM

- **Simplified payload block diagram**

Figure 3



PAYLOAD SWITCHING – CHANNEL SELECTOR

- **Input channel selection switches**

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Figure 4

PAYLOAD SWITCHING – CHANNEL SELECTOR

- **Output channel selection switches**

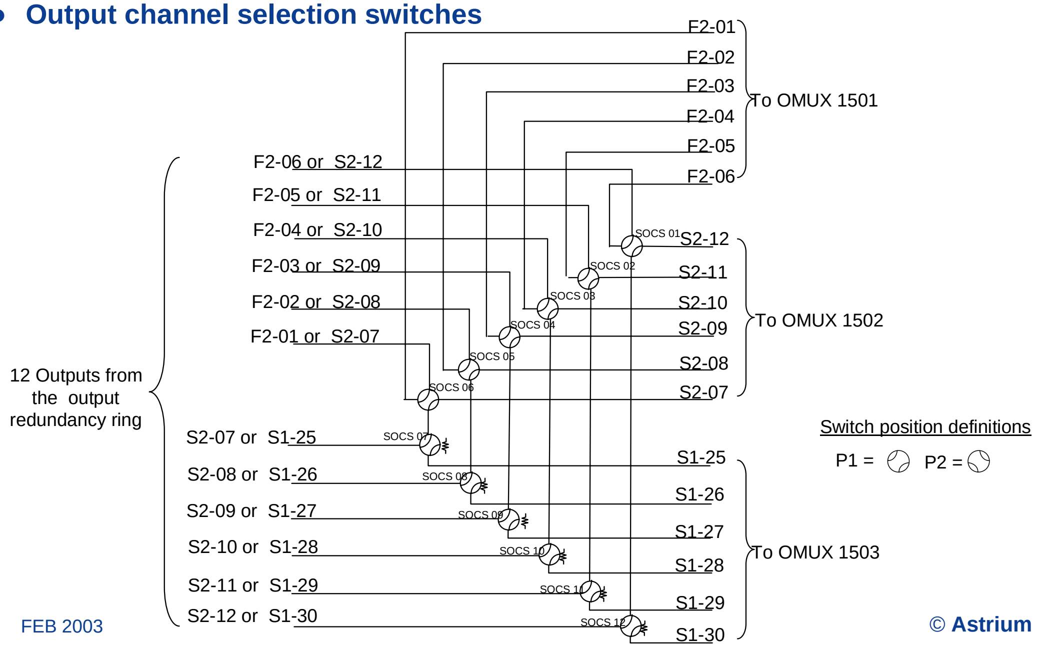


Figure 5

5.2 Payload switching

The output beam switch (Figure 6, page 14) allows the band 10.95 to 11.20 GHz to be switched from F2 to S2 antenna (uplinking in the band 14.00-14.25 GHz) and at the same time the band 11.45 to 11.70 GHz to be switched from the S2 to F2 antenna. The band 13.75-14.00 GHz can be used by both F1 and S1 while the band 14.00-14.25GHz can be used by both F2 and S2 assuming that neither S1 nor S2 are respectively steered to illuminate Europe.

From an operational point of view, it is important to note that because of the on board switching facilities it is possible to have different scenarios of beam connectivity to cope with traffic originated anywhere within the satellite coverage ; that is, uplinking in Europe and downlinking in Europe or in any area within the visible earth outside Europe, uplinking in any area within the visible part of earth and downlinking in Europe, uplinking in any visible area and downlinking in any visible area**. In other words interconnectivity can be ensured between F1 and S1, F2 and S2, S1 and S2, S2 and F1 etc.**(For example interconnectivity between F1 and S1 is depicted in Figure 7,p15)

5.3 Redundancy ring

The redundancy rings provide 19 for 15 redundancy for the Channel Amplifier/TWTA chains in each panel. This arrangement provides a total 38:30 TWTA redundancy. The redundancy rings are shown in Figure 8(p.16) for the TWTAs on the - Y panel and in Figures 9(p.17) for the TWTAs on the +Y panel. The redundancy rings are slightly different for transponders on the +Y and –Y panels.
Each input and output redundancy ring uses 21 switches. They are implemented in two blocks of six, one block of five and four single switches. Due to this arrangement even if four TWTAs of the same panel fail simultaneously, there will be not interruption of service.

PAYLOAD SWITCHING – OUTPUT BEAM SWITCH

- **The output beam switch allows the band 10.95 to 11.20 GHz (from the F2 uplink) to be block switched to the S2 downlink coverage (vertical polarisation).**
  - As a result, the band 11.45 to 11.70 GHz (from the S2 uplink) is block switched to the F2 downlink coverage (horizontal polarisation)

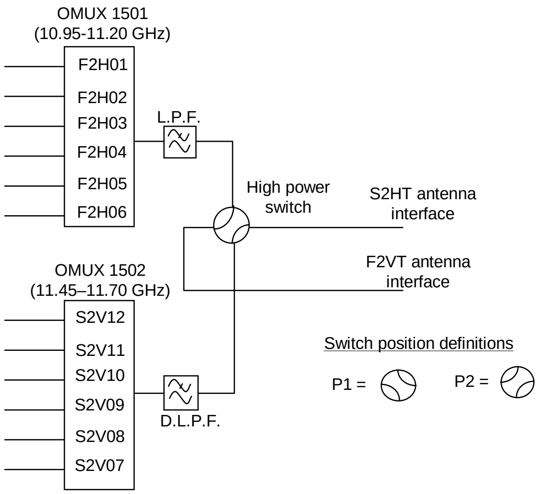
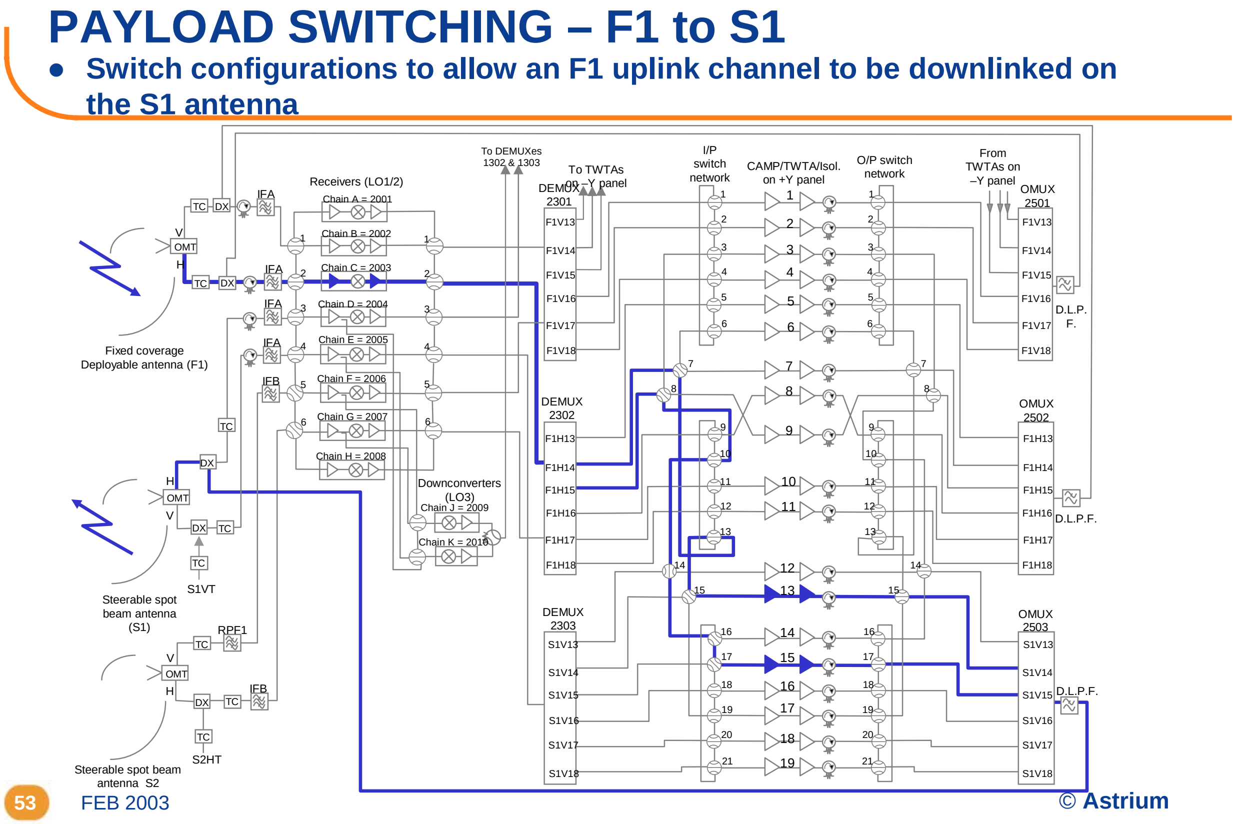


Figure 6



PAYLOAD SWITCHING – F1 to S1

- Switch configurations to allow an F1 uplink channel to be downlinked on the S1 antenna

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Figure 7

PAYLOAD SWITCHING

- **Redundancy switch network for TWTAs mounted on –Y panel**

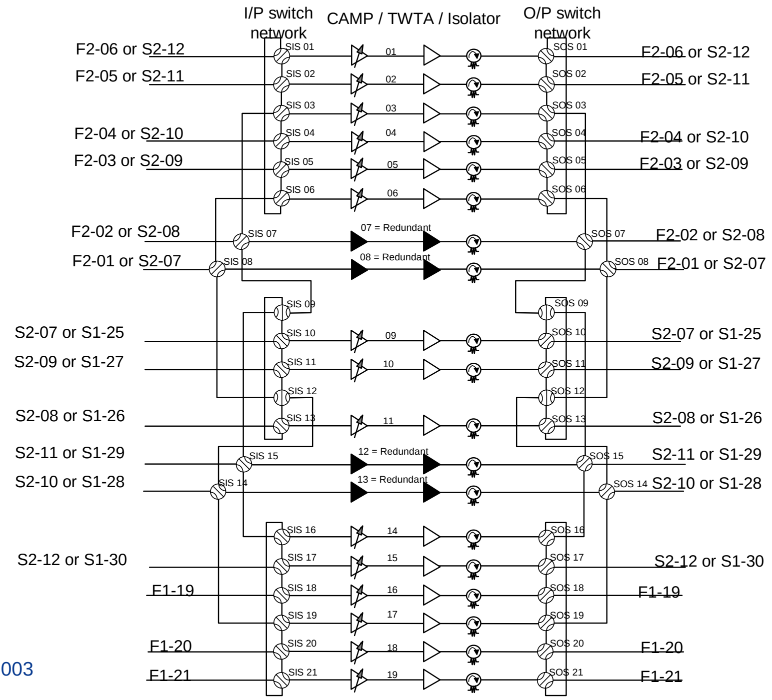


Figure 8

PAYLOAD SWITCHING

- **Redundancy switch network for TWTAs mounted on +Y panel**

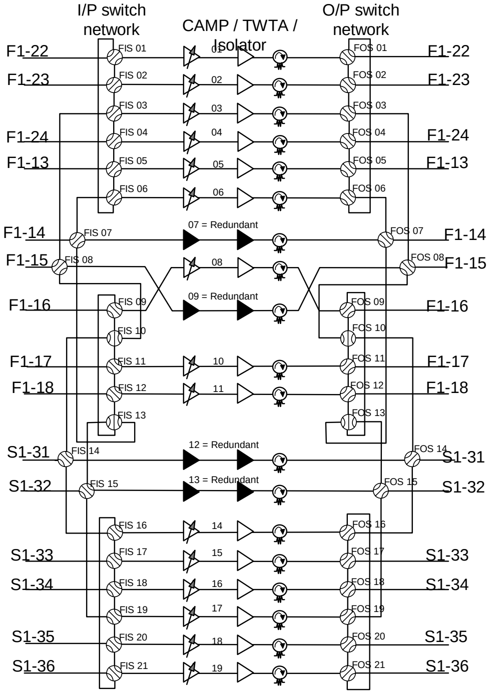


Figure 9

5.4 Transponder gain adjustment

Each transponder can be adjusted in terms of its gain. The adjustment is performed by a channel amplifier (Camp) which is located before the TWTA. The Hellas- Sat 2 payload has 38 channel amplifiers. The Camp is a variable gain preamplifier for each individual TWTA and its prime function is to limit the effects of rain fade. The Camp can be operated in two modes selectable by ground command ; Fixed Gain Mode (FGM) and Automatic Level Control (ALC) mode. In FGM, the gain of the Camp is selectable by telecommand. In this mode of operation, the Camp has 27 gain steps (step 0 to 26), with a step size of 1.5 ± 0.3 dB.
In ALC mode, the Camp output signal power is set by telecommand to the required level while the input power may vary over a specified dynamic range. In this mode of operation the Camp has 17 gain steps (0-16), with a step size of 1±0.25 dB
From the operational point of view, the above arrangement provides flexibility to the earth station operators in cases where the uplink station is power-limited and/or where power compensation is required to cater for unpredictable link fade.

6 BEACONS

A Ku- band beacon generator on board the satellite, provides a signal to a dedicated global horn antenna. The Ku-band beacon transmits a single right hand circular polarized unmodulated frequency of 11.4515 GHz with a maximum EIRP of 12 dBW within the whole visible area from the satellite. A 3 dB loss of power level is expected if linear polarization reception system is used by the station. This beacon is a two for one redundant unit and is used by the earth stations operators to track the Hellas-Sat 2 satellite.
Other frequencies in C band are employed by the monitoring stations for telemetry and ranging and are used only by dedicated HELLAS SAT operators to control the satellite.

7 INPUT POWER FLUX DENSITY (IPFD)

The input power flux density for saturation of each channel is calculated at peak satellite antenna gain. The peak saturated flux density is used in relation with the antenna G/T contours relative to peak antenna gain and the sensitivity (gain step) of the transponder. Each transponder sensitivity may be adjusted independently from the others and saturation may be obtained even in case where the uplink station is power limited for a particular application.

The IPFD for transponder saturation at peak satellite antenna gain (at the maximum satellite G/T point) ranges from about – 75 to – 115dBW/m² depending on the transponder gain step, the antenna each transponder is connected to, and the particular TWTA.

Operationally, three gain settings are usually used; Low (L), Medium (M) and High (H). However, there is the possibility to use other gain steps depending on the earth station EIRP capability, the receive earth station G/T, earth stations location, the desired quality etc.

In the Table 2(p.20) below, the IPFD values for saturation are presented for the above mentioned gain settings and for each particular satellite antenna.
The quoted figures, based on the less sensitive transponder at nominal configuration, represent average values for all transponders. This means that a difference of 1 or 2 dB from the specified values is expected. Moreover, the peak gain values correspond to the minimum available values. However, the quoted figures can be used in link budget calculations for planning purposes.

A simplified link budget example is presented in Annex A to show how IPFD for saturation is employed in link budget calculations.

Gain Step	F1 antenna		F2 antenna		S1 antenna		S2 antenna	
	Peak Gain +8.37 dB/K	Satellite Contour 0 dB/K	Peak Gain +11.10 dB/K	Satellite Contour 0 dB/K	Peak Gain +5.42 dB/K	Satellite Contour 0 dB/K	Peak Gain +5.47 dB/K	Satellite Contour 0 dB/K
5 (L)	-80.26	-71.89	-81.16	-70.06	-78.37	-72.95	-77.32	-71.85
9 (M)	-86.78	-78.41	-87.68	-76.58	-84.89	-79.47	-83.84	-78.37
15 (H)	-96.04	-87.67	-96.94	-85.84	-94.15	-88.73	-93.10	-87.63

Table 2: Average IPFD values for transponder saturation versus sensitivity

8 TWTA TRANSFER CHARACTERISTICS

All TWTA which are employed on Hellas- Sat 2 transponders provide a maximum output power of 105W.
The transfer characteristic of a typical transponder TWTA is based on actual measurements and it is provided as a tool for the calculation of the output back-off (OBO) when the input back-off (IBO) of a carrier transmitted from an earth station is known. Both input and output back-off are expressed in dB. The OBO denotes the power level available at the output of the TWTA relative to that when the transponder is saturated. The OBO is therefore very important for link budget calculations as it provides the available power per carrier for one or more carriers in the down link.
Operation of the TWTA at saturation means that the maximum output power is obtained in the down link which in turn directly affects the design of the terrestrial receive equipment.

The Figure 11(p.21) below shows the TWTA AM -to -AM and AM-to-PM Phase Shift transfer characteristic for the Hellas-Sat 2 transponders for a single unmodulated carrier.

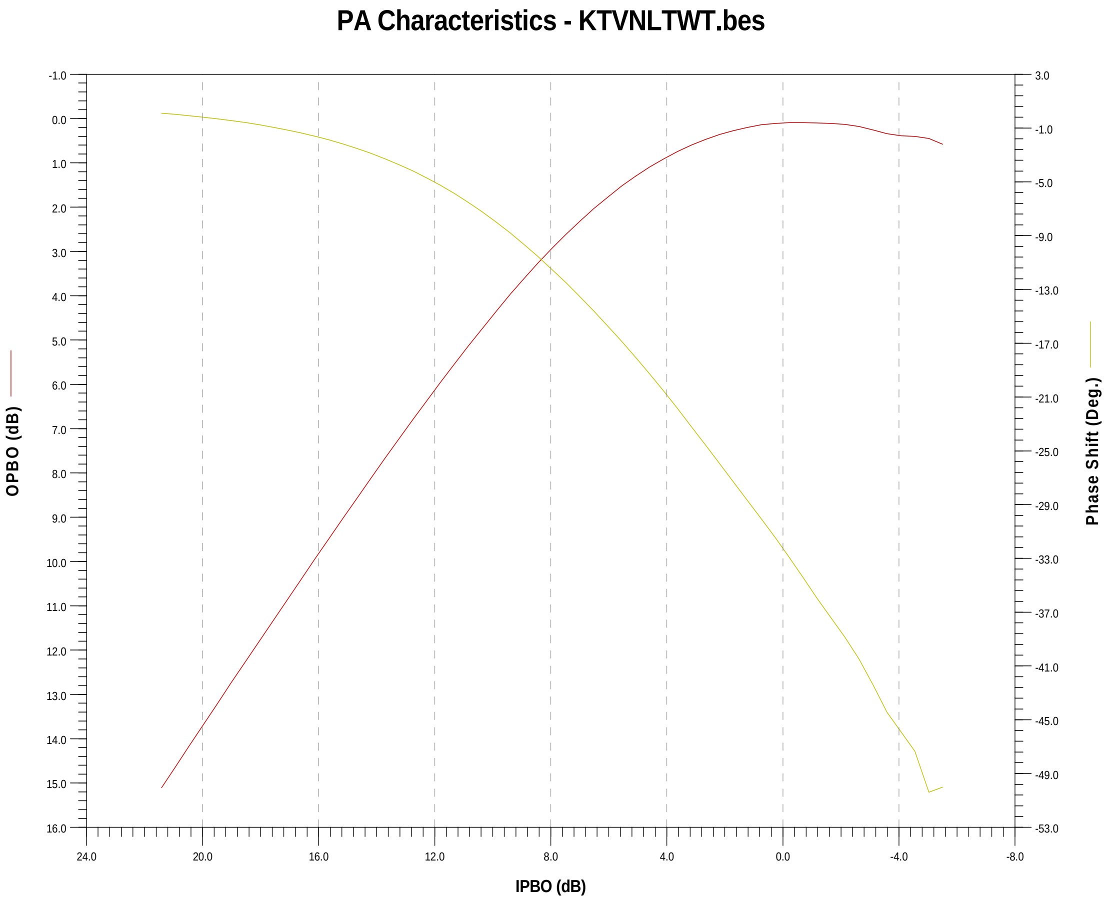


Figure 11: Single unmodulated carrier TWTA transfer characteristic

Detailed values extracted from the above curve are presented in Table 3 below. The output power (relative to the saturation power) and the output phase are given versus the input power level (relative to that required for saturation).

Input back-off (dB)	Output back-off (dB)	Output Phase (Deg)
21.42	15.08	-0.22
21.14	14.79	-0.22
20.73	14.45	-0.06
20.38	14.05	-0.37
20.04	13.58	-0.22
19.48	13.18	-0.06
19.07	12.78	-0.22
18.72	12.43	-0.53
18.37	12.14	-0.69
17.96	11.74	-0.69
17.54	11.34	-1.01
16.99	10.76	-1.16
16.02	9.78	-1.48
15.46	9.38	-1.95
14.22	8.16	-2.90
13.04	7.07	-4.01
12.14	6.38	-4.96
11.73	5.80	-5.27
10.13	4.53	-7.64
9.09	3.73	-9.38
8.12	3.03	-11.28
7.15	2.40	-13.18
6.18	1.83	-15.39
5.21	1.37	-17.76
4.24	0.96	-20.13
3.26	0.62	-22.97
2.71	0.50	-24.40
1.73	0.28	-27.24
1.32	0.22	-28.35
0.76	0.16	-29.93
0.27	0.05	-31.51

Table 3: Input back-off versus output back-off and output phase for single carrier operation

When a number of carriers are simultaneously amplified at different frequencies by the power amplifier of a satellite transponder or of a transmit E/S, non-linearities of the amplifiers cause intermodulation, i.e produce unwanted signals, called intermodulation products.

The number of intermodulation products increases very quickly with the number of input carriers (for example, for 3 carriers, there are 9 products and for 5 carriers there are 50). However, in most cases only the third-order intermodulation products falling within the frequency band of the wanted carriers are considered.

To reduce intermodulation products in multicarrier operation (FDMA mode) the TWTA needs to be driven with a sufficient back-off: i.e an input back-off of about 10 dB corresponding to an output back-off of about 4.5 dB. In the case of earth station HPAs, an output back-off is usually required (3 to 8 dB). However the situation can be improved by the utilization of linearizers.
Above limitations do not apply in the case of a single carrier occupying the whole transponder bandwidth and therefore the TWTA can be driven almost to saturation.

For a Hellas-Sat 2 TWTA, in multi-carrier operation, the following total IBO/OBO values may be employed :

Carrier No	2	3	4	≥5
IBO (dB)	7.0	7.5	8.0	10.0
OBO (dB)	3.2	3.5	3.7	4.8

Table 4 : IBO vs OBO for multi-carrier operation

Annex A to Module 200

Simplified link budget calculation
Transmit carrier 34Mbps, QPSK, FEC=3/4

UPLINK

Transponder		F1/13H	
Center Frequency		13.768	GHz
E/S Tx eirp		70	dBW
Atmospheric attenuation		-0.3	dB
E/S pointing error		-0.5	dB
Up path loss		-207.1	dB
Satellite pointing error		-0.3	dB
Satellite Rx contour (Tx E/S Location)		-1	dB/K
Boltzmann constant		228.6	dBW/K/Hz
Noise Bandwidth	(30MHz)	-74.76	dBHz
C/N UP		14. 64	dB

INPUT/OUTPUT B/O

E/S Tx eirp	70	dBW	
E/S pointing error	-0.5	dB	
Spreading Factor	-162.6	dBm²	
Atmospheric attenuation	-0.3	dB	
Satellite pointing error	-0.5	dB	
IPFD carrier	-93.9	dBW/m²	
IPFD for transponder saturation (at 0 dB/K contour)	-85.05	dBW/m²	GS13
Carrier Input B/O	8.8	dB	
Carrier Output B/O	3.5	dB	

DOWNLINK

Transponder	F1/13V	
Center Frequency	12.524	GHz
Satellite eirp(beam center)	54.9	dBW
Satellite Output B/O	-3.5	dB
Satellite Tx contour(Rx E/S Location)	-1	dB
Down Path Loss	-205.4	dB
E/S point error	-0.5	dB
Sat point error	-0.3	dB
E/S G/T	16	dB/K
Boltzmann constant	228.6	dBW/K/Hz
Noise Bandwidth	-74.77	dBHz
C/N Down	14. 03	dB

C/N TOTAL	11. 3	dB
Eb/No	9.5	calculate
BER	10exp-7	target
Margin	3.5	dB

HELLAS -SAT 2 HANDBOOK

Module 201

HELLAS- SAT 2 Coverage Maps

TABLE OF CONTENTS

1 INTRODUCTION

This Module contains the coverages of the Hellas- Sat 2 satellite which can be used for planning purposes. The coverages given for S1 and S2 have been chosen to cover S.Africa and the M.East / Eastern Europe areas respectively. However, they can be steered to cover any region of the visible part of earth following customer's demand and Hellas- Sat 2 frequency operational restrictions.

2 SATELLITE COVERAGES DESCRIPTION AND PARAMETERS

The coverages are given in terms of satellite G/T and unmodulated single carrier saturated EIRP contours. All the contours are referred to the nominal pointing of the antenna beam that is, they do not show the effect of beam pointing error (0.11degrees).

The G/T contours have been derived from a combination of theoretical and measured data. These contours, expressed in absolute G/T values, have been derived for each channel center frequency as follows :

- The antenna gain pattern at the center frequency of each channel is derived using the Grasp model. The accuracy of the Grasp model has been confirmed by correlating the predicted pattern with the measured pattern during the range test phase.
- The antenna gain at each channel center frequency is adjusted in accordance with the absolute measured gain at the range test phase.
- The G/T contours are plotted relative to the peak G/T of the antenna where G is the antenna gain (dBi), T is the payload system noise temperature (dBK) and equals to 10log (Ta+Tr) where Ta is the antenna noise temperature and Tr is the worst case repeater noise temperature.
- The antenna noise temperatures have been derived by integrating Hellas Sat 2 antenna patterns over an earth brightness temperature map and are as follows; 226K for F1, 252K for F2, 254.35K for S1 and 258.7K for S2.

For the transmit coverage, the EIRP contours are derived from the antenna iso-gain contours taking into account an input power to the satellite antenna which causes transponder saturation.

ANNEX 1 to Module 201

F1 FIXED ANTENNA, EIRP & G/T CONTOURS

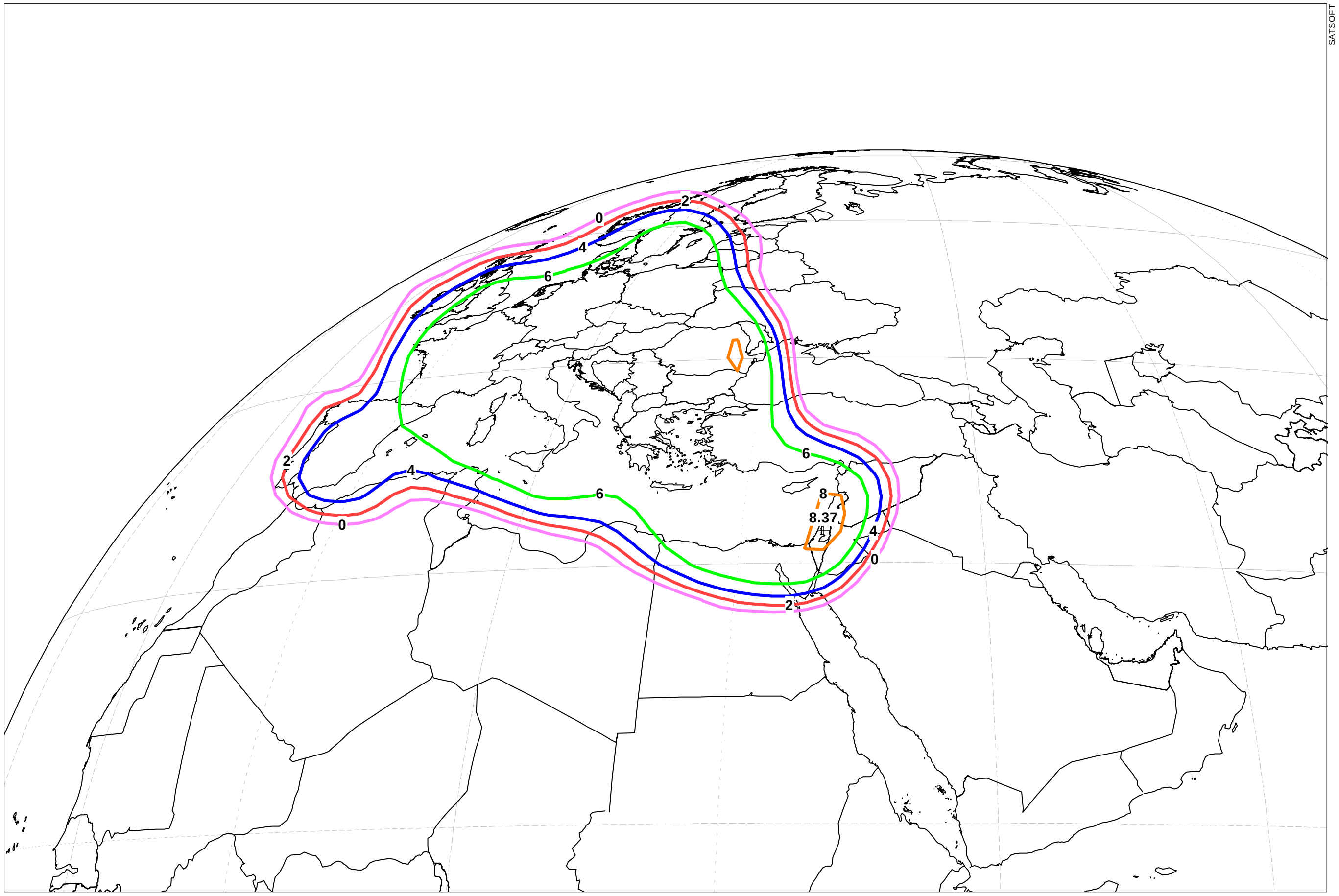


Figure A1-1: F1 Receive coverage, 13.8 GHz, G/T contours

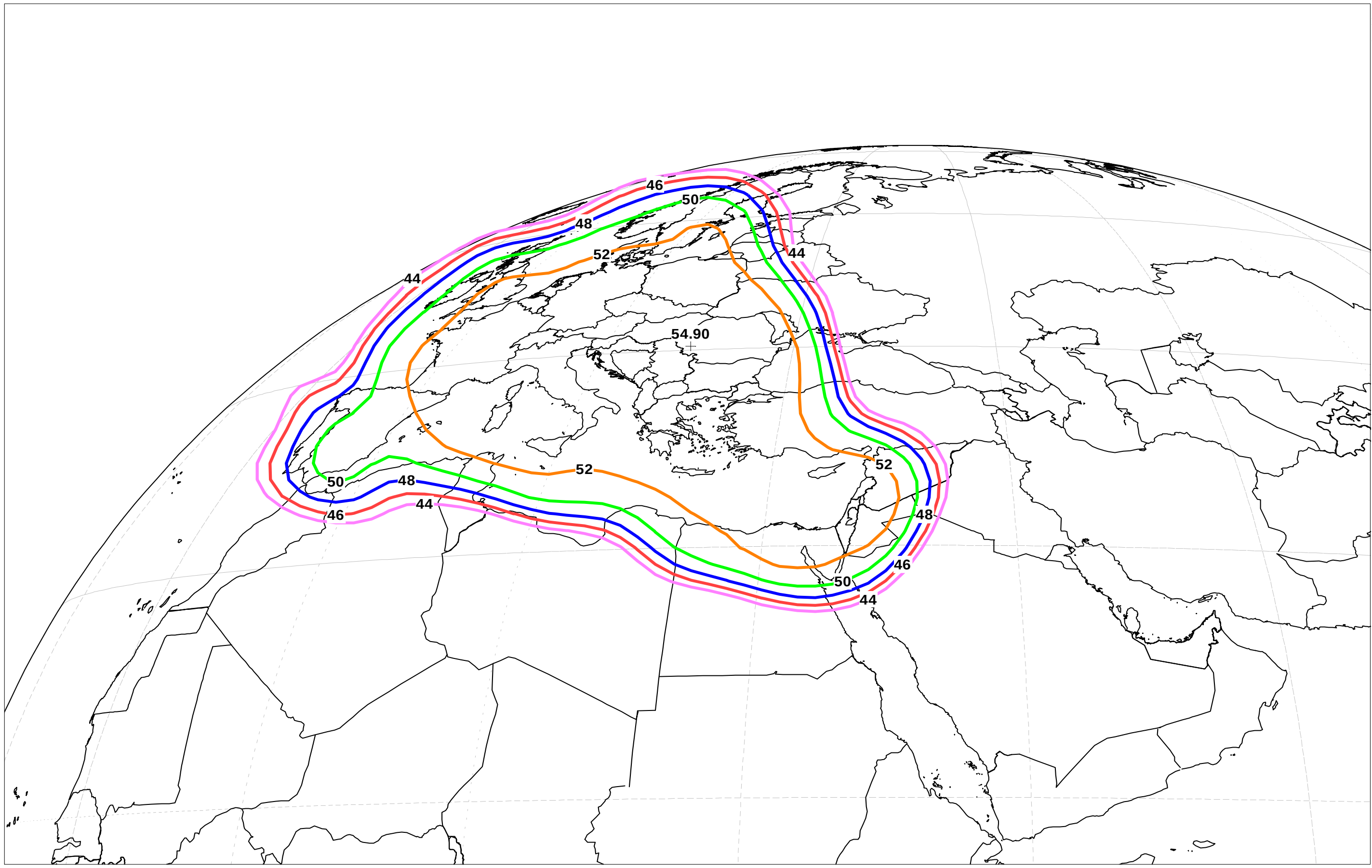


Figure A1-2: F 1 Transmit coverage, 12.5GHz, EIRP contours

ANNEX 2 to Module 201

F2 FIXED ANTENNA, EIRP & G/T CONTOURS

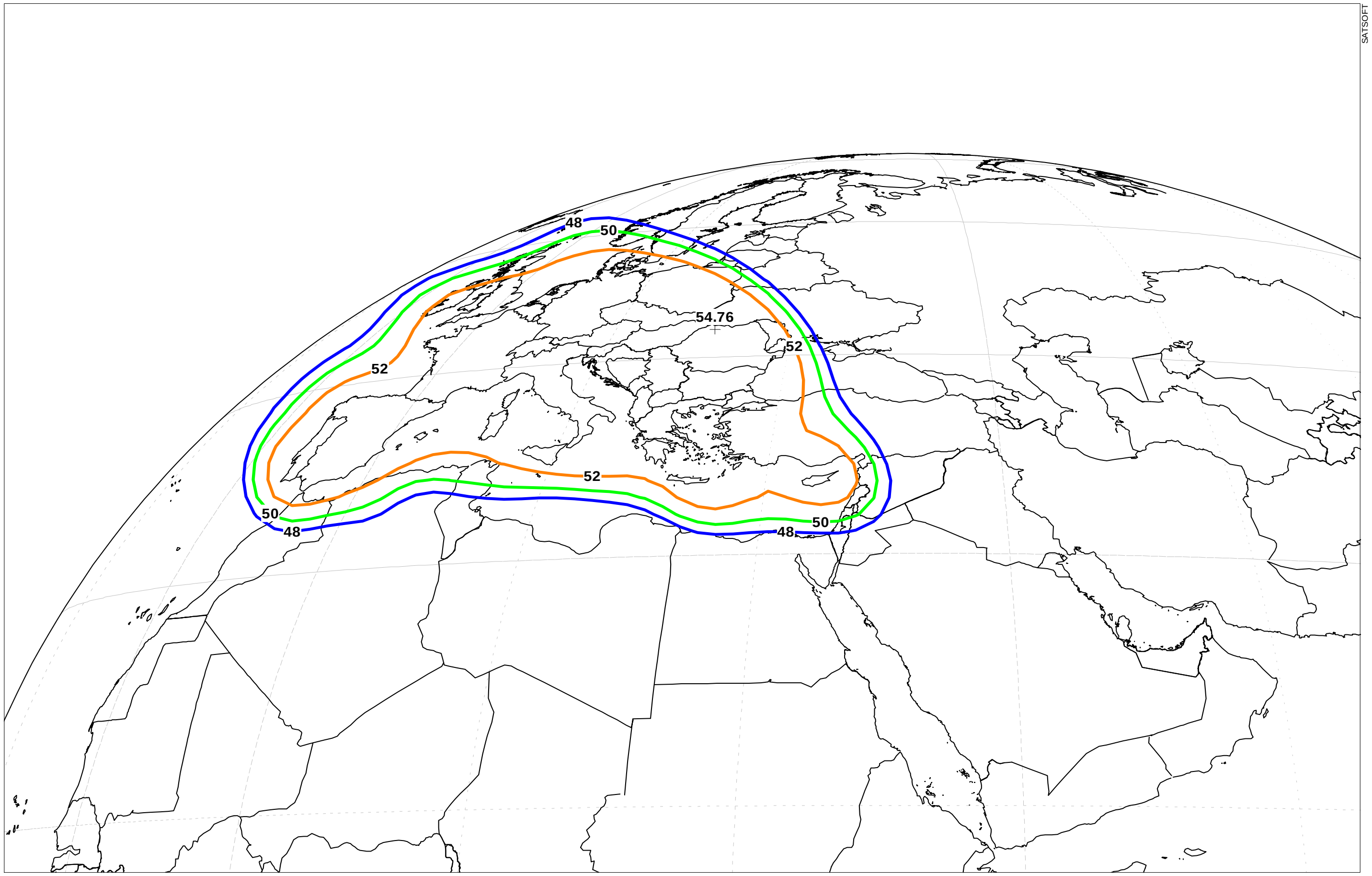


Figure A2-1: F2 Transmit coverage, 11GHz, EIRP contours

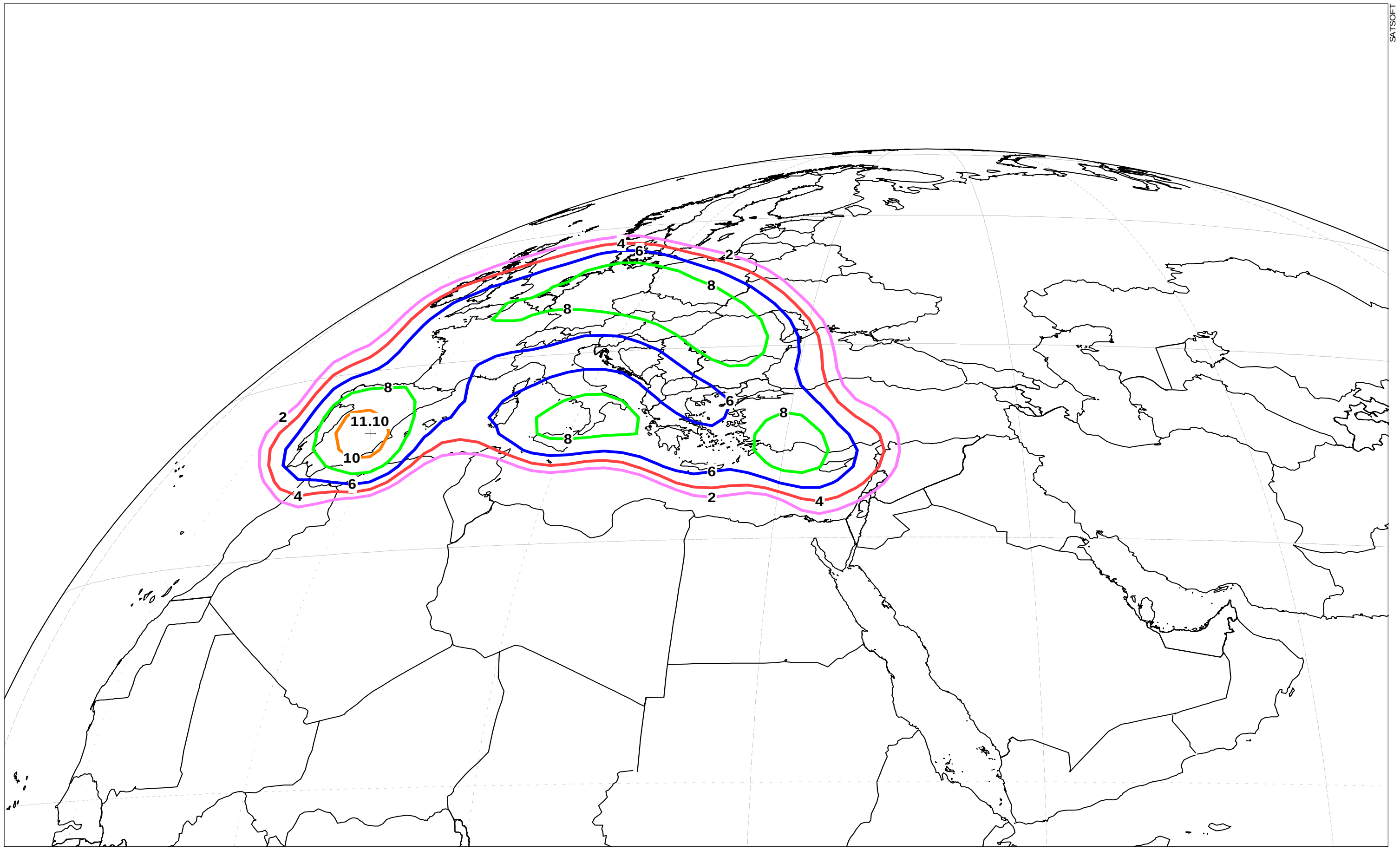


Figure A2-2 : F2 Receive coverage, 14GHz, G/T contours

ANNEX 3 to Module 201

S1 STEERABLE ANTENNA, EIRP & G/T CONTOURS

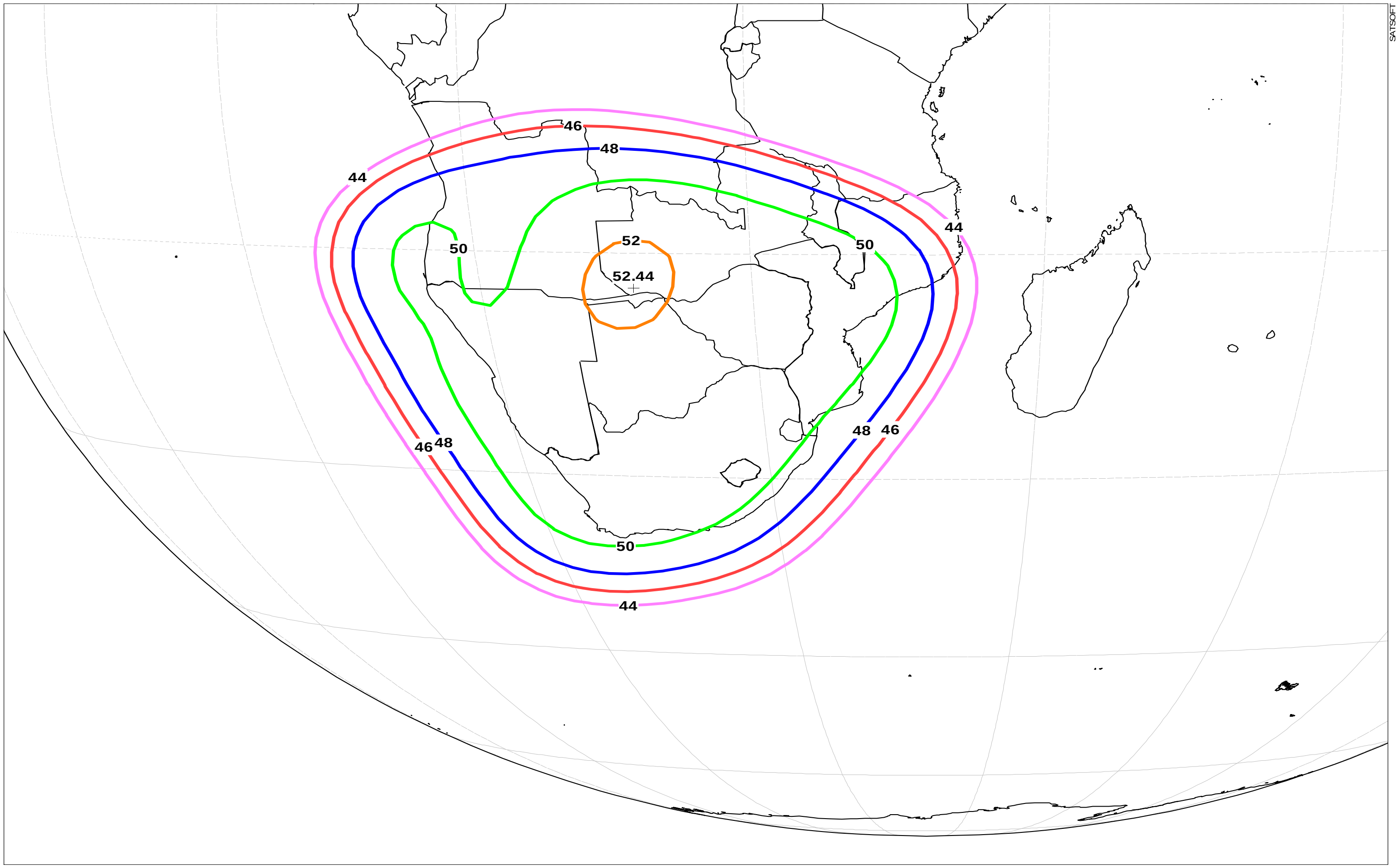


Figure A3-1 : S1 Transmit coverage, 12 GHz, EIRP contours (Provisional coverage of S.Africa)

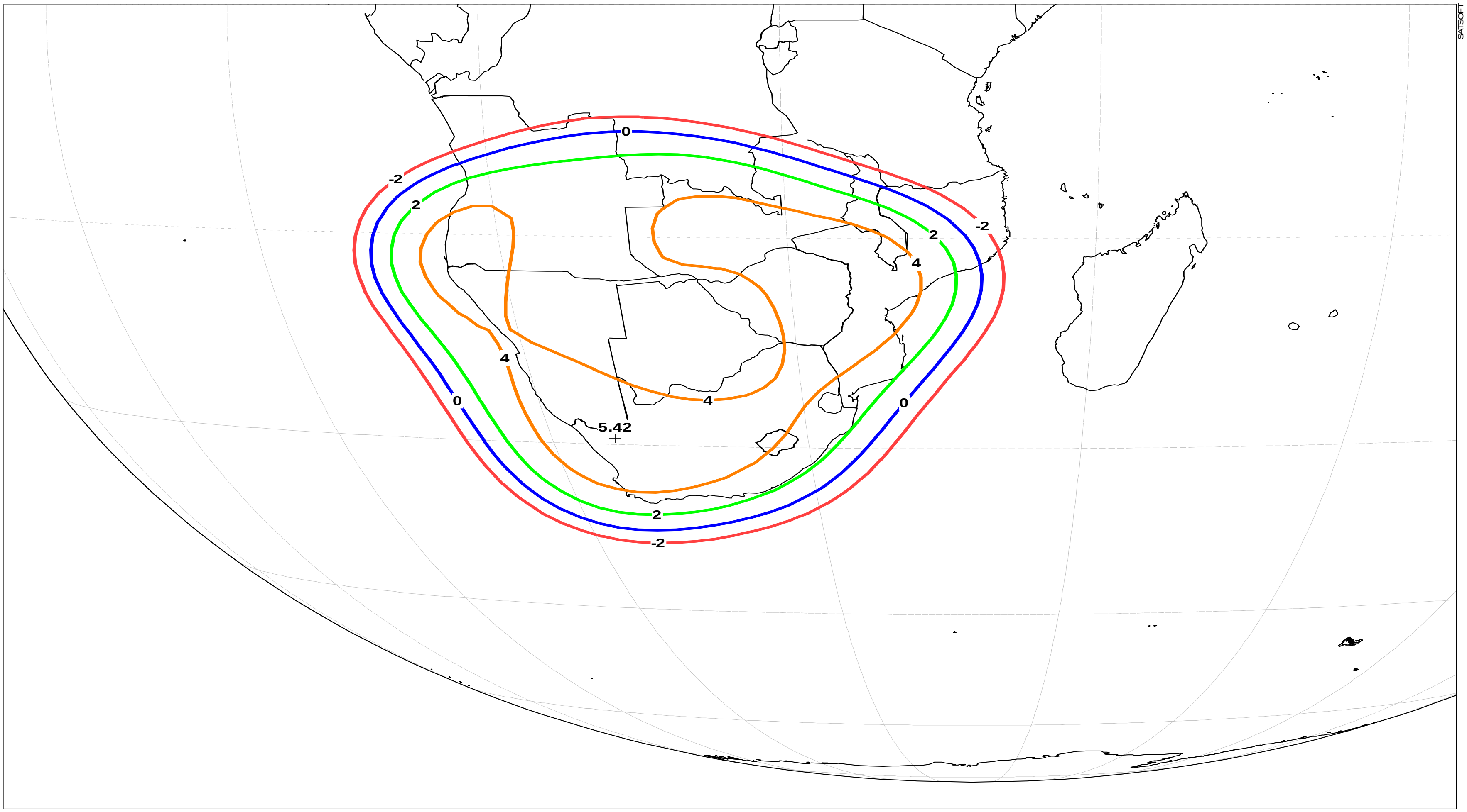
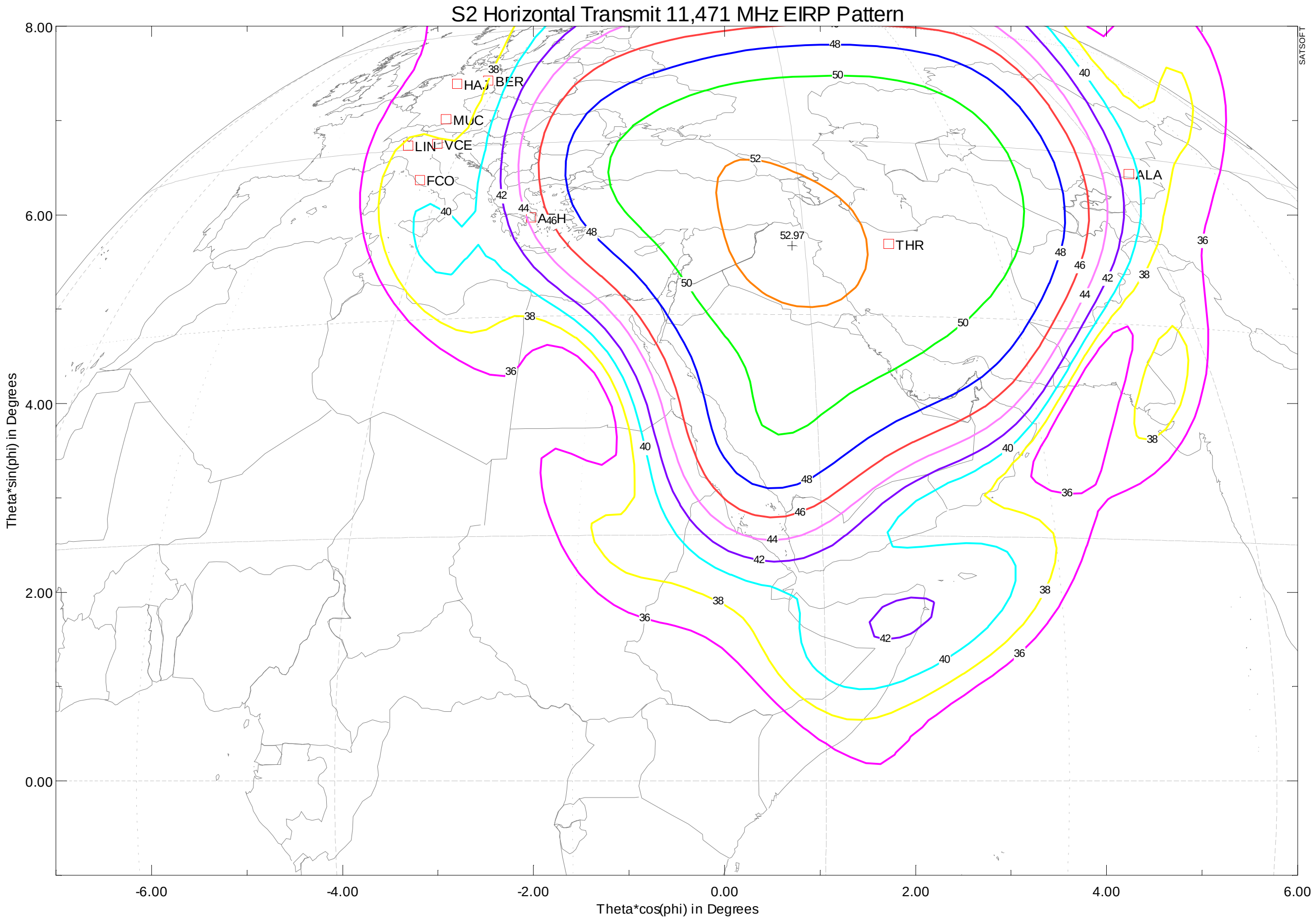


Figure A3-2: S1 Receive Coverage, 13.8 GHz, G/T contours (Provisional coverage of S. Africa)

Annex 4 to Module 201

S2 STEERABLE ANTENNA, EIRP & G/T CONTOURS



S2 Horizontal Transmit 11,471 MHz EIRP Pattern

Figure A4-1: S2 Transmit Coverage, 11GHz, EIRP contours

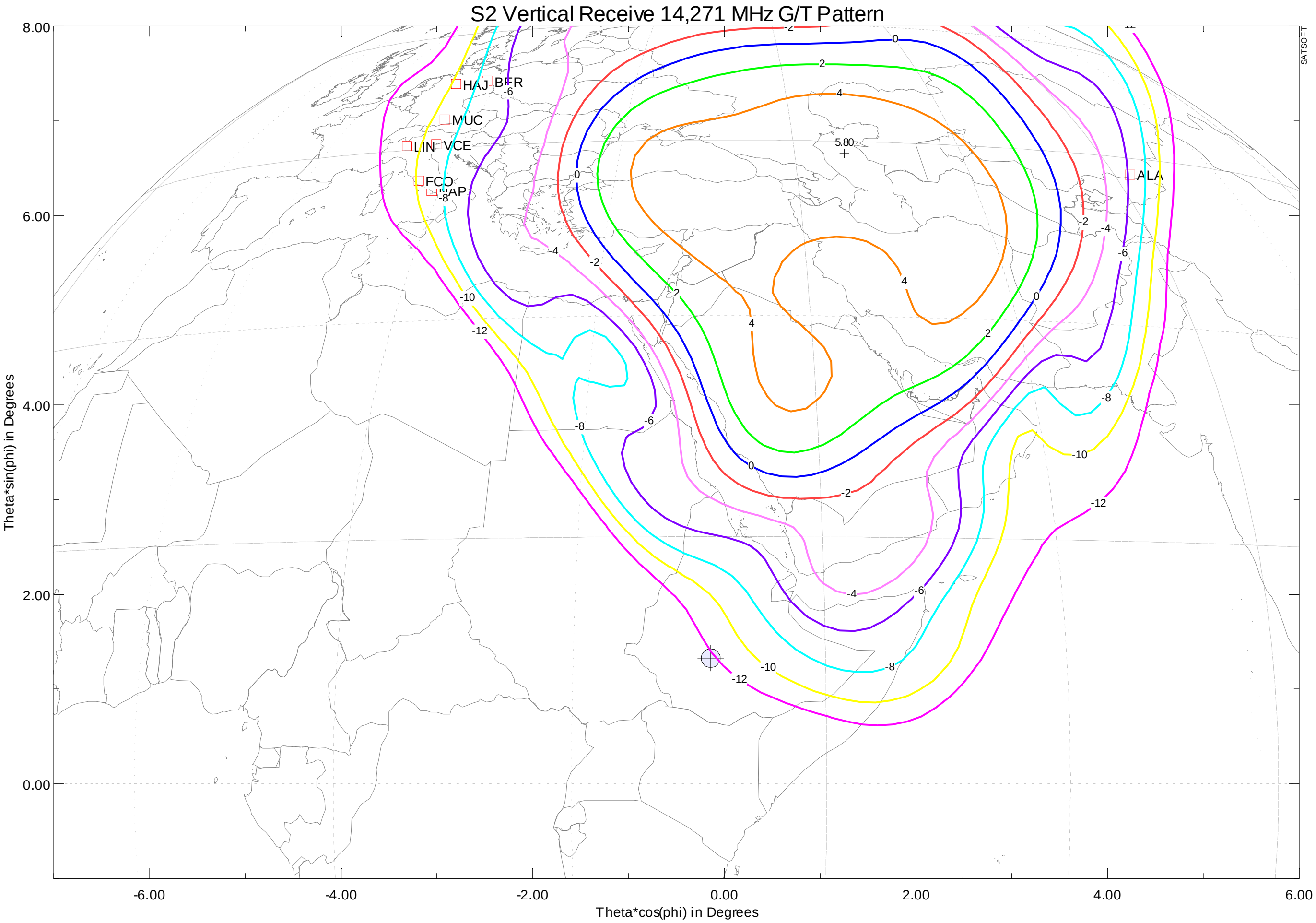


Figure A4-2: S2 Receive coverage, 14 GHz, G/T contours

HELLAS -SAT 2 HANDBOOK

Module 300

UTILIZATION OF LEASED TRANSPONDERS

TABLE OF CONTENTS

1 LEASED TRANSPONDER UTILIZATION CONDITIONS

The lessee is free to choose the mode of transponder utilization and the transmission parameters (type of carrier, bandwidth, modulation, quality etc) according to his specific needs, provided that this does not lead to unacceptable levels of interference into other transponders, either on the same satellite or on adjacent satellites. To meet the above requirements HELLAS SAT will prepare a link budget analysis and the lessee will be asked to agree upon the operational parameters for the particular applications. These operational parameters will be included in a approved Transmission Plan.

- Transmission Plans will be issued by HELLAS SAT prior to accessing the leased capacity. HELLAS SAT will assign the required set of operational parameters for each of the carriers in the Transmission Plan. Any deviation from these parameters requires special coordination and agreements with other users who may be affected and it is therefore necessary to be approved by HELLAS SAT. An example of a Transmission Plan form is provided in Annex A to this Module .

- Transmit earth stations operators prior to accessing the Hellas-Sat 2 space segment capacity have to submit to HELLAS SAT Technical Department an application to obtain approval for access for the particular earth station. This approval for access is directly related to the E/S performance characteristics.

2 LEASED TRANSPONDER APPLICATIONS

The most commonly encountered applications in leased transponders are digital TV (FDMA/SCPC and /or FDMA/MCPC) and data services (VSAT networks, Internet etc) to be used for Domestic and /or International transmissions.
A leased transponder is ideally used for similar types of applications, that is TV or data services due to the fact that TV carriers require usually large bandwidth and high power which may impose limitations to low power digital carriers (data services). However, various combinations of both applications are possible, providing that care is taken when loading the transponder (intermodulation products, frequency separation, etc).Some of the transponder loading configurations are the subject of specific Modules.These are as follows:

- Single DVB carrier per transponder (MCPC)
- Multiple digital TV carriers per transponder (FDMA/SCPC)
- VSAT applications
- Temporary TV Services
- Broadband Services Network (DVB-RCS standard)

The carrier activation in any configuration is realized following an agreed Transmission Plan which contains all the necessary operational parameters to be strictly met in order to prevent harmful interference to occur into and from other carriers **This is the reason why the Transmission Plans should be issued and reviewed only by HELLAS SAT and cannot be changed by the user without prior agreement with HELLAS SAT.**

HELLAS SAT
TRANSMISSION PLAN

SERVICE DESCRIPTION	**Type of Emission**	
	Commercial Name	
	Allocated Bandwidth	

CONTACT POINTS	**Customer (Mr/Mrs)** **TEL** **E-MAIL**	
	Hellas Sat **TEL** **E-MAIL**	

SATELLITE DATA	**Satellite System**		
	Tx Beam		
	Rx Beam		
	Trp No		
	Gain step		
	IPFD satur from Tx E/S location		**dBW/m²**
	Satellite G/T at the Tx E/S location		**dB/K**
	Satellite EIRP at the Rx E/S location		**dBW**

E/S DATA	**Tx E/S**		**RX E/S**	
	E/S Type Approval			
	E/S Name/Code		**E/S Name/Code**	
	Lat		**Lat**	
	Long		**Long**	
	Max EIRP capab		**Typical G/T**	
	Antenna size		**Antenna size**	

APPROVED OPERATIONAL PARAMETERS	**Uplink E/S EIRP**		**dBW**
	Uplink Frequency		**MHz**
	Downlink Frequency		**MHz**
	Uplink Pol		
	Downlink Pol		
	Expected Eb/No at ………		**dB**
	BER		
	Link margin		**dB**
	Total HPA power required		**W**

COMMENTS

HELLAS- SAT 2 HANDBOOK

Module 301

DIGITAL CARRIERS

TABLE OF CONTENTS

1 INTRODUCTION

In satellite communication in general and in Hellas-Sat 2 satellite, digital carriers in the great majority of cases employ either QPSK or BPSK modulation usually associated with the use of some kind of FEC code technique for improving link budget that is for obtaining better quality for less power. It is also noted that, the higher order (greater than 4-phase) PSK systems require much more power than either 2- or 4-phase systems to achieve the same performance. In this sense QPSK provides a very good power /bandwidth compromise.

The most common schemes used in satellite digital transmissions are:

- QPSK with coherent demodulation associated with FEC Rate ¾ or ½
- BPSK with coherent demodulation associated with FEC Rate ½

The most popular transmission scheme for digital TV is QPSK/ FEC ¾.

However, due to recent developments as it is mentioned further below, it is now common to use higher order PSK systems with FEC rates other than ¾ (e.g 5/6,7/8 or other) associated with new coding techniques such as Turbo coding. These new techniques allow high information bit rates (e.g 45 Mbps or higher) to be accommodated in a 36 MHz transponder bandwidth which otherwise would not be possible.

2 CODING

The most important coding schemes of FEC in satellite communications are:

i) The convolutional coding associated with soft decision Viterbi decoder which is a standard today's technique.

ii) The concatenated coding using a Reed-Solomon outer code in addition to the inner code (Viterbi). The result is a powerful FEC scheme.

All coding systems introduce a certain bandwidth expansion of the carrier depending on the FEC ratio, however they result in achieving a low Eb/No for the same quality (bit error rate). It is therefore a trade-off to be made between bandwidth expansion and less power required for the same quality of service.The concatenated systems are implemented usually to ensure a very high performance, for example, a BER of the order of 10^{-10} , required by e.g digital HDTV (High Definition TV). It is therefore important for the potential user of the Hellas Sat 2 satellite prior to his decision to lease space segment, to take into account all necessary factors (e.g proper dimensioning of the network, required grade of service for the particular application, coding schemes, bandwidth etc) that will allow for a trade-off between quality of service and relative cost.

Table 1 provides typical examples of transmission parameters with QPSK modulation for comparison purposes.

Information Bit rate (Mbit/s)	Data rate Including Overhead (Mbit/s)	FEC Ratio	Transmission Rate (Mbit/s)	Transmit Symbol Rate (Mbaud)	Allocated Bandwidth (MHz)
0,64	0,68	¾	0,90	0,45	0,585
2,048	2,170	½	4,340	2,170	2,821
2,048	2,170	¾	2,886	1,446	1,880
8,448	_	¾	11,235	5,632	7,321
41,250	_	¾	55,000	27,500	36,000
45,000	_	¾	60,000	30,000	39,000

Table 1: Allocated Bandwidth vs Information Rate in QPSK mode

The above Table was based on the following assumptions:
a) A factor of 16/15 was used in certain cases to count for the overhead bits. Available software for link budget computation do not usually take this into account.
b) The Transmit Symbol Rate (TSR) equals the Transmission Rate/ $\log_2 x$,where x equals 4 (QPSK/ OQPSK mode) or 2 (BPSK mode).
c) The carrier Noise Bandwidth is taken equal to Transmit Symbol Rate. The Allocated Bandwidth to the carrier equals theTSR times 1.3 (a factor between 1.2 and 1.4 is normally employed by software programs in order to provide guardbands to reduce interference from adjacent carriers (1+ roll-off filter characteristic).
d) All quoted figures in the Table are valid only for QPSK modulation, Viterbi coding and ½ or ¾ FEC ratios. Other values can be obtained by using different parameters (BPSK, FEC 7/8 etc).
In case that a Reed-Solomon outer code is used in addition to the Viterbi inner code, then the Transmit Symbol Rate will change according to coding scheme (e.g 204/188, 208/192, etc).

It is also noted that, in order to accommodate in a 36 MHz transponder information bit rates higher than 41 Mbit/sec, other techniques such as higher order of modulation schemes (e.g 8PSK) can be employed to increase the transponder efficiency. This increase in the information bit rate in a transponder comes at the expense of an increase in the carrier power to meet the threshold requirement into existing antennas. In other words, to achieve a given BER without any error correction coding, 8PSK requires about 5.5 dB higher C/N than QPSK.

This means that the down link margin must be reduced or the size of the receive antenna has to be increased. However, the introduction of a new code, named Turbo code which has been recently developed, together with an 8PSK modulation may now provide an increase of the information throughput of about 35% when compared to QPSK, allowing the same satellite power and receiving antennas to be used according to the Table 2 below (Scientific –Atlanta,Inc paper).

Modulation Scheme	FEC Code	FEC Rate	Symbol Rate (Mbaud)	Information Rate (Mbps)	Threshold C/N (dB)
QPSK	RSV(*)	5/6	26.67	40.96	7.86
8PSK	Turbo	2/3	28.80	55.20	7.60

(*) Reed-Solomon (204/188) plus Viterbi

Table 2 : Information Rate and Symbol Rate (noise bandwidth) vs Coding

3 SERVICE OBJECTIVES

The Eb/No is commonly used to evaluate the performance of a digital link. It is defined by the general formula as Eb/No =C/No-10log (R) [dB] where Eb is the energy per bit (dBW/Hz), No is the noise spectral density (dBW/Hz), C is the carrier power (dBW) and R is the information bit rate or the transmission rate (usually).
The Eb/No values depend on the coding scheme and the BER (Bit Error Rate) performance.. The value entered for Eb/No is the threshold value and represents the maximum BER allowed in the link before declaring it unavailable.
Typical BER threshold values are 10^{-3} for digital voice links and 10^{-6} for data links. The Eb/No typical values for various BER thresholds and FEC ratios are presented in the Table 3.

BER		10^{-4}	10^{-6}	10^{-7}	10^{-8}	10^{-10}	10^{-11}
Eb/No (dB)	FEC Ratio 3/4	6.3	8.3	8.9	9.8	7.5	10.3
	FEC Ratio 1/2	5	7	7.5	8.4	6.4	9

Table 3 : Eb/No versus BER for BPSK/QPSK and different FEC Ratios with Viterbi decoding

Above values are theoretical and depend mainly on E/S modem performance.
It is therefore advisable to cater for about 2 dB margin on top of these values. It is shown here that for the same quality objective (e.g BER= 10^{-6}) the required Eb/No is about 1dB higher in case of FEC ratio 3/4 than for FEC 1/2. It is noted however that, the higher power required for FEC 3/4 is compensated by the narrower bandwidth required to transmit the given information rate, since the transmission rate depends on the FEC ratio.

Better performances (high BER threshold for low Eb/No) are obtained with the use of an RS outer code. That is, in case of FEC 1/2, the Eb/No required according to the Table 3 for a BER of 10^{-4} is 5 dB but if RS code is used then the required Eb/No is only 4.5 dB to obtain a BER of 10^{-11} . It is also noted that, according to the same Table, in order to achieve a BER of 10^{-11} without an RS code the required Eb/No would be about 9dB which means 4.5 dB more power required or 1.7 times larger receiving diameter antenna.

4 FILTERING

Digital signals are often transmitted close to each other and in order to limit the amount of energy that falls outside the bandwidth allocated to each carrier, the transmitted phase modulated signals are filtered. The digital signal is also filtered at reception to limit the amount of noise and to reject other signals transmitted outside the allocated bandwidth.

In a non-linear device such as an HPA employed normally by earth stations, the use of square –root 40% cosine roll-off filtering in both transmission and reception is a good compromise between adjacent channel interference and degradation. This means that the required Symbol Rate is multiplied by a factor of 1.4 to provide the allocated bandwidth. However, other factors such as 1.3 or 1.35 may also be used as it has been previously mentioned.

5 SPECTRAL SIDELOBES

When a filtered QPSK or BPSK digital carrier passes through an amplifier operated in the non-linear amplification zone, carrier spectral sidelobes are formed which can fall outside of the bandwidth allocated to the carrier. For the same HPA output back-off, BPSK produces higher sidelobes than QPSK.

In practice, to limit the adjacent channel interference, the EIRP density of the spectral sidelobes of a transmitted digital carrier should usually be at least 26 dB below the carrier spectral density.

To keep the density of the carrier sidelobes 26 dB down from the carrier density for a TWT-type HPA the output back-off required should be in the order of : 3 dB for QPSK and 5 dB for BPSK.

For a sidelobe density 30dB down, the output back-off values are increased to: 5.0 dB for QPSK and 7.0 dB for BPSK

It is therefore important for the E/S operators to observe that above limits are met.

HELLAS- SAT 2 HANDBOOK

Module 302

MULTIPLE DIGITAL TV CARRIERS PER TRANSPONDER

TABLE OF CONTENTS

1 INTRODUCTION

This module is intended to assist operators in planning the use of a leased 36 MHz transponder or the use of fraction of it for the transmission of digital TV-like carriers. Additional information is provided in modules 200 and 300.

The most common case applicable to multiple digital TV carrier operation is the loading of one transponder by different sources, that is by different earth stations located within the satellite coverage and transmitting TV signals of the same or different bandwidth, at different uplink frequencies and with power levels depending on the quality objectives.

Due to complexity of this subject and taking into account the considerations already made in the previous Modules, it is evident that a number of computations is required in order to optimize the loading of the transponder without affecting the overall quality of each link. To cope with this situation HELLAS SAT uses a very powerful software tool (COMPLAN) which optimizes the transponder utilization.

2 TRANSPONDER OPERATING CONDITIONS

2.1 Input Power Flux Density and Operating Input/Output Back-Offs

The leased transponder's input power flux density for saturation at peak satellite antenna gain may have a range of -75dBW/m² up to - 115 dBW/m² (see Module 200). For one carrier operation any value within this range is adequate, however the range of -85 up to -90 dBW//m² would be more preferable for an E/S operator. For multicarrier operation the range of values between -75 up to – 85 dBW//m² should be used by the lessee. In this case the recommended operating input/output back-offs for a dual carrier operation of equal power and bit rate (18 MHz allocated bandwidth each) will be as follows :

Total IBO (dB)	Total OBO (dB)	IBO (dB) Per carrier	OBO (dB) Per carrier
7.0	3.2	10.0	6.2

Table 1 :Type 1 traffic for two carriers of equal power per transponder

Note : IBOt = IBOc+10log N, OBOt = OBOc+10log N, N = number of carriers

In case of four (4) carrier operation of equal power and bit rate per transponder the following values are recommended:

Total IBO (dB)	Total OBO (dB)	IBO (dB) per Carrier	OBO (dB) per carrier
8.0	3.7	14.0	9.8

Table 2 : Type 2 traffic for four carriers of equal power per transponder

2.2 Frequency Assignments

The frequency assignments per carrier are provided by HELLAS SAT. Care is taken so that in the cross-polar transponder the high bit rate carriers are assigned frequencies which will be the same or closed to those assigned to high bit rate carriers in the co-polar transponder. The same applies to low bit rate carriers in order to avoid interference from high power into low power carriers.

3 INTERFERENCE

In order to evaluate the net power required by each carrier and at the same time to take advantage of the full transponder resources, it is necessary to take into consideration apart from the thermal noise, the intermodulation as well as the interference noise levels which appear in any satellite link.
The noise due to the intermodulation products is produced in the satellite TWTA and the earth station HPA in case of multicarrier operation. The level of this type of noise depends on the TWTA/HPA operating input back-off and plays a dominant role in a link budget calculation. This particular component (C/Im) is calculated by a software program on a case by case basis and is provided by HELLAS SAT on demand.

The noise due to interference falls into three main categories :

- The interference from an adjacent carrier in the same transponder (ACI) due to lack of sufficient guardband between the carriers.
- The interference from a carrier in cross-polar transponder on the same satellite or otherwise frequency re-use interference (CPI) which depends on the satellite and earth station antennas polarization discrimination

- The interference from a carrier on an adjacent satellite (ASI) which depends on the adjacent satellite location and the earth station antenna misalignment.

A Hellas -Sat 2 service provider may use, for planning purposes, the figures quoted in the Tables 3 and 4

Carrier No.	1	2	3	4	≥5
IBO Total (dB)	0.5	7.0	7.5	8.0	10
OBO Total (dB)	0.13	3.23	3.46	3.7	4.83
C/Im	50	15.92	15.98	16.65	16.34

Table 3 : IBO/OBO values versus number of equal power carriers and level of carrier to noise (C/Im) due to intermodulation

C/I (dB)	ACI		CPI		ASI	
	Up	Down	Up	Down	Up	Down
	30	30	27	27	22	22

Table 4 : Carrier to Noise level due to interference from different sources

- It is evident that in case of F2 and S2 transponders where there is not cross – polar transponders, above values (CPI) should be amended accordingly.

All these components, either in the uplink or downlink budget, are added up to compose the total interference level (C/I up +C/I down)) which will be added to the total thermal noise level (C/N up + C/N down).

3.1 Transmission Constraints

In order to obtain the interference level into adjacent satellite systems quoted above, the off-axis EIRP limits emitted by an earth station in any direction within 3º should follow the law (ITU Regulations) :

EIRP off-axis =$32-25\log\theta$ per 40KHz while the gain of the antenna will be equal to $G(\theta)= 29-25\log \theta$ in dB where θ is the angle of the main beam axis and the considered direction of a sidelobe beam axis.
As a consequence, the off-axis EIRP density in any 40KHz would be equal to:
$32-25\log \theta$ (dBW/40KHz)=$P+29-25\log\theta-10\log (B/40KHz)$, where B is the bandwidth required for the transmission considered and P is the power of the high power amplifier at saturation.
The maximum permitted HPA power therefore will be equal to : $P= 3 +10\log B/40KHz$ in dBW.

HELLAS- SAT 2 HANDBOOK

Module 303

SINGLE DVB CARRIER PER TRANSPONDER

TABLE OF CONTENTS

1 INTRODUCTION

This Module highlights the main transmission characteristics of a Digital Video Broadcasting (DVB) carrier which consists of a number of TV programs (usually 4.5 Mbit/s each) or other service components multiplexed in a Time Division Mode (TDM) into a single MPEG-2/4 transport stream, which is then transmitted on a single digital carrier (DVB). This configuration is often referred to as Multiple-Channel-Per-Carrier (MCPC).
The system input stream is organized in fixed packets following the MPEG-2 video standard compression technique which is required in order to transmit the video information into the MPEG-2/4 multiplexer of a digital platform. The established MPEG-2/4 standard was adopted in DVB for the source coding of audio and video information and for multiplexing a number of source data streams and ancillary information into a single data stream suitable for transmission.

The maximum information rate of such a digital carrier is about 45 Mbit/s. This capacity provides the possibility to deliver at least 4 standard definition TV programs, or some hundreds of radio and ISDN channels or any combination of these services. This multimedia carrier can be accommodated in a 36 MHz transponder

ETSI standard specifies the modulation and channel coding system for the above application which is commonly referred to as the “ DVB-S” standard. The modulation is classical QPSK while a concatenated error protection scheme is employed based on an “outer” coding (Reed-Solomon) with coding rate 204/188 and an “inner” variable coding (convolutional) with code rates of 1/2, 2/3, 3/4, 5/6 and 7/8 . Other rates are also possible.

Operational flexibility is therefore possible by varying the rate of the convolutional code (soft Viterbi decoder) so that transmission capacity
can be traded –off against increased error protection as it will be shown below.
By employing a 3/4 coding rate, a data source of about 41 Mbit/s information rate provides a transmission symbol rate of 27.5 MSymbols/s.
This carrier symbol rate is used by the *HELLAS SAT* **digital platform** and is accommodated in a Hellas- Sat 2 36 MHz transponder bandwidth.

2 TRANSPONDER OPERATING CONDITIONS

A digital TV full transponder lease allows the transmission of a single 34 up to about 45 Mbit/s carrier information rate in a 36 MHz transponder.
The DVB-S standard is intended for Direct-To -Home (DTH) services to consumer Integrated Receiver Decoders (IRD), as well as for reception via collective antenna systems (Satellite Master Antenna Television (SMATV)) and cable television head-end stations. Due to the fact that small receive only antennas are employed , transponder saturation is necessary in order to obtain the maximum output power.

2.1 Operating IPFD and HPA I/O back-off

The IPFD for transponder saturation at the gain step 15 (high gain) from the 0 dB/K satellite contour and for the F1 antenna is -88.4 dBW/m² (according to the relative Table 2 presented in Module 200).

The nominally assigned earth station EIRP, located on the 0 dB/K contour, is therefore 74.6 dBW in order for a receive-only terminal of 60 cm dish (DTH) located at the 50 dBW satellite F1 contour, to be able to receive the TV programs with an acceptable quality (BER=10^{-6}).

In order to keep the spectral sidelobes of the digital carrier, which are formed when passing through the earth station HPA, at an acceptable level, it is necessary to operate the HPA at an output back-off of about 3dB. This implies an earth station EIRP capability of about 78 dBW.

In case that reception is done by cable head-ends or SMATV, lower values of EIRP are required and consequently lower values of HPA output back-off.
The following Table 1 provides the minimum TVRO antenna diameter values which are required to receive a DVB TV signal transmitted from the ***HELLAS SAT*** **platform** located in Athens or from any other platform within the Hellas- Sat 2 satellite receive coverage.

Satellite EIRP contours (dBW)	TVRO antenna diameter (m)
50	0.6
48	0.7
46	0.8
44	1.0
42	1.2

Table 1 : Transmit satellite contours versus TVRO antenna diameter

The above figures are based on a DVB-S carrier uplinked from any Hellas-Sat 2 receive service area and received with a TVRO antenna located within the Hellas-Sat 2 transmit service area with an IRD threshold of Eb/No = 8dB with 99.9% satellite availability and under clear sky conditions.

2.2 Service Objectives

The DVB-S system is designed to provide almost error-free quality (QEF).
This means that a BER of between 10^{-10} and 10^{-11} at the MPEG-2 demultiplexer input can be obtained (i.e. after all error correction decoding)[1]

This quality target translates to a minimum Eb/No requirement for the satellite link, which in turn determines the requirements for the transmit earth station and the user's satellite reception equipment for a given broadcasting network.

The Eb/No values range from about 4.5 dB for rate 1/2 to 6.4 dB for rate 7/8 convolutional coding.
As mentioned previously, the inner code (convolutional) can be varied to increase or decrease the degree of error protection for the satellite link at the expense of required capacity and receive antenna diameter. Table 2 illustrates this trade-off with respect to the common case of rate 3/4 inner coding, **assuming a fixed transponder bandwidth and a given R-S outer code.**

---

[1] This corresponds to a BER of about 2*10-4 at the output of the Viterbi decoder

Inner Code Rate	Required Capacity	Power Requirement (*)	Receive Antenna Diameter
1/2	+33%	-1.0	-11%
2/3	+11/%	-0.5	-6%
3/4	Reference level	Reference level	Reference level
5/6	-11%	+0.5	+6%
7/8	-16.7%	+0.9	+11%

(*) In terms of Eb/No

Table 2 : Link power requirement versus required capacity and receive antenna diameter in terms of inner code rate (Viterbi)

HELLAS -SAT 2 HANDBOOK

Module 400

VSAT TECHNOLOGY AND APPLICATIONS

TABLE OF CONTENTS

1 INTRODUCTION

Very Small Aperture terminal (VSAT) networks provide low-cost access to communication services via satellite.

A VSAT station is a micro-Earth station that uses the latest innovations in the field of satellite communications to allow users to be provided with services comparable to those of large gateways and terrestrial networks. A typical VSAT consists of communications equipment and an antenna with a diameter as small as 1.2m in the case of Ku-band transmissions.

VSAT operators prefer Ku-band to C-band satellites because it allows them to reduce the capital investment by using smaller antennas

VSAT networks provide users with simple equipment that requires minimal installation and repair. They are easy to operate and simple to troubleshoot. VSAT installations do not require staff with extensive expertise.The power requirement for each VSAT is low and therefore it is possible, if required, to supply the power by means of solar cells. A VSAT installation may take a couple of hours and the terminal is ready for service.

VSAT terminals are generally part of a network, with a larger Earth station that serves as a network " master" station or otherwise called "Hub". The hub contains the intelligence to control the network operation, configuration and traffic Hubs are usually located where the bulk of network traffic originates and/or terminates.

A hub consists of the RF equipment, the VSAT interface equipment and the user interfaces. It records the performance, status and activity level of each VSAT terminal and generates databases for billing purposes. In certain networks the role of the Hub is assigned to a VSAT terminal and in this case the network is said to operate hublessly.

From the application point of view, VSAT networks offer a wide range of possibilities and benefits such as :

- Wide range of applications (Tele-Medicine, Distance Training, Telephony for remote areas, etc)
- Quick network deployment (Disaster situation, military actions)
- Ease of network expansion following rapid growth of the market
- Reliability and ease of maintenance
- Cost competitive and more effective than terrestrial networks
- Reliable 24 hour operation with the support of Hellas Sat Operations Center

2 VSAT APPLICATIONS

2.1 Network Topology

There are three types of VSAT network topologies : Star, Mesh and Mixed.

In Star topology, each VSAT terminal transmits and receives only to and from the Hub. Communication traffic among VSAT terminals is routed via the Hub using a satellite double hop. This results in extra satellite resources required by the double hop and in doubling the delay for VSAT to VSAT communications but on the other hand the large antenna gain of the Hub allows to minimize the size of VSAT terminals. This topology suits best to one-way applications (distribution of information).

In Mesh topology all terminals are allowed to communicate with each other directly and consequently there is no need for a Hub to be involved for carrying traffic. However, the terminals must have sufficient EIRP capability and higher G/T than in Star topology to allow a direct communication. The network management and traffic control is ensured by the terminals themselves. Mesh topology is recommended for voice applications where extended delay cannot be tolerated.

Mixed topology allows a group of VSAT terminals to communicate in Mesh topology while others communicate in Star topology. The reason for this is that certain terminals with higher traffic demand can be accommodated in Mesh to reduce cost that a Hub would incur and save satellite resources. The rest of the network can communicate with any of these large terminals or each other via a Star topology.

2.2 Applications for Voice, Data and Video

VSAT networks are used for domestic and/or international applications as they offer a wide span of solutions for most telecommunication needs.
VSATs are suited for many applications which broadly fall into two categories: one-way applications or broadcasting and two-way applications or interactive.

Broadcasting is the simplest VSAT application and applies to voice, data and video transmitted from a central station (could be a hub) and received by small receive-only VSAT terminals .End-users may use a return channel via the normal Public Telephone Network (PSTN) to access the broadcaster and put his request.

The required space segment depends only on the size of the information to be transmitted and is irrelevant from the number of VSAT terminals. The size of information and consequently the satellite bandwidth depends on the range of services to be offered by the service provider :

- stock and commodity information ,weather bulletins, sports scores, inventory records and sound broadcasting may use not more than 64 Kbit/s however the cost of service would be based rather on the required satellite power to establish the link than on the allocated satellite bandwidth.
- Video for conferencing or entertainment and Internet distribution need high-speed satellite channel (from 384 Kbit/s up to 40 Mbit/s for Internet downloading).

Interactive applications allow two-way communications via the VSAT terminal. The carrier from the Hub station to the VSAT is called " outbound" while the carrier from the VSAT to the Hub is called " inbound". These applications cover data, voice, video and high-speed point-to-point services.

a. Interactive data services

This category involves an inquiry from one terminal and a subsequent response from another terminal. Some applications are:

- File transfers for banks (offices to headquarters), stock brokers etc ;
- Management of point-of-sale operations for retail shops, gas station, ATM transactions, reservation request and confirmation (travel agencies, etc) ; and
- Data request retrieval from remote sensing on oil drilling, pipe lines, gas and electric industries.

The gas station application, for instance, provides an ideal match for VSAT networking. Indeed, due to its nature as a one-stop-shop center (pump/store/restaurant) highly frequented by a large number of people from early morning till late night, there is great need for credit cards authorization on an international level.

b. Interactive voice services

This category involves the following services :

- Voice services for private networks and corporations
- Voice services to extend the PSTN facilities to rural and remote areas

The combination of VSAT and a Wireless Local Loop (WLL) can extend the basic phone service to places where other technologies are not cost effective.
Figure 1 provides a voice application example.

c. Interactive video services

Current compression techniques enable video conferencing at data rates as low as 64kbit/s. However, a 384kbit/s rate is the best trade off between quality and cost. VSAT users generally implement outbound video at 384 kbit/s and inbound video at 64kbit/s which ensures good quality in the outbound and cost savings in the inbound.

- Telemedicine is an application that is suitable for remote areas where, in case of medical emergency, the local doctor needs help from a central hospital. All data (x-ray graphs, etc) concerning the situation of the patient may be transmitted immediately to the hospital in order to be evaluated and the local doctor be instructed accordingly. A surgery is also possible to be materialized in real time in a hospital by using the experience of specialized doctors located in another country. The required bit rate for such an application might range from 384 Kbit/s up to 3 Mbit/s

d. High-speed point-to-point

These networks typically have a small number of VSATs and can handle up to 2 Mbit/s. They are mainly used for reasons of availability, security and/or economies when compared to terrestrial networks.

e. Broadband services

The recently developed system which is based on the DVB-RCS network (Digital Video Broadcasting-Return Channel System) provides interconnection between users who are exchanging real time applications.

The forward link (from the Hub to the satellite) is based on a DVB/MPEG-2 format (e.g 45Mbps) and the return link (from the user terminal to the Hub) is using a Multi- Frequency TDMA scheme allowing a two-way exchange of large amount of data (up to 2Mbps or more per carrier) between users. The return link may consist of the multiplexing of several components (e.g video, data ,audio) that originate from the particular home or office.

The network is designed to serve up several thousands simultaneously logged-in terminals.

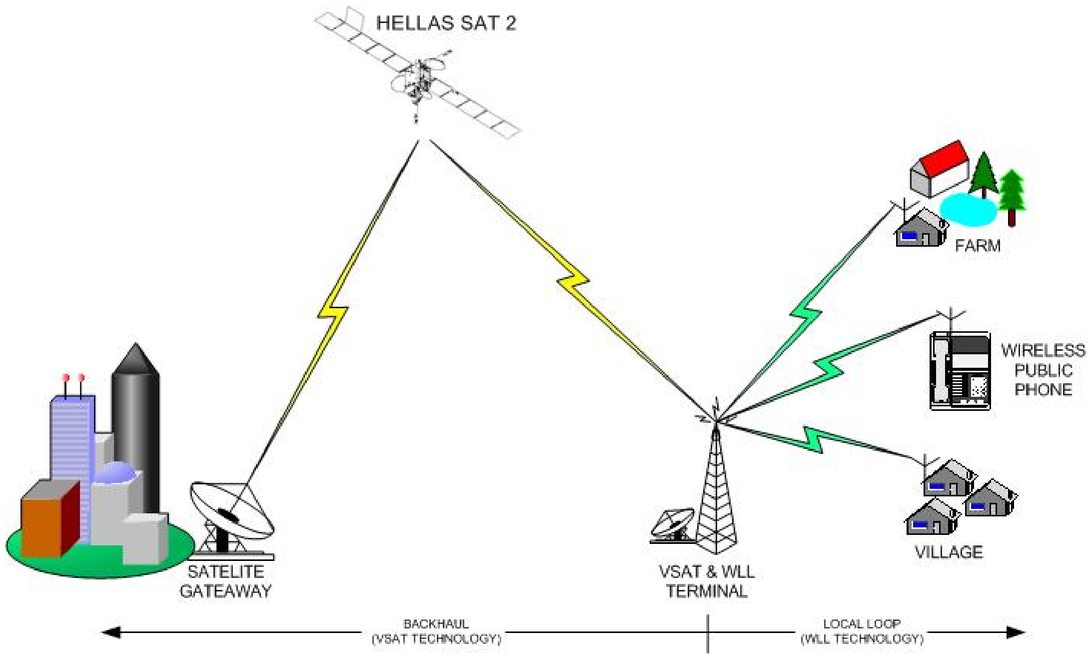


Figure1 : The combination of a VSAT equipped with less than 10 satellite channels and a wireless local loop (WLL) base station can serve a population of some hundreds telephones. The public phones are wireless and powered by solar cells.

This application is an easy and cost-effective solution to extend basic telephony service in remote areas where the necessary infrastructure is missing.

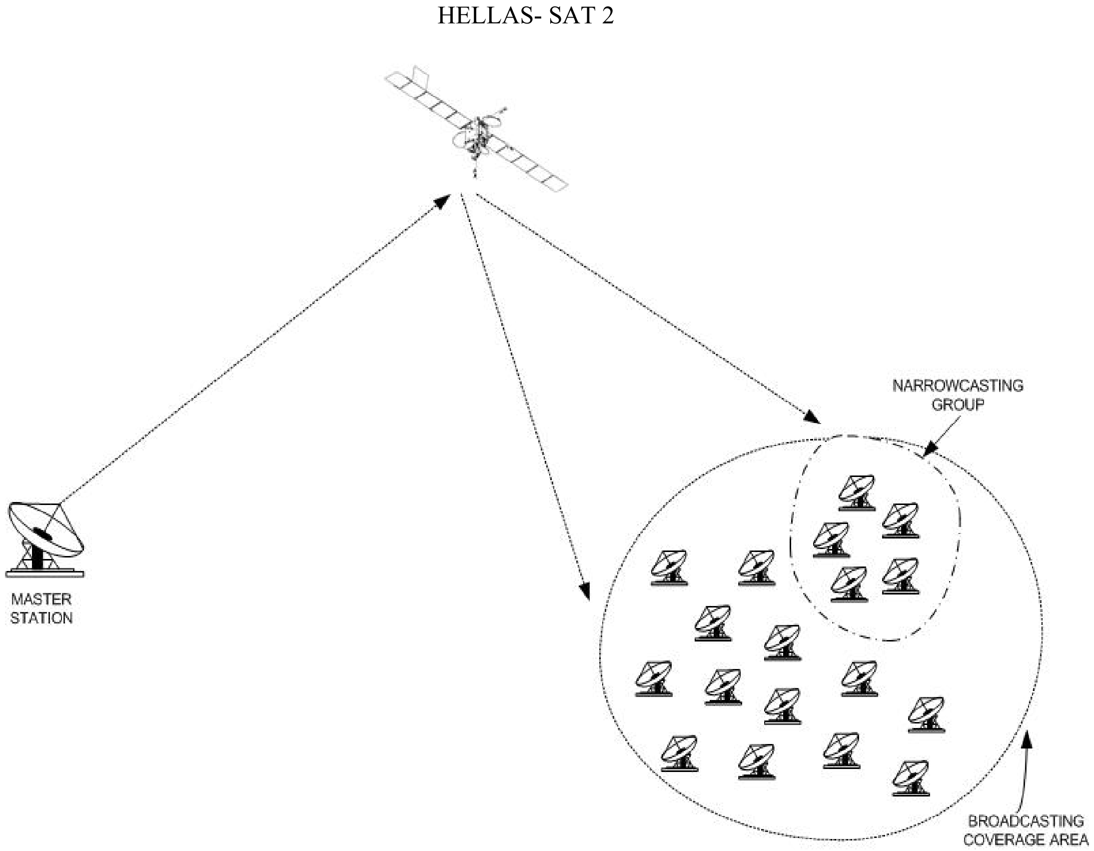


Figure 2: One-Way or Broadcasting applications where the broadcaster controls the information to be received by unauthorized VSAT users. Often, the end-user uses the public telephone lines as a return channel to put his request to i.e a TV program provider.

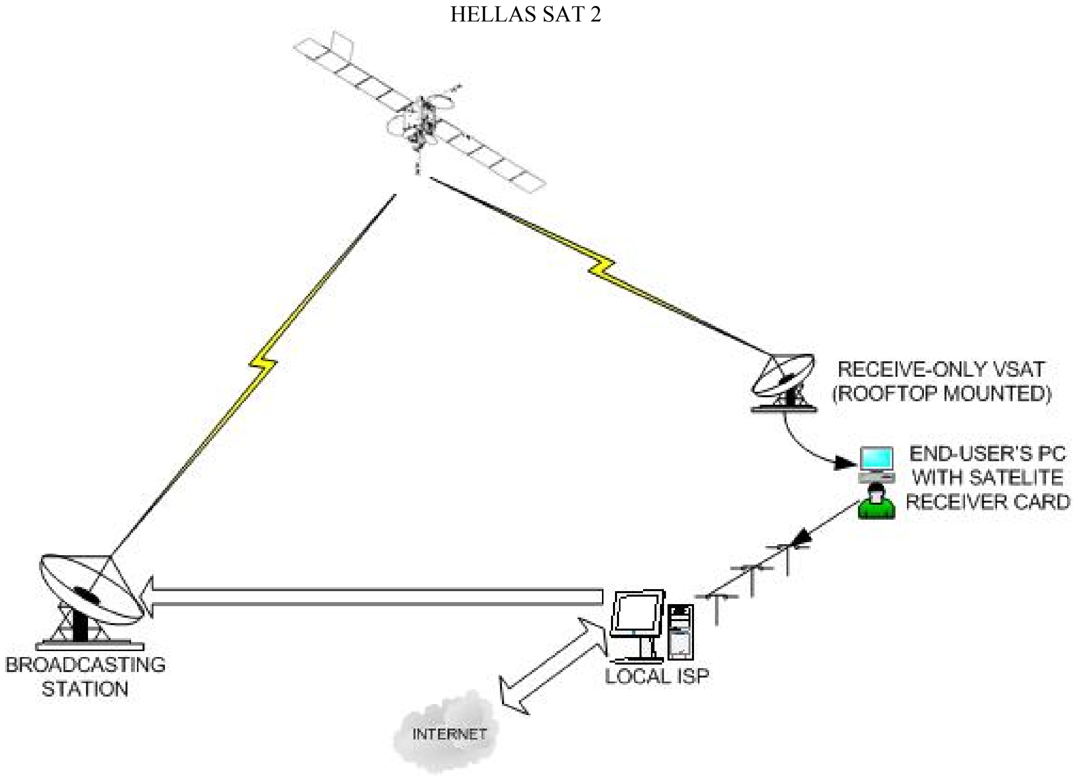


Figure 3: Internet applications via satellite using receive –only VSATs and existing telephone lines (not dedicated). The ISP downloads the requested information via a high-speed satellite channel.

3 ACCESS PROTOCOLS

For the implementation of VSAT networks, there are different layers of protocols which have to be considered. In the following only the issue of satellite capacity access protocol is addressed.

The performance of a network is directly affected by the protocol used in the sense that a proper network design objective is to use protocols that achieve, for the particular application, the highest performance while minimizing the required satellite resources (bandwidth and power).

FDMA is the simplest access used by VSATs allowing the network to share the satellite capacity by using a different frequency assignment for each carrier. These carriers need not have the same power or bandwidth,but their sum must be within the allocated capacity.

TDMA allows users to access the allocated capacity in a time-shared mode. At any given time slot, in contrast with the FDMA technique, the entire allocated bandwidth and power are filled by one user (carrier) and therefore provides certain operational advantages over FDMA.

CDMA is the third access technique where all VSATs transmit simultaneously in the same allocated bandwidth, frequency and power.

Satellite network access protocols usually combine two satellites' capacity access techniques with some kind of traffic control.

There are two commonly used satellite access protocols that use a combination of on-demand assignment, random and permanent assignment.

These are TDM/TDMA and SCPC/DAMA. TDM/TDMA uses a permanent TDM carrier for the outbound traffic to transmit information from the Hub to VSATs.

VSATs use TDMA to access share inbound carriers. The TDM/TDMA access is a combination of FDMA and TDMA.

SCPC/DAMA uses a single channel per carrier to convey traffic. When traffic exists, carriers are assigned in pairs, one from the hub to the VSAT and another from the VSAT to the hub for the return channel.

The above referred access techniques as well as others, which have not been mentioned here, present advantages and disadvantages in terms of operational flexibility and cost. It is therefore advisable for a service provider prior to his decision to offer any of the services mentioned above, to properly identify and quantify the service requirements and communicate with Hellas Sat in order to jointly dimension and optimize the network configuration for each particular application.

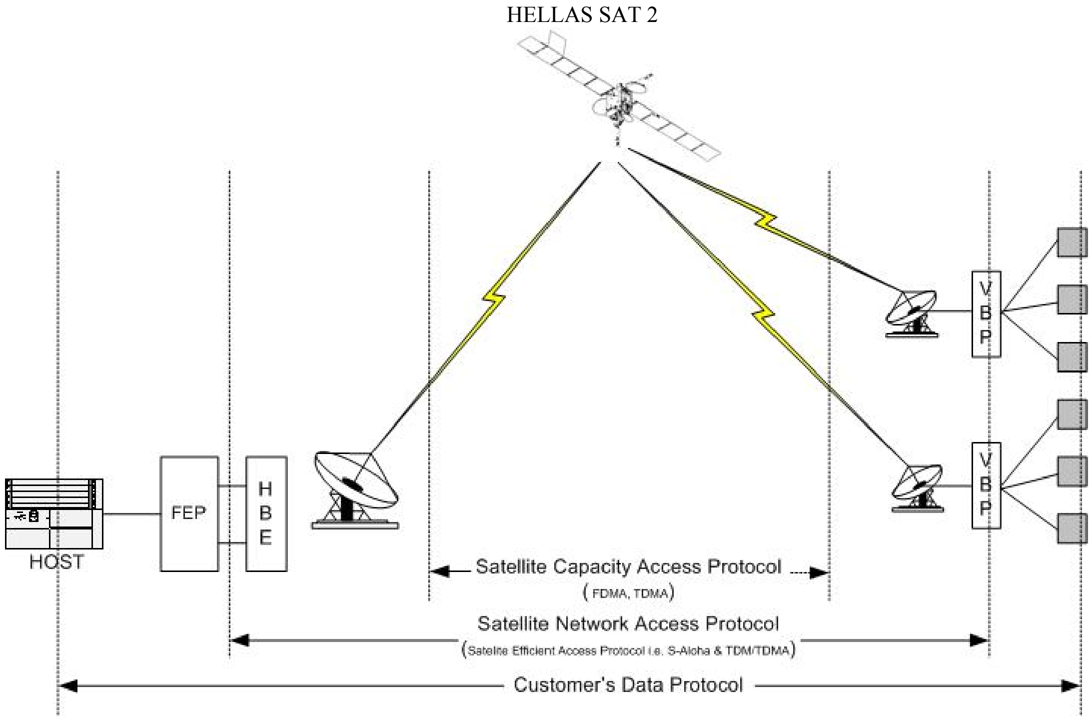


Figure 4 : Access and Network protocols to be employed are responsible for the efficiency of the application.

4 CALCULATION OF SATELLITE BANDWIDTH

The satellite bandwidth required for a VSAT application is one of the most important factors which affect the overall cost of a VSAT network. This is an incurring cost and it gets lower as smaller the required bandwidth becomes.
However, it may happen that due to stringent operational requirements (high quality objectives, insufficient antennas size, geographical coverage) the dominant cost factor becomes the required satellite power rather than the satellite bandwidth. This means that the carriers require more power from the satellite than the power corresponding to the carrier’s allocated bandwidth and the link is considered to be power limited. The cost in this case will be based on the power equivalent bandwidth which is obtained by means of a link budget calculation.

The factors which affect the required satellite bandwidth in any network are mainly the offered traffic, the antenna sizes employed in the network, the service quality objective (BER threshold), the transmission parameters, the efficiency of the multiple access protocols and the satellite link availability (rain margin).

<u>The traffic</u> to be offered affects the number of satellite channels required for a given network. Traffic reduction leads to fewer satellite carriers and therefore to less bandwidth. However, eventual underestimation of the traffic demand might lead to severe congestion.
<u>The antenna size</u> is directly related to the G/T of the antenna which plays an important role in the determination of the Eb/No. As it has already been stated, the G/T defines the eirp required from the satellite and thus the power equivalent required satellite capacity which is reduced when the G/T is increased. Improving the VSAT G/T has more impact on the link than improving the Hub G/T.
<u>The quality objective</u> (BER threshold) defines the service availability and it is directly related to Eb/No which depends on modulation scheme and FEC. The service provider should select carefully the right value for BER depending on the type of application (voice,data etc) in order to minimize the required Eb/No.
<u>The transmission parameters</u> such as modulation scheme, FEC ratios, coding etc define the Symbol Rate or the allotted capacity. The choice of modulation, coding and FEC depend on the type of application. The use of i.e Reed-Solomon code although improves the BER is not recommended for applications of low bit rate where delay is not tolerated
Margins are also very important because they are used to cater for rain attenuation which might be very severe in the Ku-band (up to 8 dB). The values of the uplink and downlink margins depend on the availability target set for the in subject link. It is noted that the Eb/No defines the link quality threshold whereas the margins define the link availability. The addition of margin to the threshold allows the link to operate with higher quality during clear-sky conditions.
The calculation of the required bandwidth to be leased for a given application can be made after having collected all the data referred above by means of a link budget in

which the target would be to match the equivalent power bandwidth value (which depends on the satellite coverage area, G/T of receive antennas etc) with the typical allocated bandwidth value which is based only on the transmission parameters (i.e number of carriers, bit rate, FEC ratio). In some cases the equivalent power bandwidth cannot be matched with the allocated bandwidth due to a number of factors such as low G/T values, high quality requirements, edge of coverage etc. **The capacity to be leased in this case would be the larger of these two values (equivalent power bandwidth value versus allocated bandwidth value).**

HELLAS -SAT 2 HANDBOOK

Module 500

TEMPORARY TV TRANSMISSIONS

TABLE OF CONTENTS

1 Introduction

2 Operational Conditions

3 Booking Office

1 INTRODUCTION

Due to the various beam interconnectivities facilities of Hellas-Sat 2 satellite, the temporary TV transmissions become a very attractive application. This type of application is accommodated in either a whole transponder or fraction thereof usually leased for a limited period of time. A service provider may get access to the satellite at short notice and at affordable cost may cover special events of short duration occurring anywhere within the satellite coverage area. These events might be anything like a foot ball match, an important congress, foreign official visits, disaster situations e.t.c.

To this end, HELLAS SAT has dedicated a number of channels in fixed and steerable beams transponders, each of which can accommodate occasional TV carriers of a standard satellite bandwidth (e.g 9 or 4.5 MHz) and at pre-defined uplink/downlink frequencies. 18 MHz slot or a whole transponder (36 MHz) may also be made available for occasional transmissions for high definition TV (HDTV) service.

2 OPERATIONAL CONDITIONS

The transmission parameters are always set by HELLAS SAT on a case by case basis. Indicatively it is noted that, the permissible uplink EIRP for a carrier occupying a 9 MHz slot is about 62 dBW when the uplink E/S is located on the 6 dB/K of F1 or F2 satellite receive contour (it is reminded that the 6 dB/K contour practically covers the whole Europe and M.East).

In case of a single 34 Mbps carrier transmission, the nominally assigned EIRP to the uplink E/S located on the F1 or F2 6 dB/K contour is 75 dBW. In order to keep the spectral sidelobes of the digital carrier at an acceptable level, the E/S high power amplifier should operate at an OBO of about 5 dB. This implies an E/S EIRP capability of about 80 dBW.

3 BOOKING OFFICE

The final operational parameters of the transmissions which should be met in order to protect other Occasional TV transmissions taking place in the same transponder as well as the necessary procedures to get access to an Occasional Use Transponder will be provided by the HELLAS SAT Booking Office

The HELLAS SAT Booking Office is manned on a 24 hour basis. The telephone and fax numbers for reservation and technical matters are as follows :
Tel : +30 210 6100701/+30 210 6100702
Fax : +30 210 6100700
For line-up procedures, the E/S Thermopylae can be contacted at the following numbers :
Tel : +30 210 8836278 or Fax : +30 2108842631