EMBRATEL STAR ONE

ENGINEERING DIRECTORATE

COMMUNICATIONS SYSTEMS MANAGEMENT

SYSTEM TECHNICAL CHARACTERISTICS

CHARACTERISTICS OF THE STAR ONE D1 FOR KU BAND COMMUNICATIONS NETWORK TECHNICAL PROJECT

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INTRODUCTION

The objective of this document is to set out the necessary technical characteristics for design and sizing of satellite communications networks via Star One D1 satellite in Ku band.

1. Basic Characteristics of the Space Segment

The Star One D1 satellite is located at the orbital position 84.0°W.

1.1. Frequency Band

1.1.1. Transponders

The Star One D1 satellite operates in the Ku-band in the frequency bands 13750.0 MHz to 1450.0 MHz in the uplink and 10950.0 MHz to 11200.0 MHz and 11700.0 MHz to 12200.0 MHz in the downlink. using 36.0 MHz bandwidth transponders in both Horizontal (H) and vertical (V) polarizations.

1.1.2. Beacons

The Star One D1 satellite Ku Band non modulated beacons are located at 11,701.25 MHz (Horizontal polarization) and 12,198.75 MHz (Vertical polarization) center frequencies with a minimum EIRP of 13.0 dBW.

1.1.3. Frequency Conversion (Extended Ku Band and Standard Ku Band)

Banda Ku	Uplink (MHz)	Downlink (MHz)	Conversion (MHz)
Extended	13,750,0. to 14,000.0	10,990.0 to 11,200.0	2,805.0
Standard	14,000.0 to 14,500.0	11,700.0 to 12,200.0	2,300.0

Table 1 – Ku Band Frequency Conversion

1.2. Polarization

The Star One D1 satellite operates with linear polarization. Due to the fact that the Star One D1 satellite reuses frequencies through the use of dual polarization, the isolation of the satellite antennas between the two orthogonal polarizations is 30.0 dB within the coverage area, for both uplink and downlink.

1.3. Coverage Characteristics

The Star One D1 satellite operates in Ku Band using Brasil (BRAK beam), West of South America (WSAK beam) and Mexico and Central America (MCAK beam) coverages.

The typical Ku band coverage maps (footprints) are presented in Figure 1 (BRAK beam Uplink), Figure 2 (BRAK beam Downlink), Figure 3 (WSAK beam Uplink) ,Figure 4 (WSAK beam Downlink), Figure 5 (MCAK beam Uplink – Hemispherical View), Figure 6 (MCAK beam Uplink – Mexico and Central America Region), Figure 7 (MCAK beam Downlink – Hemispherical View) and Figure 8 (MCAK beam Downlink – Mexico and Central America Region.

Notes:

1. Actual coverage may present certain differences in light of a specific transponder.

2. The references contours for Saturation Flux Density, satellite G/T and satellite EIRP mentioned in this document correspond to the 0.0 dB advantage coverage curve.

1.3.1. BRAK Beam – Typical Coverage

1.3.1.1. Uplink

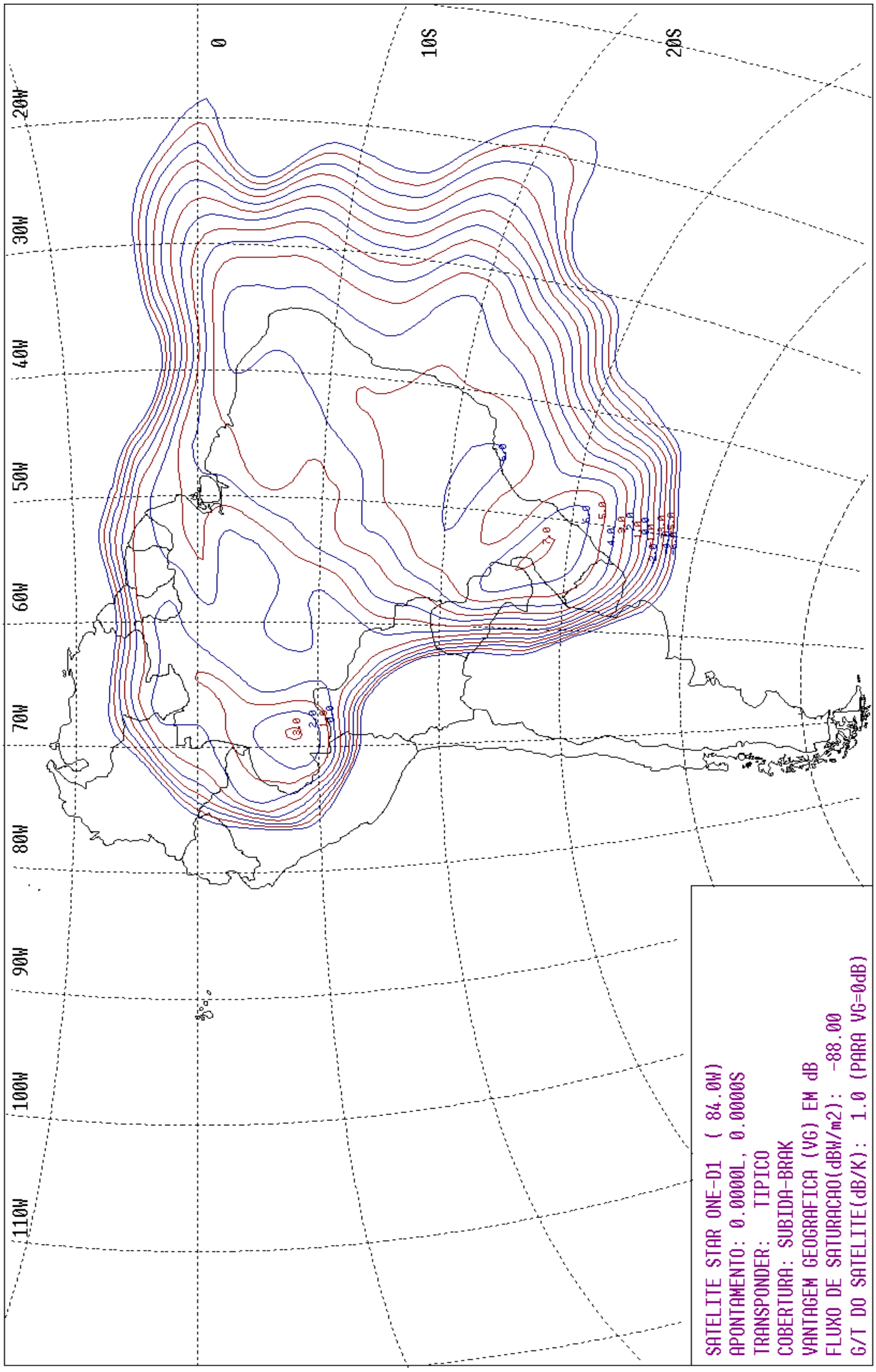


Figure 1 - Star One D1 (G/T) BRAK Typical Uplink Coverage

1.3.1.2. Downlink

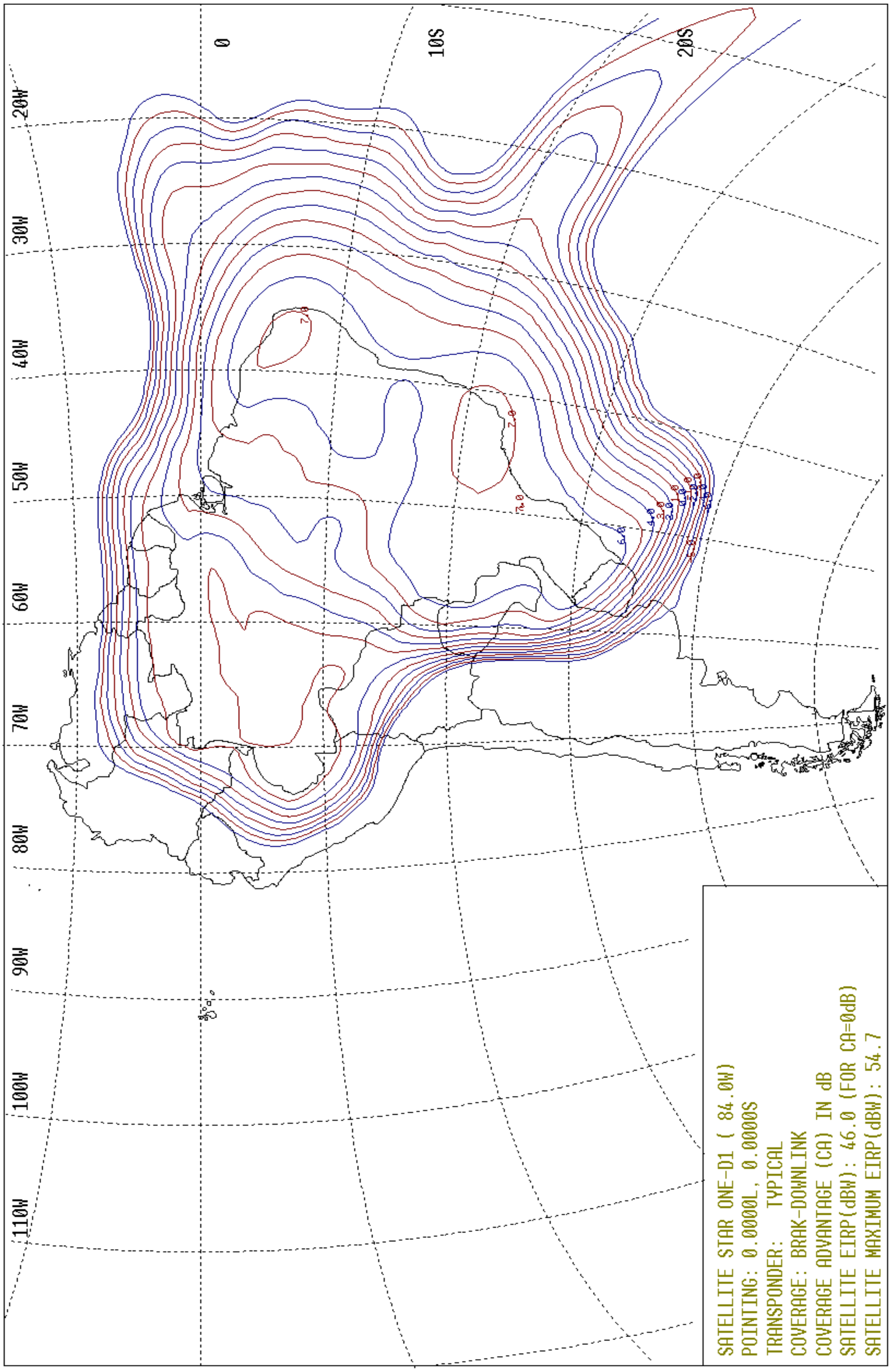


Figure 2 - Star One D1 (EIRP) BRAK Typical Downlink Coverage

1.3.2. WSAK Beam - Typical Coverage

1.3.2.1. Uplink

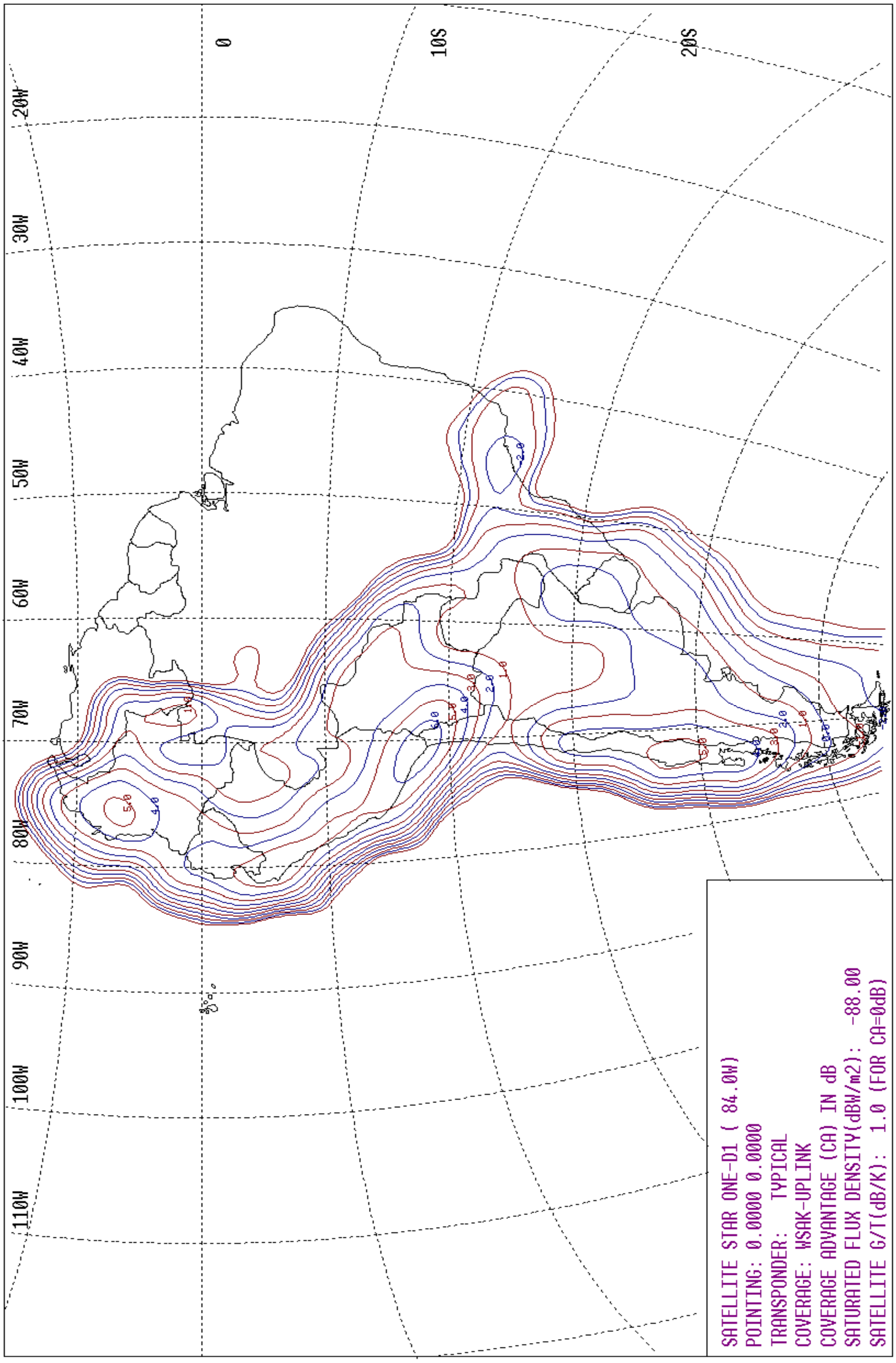


Figure 3 - Star One D1 (G/T) WSAK Typical Uplink Coverage

1.3.2.2. Downlink

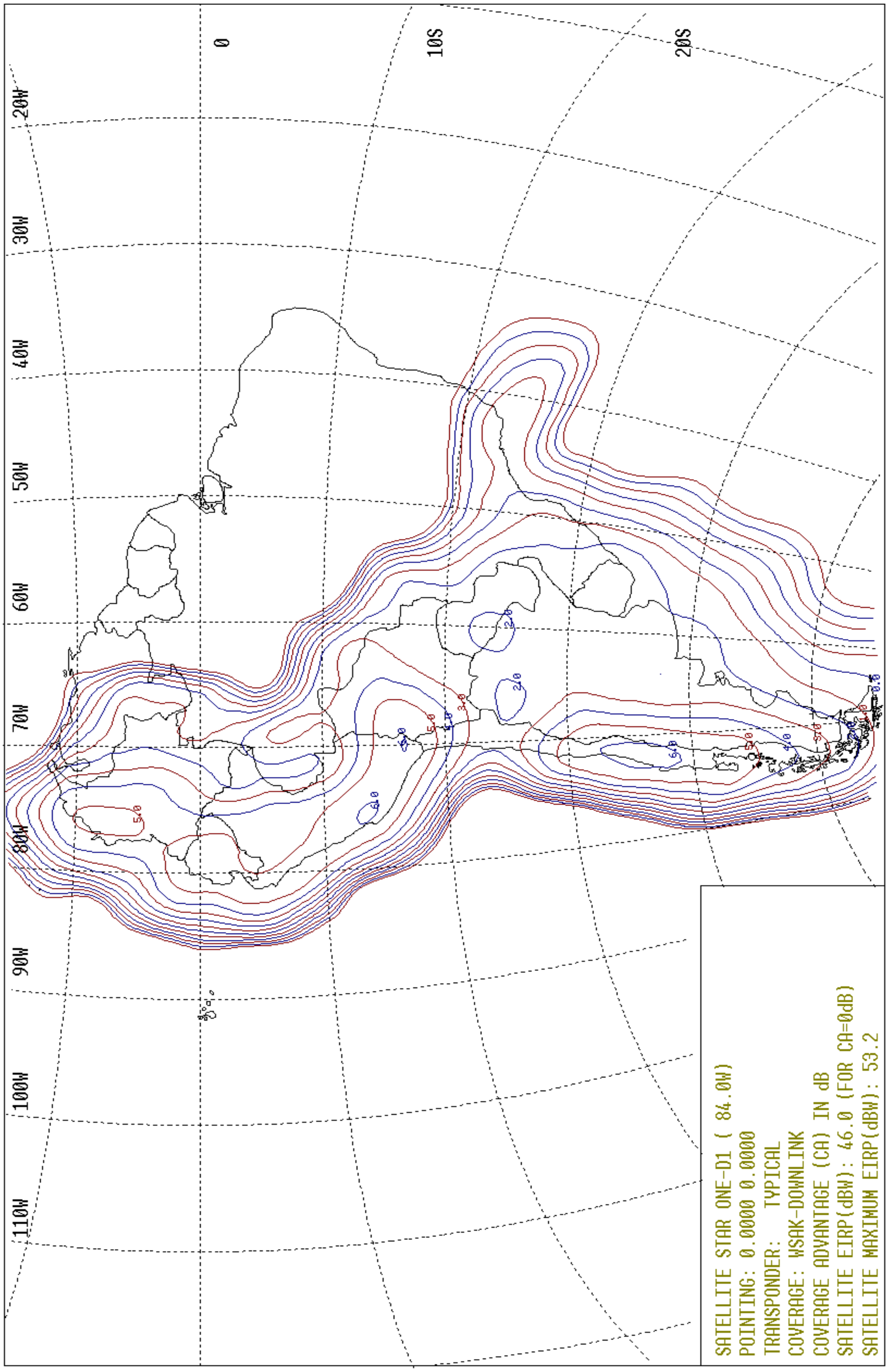


Figure 4- Star One D1 (EIRP) WSAK Typical Downlink Coverage

1.3.3. MCAK beam – Typical Coverage

1.3.3.1. Uplink

1.3.3.1.1. Hemispheric View

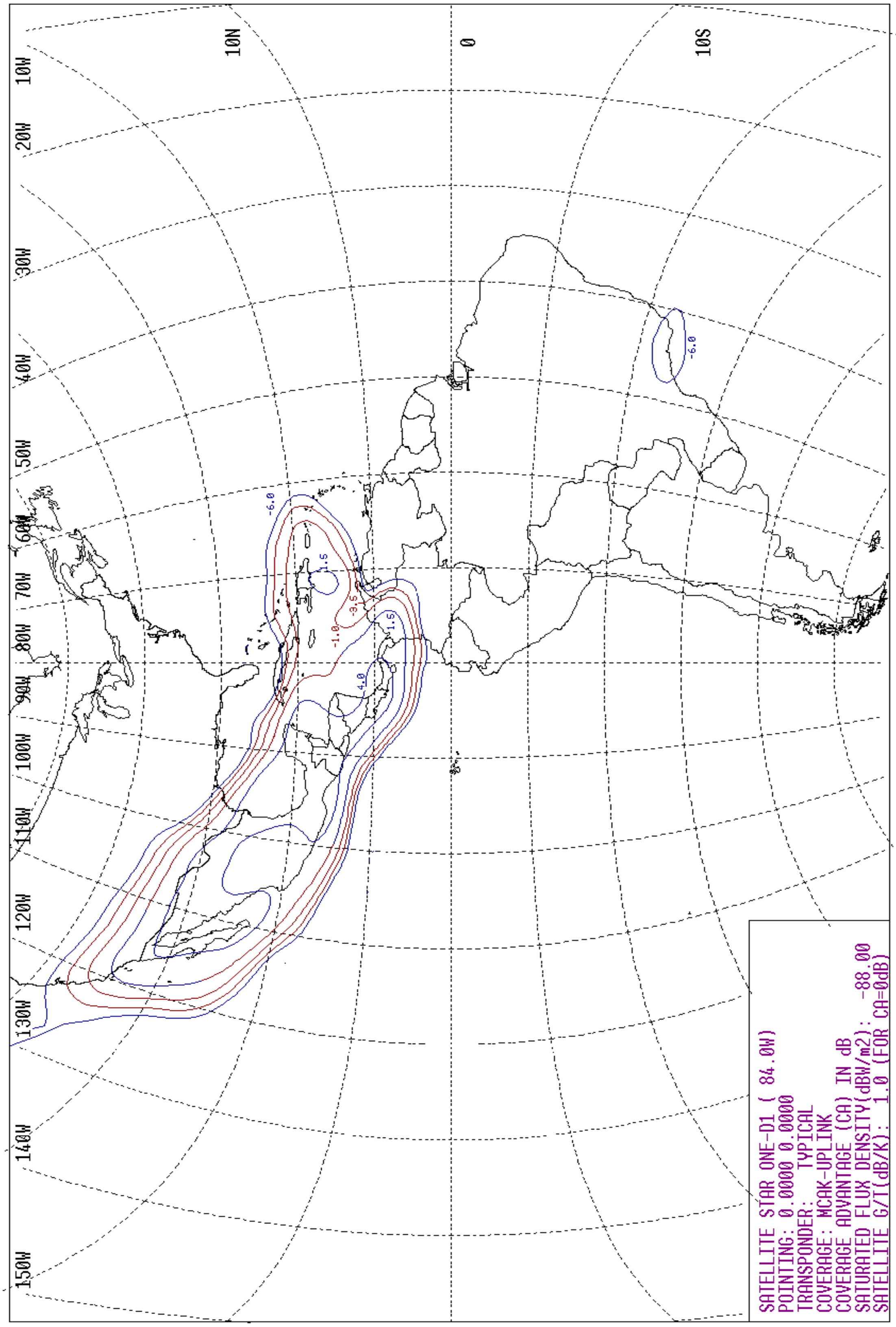


Figure 5 - Star One D1 (G/T) MCAK Typical Uplink Coverage - Hemispheric View

1.3.3.1.2. Mexico and Central America Region

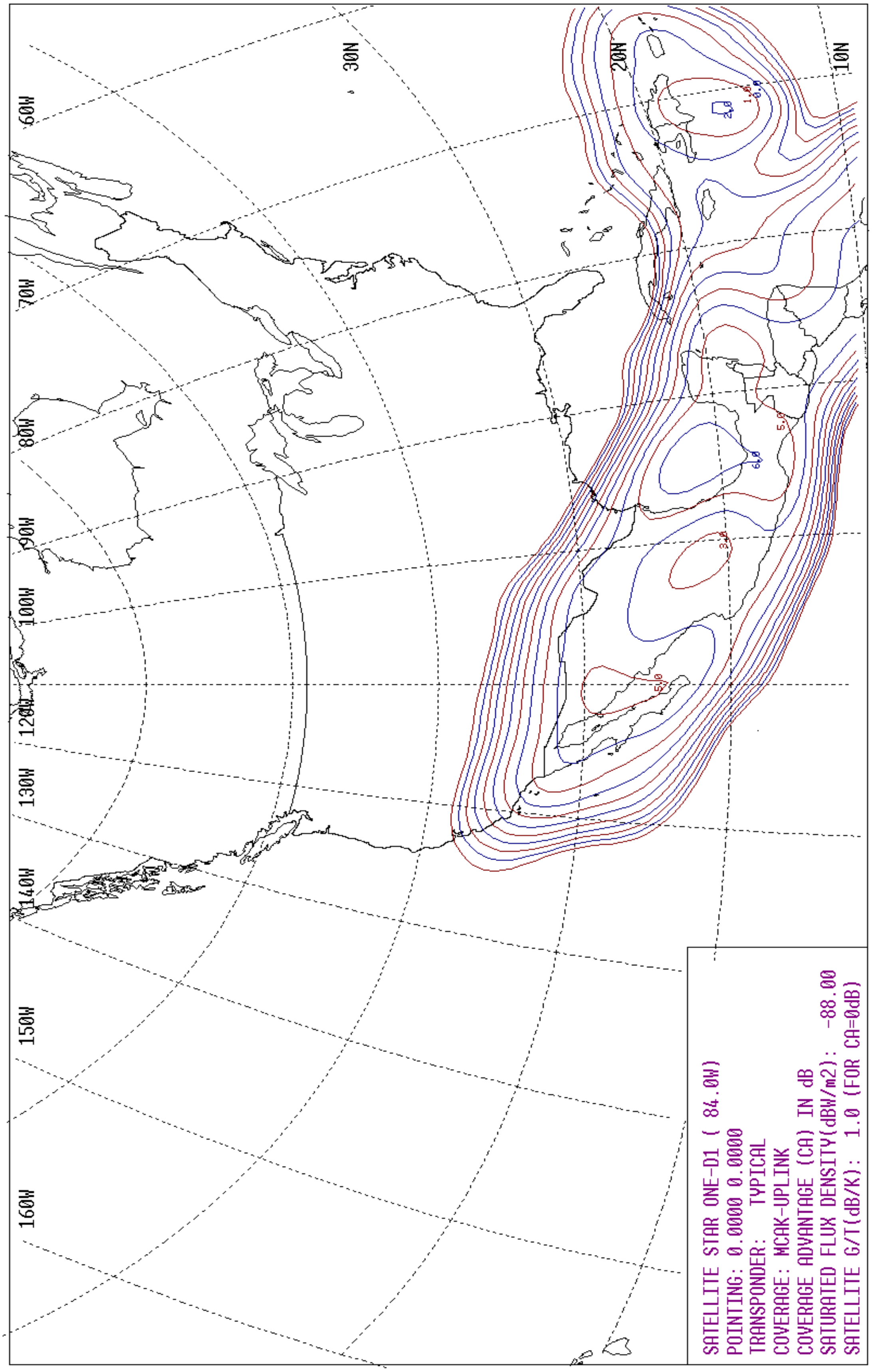


Figure 6 - Star One D1 (G/T) MCAK Typical Uplink Coverage – Mexico and Central America Region

1.3.3.2. Downlink

1.3.3.2.1. Hemispheric View

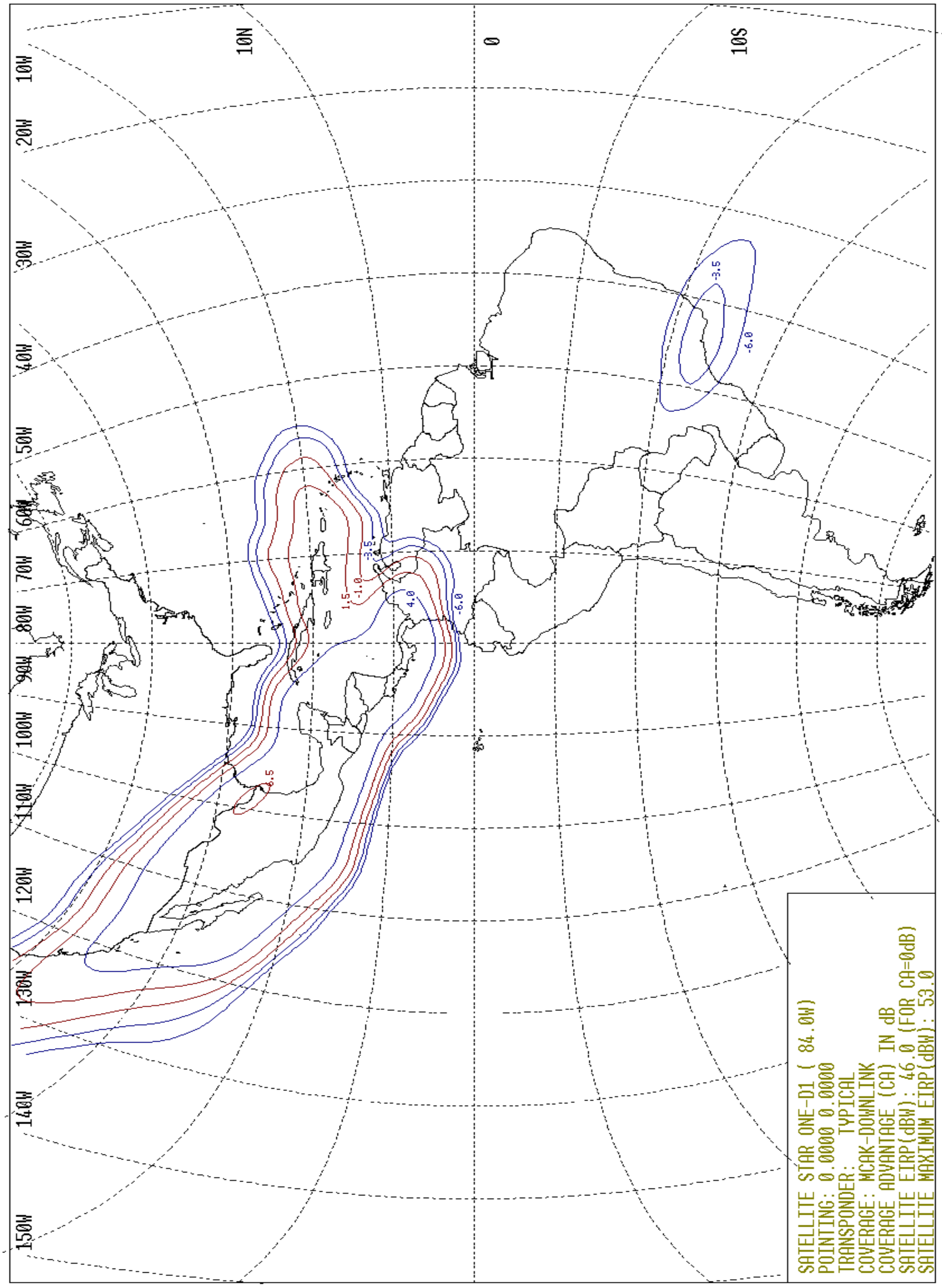


Figure 7 - Star One D1 (EIRP) MCAK Typical Downlink Coverage - Hemispheric View

1.3.3.2.2. Mexico and Central America Region

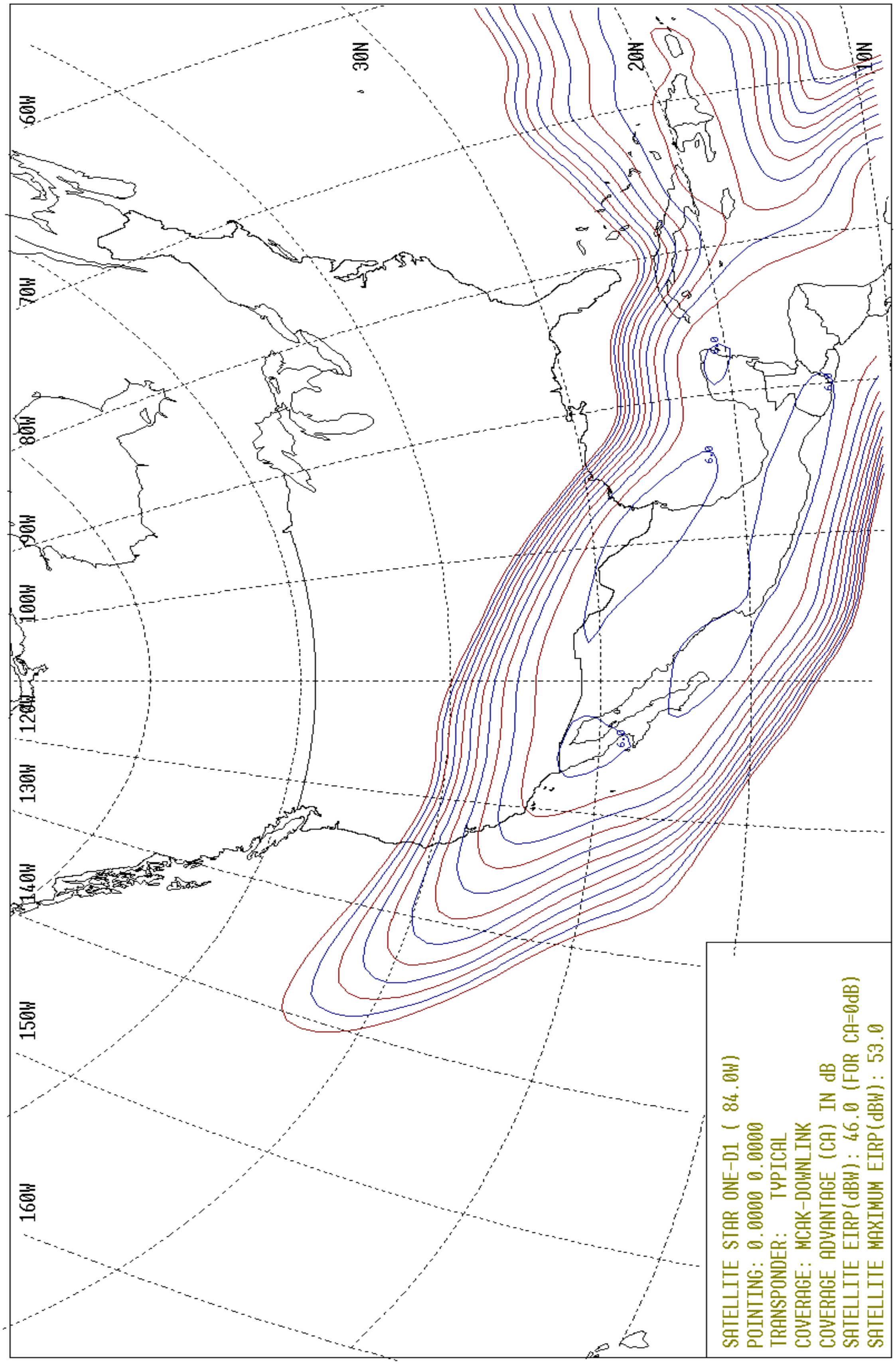


Figure 8 - Star One D1 (EIRP) MCAK Typical Downlink Coverage – Mexico and Central America Region

1.4. EIRP

The Star One D1 satellite typical EIRP at the reference contour is 46.0 dBW in the Ku Band.

1.5. G/T

The typical Star One D1 satellite G/T at the reference contour is 1.0 dB/K in the Ku Band.

1.6. Saturation Flux Density

For Star One D1 satellite, in Ku Band, It should be considered a typical Saturation Flux Density of -88.0 dBW/m^2 in the reference contour.

The Saturation Flux Density may be adjusted in a range of -4.0 dB to + 4.0 dB in steps of 1.0 dB to be assigned by Embratel Star One in light of service characteristics and selected transponder.

1.7. Typical Input and Output Back-off and Intermodulation Noise Density

The typical Star One D1 satellite input and output back-off for transponders allocated to multi-carrier (multi-carrier mode) are 5.5 dB and 4.0 dB, respectively. The intermodulation noise density in this case is -97.0 dB/Hz, related to the saturation power output, corresponding to -15.0 dBW/4kHz, at the reference contour.

The typical Star One D1 satellite input and output back-off for transponders allocated to 2 (two) carriers (dual-carrier mode) are 3.0 dB and 2.0 dB, respectively. The intermodulation noise density in this case can be disregarded because its major part will occur outside the frequency limits of the transponder.

The typical Star One D1 satellite input and output back-off for transponders allocated to1 (one) carrier (single-carrier mode) are 1.0 dB and 0.5 dB, respectively. In the case of 16APSK carriers, the input and output back-off of -3.0 dB and -1.5 dB respectively must be used.

1.8. Operational Conditions

Carriers allocated in Star One D1 satellite transponders are subject to the following operational conditions:

1.8.1. Adjacent Satellites

Considering the Anatel Resolution 288: "***Operating Conditions of Geostationary Satellites, in Ku-Band, with Coverage over Brazilian Territory***", as well coordination agreements with operators of adjacent satellites sharing the same frequency band at the geostationary orbital arc, the carriers shall comply with the maximum densities levels listed below.

Note: the densities shall be calculated in a 1.0 Hz reference bandwidth, with the digital carrier bandwidth expressed in terms of its symbol rate.

1.8.1.1. Maximum Uplink Density

The maximum allowable uplink power density for carriers operating in Star One D1 satellite for BRAK, WSAK and MCAK coverages is -48.0 dBW/Hz, referred to the earth station antenna input. Density values greater than -48.0 dBW/Hz requires **Embratel Star One prior written authorization**.

1.8.1.2. Maximum Downlink Density

The maximum allowable downlink EIRP density for carriers operating in Star One D1 satellite for BRAK, WSAK and MCAK coverages is -22.0 dBW/Hz, referred to the beam center. Density values greater than -22.0 dBW/Hz requires **Embratel Star One prior written authorization**.

Note: Star One D1 satellite maximum saturated EIRP is about 54.7 dBW for BRAK coverage, 53.2 dBW for WSAK coverage and 53.0 for MCAK coverage.

1.8.1.3. Minimum Antenna Diameter

Antennas with diameters within the conditions **1.** to **3.** described below may be used only with **Embratel Star One written authorization**, after evaluating their technical characteristics as well as its geographic location:

1. Strictly receiving antennas with diameter lower than 75.0 cm, operating in the standard Ku band;
2. Strictly receiving antennas with diameter lower than 60.0 cm, operating in the extended Ku band;
3. Antennas with diameter lower than 96.0 cm, operating in the standard Ku band;
4. Antennas with diameter lower than 1.2 m, operating in the extended Ku Band.

Note: Transmissions in the extended Ku band using antennas with diameter lower than 1.2 m are prohibited, as per resolution of the World Radiocommunication Conference 2003.

1.8.2. System/ Link Margins

- An overall margin of 2.2 dB to cover adjacent satellites interference, terrestrial interference, co-transponder cross-polarization interference and earth station spurs shall be assumed;

- An additional margin of 0.5 dB in TX and 0.5 dB in RX shall be assumed to cover mis-pointing of earth station antennas with diameter larger than 4.5 m, equipped with tracking system. For antennas with diameter less than or equal to 4.5 m without tracking system, it is recommended to use the following margins to cover mis-pointing due to movement of the satellite in its orbital control box (+ / - 0.05 °):

Diameter (m)	TX Margin (dB)	RX Margin (dB)
D ≤ 1.8	0.3	0.2
2.4	0.4	0.3
3.6	1.0	0.7
4.5	1.5	1.1

Table 2 – Typical Mis-pointing Margin for Antennas without Tracking System

- An additional earth station HPA margin of 2.0 dB shall be assumed to cover: differences between the real coverages, switching from primary to redundant satellite units in case of failures and possible degradations during satellite lifetime.

2. Mandatory Characteristics for Transmit Earth Stations

2.1 Emissions Characteristics

2.1.1. Frequency Stability

The tolerance in RF frequency accuracy (maximum frequency uncertainty of initial adjustment plus change over time) shall not exceed +/-800.0 Hz in one day and +/-3500.0 Hz in one month, for earth stations with equipment installed indoor, with temperature control as well as those installed outdoor.

2.1.2. Off-Axis EIRP Density Limits

The maximum off-axis EIRP density emission for any angle equal or greater than 1.9° outside the earth station antenna main lobe, within the geostationary satellite orbital arc, must not exceed the values presented on Table 3 (reference document: ANATEL Resolution 288):

Off-Axis EIRP Density Limit (dBW/Hz)	Angle
-48 + 29 - 25 log θ	$1.9° \leq \theta < 36°$
-48 - 10	$36° \leq \theta \leq 180°$

Table 3 – Off-Axis EIRP Density Limit

Notes:

1. Densities shall be calculated in 1.0 Hz reference bandwidth, with the digital carrier bandwidth expressed in terms of its symbol rate;
2. Use of an antenna/ transmission configuration exceeding Table 3 values requires **Embratel Star One prior written authorization**.

2.1.3. Out of Band Emission

The EIRP density transmitted outside the allocated band of the carrier shall not exceed the value of 10.0 dBW/4 kHz for intermodulation and 0.0 dBW/4 kHz for spurious, resulting in an aggregate of 10.4 dBW/4 kHz.

The limits presented above must be lowered from the value corresponding to the receive gain increase of the satellite antenna relative to the reference contour.

In any case, when an emission outside the authorized band causes prejudicial interference an additional decrease may be requested from those limits established above.

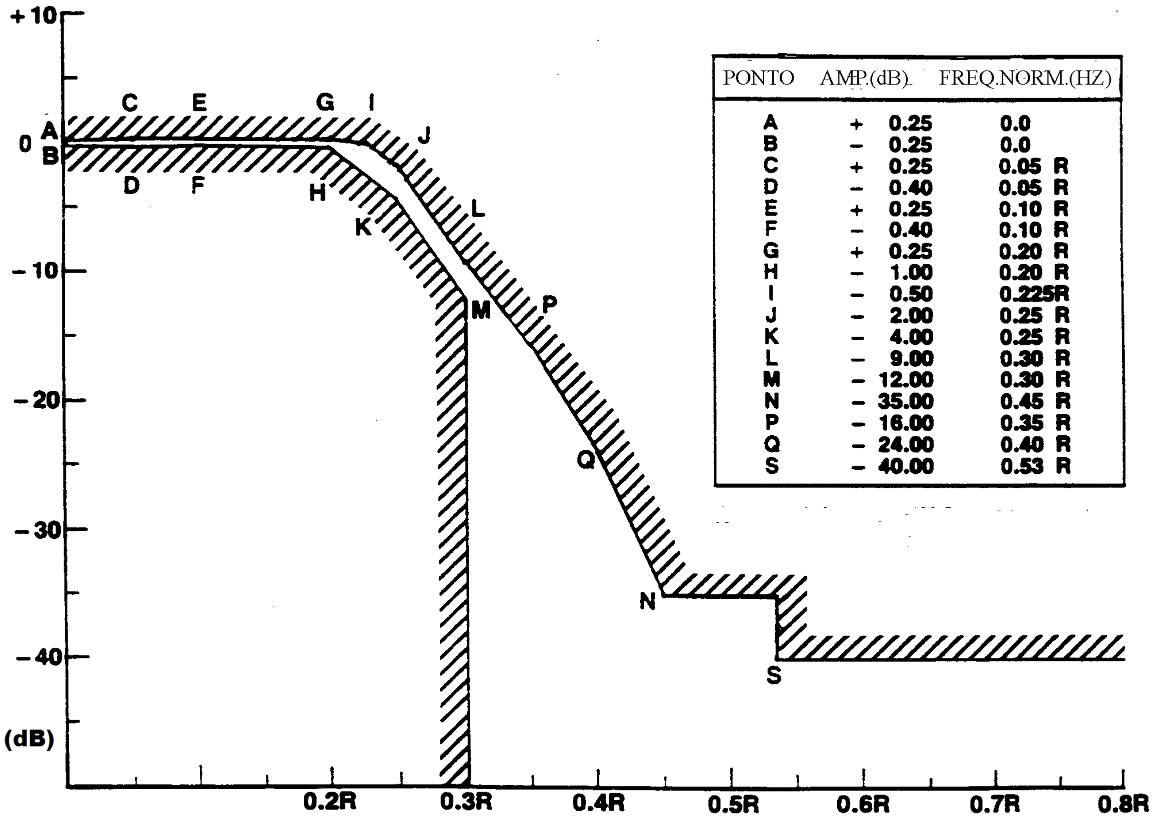
2.1.4. EIRP Stability

The daily earth station EIRP variation shall be below to 2.0 dB peak-to-peak, excluding the contribution of the satellite excursion through the control box and those of adverse weather condition. This performance shall apply for earth stations with equipment installed indoor, with temperature control, as well as those installed outdoor.

2.1.5. Spectral Power Density

The spectral power density of the modulated carrier at the modulator output and at the output of the earth station transmitter shall be in conformity with the masks presented in the figures below. (Figures 9 and 10)

2.1.5.1. Spectral Power Density Mask at Modulator Output



PONTO	AMP.(dB)	FREQ.NORM.(HZ)
A	+ 0.25	0.0
B	− 0.25	0.0
C	+ 0.25	0.05 R
D	− 0.40	0.05 R
E	+ 0.25	0.10 R
F	− 0.40	0.10 R
G	+ 0.25	0.20 R
H	− 1.00	0.20 R
I	− 0.50	0.225R
J	− 2.00	0.25 R
K	− 4.00	0.25 R
L	− 9.00	0.30 R
M	− 12.00	0.30 R
N	− 35.00	0.45 R
P	− 16.00	0.35 R
Q	− 24.00	0.40 R
S	− 40.00	0.53 R

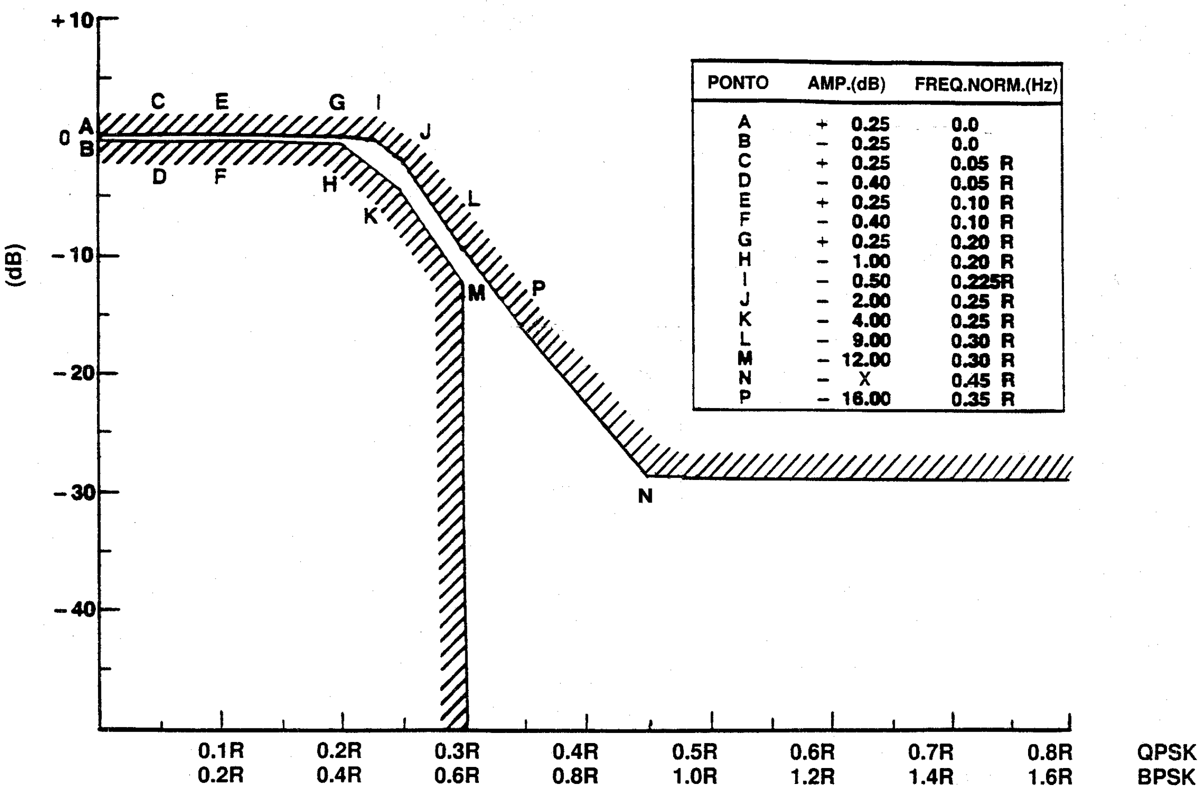
NORMALIZED FREQUENCY IN RELATION TO CENTER (Hz)

Figure 9 - Spectral Power Density Mask at Modulator Output

Notes:

1. R = Transmission rate in bits per second;
2. The normalized frequency of the abscissa axis corresponds to the QPSK modulation; in order to obtain the frequency for BPSK modulation the values contained in the abscissa should be multiplied by 2 (two); in order to obtain the frequency for 8PSK modulation, divide the values contained in the abscissa by 1.5;
3. The relative power of 0.0 dB, for QPSK modulation corresponds to -10 log (R/2) dB/Hz in relation to the power of the carrier without modulation; in order to obtain the relative power for BPSK modulation, use R instead of R/2; in order to obtain the relative power for 8PSK modulation, use 3R/2 instead of R/2.

2.1.5.2. Spectral Power Density Mask at Transmitter Output



PONTO	AMP.(dB)	FREQ.NORM.(Hz)
A	+ 0.25	0.0
B	− 0.25	0.0
C	+ 0.25	0.05 R
D	− 0.40	0.05 R
E	+ 0.25	0.10 R
F	− 0.40	0.10 R
G	+ 0.25	0.20 R
H	− 1.00	0.20 R
I	− 0.50	0.225R
J	− 2.00	0.25 R
K	− 4.00	0.25 R
L	− 9.00	0.30 R
M	− 12.00	0.30 R
N	− X	0.45 R
P	− 16.00	0.35 R

Figure 10 - Spectral Power Density Mask at Transmitter Output

Notes:

1. R = Transmission rate in BITS per second;
2. NBPS = Number of BITS per symbol (1 for BPSK, 2 for QPSK);
3. The relative power of 0 dB corresponds to -10 log (R / NBPS) dB/Hz related to the power of the carrier without modulation;
4. X (dB) = $EIRP_{TX}$ (dBW) + VG_{UP} (dB) + 25.6 dB - 10 log (R / NBPS);
5. The value of X plotted refers to a BPSK carrier of 512KBPS+FEC1/2

   with a typical $EIRP_{TX}$ = 56.0 dBW in an uplink contour of 7.0 dB;
6. The secondary lobe may not have relative amplitude (x) above -26.0 dB at

   the normalized frequency in relation to the center of 0.75R for QPSK and

   1.5R for BPSK;
7. Note 6. may supersede note 5.;
8. Independent spurious should meet the criteria of 0.0 dBW/4kHz.

2.2. Antenna Characteristics

The minimum technical characteristics of antenna radiation at earth station used in communications links via geo-stationary satellites in Brazilian territory are indicated below:

- G = 29 - 25 log φ dBi for φ between 1 ° or 100 λ / D (whichever is greater) and 20 °
- G = - 3.5 dBi for 20 ° <φ ≤ 26.3 °
- G = 32 - 25 log φ dBi for 26.3 ° <φ <48 °
- G = –10 dBi for 48 ° ≤ φ ≤ 180 °

Where G is the gain of the antenna, φ the angle between the direction considered and the antenna axis, D the largest diameter of the antenna aperture area and λ the wavelength.

- Cross polarization isolation on the shaft
  - 27 dB for D ≤ 2.4 m
  - 30 dB for 2.4 m <D ≤ 7m
  - 35 dB for 7 m <D

Note: As the *“**Norma para Certificação e Homologação de Antenas de Estações Terrenas Operando com Satélites Geoestacionários**”.*” (Annex to Resolution No. 572 issued by Anatel at 28/09/2011) was revoked, Embratel Star One started to adopt as reference the Recommendation **ITU-R S.580-6 Radiation diagrams For Use as Design Objectives for Antennas of Earth Stations Operating with Geostationary Satellites,** in particular the items 1 and 2.

3. Information

In case of doubts, suggestions or clarifications, please contact us or send mail to:

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