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Technical Specification

Satellite Earth Stations and Systems (SES); Regenerative Satellite Mesh - A (RSM-A) air interface; Physical layer specification; Part 6: Radio link control

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Contents

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Satellite Earth Stations and Systems (SES).

The present document is part 6 of a multi-part deliverable covering the BSM Regenerative Satellite Mesh - A (RSM-A) air interface; Physical layer specification, as identified below:

Part 1: "General description";

Part 2: "Frame structure";

Part 3: "Channel coding";

Part 4: "Modulation";

Part 5: "Radio transmission and reception";

Part 6: "Radio link control";

Part 7: "Synchronization".

1 Scope

The present document presents the requirements for synchronizing timing and frequency between the ST and the satellite network within the SES BSM Regenerative Satellite Mesh - A (RSM-A) air interface family.

2 References

Void.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

Network Control Centre (NCC): centre that controls the access of the satellite terminal to an IP network and also provides element management functions and control of the address resolution and resource management functionality

satellite payload: part of the satellite that provides air interface functions

NOTE: The satellite payload operates as a packet switch that provides direct unicast and multicast communication between STs at the link layer.

Satellite Terminal (ST): terminal installed in the user premises

terrestrial host: entity on which application level programs are running

NOTE: It may be connected directly to the Satellite Terminal or through one or more networks.

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

DDID	Downlink Destination ID
EIRP	Effective Isotropic Radiated Power
IP	Internet Protocol
LLA	Latitude, Longitude and Altitude
Mbps	Mega bits per second (millions of bits per second)
MIP	Management Information Packet
MMI	Man-Machine Interface
NCC	Network Control Centre
PCE_{STD}	Power Control Error Standard
PHY	PHYsical
PTP	Point-to-Point
RS	Reed-Solomon
RSM	Regenerative Satellite Mesh
SLC	Satellite Link Control
ST	Satellite Terminal
TDMA	Time Division Multiple Access
TIP	Transmission Information Packet
ULPC	UpLink Power Control
UW	Unique Word

4 General description of radio link control system

BSM RSM-A is a multi-spot beam, multicarrier, synchronous system where the timing and frequency on the satellite serve as the reference to synchronize the TDMA transmissions for the STs, and other network elements. The satellite includes a packet switch designed to provide single-hop, point to point packet routing between downlink cells.

The functions of the physical layer are different for the uplink and downlink. The major functions are illustrated in figure 4.

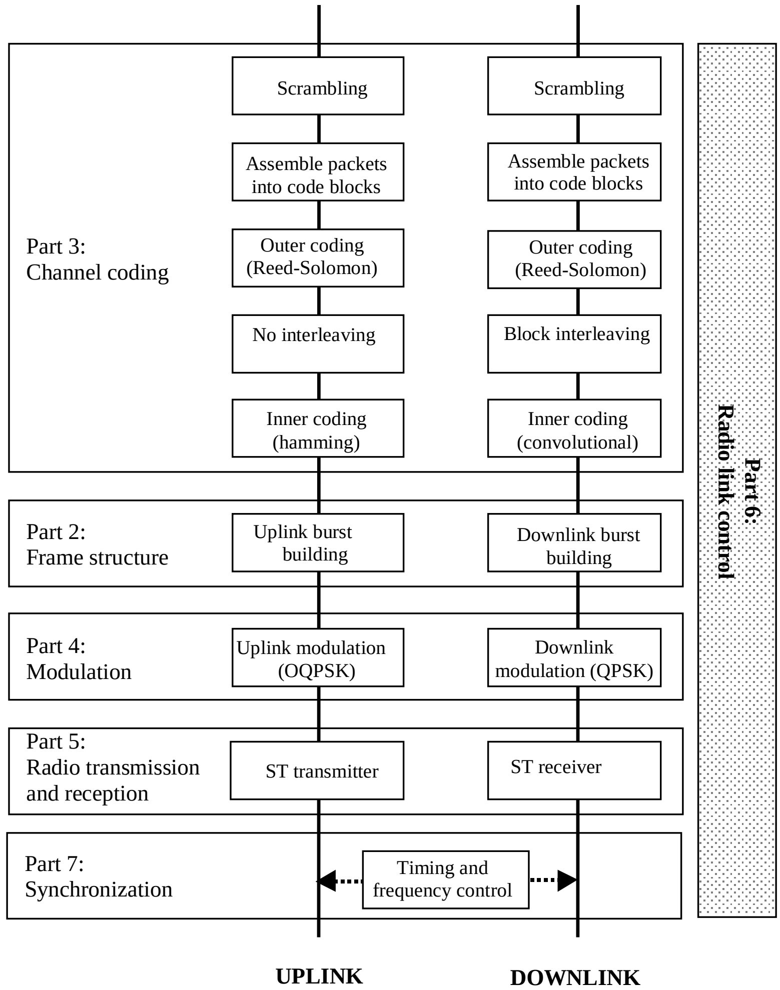

Figure 4: Physical layer functions

The present document describes the radio link control functions. This group of functions is highlighted in figure 4.

Clause 5 describes ST antenna pointing. Clause 6 describes cell and microcell selection. Clause 7 describes system information reception. Clause 8 describes power control. Clause 9 describes radio link failure. Clause 10 describes fallback mode of operation and transition requirements. Clause 11 describes radio link measurements. Clause 12 describes the control parameters required to perform radio link control.

Clauses 5 and 6 describe the procedures used for installation of the ST. These procedures require knowledge of the ST location and also the location and cell parameters of the desired RSM-A satellite. This information may be obtained by any suitable combination of internal and external mechanisms, provided that the resulting accuracy complies with the requirements given in the present document. The calculations in the present document assume ST location in the form of the ST Latitude, Longitude and Altitude (LLA). The ST may have an integrated GPS receiver or may have a suitable Man-Machine Interface (MMI) such that the information may be entered into the ST by an installer. Alternatively, some GPS receivers can output in earth centred earth fixed (ECEF) Cartesian coordinates. Required accuracy of LLA is given in RSM-A; Air Interface; Physical layer specification, TS 102 188-7.

The details of the MMI are outside the scope of the present document.

5 ST antenna initial pointing

In order to determine the proper initial pointing of an ST antenna, the ST antenna elevation angle and azimuth angle shall be calculated from knowledge of the ST position and the location of the desired RSM-A satellite.

5.1 Calculating ST Antenna Elevation and Azimuth Angles

The inputs to this procedure are the Satellite location and the ST location information. These calculations assume the ST location information, the geodetic latitude and longitude (*ST_LAT* and *ST_LONG*), are known. The Geodetic coordinate system is the coordinate system which uses the Prime Meridian and the Equator as the reference planes to define the latitude and longitude. The geodetic latitude of a point is the angle from the equatorial plane to the vertical direction of a line normal to the reference ellipsoid. The geodetic longitude of a point is the angle between a reference plane and a plane passing through the point, both planes being perpendicular to the equatorial plane. The geodetic height at a point is the distance from the reference ellipsoid to the point in a direction normal to the ellipsoid. The geodetic height of the ST shall be required in the calculations performed in clause 6.

In order to determine the ST latitude, longitude and height, as required to perform the calculations in this clause and clause 6, the ST may have an integrated GPS receiver or may have a suitable Man-Machine Interface (MMI) such that the information may be entered into the ST by an installer. Alternatively, any other algorithm may be used to locate an ST provided that the timing requirements described in BSM RSM-A physical layer specification, TS 102 188-7 and cell selection requirements can be met.

The ST may calculate the ST antenna elevation and azimuth pointing angles or may use any other algorithm to locate an ST provided that the ST may be pointed accurately so as to meet the transmitter and receiver requirements in RSM-A physical layer specification, TS 102 188-5.

The ST may have a lookup table listing all the satellite locations or this may be information entered at the time of installation. Since there may be new BSM RSM-A systems in the future, an ST manufacturer should have a method whereby an ST might be located anywhere in the world and use any BSM RSM-A satellite which may be in view of that location.

The ST Elevation angle (ST_EL) and the ST azimuth angle (ST_AZ) are computed as follows:

$$\mathrm{Sin}(\zeta) = \cos(\mathrm{ST\_LAT})\cos(\Delta\mathrm{Long})$$

$$y_e = \sin\zeta - R_C / R_{geo}$$

$$x_e = \cos(\zeta)$$

$$\mathrm{ST\_EL} = \tan^{-1}(y_e / x_e)$$

$$y_a = -\sin(\Delta\mathrm{Long})$$

$$x_a = -\sin(\mathrm{ST\_LAT})\cos(\Delta\mathrm{Long})$$

$$\mathrm{ST\_AZ} = \tan^{-1}(y_a / x_a)$$

where $R_C = a/K$ and where a is the radius of the earth. K is a latitude dependent constant given by:

$$K = (1 - F (2 - F) \sin^2 (ST\_LAT))^{1/2}$$

The parameter R_{geo} is the geosynchronous orbit radius. The parameter F is the flattening defined by:

$$F = (a - b) / a$$

where a is the semi-major earth axis (ellipsoid equatorial radius) and b is the semi-minor earth axis (ellipsoid polar radius); and

$\Delta Long$ is the angular difference between the satellite location and the geodetic longitude location of the ST.

$$\Delta Long = \Theta - ST\_LONG$$

where Θ is the orbital location in degrees longitude West and *ST_LONG* is the terminal location is degrees longitude West. Table A.1.1 lists the RSM-A satellite positions for North America.

Note that all trigonometric calculations should be in radians.

If the ST performs these calculations, the pointing angles shall be saved in non-volatile memory and output through a suitable MMI to the installer to use for initial antenna pointing.

6 Selection of Cell/Microcell and Beam Polarization

6.1 Conversion of geodetic LLA coordinates to antenna coordinates system

These calculations determine the slant path (distance from satellite to ST) and help determine the cell and microcell based on the ST position.

First transform the latitude and longitude to the Cartesian coordinate systems (Xp, Yp, Zp) as shown in figure 6.1. The coordinate system is shifted by the geosynchronous radius in order to place the origin at the centre of the Earth. The elements of vector (Xp, Yp, Zp) are computed as follows

Given the ST location in geodetic coordinates (Height, Latitude and Longitude) the following procedure will convert them to Cartesian coordinates (X, Y, Z).

The elements of the ST location (in Cartesian coordinates) are computed as follows:

$$X_{ST} = (R_C + \text{height}) \cos (ST\_LAT) \cos (\Delta Long)$$

$$Y_{ST} = (R_C + \text{height}) \cos (ST\_LAT) \sin (\Delta Long)$$

$$Z_{ST} = (R_C (1-F)^2 + \text{height}) \sin (ST\_LAT)$$

$$X_p = X_{ST} - R_{geo}$$

$$Y_p = Y_{ST}, \text{ and}$$

$$Z_p = Z_{ST}$$

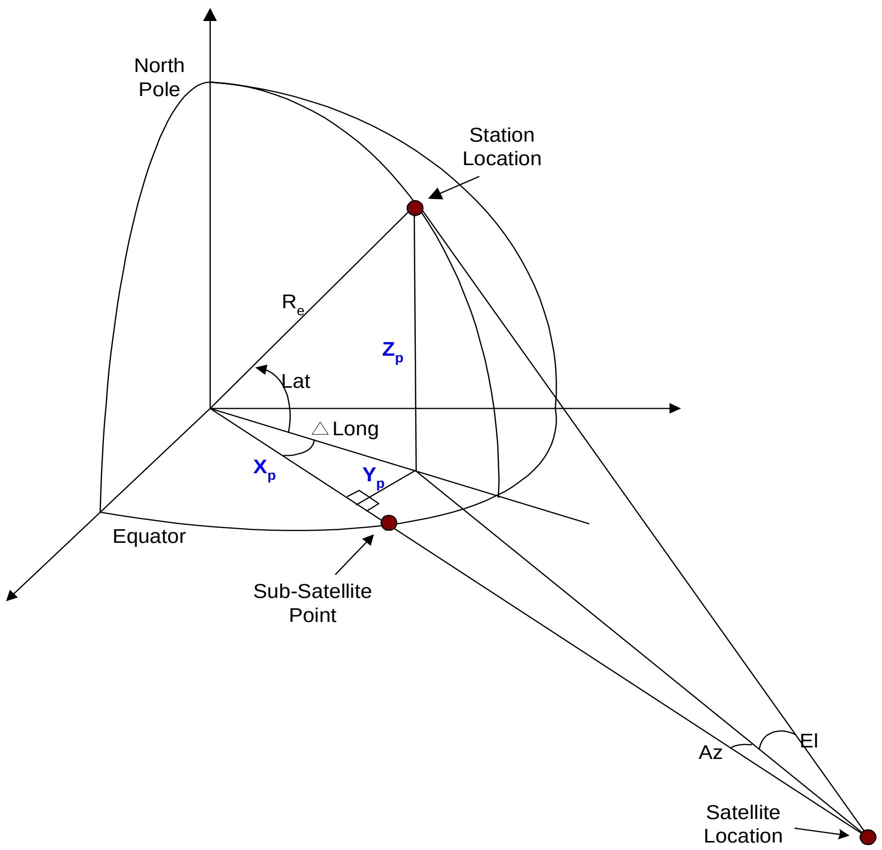

Figure 6.1: On-orbit geometry

The vector (Xp, Yp, Zp) is placed into a rotated coordinate system to take into account the boresight pointing of the antenna. This rotation is performed through the following linear equation:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = M \begin{bmatrix} X_p \\ Y_p \\ Z_p \end{bmatrix}$$

where M is a rotation matrix given by:

$$M = \begin{bmatrix} \cos(\theta_Y) & 0 & -\sin(\theta_Y) \\ 0 & 1 & 0 \\ \sin(\theta_Y) & 0 & \cos(\theta_Y) \end{bmatrix} \begin{bmatrix} \cos(\theta_X) & -\sin(\theta_X) & 0 \\ \sin(\theta_X) & \cos(\theta_X) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

θ_X is the boresight azimuth angle and θ_Y is the boresight elevation angle defined in annex A. Finally, compute the azimuth and elevation angles.

$$Az = \tan^{-1}\left(\frac{-Y}{X}\right)$$

$$El = \tan^{-1}\left(\frac{Z}{\sqrt{X^2 + Y^2}}\right)$$

where *Az* and *El* are the ST angular coordinates relative to the satellite boresight.

6.2 Cell selection

At installation, after mapping the ST position into satellite antenna (Az, El) coordinates, the ST may use a look-up table to determine cell, and uplink polarization, microcell and downlink polarization, and downlink destination IDs to be used at that location. Example look-up tables are presented in annex A for some RSM-A systems. Because the coverage grids used are hexagonal in angle space, the cell (or microcell) centre closest to this point defines the cell (or microcell) location for the ST. Alternatively, this information may be entered into the terminal at the time of installation through a suitable MMI. An automatic algorithm for determining this information is described, but it is not required.

After antenna pointing and after acquiring the Beacon on LHCP, the ST may scan the downlink for TIP messages (see RSM-A, SMAC/SLC layer specification, TS 102 189-2). In order to do this the ST may filter on the destination sub addresses 0 to 127 instead of the downlink destination IDs. The ST should rank order the TIP messages by received relative power. The ST should remember the two strongest signals. In clear weather, these should be averaged over 5 successfully received TIP messages. The ST should then acquire the RHCP beacon (see RSM-A, Physical layer specification, TS 102 188-7) and perform this measurement on the RHCP downlink. The ST shall compare its satellite antenna (*Az*, *El*) coordinates to the cell centres and select the cell with the minimum squared angular distance. In the event of a tie, the ST should select the one which had the strongest relative received power.

6.3 Microcell selection

The ST should then select the microcell beam centre within the selected cell that is the closest to the ST location in the satellite angular space by calculating the squared angular distance.

From the satellite point of view figure 6.3 shows the microcell centre relative to a given cell centre. The offsets correspond to a hexagonal grid with spacing of (0,189 × sqrt(3) / 2) degrees between points and a 10,8934 degree clockwise rotation relative to the elevation-axis. These offsets are applied in angular coordinates to the centre of the cell.

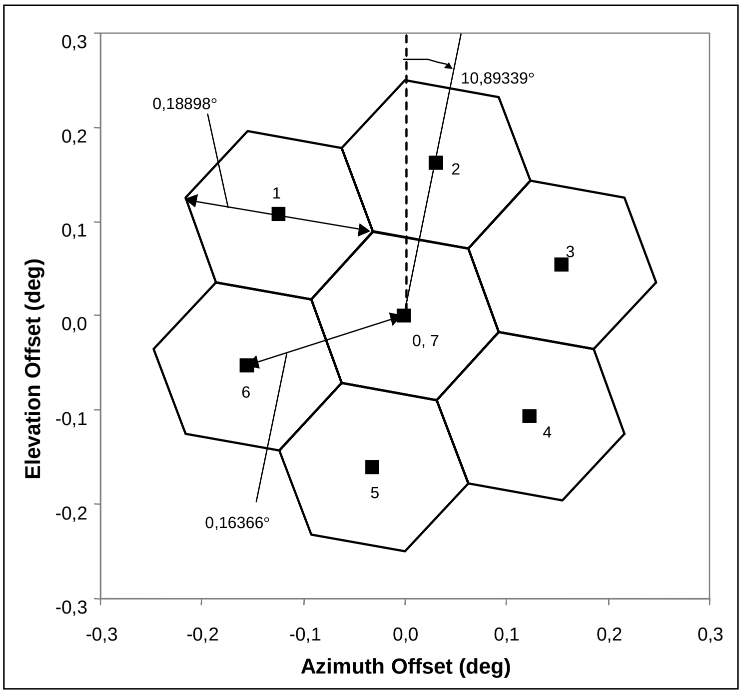

Figure 6.3: Microcell orientation relative to cell centre

A downlink microcell ID is represented using two indices corresponding to a cell ID (CID) (1 to 112) and the associated Microcell Local ID (MLID) (1 to 7). Microcell local ID 0 represents cellcast. The offsets are added to El_{CC} and Az_{CC} coordinates at the centre of the cell. The microcell centres are calculated using the following relationships:

$$Az_{MCC}(CID, MLID) = Az_{CC}(CID) + \Delta Az(MLID)$$

$$El_{MCC}\ (CID, MLID) = El_{CC}\ (CID) + \Delta El(MCID)$$

where: Az_{CC} *(CID)* and El_{CC} *(CID)* are the cell centre coordinates for the cell from table 6.3, and

ΔAz(MLID) and *ΔEl(MCID)* are the microcell offsets from table 6.3.

Table 6.3: Microcell centre offset from cell centre

Δ Azimuth Offset [degree] *ΔAZ(MLID)*	Δ Elevation Offset [degree] *ΔEL(MCID)*	Microcell Local ID MCID
0,000000	0,000000	0
-0,123718	0,107143	1
0,030929	0,160714	2
0,154647	0,053571	3
0,123718	-0,107143	4
-0,030929	-0,160714	5
-0,154647	-0,053571	6
0,000000	0,000000	7

6.4 Downlink Destination ID

The downlink destination ID is an eleven bit field. The msb indicates the polarization (pol) where pol = 0 indicates LHCP and pol = 1 indicates RHCP.

The downlink destination ID which the terminal shall use during installation is calculated from the following steps:

1) With knowledge of its location, an ST shall determine its CID and MLID within the cell from the method described in clauses 6.1 through 6.3.

2) The ST may determine the default polarization from a lookup table using the cell ID or the ST may use measurements of TIP message transmissions described in clause 6.2 to determine the downlink polarization.

3) The ST shall then determine the Downlink Destination ID (DDID) to use for PTP from the CID, MLID and the pol using the following formula:

$$DDID = 32 + 8 \times (CID\text{-}1) + (MLID) + pol \times 1\,024$$

4) The ST shall determine the DDID to use for cellcast from the CID and the pol using the following formula:

$$DDID = 32 + 8 \times (CID\text{-}1) + pol \times 1\,024$$

The ST shall use both of these DDIDs at installation.

In general, other DDIDs, which the ST shall learn from the commissioning process, may not have this relationship to CID or MLID.

An example of the downlink destination ID numbering method for null, shaped beam broadcast, beacon, cellcast and PTP bursts are shown in tables A.1.3 and A.1.4.

7 System information reception

The ST should then filter on the DDID associated with the selected cell and microcell and receive the indirect Management Information Packet (MIP) message. The indirect MIP message (see RSM-A, SMAC/SLC, TS 102 189-2) contains the DDID the ST shall use for commissioning and configuration. This may be a shaped beam address or a cell address. The ST should convey all information it acquired by this procedure to the installer. The ST shall store all information in non-volatile memory.

The ST should read the uplink polarization in the TIP message (see RSM-A, SMAC/SLC, TS 102 189-2) broadcast in the selected cell.

The ST shall read the TIP message every superframe.

8 RF uplink power control

8.1 Burst probing power

Initial burst probing for timing synchronization is described in BSM RSM-A PHYS layer specification TS 102 188-7.

The ST shall use the nominal transmit power, P_o, calculated below:

$$P_o = (-172{,}55 + \textit{Path Loss} - \textit{Directivity})\ \text{dBWi, where}$$

Path Loss is calculated by:

$$\text{Path Loss} = 20\ \text{Log10}\ (4\pi \text{*Uplink Frequency*Path Length} / 0{,}3)\ \text{dB}$$

And Directivity is the satellite antenna directivity of the uplink beam calculated by:

$$\textit{Directivity} = 4{,}5 * (1 - (\ \varphi\ / 0{,}25)^2$$

where:

$$\varphi^2 = (\text{Az} - \text{Az}_{\text{CC}})^2 + (\text{El} - \text{El}_{\text{CC}})^2$$

where *Az* and *El* are the ST angular coordinates relative to the satellite boresight calculated in clause 6.1 and Az_{CC} and El_{CC} are the cell centre coordinates given in table A.1.2. Path Length is derived in BSM RSM-A PHY layer specification TS 102 188-7.

8.2 Power control maintenance

An ST shall be required to control output power within a target range so as to maintain as acceptable packet loss ratio and at the same time, limit interference to the rest of the system. The ST shall adjust the uplink power in order to maintain a target SNR at the satellite, based on the UPLC reports received from the satellite. The instantaneous SNR for each burst received at the satellite, is reported by the satellite to the ST in the ULPC status packet messages (see RSM-A, SMAC/SLC, TS 102 189-2). The standard deviation of power control error (PCE_{STD}) at time slot *k* over the last *M* transmissions, is defined as:

$$PCE_{STD}(k) = \frac{1}{M}\sqrt{\sum_{i=k-M+1}^{k}\left[\left(\frac{C}{N}\right)(i) - \left(\frac{C}{N}\right)_{Target}\right]^2}$$

where $(C/N)(i)$ is the i(th) measurement reported by the satellite of SNR, $(C/N)_{Target}$ is the target SNR.

At installation after the first 1 000 transmissions and with M = 100, the PCE_{STD} shall be less than 1,5 dB.

In steady state, after 10 000 transmissions, the PCE_{STD} shall meet the requirements shown in table 8.2.1.

Table 8.2.1: Power control requirements

	Rate/Volume (note 1)	Contention (note 2)
Normal	PCE_{STD} < 0,7 dM (M = 1 000)	PCE_{STD} < 1,2 dB (M = 100)
Faded	PCE_{STD} < 1,0 dB (M = 1 000)	PCE_{STD} < 1,5 dB (M = 100)
NOTE 1: Rate/Volume is defined as continuous transmission, at least one time slot per frame for every frame, over at least 3 different carrier designators during the measurement period. NOTE 2: Contention is defined as 100 transmissions with a gap of at least 9,6 s between each transmission over at least 3 carrier designators.		

Normal is defined as a period wherein at least 99 % of the time the random uplink fade is less than 2 dB. Faded is defined as a period wherein at least 99 % of the time the random uplink fade is greater than 2 dB but less than the maximum fade at which the uplink can be closed. Table 8.2.2 gives some examples of the relationship between the ST EIRP and the maximum fade for reference values of EIRP. See RSM-A, physical layer specification, TS 102 188-5, for more information.

Table 8.2.2: Maximum uplink fade

Carrier mode	Reference EIRP (dBW)	Maximum fade (dB)
128 Kbps	48	17,8
512 Kbps	48	11,2
2 Mbps	52,5	8,7

8.3 ULPC information

The ULPC status packet messages (see RSM-A SMAC/SLC, TS 102 189-2) contains information about the quality of the uplink signal as received by the satellite. The following clauses describe how the information in this message is used by the ST.

8.3.1 SNR

The STs calculate the SNR in dB using the SNR field from the ULPC status packet message (see RSM-A, SMAC/SLC, TS 102 189-2) using the following equation:

$$\text{SNR in dB} = \tfrac{1}{4}\ \text{SNR}_{\text{field}} + k_2$$

where:

k_2 = -6,0 for 128 Kbps,

k_2 = 0,0 otherwise.

8.3.2 Block Decoder Metric

The ST shall interpret the 4-bit Block Decoder Metric as shown in table 8.3.2.2.

The satellite counts the number of bit errors detected by the inner block decoder (see RSM-A, Physical layer, TS 102 188-3) during the initial 244 bytes (one Reed-Solomon code block) of each time slot on each carrier. This error count is mapped to the 4-bit Block decoder Metric.

The bit error count corresponding to the target $E_c / (N_o + I_o)$ required to achieve the Packet Loss Ratio (PLR) in table 8.3.2.1 is provided to the ST in the ULPC status message (see RSM-A, SMAC/SLC, TS 102 189-2).

Table 8.3.2.1: Packet Loss Ratio

Rate	PLR
128 Kbps	$1{,}0 \times 10^{-5}$
512 Kbps	$1{,}0 \times 10^{-5}$
2 Mbps	$7{,}5 \times 10^{-7}$
16 Mbps	$2{,}5 \times 10^{-7}$

The average number of bit errors detected, as a function of the input $E_c / (N_o + I_o)$ in the range of -2 dB to 8 dB shall be made available to the ST.

Table 8.3.2.2: Block Decoder Metrics

Binary Bit Value	Block Decoder Error Count (per Code Block)		Estimated Ec/(No+Io) (dB)
	≥Lower bound	< Upper bound	
0000	0	2	6,2143
0001	2	3	5,7857
0010	3	5	5,3571
0011	5	9	4,9286
0100	9	14	4,5000
0101	14	20	4,0714
0110	20	28	3,6429
0111	28	39	3,2143
1000	39	50	2,7857
1001	50	63	2,3571
1010	63	78	1,9286
1011	78	95	1,5000
1100	95	112	1,0714
1101	112	129	0,6429
1110	129	488	0,2143
1111	RS Failure		N/A

8.3.3 Uplink noise measurement

The uplink noise measurement reported to the ST in the ULPC status packet message (see RSM-A, SMAC/SLC, TS 102 189-2) correlates with carrier bandwidth. The noise measurement represents an estimate of the standard deviation, σ_N, of the noise process during the frame dead time. This 8-bit value, Noise Estimate, can be used to obtain an estimate of the noise density at the reference point used for satellite SNR measurements using the following equation:

$$\text{Noise Density (dBm/Hz)} = 20 \log_{10} \text{(Noise Estimate)} - 133{,}68 \text{ dB}$$

9 Radio link failure

This clause describes the physical layer criteria by which an ST moves from Registered_Active State to Registered_No_Link state.

An ST shall move from the Registered_Active State to the Registered_No_Link state if it fails to receive TIP messages (see RSM-A, SMAC/SLC, TS 102 189-2) in five consecutive superframes.

10 Fallback mode

This clause describes the physical layer criteria by which the ST shall initiate fallback mode of operation. This clause also describes the physical layer criteria by which the ST shall recover from fallback mode.

An ST shall enter fallback mode after experiencing an uplink fade of at least X dB for 192 s.

For 512 Kbps:

$$X = (C/N)_{DL} - [5{,}3 + (P_{max} - 48{,}1) / 1{,}9]$$

For 2 Mbps:

$$X = (C/N)_{DL} - [5{,}3 + (P_{max} - 48{,}1 - 6) / 1{,}9]$$

Where $(C/N)_{DL}$ is the normal downlink C/N which is averaged over at least 24 hours and P_{max} is the ST maximum uplink EIRP.

An ST in fallback mode shall enter normal mode after experiencing an uplink fade that is less than Y dB for 192 s.

For 512 Kbps:

$$Y = (C/N)_{DL} - [2,3 + (P_{max} - 48,1) / 1,9]$$

For 2 Mbps:

$$Y = (C/N)_{DL} - [2,3 + (P_{max} - 48,1 - 6) / 1,9]$$

11 Control Parameters

This clause gives the values of the physical layer control parameters used in the calculations shown in clause 6.

11.1 Parameters for installation and cell selection

These parameters shall be conveyed to the ST.

Parameter	Description	Unit	Range	Default	Resolution	#Bits
a	Semi-major axis = equatorial radius	m	-	6378137	1	-
b	Semi-minor axis = polar radius	m	-	6356752	1	-
F	Earth flattening		-	1/298,2572235		-
Rgeo	Geostationary orbit radius	m	-	42163203	1	-
						$5 \times 6 = 30$

Annex A (informative): Cell parameters

A.1 General Description

The Cell Parameter information is predefined for each of the available satellites. The information may be embedded in the ST (e.g. embedded look-up tables) or may be entered at the time of installation as described in clause 6. As an example of the information that is required, this annex gives the parameters which describe the North American RSM-A system.

NOTE: This information is informative and subject to regulatory agreements.

A.1.1 Antenna boresight angles for North American Satellites

Table A.1.1 shows the boresight angles for the three orbital locations, Θ.

Table A.1.1: Antenna boresight angles

Orbital slot (degrees west longitude), Θ	**99**	**101**	**103**
Boresight azimuth (degree), θ_X	-0,28	0,00	0,28
Boresight elevation (degree), θ_Y	+6,00	+6,00	+6,00

A.1.2 Cell definition, mapping, polarization, and unique word assignment

The cells that provide the required coverage lie on a triangular grid in elevation-over-azimuth angle coordinates. Each cell is composed of 7- microcells as illustrated in figure A.1.2, as viewed from the satellite in the coordinate.

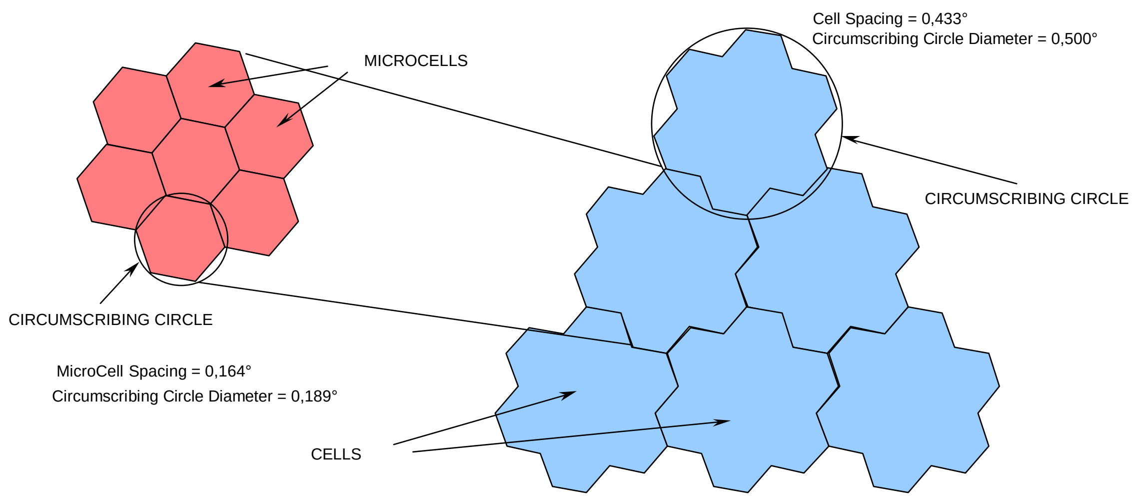

Figure A.1.2: Cell to seven microcells relationship

Cells can be circumscribed with 0,500 degrees diameter circles. The 7-microcells that make up each cell can each be circumscribed with a 0,189 degrees diameter circle.

Table A.1.2 lists the cell centres in antenna coordinates using the El over Az coordinate system. The spacing between cell centres is 0,433 degrees (= 0,5 × sqrt(3) / 2). 112 cells are required to completely tile the coverage region.

Table A.1.2: Baseline cell centre location, uplink cell polarization, and unique word

Cell ID	Azimuth (degree)	Elevation (degree)	Uplink pol	7-cell UW select ID		Cell ID	Azimuth (degree)	Elevation (degree)	Uplink pol	7-cell UW select ID
1	0,3830	1,7819	LHCP	1		57	1,8985	0,0930	RHCP	6
2	2,9810	1,7819	LHCP	7		58	2,3315	0,0930	LHCP	7
3	0,1665	1,4069	RHCP	5		59	2,7645	0,0930	RHCP	1
4	0,5995	1,4069	LHCP	6		60	3,1975	0,0930	LHCP	2
5	2,7645	1,4069	RHCP	4		61	2,6480	0,4680	LHCP	7
6	3,1975	1,4069	LHCP	5		62	2,2150	0,4680	RHCP	1
7	1,3490	1,0320	RHCP	6		63	1,7820	0,4680	LHCP	2
8	0,4830	1,0320	RHCP	1		64	1,3490	0,4680	RHCP	3
9	0,0500	1,0320	LHCP	2		65	0,9160	0,4680	LHCP	4
10	0,3830	1,0320	RHCP	3		66	0,4830	0,4680	RHCP	5
11	0,8160	1,0320	LHCP	4		67	0,0500	0,4680	LHCP	6
12	1,2490	1,0320	RHCP	5		68	0,3830	0,4680	RHCP	7
13	1,6820	1,03206	LHCP	6		69	0,8160	0,4680	LHCP	1
14	2,1150	1,0320	RHCP	7		70	1,2490	0,4680	RHCP	2
15	2,5480	1,0320	LHCP	1		71	1,6820	0,4680	LHCP	3
16	2,9810	1,0320	RHCP	2		72	2,1150	0,4680	RHCP	4
17	-2,4315	-0,657	LHCP	1		73	2,548	0,468	LHCP	5
18	-1,9985	-0,657	RHCP	2		74	2,981	0,468	RHCP	6
19	-1,5655	-0,657	LHCP	3		75	3,414	0,468	LHCP	7
20	-1,1325	-0,657	RHCP	4		76	-2,4315	0,843	LHCP	5
21	-0,6995	-0,657	LHCP	5		77	-1,9985	0,843	RHCP	6
22	-0,2665	-0,657	RHCP	6		78	-1,5655	0,843	LHCP	7
23	0,1665	-0,657	LHCP	7		79	-1,1325	0,843	RHCP	1
24	0,5995	-0,657	RHCP	1		80	-0,6995	0,843	LHCP	2
25	1,0325	-0,657	LHCP	2		81	-0,2665	0,843	RHCP	3
26	1,4655	-0,657	RHCP	3		82	0,1665	0,843	LHCP	4
27	1,8985	-0,657	LHCP	4		83	0,5995	0,843	RHCP	5
28	2,3315	-0,657	RHCP	5		84	1,0325	0,843	LHCP	6
29	2,7645	-0,657	LHCP	6		85	1,4655	0,843	RHCP	7
30	3,1975	-0,657	RHCP	7		86	1,8985	0,843	LHCP	1
31	-2,648	-0,282	RHCP	5		87	2,3315	0,843	RHCP	2
32	-2,215	-0,282	LHCP	6		88	2,7645	0,843	LHCP	3
33	-1,782	-0,282	RHCP	7		89	3,1975	0,843	RHCP	4
34	-1,349	-0,282	LHCP	1		90	3,6305	0,843	LHCP	5
35	-0,916	-0,282	RHCP	2		91	-2,648	1,218	RHCP	2
36	-0,483	-0,282	LHCP	3		92	-2,215	1,218	LHCP	3
37	-0,05	-0,282	RHCP	4		93	-1,782	1,218	RHCP	4
38	0,383	-0,282	LHCP	5		94	-1,349	1,218	LHCP	5
39	0,816	-0,282	RHCP	6		95	-0,916	1,218	RHCP	6
40	1,249	-0,282	LHCP	7		96	-0,483	1,218	LHCP	7
41	1,682	-0,282	RHCP	1		97	-0,05	1,218	RHCP	1
42	2,115	-0,282	LHCP	2		98	0,383	1,218	LHCP	2
43	2,548	-0,282	RHCP	3		99	0,816	1,218	RHCP	3
44	2,981	-0,282	LHCP	4		100	1,249	1,218	LHCP	4
45	3,414	-0,282	RHCP	5		101	-1,1325	1,593	LHCP	3
46	-2,8645	0,093	LHCP	2		102	-3,514	1,968	LHCP	2
47	-2,4315	0,093	RHCP	3		103	-3,081	1,968	RHCP	3
48	-1,9985	0,093	LHCP	4		104	-2,648	1,968	LHCP	4
49	-1,5655	0,093	RHCP	5		105	-7,3115	-2,6799	RHCP	1
50	-1,1325	0,093	LHCP	6		106	0,304	-2,666	RHCP	7
51	-0,6995	0,093	RHCP	7		107	5,314	-2,954	RHCP	1
52	-0,2665	0,093	LHCP	1		108	5,44	-4,195	RHCP	2
53	0,1665	0,093	RHCP	2		109	4,527	-5,186	RHCP	3
54	0,5995	0,093	LHCP	3		110	7,205	-9,607	RHCP	4
55	1,0325	0,093	RHCP	4		111	4,01	-8,058	RHCP	5
56	1,4655	0,093	LHCP	5		112	5,368	-11,332	RHCP	6

A.1.3 Downlink destination ID

Table A.1.3: Downlink destination ID numbering

LHCP				RHCP		
DDID	**Burst type**	**ULCID**		**DDID**	**Burst type**	**ULCID**
0	Null Burst	N/A		1024	Null Burst	N/A
1	Shaped beam			1025	Shaped beam	
2	Calibration Burst			1026	Calibration Burst	
3	Reserved	N/A		1027	Reserved	N/A
4	Reserved	N/A		1028	Reserved	N/A
5	Reserved	N/A		1029	Reserved	N/A
6	Beacon Burst 0	1 to 112		1030	Beacon Burst 0	1 to 112
7	Beacon Burst 1	1 to 112		1031	Beacon Burst 1	1 to 112
8	Beacon Burst 2	1 to 112		1032	Beacon Burst 2	1 to 112
9	Beacon Burst 3	1 to 112		1033	Beacon Burst 3	1 to 112
10	Beacon Burst 4	1 to 112		1034	Beacon Burst 4	1 to 112
11	Beacon Burst 5	1 to 112		1035	Beacon Burst 5	1 to 112
12	Beacon Burst 6	1 to 112		1036	Beacon Burst 6	1 to 112
13	Beacon Burst 7	1 to 112		1037	Beacon Burst 7	1 to 112
14	Beacon Burst 8	1 to 112		1038	Beacon Burst 8	1 to 112
15	Beacon Burst 9	1 to 112		1039	Beacon Burst 9	1 to 112
16	Beacon Burst 10	1 to 112		1040	Beacon Burst 10	1 to 112
17	Beacon Burst 11	1 to 112		1041	Beacon Burst 11	1 to 112
18	Beacon Burst 12	1 to 112		1042	Beacon Burst 12	1 to 112
19	Beacon Burst 13	1 to 112		1043	Beacon Burst 13	1 to 112
20	Beacon Burst 14	1 to 112		1044	Beacon Burst 14	1 to 112
21	Beacon Burst 15	1 to 112		1045	Beacon Burst 15	1 to 112
22	Shaped beam			1046	Shaped beam	
23	Shaped beam			1047	Shaped beam	
24	Shaped beam			1048	Shaped beam	
25	Shaped beam			1049	Shaped beam	
26	Shaped beam			1050	Shaped beam	
27	Shaped beam			1051	Shaped beam	
28	Shaped beam			1052	Shaped beam	
29	Shaped beam			1053	Shaped beam	
30	Shaped beam			1054	Shaped beam	
31	Reserved			1055	Reserved	
32	PTP or Cellcast	Note		1056	PTP or Cellcast	Note
:	:	Note			:	Note
927	PTP or Cellcast	Note		1950	PTP or Cellcast	Note
928	PTP or Cellcast	N where 1 ≤ N ≤ 112		1951	PTP or Cellcast	N where 1 ≤ N ≤ 112
:	:				:	
1023	PTP or Cellcast	N where 1 ≤ N ≤ 112		2047	PTP or Cellcast	N where 1 ≤ N ≤ 112
NOTE: Defined by the relationship: ULCID = INT[(DDID-32-pol × 1024)/8] + 1.						

A.1.4 Downlink microcell polarization assignments

Table A.1.4 lists the individual microcell centres by cell ID and their predefined polarization. An ST shall use this predefined polarization to receive microcell addressed packets during commissioning and operation.

Table A.1.4: Downlink polarization

Cell ID	polarization		Cell ID	polarization
1	LHCP		57	LHCP
2	LHCP		58	RHCP
3	LHCP		59	LHCP
4	RHCP		60	RHCP
5	LHCP		61	LHCP
6	RHCP		62	RHCP
7	RHCP		63	LHCP
8	RHCP		64	RHCP
9	LHCP		65	LHCP
10	RHCP		66	RHCP
11	LHCP		67	LHCP
12	RHCP		68	RHCP
13	LHCP		69	LHCP
14	RHCP		70	RHCP
15	LHCP		71	LHCP
16	RHCP		72	RHCP
17	RHCP		73	LHCP
18	LHCP		74	RHCP
19	RHCP		75	LHCP
20	LHCP		76	RHCP
21	RHCP		77	LHCP
22	LHCP		78	RHCP
23	RHCP		79	LHCP
24	LHCP		80	RHCP
25	RHCP		81	LHCP
26	LHCP		82	RHCP
27	RHCP		83	LHCP
28	LHCP		84	RHCP
29	RHCP		85	LHCP
30	LHCP		86	RHCP
31	RHCP		87	LHCP
32	LHCP		88	RHCP
33	LHCP		89	LHCP
34	LHCP		90	RHCP
35	RHCP		91	RHCP
36	LHCP		92	LHCP
37	RHCP		93	RHCP
38	LHCP		94	LHCP
39	RHCP		95	RHCP
40	LHCP		96	LHCP
41	RHCP		97	RHCP
42	LHCP		98	LHCP
43	RHCP		99	RHCP
44	LHCP		100	LHCP
45	RHCP		101	RHCP
46	RHCP		102	RHCP
47	LHCP		103	LHCP
48	RHCP		104	RHCP
49	LHCP		105	LHCP
50	RHCP		106	RHCP
51	LHCP		107	LHCP
52	RHCP		108	RHCP
53	LHCP		109	LHCP
54	RHCP		110	LHCP
55	LHCP		111	RHCP
56	RHCP		112	RHCP

Annex B (informative): Bibliography

ETSI TR 101 984: "Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia; Services and Architectures".

ETSI TS 102 188-1: "Satellite Earth Stations and Systems (SES); Regenerative Satellite Mesh - A (RSM-A) air interface; Physical layer specification; Part 1: General description".

ETSI TS 102 188-2: "Satellite Earth Stations and Systems (SES); Regenerative Satellite Mesh - A (RSM-A) air interface; Physical layer specification; Part 2: Frame structure".

ETSI TS 102 188-3: "Satellite Earth Stations and Systems (SES); Regenerative Satellite Mesh - A (RSM-A) air interface; Physical layer specification; Part 3: Channel coding".

ETSI TS 102 188-4: "Satellite Earth Stations and Systems (SES); Regenerative Satellite Mesh - A (RSM-A) air interface; Physical layer specification; Part 4: Modulation".

ETSI TS 102 188-5: "Satellite Earth Stations and Systems (SES); Regenerative Satellite Mesh - A (RSM-A) air interface; Physical layer specification; Part 5: Radio transmission and reception".

ETSI TS 102 188-7: "Satellite Earth Stations and Systems (SES); Regenerative Satellite Mesh - A (RSM-A) air interface; Physical layer specification; Part 7: Synchronization".

ETSI TS 102 189-2: "Satellite Earth Stations and Systems (SES); Regenerative Satellite Mesh - A (RSM-A) air interface; MAC/SLC layer specification; Part 2: MAC layer".

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