SOMAP

Satellite Operator’s Minimum Antenna Performance Requirements

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GVF

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Contents

1) General Introduction

The satellite industry has experienced unprecedented growth over the last decade. With that growth, the focus on antenna performance and the impact of interference due to closely spaced satellites has become a higher priority amongst satellite operators. As a result, it has become desirable for these operators to work with antenna manufacturers to improve the antenna terminal qualification process. In the year 2013, based on frequent discussion during meetings, members of the “Mutual Recognition Agreement Group”, or “GVF-MRA group” within the Global VSAT Forum (GVF), originated a request for satellite operators to evaluate the possibility of defining Minimum Antenna Performance Requirements for earth stations.

Accordingly, given increasing concerns regarding antenna characteristics in general and more specifically with the proliferation of Comms-On-The-Move (COTM) products, industry leading satellite operators (consisting of AsiaSat, Eutelsat, Inmarsat, Intelsat and SES), came together with the aim of developing an antenna qualification framework that would be adopted by the participating members. The group, identified as “SOMAP” (Satellite Operator’s Minimum Antenna Performance Requirements), endeavours to offer consistency across the industry, for customers and antenna manufacturers.

This framework is primarily intended to address the qualification of new antenna products being introduced to the market. The framework, developed and endorsed by the SOMAP working group, consists of the following key elements.

1) **Minimum Antenna Performance Requirements Matrix**
   This matrix consists of individual tables for C-Band, Ku-Band and Ka-Band antennas. Each of the tables has requirements listed as well as the corresponding values and recommendations.

2) **Definition of Mandatory Test Data**
   This lists in detail the data which the participating satellite operators intend to request on a mandatory basis solely from manufacturers of COTM systems.

3) **Performance Data on Datasheets**
   Antenna manufacturers are requested to list a dedicated set of performance data on future datasheets, so as to enable engineers to utilize these data in link-budget analyses, to compare products which are alike and to assist satellite operators in the antenna approval process.

It has to be emphasized that with the Minimum Antenna Performance Requirements Matrix the SOMAP group does not intend to introduce another standard, replacing existing standards originating from ITU, FCC or ETSI for example. Those will remain in place, as well as the antenna performance requirements which every satellite operator defined for themselves. The intention is to set a minimum of performance criteria, which have to be fulfilled in situations when an antenna does not meet the standards currently in place, but in theory could work well in a given environment, as long as contractual constraints with adjacent satellite operators are met. Regular operation still requires compliance with existing standards, which future antennas should be designed for.

The Minimum Antenna Performance Requirements Matrix was created on a non-mandatory basis. Satellite operators, however, will adhere to it to the best of their capabilities, which in certain cases could mean that either additional test data or additional information from the manufacturer will be requested, restrictions will be applied and a specific conditions will be imposed during operation.

As stated previously, the participating satellite operators are of the opinion that there is a need for a consistent set of minimum test data, especially in light of the numerous advanced and highly complex COTM antenna terminals being introduced to the market.

SOMAP Goals and Objectives

The goals are:

- To achieve a clear and reliable understanding of product specifications and capabilities under anticipated operational conditions.

- To gain confidence that the antennas meet the specified performance through an agreed minimum testing regimen.

- To have all participating satellite operators seek the same information from vendors.

The Minimum Antenna Performance Requirements will be introduced with a significant time margin towards implementation. They will only apply to new antenna models which are introduced to the market after September 1st, 2018

Mandatory Test Data (Comms-On-The-Move only)

Satellite Operators experience a significant change of applications deployed on satellites, mainly in the (COTM) area, accompanied by an impressive variation in the performance of antenna systems. The performance of advanced antenna systems depends not only on antenna size, but also on the actual position of the moving object and on other parameters like elevation angle and skew angle, which are directly related to the area of operation in a specific satellite orbital slot. Since no model performs like another, securing manufacturer's performance data per antenna system is absolutely essential for satellite operators. It is the satellite operator's responsibility to validate the service configuration based on high quality link-budget analyses and at the same time enforce contractual and inter-system coordination agreements. This can only be done with an extensive set of manufacturer's data regarding a particular antenna model.

The number of COTM antenna systems to access the collective fleet is expected to increase significantly, and satellite operators believe that mobile applications will use a substantial part of space capacity in the future, especially in view of new High Throughput Satellites (HTS).

As per September 1, 2018 the satellite operators participating in the SOMAP will request a mandatory set of test data for COTM products, as explained in Chapter 2. Further, more attention will be given to radomes.

SOMAP Compliance and Operation on the Satellite

All satellite operators are obliged to design and operate their services in accordance with coordination agreements that have been contractually established between themselves, besides applicable ITU recommendations, and rules of administrative bodies in charge in the specific country or region. When an antenna model meets the Minimum Antenna Performance Requirements (SOMAP), it does not guarantee that it will be able to support customer's specific wishes for carrier configuration in a specific orbital slot. It merely implies that the activation of this particular product is taken into consideration by the satellite operator in question, which means that the operator will do everything in his power to adhere to customer's wishes. However, eventually a customer's desired service configuration may have to be modified in order to remain within the coordination agreements. This can be done by

1) choosing a less restrictive orbital slot if another satellite is available,
2) applying more bandwidth to the service, which is in essence to alter the link configuration, or
3) choosing an antenna model with a larger dish size, for transmission, for reception, or for both.

2) Mandatory Test Data (COTM Only)

The satellite operators who are taking part in the SOMAP project will request the data below be provided by antenna manufacturers as of September 1st, 2018:

A.) Basic information

a. Manufacturer name:
b. Antenna model:
c. Shape and Dimensions:
d. Antenna type/used principles:
e. Frequency Band (Tx/Rx)

B.) Technical data

Requirements for *Parabolic* Comms-On-The-Move antennas

Document	Description
Datasheet with	• specified Rx Gain, Tx Gain, and G/T (including relevant conditions like frequency, elevation angle x, LNA/LNB temperature in Kelvin) as well as • on-axis cross-pol isolation performance for a specified Tx and Rx frequency and • a picture of the antenna without radome.
Antenna Radiation Patterns of	• both transmit and receive frequency band at low, intermediate and high frequencies, • both polarizations, HLP and VLP or RHCP and LHCP, whichever is applicable, • both the azimuth and elevation plane.
Radiation Pattern Resolution and Format	• Wide angle span (±180° or minimum ±100°), for various elevation angles, azimuth angles, in a grid of 1°, • Narrow angle span (ideally ± 10°, ± 15° as a maximum) in a grid of 0.1°, • Numerical, preferably in Excel- or text format with comprehensive description.

Requirements for *Non-Parabolic* Comms-On-The-Move antennas

Document	Description
Datashee t With	• specified Rx Gain, Tx Gain, and G/T (including relevant conditions like frequency, elevation angle x, LNA/LNB temperature in Kelvin) as well as • on-axis cross-pol isolation performance for a specified Tx and Rx frequency and • a picture of the antenna without radome.
Antenna Radiation Patterns of	• both transmit and receive frequency band at low, intermediate and high frequencies, • both polarizations, HLP and VLP or RHCP and LHCP, whichever is applicable, • both the azimuth and elevation plane.
Document	Description
Additional Antenna Radiation Patterns for skew angles	• Radiation patterns should be made available for various skew angles from -90° to 90°, in increments of 10° (preferably 5°) in the horizontal and vertical plane
Radiation Pattern Resolution and Format	• Wide angle span (±180° or minimum ±100°), for various elevation angles, azimuth angles, in a grid of 1°, • narrow angle span (ideally ± 10°, ± 15°as a maximum) in a grid of 0.1°, • numerical, preferably in Excel- or text format with comprehensive description.

Notes:

1. *Numerical data are mandatory, however, if plots are provided, they should be labeled clearly for each axis, and provide an indication of the conditions within which they were taken (frequency, polarization, plane, etc.).*
2. *Please provide antenna patterns taken with radome. If not available then it must be indicated on each plot.*
3. *The radiation patterns should be provided for antenna gain. For the normalized gain, the peak antenna gain should be indicated for each plot.*
4. *If the radiation patterns are based on power spectral density (PSD), then each plot should indicate peak power (Equivalent Isotropic Radiated Power (E.I.R.P.), in dBW). Please indicate the relationship of radiated power and associated BUC with post amplifier losses.*
5. *Please elaborate on the expected performance variation across the anticipated operating environment (on-aircraft, train, vehicle or maritime).*
6. *An executive summary shall be provided, summarizing performance, and highlighting any aspects that require special consideration.*

C.) Radome

1. Provide the name of the designer and the name of the manufacturer of the radome.
2. Which information on the radome is visible on the product in the field (logo, serial number, type/model indication, production date, etc.)?

3. Indicate the radome type (sandwich, etc.), the number of layers and the number of segments or petals.
4. Provide the radome dimensions (including thickness), and its weight, attach pictures if possible.
5. What is the impact of the radome on the increase in noise temperature [dB] and G/T?
6. What is the expected effect of the radome on antenna beam deflection (for open loop tracking systems)?

3) Matrix Interpretation

The SOMAP Group defined the future requirements in a matrix, listing the relevant parameters divided into sections for C-Band, Ku-Band and Ka-Band.

The horizontal axis represents the antenna type in terms of size and application. The vertical axis represents the parameters for which the requirements are specified in the individual cells.

The matrix includes a list of the following antenna types and parameters:

Antenna Types

- Fixed Central Station (aka Teleport Antenna System, Gateway Antenna System)
- VSAT (Very Small Aperture Terminal)
- SNG (Satellite News Gathering)
- Maritime
- Mobile, non-maritime and Small Diameter, On-The-Move Terminals, Atypical Construction, Advanced Technology

Parameters

- Diameter equivalent
- D/λ
- Antenna sidelobe characteristics (aligned to geostationary arc)
- Measured Co-polar pattern - with radome if applicable (low- mid- end high frequency band)
- Spurious transmission (Carrier off)
- Starts at α
- X-pol isolation (cross-pol isolation within 1 dB contour) C-, Ku- and Ka-Band
- Measured Cross-polar pattern
- Polarization Alignment Accuracy
- Azimuth / Elevation fine adjustment mechanics
- Transmit E.I.R.P. indicator
- Tracking
- Structural stability
- Windload / Operational
- Minimum / Maximum Temperature
- Maximum E.I.R.P. rating
- Investigate the possible influence on the antenna pattern introduced by the de-icing system
- Installation of an Antenna Control Unit
- To issue a look-up table for polarization / skew angle off-set to the antenna operator
- E.I.R.P. Adjustment Resolution in the Full Range of HPA power
- E.I.R.P. stability
- Maximum deviation from direction to satellite
- Automatic carrier mute, mandatory if mispointing exceeds…
- Time within which the automatic carrier mute will have to take place
- Transmission to resume at (or less than) angle
- Software may not be modifiable by operator

- Radome in production must be identical to the radome with which the antenna system has been tested
- Transmit earth stations must be equipped with a receive chain which allows pointing optimization and tracking prior to and during transmission

Antenna Types

Fixed Central Station
Larger, high powered earthstations supporting video services, or earthstations which could have the functionality of a HUB (main point supporting multiple routes; the traffic is distributed, dispensed or diverted) within satellite networks. They operate in single carrier transponder mode, or in a fraction of a transponder bandwidth on single or multiple transponders.

VSAT (Very Small Aperture Terminal)
Earthstations which are part of a satellite network, but which are not functioning as a HUB. These earthstations were designed for low-powered applications. They are usually fixed and stationary for an extended period of time, as well as subjected to a vast range of changing environmental conditions in terms of weather and territory.

SNG (Satellite News Gathering)
Stations which are mounted on a vehicle, or which are temporarily or permanently positioned on the ground. SNG antennas support occasional use video services for a limited time. They mainly support services which demand substantial uplink power. They are not transmitting while in movement, but operating "On-the-Pause".

Maritime
Maritime antennas operate as part of a satellite network, supporting On-The-Move services while transmitting at low data rates. They are usually used on vessels, but occasionally also on platforms fixed to the sea-bed. Satellite auto-acquiring maritime antennas are equipped with stabilized platforms to account for the ship's motion. They operate under a radome and their system design is robust, to support a challenging environment at sea.

Mobile, non-maritime and Small Diameter, On-The-Move Terminals, Atypical Construction, Advanced Technology
Mobile earthstations operate On-The-Move on vehicles, trains, or aircraft. These sometimes very small aperture terminals of specific/advanced designs find their application in governmental-, military- or commercial applications, where a mobile service is demanded. They operate under a radome and can be subjected to strong environmental influences. The antenna systems are equipped with motion sensors and intelligence to control applied power and to handle satellite acquisition and re-acquisition when necessary. Their performance may vary substantially from (antenna-) model to model.

Parameters

Diameter equivalent
In antenna models of an atypical design, it is often not adequate to refer to a diameter which is based purely on physical reflector dimensions. When the diameter is based on typical performance parameters like the antenna gain, it is referred to as the diameter equivalent. This number will then be used for performance calculations.

D/λ
The ratio of the antenna diameter over the wavelength. Often applied to determine at which off-axis angle antenna side-lobe patterns are considered relevant.

Antenna sidelobe characteristics (aligned to geostationary arc)
The reference level which defines the upper limit of an antenna off-axis gain performance. It is important that for each antenna operating under a radome the antenna pattern is provided **with** radome, taking into account the losses which are introduced by it. The horizontal plane should be in alignment with the geostationary arc.

Measured co-polar pattern - with radome if applicable (low- mid- end high frequency band) The precise requirements for these mandatory data are explained in the document "Mandatory Test Data".

Starts at α
The off-axis angle at which the side-lobe characteristics are to start.

X-pol isolation (cross-pol isolation within 1 dB contour) C-, Ku- and Ka-Band
The margin until a signal is visible in transponder capacity in the opposite polarization.

Measured cross-polar pattern
The antenna pattern displayed for the opposite polarization, measured individually.

Polarization Alignment Accuracy
The accuracy within which the operator will be able to align his feed towards the desired polarization.

Azimuth / Elevation fine adjustment mechanics
Additional, low-cost fine adjustment devices to reduce the mis-pointing to less than 0.5 ° (in antenna models where the original design does not account for mis-pointing).

Transmit E.I.R.P. indicator
Additional device to enable operators of large and medium-sized earthstations (if not built-in), and especially SNG operators, to have a perception of their radiated E.I.R.P. and thus to develop an understanding of the involved numeric values. In addition, the ability to associate the desired uplink power with the link-budget at hand can be developed.
Strongly recommended.

Tracking
The ability of an antenna with a tracking system to lock to a satellite beacon or a designated signal and thus remain accurately pointed during transmission.

Structural stability
The ability of an antenna or antenna system to withstand environmental forces working on the system.

Windload / Operational
In km/h, the maximum wind-speed that an antenna must be able to support without shifting the structure (hence resulting into mis-pointing).

Minimum / Maximum Temperature
The ability of antenna or antenna system to correctly operate in extreme temperature conditions, without deformations or modification of the structural design.

Maximum E.I.R.P.
The maximum uplink power the antenna or antenna system is tested and designed for.

Investigate the possible influence on the antenna pattern introduced by the de-icing system and Installation of an Antenna Control Unit
The maximum E.I.R.P. capability of an earth station is a key parameter indispensable for both interference investigation and earth station acceptance. In view of the quality of a satellite link, the value of the EIRP in the direction toward a given satellite has to be considered. In this context the following contributions must be taken into account:

- The possible influence on the antenna pattern introduced by the de-icing system
- The specific tracking algorithm applied by the Antenna Control Unit.

To issue a look-up table for polarization / skew angle off-set to the antenna operator
Considering that the polarization skew angle may differ depending on the specific satellite, COTM Terminals must be equipped with look-up tables, providing the adequate polarization skew data to assure optimized polarization alignment.

E.I.R.P. Adjustment Resolution in the Full Range of HPA power
To adapt to the operational requirements as set per transmission plan, a sufficiently fine resolution of the E.I.R.P. adjustment has to be available.

E.I.R.P. stability
The ability of an antenna system to maintain a specified uplink power over time.

Maximum deviation from direction to satellite
The maximum angle for an antenna system to off-point from the satellite before mechanisms are put in place to signal to operator that a pointing correction is necessary.

Automatic carrier mute, mandatory if mis-pointing exceeds…

If the value of the error pointing exceeds the limit as specified in the matrix, an automatic mute functionality will have to be in place in order to stop the system to deviate even more, with the risk of causing a service disruption on neighboring satellites.

Time within which the automatic carrier mute will have to take place

This value is specified in the matrix.

Transmission to resume at (or less than) angle

This value is specified in the matrix.

Automatic carrier mute, mandatory if mis-pointing exceeds (angle in degrees)

This value represents the maximum acceptable angle to which the antenna may off-point until the transmission will have to be muted.

Time within which the automatic carrier mute will have to take place

This value represents the time in milliseconds within which the carrier will have to be muted.

Transmission to resume at (or less than) angle

This value represents the maximum off-point angle at which transmission may resume in case an off- point angle error has been detected earlier.

Software may not be modifiable by operator

The internal antenna system software may not be modifiable by a third party, to for example overwrite built-in safety measures, or to change the parameters of the implemented algorithms. This applies to SNG- and mobile, auto-acquiring On-The-Move systems only. This includes data for the tracking mechanism, the acquisition, for mis-pointing and power levels to the antenna flange etc. It includes any unit where software is installed, like BUC, modem and ACU, or other components.

Radome in production must be identical to the radome with which the antenna system has been tested

4) List of Abbreviations

ACU	Antenna Control Unit
BUC	Block Up-Converter
E.I.R.P.	Equivalent Isotropic Radiated Power
GVF	Global VSAT Forum
GVF-MRA	Mutual Recognition Agreement
Group HPA	High-Power Amplifier
ITU	International Telecommunication Union
MF-TDMA	Multi-Frequency Time Division Multiple Access
RF	Radio Frequency
SNG	Satellite News Gathering
VSAT	Very Small Aperture Terminal