Global VSAT Forum

GVF-104

PERFORMANCE AND TEST GUIDELINES FOR TYPE APPROVAL OF AUTO-DEPLOY AND VMES SATELLITE COMMUNICATIONS TERMINALS

This document defines the applicable performance requirements and test procedures for GVF Type Approval of Auto-Deploy and Vehicle Mounted Earth Station (VMES) VSAT communications antenna systems.

Revision History:

Revision	Date	Notes
Rev 0		CMR / Draft document
Rev 1	25 Feb 2010	Restructured and created Appendix A. Added specification document reference detail. Incorporated comments for CMR. (RLB)
Rev 2	3 Mar 2010	Edited (DH/RLB) and incorporating assessment of two pointing error tests (FF), as well as further input arising from meeting of drafting group
Rev 3	31 May 2010	Incorporates comments received at the last meeting of the drafting group on the 30 April 2010
Rev 4	10 Jun 2010	Expands definitions and configurations of the terminals

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1 Purpose

This document is intended to serve as a best-practices guide for interpreting international regulatory specifications for the purpose of GVF type approval of auto-deploy VSAT terminals.

The GVF type approval process is defined in detail in document GVF-101. That document assumes that the satellite operator for whom the type approval is to be issued defines performance specifications.

It is the objective of this document to provide best-practices guidance to satellite operators who wish to offer a type approval for auto-deploy terminals, or for use in GVF-issued type approvals.

GVF-101 also defines general test procedures for VSAT terminals. This document adds guidance for testing parameters that are unique to auto-deploy terminals.

2 Terminal Definition

An auto-deploy terminal is defined for the purposes of this document as follows:

a) C or Ku-band operation (Ka- and X-band TBD).

b) Intended for operation on geostationary (non-inclined) satellites.

c) Automatically deploys, and accurately points, its antenna towards a designated target satellite.

d) Includes the following types of motorized platforms: (1) fixed (automatically deploys and points); (2) semi-fixed (automatically deploys and points but can compensate in real time for small movements of its base, like people getting in or out of a stationary vehicle); (3) stabilized (fully stabilized and suitable for vessels and moving vehicles).

e) Either (1) operates as part of a managed network, in which there is a hub or other counterpart earth station that is required for the terminal to operate and which supports terminal operations, or (2) operates as a standalone uplink station and all control functions are self-contained.

f) The type approval is granted to an agreed unique configuration, comprising the antenna (identified by manufacturer, model and diameter), mount, antenna control system, RF chain and modem. The maximum allowed eirp density will be defined on the basis of the antenna RF performance and the results of the auto-deploy tests. The existing communication between modem and the platform shall be explicited by the manufacturer e.g. presence of power control in the modem, modem locking signal characteristics etc. In case of a different type of modem replacing the one of the originally type approved configuration, additional test plans will have to be mutually agreed between the applicant and the ATE (Authorized test Entity). If the manufacturer demonstrates that the pointing and RF parameters are not subject to a high level of modem dependency, other types of modems can be validated by analysis only.

3 Performance Requirements

In all cases, the version of the specification document that is current at the time of initial submission of GVF Type Approval application shall apply. Summary specifications listed in this document are to be used for reference only.

3.1 Co-pol Off-Axis EIRP Spectral Density (EIRPSD) Mask

The following specifications apply for auto-deploy terminals:

Specification	Summary* (normalized to dBW/40 kHz, N = 1)	Start angle*
FCC 47 CFR 25.218 (8th order); FCC 47CFR25.209 & 212 (pattern/power); FCC 47CFR25.222 (ESV)	25 – 25 log(θ)	1.5° 1.25° 1.25°
Eutelsat Standard M	31 – 25 log(θ)	1.0 - 2.0°
UK OFCOM Licensing Procedures Manual For Satellite (Network Earth Station) Applications. Schedule 1, sec 4 f).	20	2.5°
ITU-R S.728-1 (Ku-band VSAT)	33 – 25 log(θ)	2.0°
ETSI EN 301 428, 4.2.3.2 (V1-2-7)	33 – 25 log(θ)	2.5°
ITU-R S.524-9 for Ku-band; UK OFCOM; ETSI TS 101 136	39 – 25 log(θ)	2.5°
Anatel Resolutions 364 (C, Ku) and 288 (Ku)	TBD	TBD

* Summary information is for reference only.
The terminal shall meet the applicable specification at its maximum Beam Pointing Error. See Fig 1.

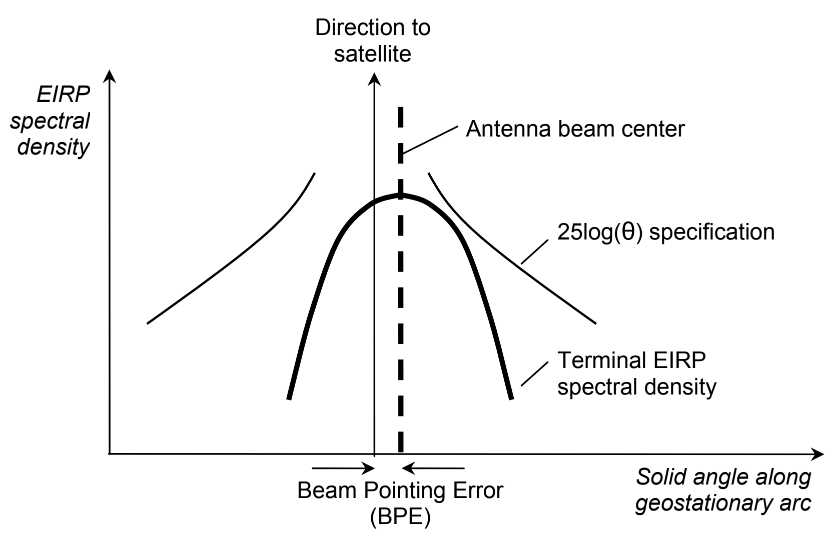

Figure 1. Off-axis EIRP spectral density and BPE

3.2 Cross-pol Off-Axis EIRP Spectral Density (EIRPSD) Mask

The following specifications apply for auto-deploy terminals:

Specification	Summary* (normalized to dBW/40 kHz, N = 1)	Start angle*
FCC 47CFR25.222 (ESV)	15 – 25 log(θ)	1.8°
Eutelsat Standard M	21 – 25 log(θ)	2.0°
ITU-R S.728-1 (Ku-band VSAT)	23 – 25 log(θ)	2.0°
ETSI EN 301 428, 4.2.3.2 (V1-2-7)	25 – 25 log(θ)	2.5°

* Summary information is for reference only.

The terminal shall meet the applicable specification at its maximum Beam Pointing Error.

3.3 Cross-pol Discrimination (XPD)

Specification	XPD summary*
ITU-R S.727	25 dB within 0.3 dB** contour of the main lobe. 20 dB within 20 dB contour
Intelsat Std G, Std K	26 dB
ETSI TS 101 136 Class C30	30 dB
ETSI TS 101 136 Class C35; Eutelsat Standard M	35 dB 25 dB within -1 dB contour of the main lobe**

* Summary information is for reference only. Additional specification TBD
**For broad beam antennas (e.g. C-band) angles may be considered instead of dB.

The terminal shall meet the applicable specification at its maximum Beam Pointing Error (BPE). See Fig 2. BPE should include wind loading deflection and backlash.

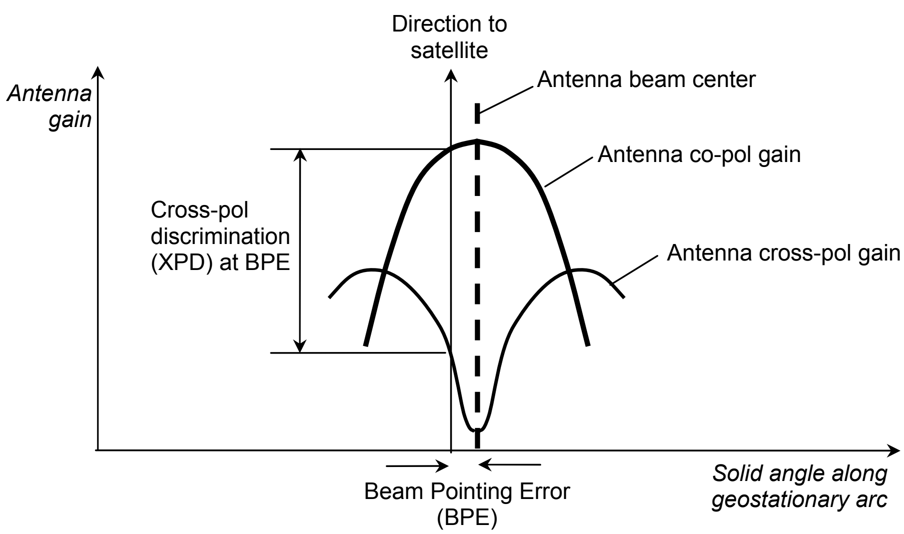

Figure 2. Cross-pol discrimination and BPE

3.4 Antenna Pointing Accuracy

Note: The following recommendations are assumed to reflect the intent of FCC ESV and other regulatory mobile earth station specifications. Specific references are needed.

In normal clear-sky operation, the terminal shall not exceed the specified maximum off-axis co-pol EIRPSD, cross-pol EIRPSD, and XPD. This requirement shall apply under all conditions except during the first 500 ms of a transient event.

A transient event is defined as any disturbance to the antenna pointing and/or uplink power. It may include events such as wind gusts, vehicle rocking, movement of the antenna base, satellite acquisition, re-peaking,

During a transient event, the off-axis co-pol and cross-pol EIRPSD may exceed the specification by up to 6 dB and the XPD specification is reduced to TBD. The terminal shall automatically detect a transient event (as a minimum pitch and roll) and if necessary adjust transmit power or cease transmitting in order to remain compliant with the off-axis EIRPSD mask.

EIRPSD co-pol and cross-pol mask may be exceeded during a rain fade by the amount of loss in the path at the transmit frequency. For this reason tests should preferably take place in clear sky conditions.

4 Type Approval Test Requirements

4.1 Pre-defined parameters

The manufacturer or type approval applicant must propose the following parameters that define the terminal's limits for performance specification compliance:

1) Terminal's rated maximum on-axis EIRP spectral density (EIRPSD). This should include some margin for transmitter chain gain variation, EIRP stability, etc. It should also include enough margins for the terminal to meet EIRPSD limits at its maximum BPE. EIRPSD should be controlled so it is never exceeded.

2) Rating for minimum detected transient BPE. For example, a terminal may be rated to recognize a transient angular deflection as low as 0.2 degrees. Certain terminals may have the additional capability of automatically compensating transient angular deflections up to TBD degrees, provoked by external influences (e.g. wind load, step transients).

3) For highly elliptical antennas which do not rotate to align along the arc or if the rotation is not performed optimally, the equivalent beam width of the main lobe along the arc could be wider, thus potentially increasing the risk of interference to adjacent satellites. Specific tests and restrictions TBD.

4.2 Required Tests

Tests shall include:

1) Antenna patterns;

2) All pointing error contributors – initial pointing, backlash, deflection under wind load;

3) Pointing accuracy repeatability satellite-to-satellite. Since antennas may be on fixed networks, pointing to user satellite from stow condition is to be considered. At least two different satellites should be used to assess the performance of the antenna control system in different operational conditions (e.g. different satellite polarization's skew angles);

4) Confirm that transmission does not take place until modem shows lock conditions. Confirm that if modem is out of lock, transmission is inhibited within TBD msec;

5) Pointing accuracy repeatability deploy-stow-deploy;

6) Pointing error and accuracy repeatability when rotating the antenna assembly with reference to the initial on-ground position;

7) Pointing accuracy and EIRP during simulated rain fade. (wet cloth over feed; look for increased power level and erroneous pointing deviations);

8) Transient event response. Induce a transient rotation of the antenna base by the rated BPE; measure change in pointing angle and transmit power vs. time. Repeat for all three orthogonal angles;

9) Transient event response. Induce a transient rotation of the antenna base by angular values higher than the BPE and assess/measure the antenna performance (stow, mute transmission or reduce power);

10) In case of terminals equipped with automatic compensation of transient angular deflections, induce a step transient sufficient to cause a deflection by TBD degrees (e.g. putting a load on a vehicle mounted antenna) and verify the pointing accuracy response;

11) XPD repeatability satellite-to-satellite;

12) XPD repeatability deploy-stow-deploy;

13) G/T (measured or calculated using nominal values);

14) Other tests as defined in GVF-101 (VSAT level).

The type approval should be conditioned to proof provided by the manufacturer that the performance of the auto-deploy terminal is not affected by wear and tear on mechanical components and antenna optics.

4.3 Test Methods

Calibration: To make the tests prescribed above, the terminal must be calibrated to establish a relationship between power and modulation settings, and on-axis EIRPSD, based on the RF antenna performance.

Pointing accuracy repeatability test method (concept): attach laser pointer to antenna and aim towards a graph paper target(s) when the antenna is pointed and peaked at the satellite(s). Mark laser spots as pointing accuracy tests are performed. Test method for assessing backlash and wind deflection TBD.

To complement to the laser pointer method, the signal level may be measured at the NOC or reference station. When coordinating the tests, once the auto-pointing is completed, the antenna can be manually slewed in azimuth and elevation to find, with the support of the NOC, the maximum peak signal and then from the difference in the values of the Az and El position calculate the pointing error. The manufacturer needs to ensure that the measurement accuracy is sufficient to provide accurate measurements.
Similar measurements may be performed for the cross-polarization discrimination, with the NOC or reference station guiding the operator through a manual nulling of the crosspolar and assessing the resulting error of crosspol nulling with respect to auto-pointing.

A. Appendix: Background Notes

1. The GVF Auto-Deploy Type Approval Initiative

Technology has now become available to provide true broadband satellite communications services from remote locations on a transportable basis and while moving on Land Mobile platforms. The temporary-fixed applications employing auto-deploy, VSAT hardware have proven to be in high demand for military communicators as well as for other users who operate in remote locations like Oil & Gas exploration companies, Emergency First-Responders, and others. The broadband Land Mobile terminals go by various names but the term increasingly in use by the international regulatory community is “Vehicle Mounted Earth Stations”, or “VMES”.

Major objectives of these new classes of Earth Stations, which are finding very broad applications in FSS Ku-Band, are that they are supposed to require little or no operator training. Most such terminals are actually being used by operators that have no training in their operation or maintenance whatsoever. With this being the case, the Earth Stations either have to function flawlessly or interference to other FSS users and networks is assured.

Not all such Earth Stations are “created equal” and some have demonstrated very repeatable, reliable performance, while others have experienced difficulty pointing accurately towards the desired satellite. There have been incidents where some of these terminals actually acquired satellites several degrees away from the intended orbital location and transmitted for hours or days before being corrected. In some cases, users on the “distant end” of these links were unable to see the downlink so the transmitter power was simply increased to the maximum possible output level, causing extensive interference to unintended victims on completely different satellites. Other frequent incidents relate to interference to the services carried on orthogonal polarized transponders, due to poor polarization alignment algorithms and/or antenna performance. Such irresponsible operation severely reduces the performance and value of the communications link and, potentially, other networks on the same and adjacent satellites.

To maintain the value of critical FSS services, it is imperative that the satellite communications industry develop a workable solution to provide for the use of these new classes of satellite communications Earth Stations. Users are demanding their deployment and they are transmitting on more satellites every day, with or without an orderly methodology or standard. Only with an industry-wide solution can FSS satellite communications users be assured of the reliable services they have come to expect.

The VMES regulations recently ordered by the United States Federal Communications Commission (FCC) – and those currently being considered in Europe – are a good example of what can be done, but even there, one can see that Regulators are leaving much of the approach to equipment designers and system operators. The VMES regulations prescribe critical antenna pointing accuracy requirements combined with EIRP spectral density limits which are carefully crafted to protect services carried on orthogonal polarized transponders and/or adjacent satellites. The FCC mandates that those standards must be simultaneously met. It is left to manufacturers to determine how to design systems to meet those standards and how to demonstrate that the expected level of performance is being achieved. The FCC clearly expects the industry to rise to the challenge and make maximum use of the newly-granted privileges without having regulated a technology-specific technology, approach, or limitation.

Accordingly, the GVF has been called upon by the industry to facilitate industry-wide consensus on the harmonization of test procedures and acceptance criteria in standards, on a global basis, for the design and operation of such terminals. Therefore, the GVF plans to establish a consensus among industry participants regarding a suitable level of Performance Validation that will assure continuation of the exceptionally high reliability and value of FSS satellite systems.

The GVF, through the MRA process, plans to follow the road-map which has been successfully implemented for the FSS VSAT Industry. This process calls for an independent evaluation of a manufacturer's product design, manufacturing procedures and performance against SSP specifications culminating with a formal type approval. The independent objectivity of the design, manufacturing and test program is such that the test results are recognized by multiple satellite operators. This process ensures that only compliant, performance-proven designs are deployed in the marketplace, thereby eliminating problems that cause interference to adjacent satellites and to transponders on the intended satellite.

As a subordinate objective, the GVF will work with participating satellite operators to harmonize ground equipment performance specifications in two or three tier standards based on the ground equipment performance capabilities. The GVF looks forward to working with industry, satellite service providers and regulatory agencies to facilitate the introduction of qualified equipment in to the developing auto-deploy VSAT market.

2. Off-axis EIRP Spectral Density Regulations

The provisions of ITU-R S.542-9 (or the most current version thereof) shall set the maximum permissible off-axis EIRP limits. Regional or national limits may modify the provisions of ITU-R S.542.9 providing that they do not exceed the recommended EIRP limits in any direction. The radiation pattern characteristics of all auto-deploy and VMES antenna systems are expected to comply with the most current requirements of ITU-R S.580 or those in force for a particular geographic or national region providing that the EIRP density does not exceed the limits of ITU-R S.580. Terminals failing to meet the requirements of ITU-R S.580 (or those of local regulatory limitations) may be authorized by limiting the input power to the terminal such that its up-link EIRP density does not exceed the limits of ITU-R S.524 (or local regulatory limit) in any direction.

A2.1 Notes and excerpts from ITU-R S.524-9 for Ku-Band FSS Operation

Operation in this band shall be confined to the 12.**75** – 13.25 GHz for the satellite to earth path and 13.75 – 14.50 GHz for earth to satellite link.
Certain satellite operators require different satellite to earth path frequency ranges ((i.e. for Eutelsat: 11.7 -12.75 GHz; Star One: 10.9-12.2 GHz)

The uplink EIPR shall be restricted such EIRP density in any direction along the GSO does not exceed the following values.

Angular Range	Maximum EIPR per 40 kHz
2.5 <= θ <= 7.0 deg	39 – 25 log (θ) dBW / 40 kHz
7.0 < θ <= 9.2 deg	18 dBW / 40 kHz
9.2 < θ <= 48 deg	42 – 25 log (θ) dBW / 40 kHz
48 < θ <= 180 deg	0 dBW / 40 kHz

A2.2 Notes and excerpts from FCC regulations

Until recently the FCC did not establish an off-axis EIRP mask in the same way as specified by the provisions of ITU-R S.524. Rather the FCC set limits on the input power to the antenna flange and the off-axis radiation characteristics for the antenna under consideration. The combination of these two requirements effectively set the off-axis EIRP radiation levels. Recently FCC Eight Order resulted on a new ruling 47 CFR 25.218 which combined the provisions of 47 CFR 25.212 and 47 CFR 25.209 to establish an off-axis EIRP mask which extended from 1.5 degrees to 7 degrees. Thus the key provisions of FCC requirements for narrow Ku-band transmissions can be summarized by the following:

A2.2.1 FCC sidelobe mask (47 CFR 25.209)

The antenna gain for a compliant antenna shall not exceed the following limits over the defined angular limits

Angular Range	Maximum gain
1.0 deg <= (θ) <= 7.0 deg	29 – 25 log (θ) dBi
7.0 deg <= (θ) <= 9.2 deg	+ 8 dBi
9.2 deg <= (θ) <= 48.0 deg	32 – 25 log (θ) dBi
48. deg <= (θ) <= 180. deg	- 10 dBi

The close in sidelobe mask for small antennas (1.2 meters) is increased to start at 1.25 degrees than 1.0 degrees.

A2.2.3 Input power limitations, Narrowband Ku-band transmissions (46 C.F.R. 25.212)

The power density presented to the antenna input flange shall not exceed -14 dBW / 4 kHz for narrow band transmissions. This equates to -4 dBW / 40 kHz when comparing with the ITU bandwidth designations.

A2.2.3 FCC New Eighth Report and Order (47 C.F.R. 25.218)

This rule expanded the starting angle for the initial 29 – 25 log (θ) mask to 1.5 degrees. The rule also set the EIRP density limit over the angular range from 1.5 deg <= (θ) <= 7 deg to a maximum EIRP of 15 – 25 log(θ) dBW / 4 kHz. This equates to an EIRP density of 25 – 25 log(θ) dBW / 40 kHz when comparing with the ITU bandwidth designations.

If antenna does not meet 29-25 log(θ) then power density at the antenna flange shall be reduced such that the radiated EIRP complies with the 15-25 log(θ) dBw/4kHz limit from 1.5deg < θ > 7deg.

A2.2.4 FCC ESV regulation (47 C.F.R. 25.222)

This rule was created for Ku-band VSATs on ships (vessels) using stabilized antennas. It essentially follows the combination of 25.209 (antenna pattern) with 25.212 (transmitter power spectral density) to give a net off-axis EIRP spectral density mask of 15 – 25log(θ) dBW per 4 kHz, starting at 1.25 degrees. It also requires that the antenna have a maximum pointing error of 0.2 degrees, cease transmission within 100 ms if the pointing error exceeds 0.5 degrees, and not resume transmission until the error returns to less than 0.2 degrees.

A2.3 Notes on UK OFCOM regulations

The U.K. Office of Communications has utilized the ITU requirements to set limits for the antenna radiation pattern coverage and off-axis EIRP limits. The antenna radiation pattern is required to comply with the provisions of ITU-R 465 or ITU-R S.580 for antennas installed after 1995. The off-axis EIRP power density mask is required to comply with the provisions of ITU-R S.524-9.

Mobile stations shall employ a stabilised platform with the ability to maintain a pointing accuracy +/–0.2 degrees towards the relevant Geostationary Satellite throughout transmissions. In addition, the maximum EIRP at angles greater than or equal to 2.5 degrees from the antenna main beam axis shall not exceed 20 dBW/40 kHz from any individual station.

B. Appendix: Performance Envelope

This table is to be completed as part of type approval and is intended to serve as operating parameter limits for users of the equipment.

Minimum automatically detected beam pointing error (deg): __________

Section	Parameter	Applicable specification
3.1	Co-pol off-axis EIRP spectral density	
3.2	Cross-pol off-axis EIRP spectral density	
3.3	XPD	

Specification	Maximum allowable EIRP spectral density operating points		
	On-axis EIRP spectral density (dBW in 40 kHz)	Transmitter output power, dBm (max)	Modem symbol rate, ksps (min)