555 Eleventh Street, N.W., Suite 1000
Washington, D.C. 20004-1304
Tel: +1.202.637.2200 Fax: +1.202.637.2201
www.lw.com

LATHAM & WATKINS LLP

February 13, 2009

Mr. John Giusti
Acting Chief, International Bureau
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: Call Sign E080100: Applications of Row 44, Inc. for

Authority to Operate up to 1,000 Technically-Identical Aeronautical-Mobile Satellite Service Transmit/Receive Earth Stations Aboard Commercial and Private Aircraft, FCC File Nos. SES-LIC-20080508-00570; SES-AMD-20080619-00826; SES-AMD-20080819-01074; SES-AMD-20080829-01117; SES-AMD-20090115-00041 and

Special Temporary Authority, FCC File No. SES-STA-20080711-00928.

Ex Parte Presentation

Dear Mr. Giusti:

ViaSat, Inc. ("ViaSat") responds to the February 11, 2009 ex parte submission of Row 44, Inc. ("Row 44") in these proceedings (the "February 11 Letter"). We will focus only on four major points.

1. The key issue in these proceedings is ensuring two-degree spacing compatibility.

Contrary to what Row 44 would have the Commission believe, ViaSat's concerns in this proceeding have been consistent: Row 44 simply has not demonstrated that its system would operate in a manner consistent with a two-degree spacing environment. Namely, Row 44 has failed to establish that the combined effect of its non-FCC-compliant antenna and its proposed power-density levels, when used on moving aircraft, would not cause harmful interference.

ViaSat's main point is that *all* of the unresolved antenna pointing issues could be rendered moot if Row 44 were to reduce its proposed power-density level to the point where its antenna mispointing simply would not matter.[1] Others in the mobile industry have done

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[1] Row 44's claim that ViaSat's "primary attack has shifted" from "antenna misorientation" to "power density," February 11 Letter at 1 n.1, is simply untrue, and suggests that Row

precisely that. In fact, that is how ViaSat's architecture supports the simultaneous operation of dozens of aeronautical terminals emitting an aggregate power-density level toward adjacent spacecraft with far less interference potential than even a single Row 44 terminal.[2]

There is nothing novel about the issues ViaSat has identified. These are the same problems that troubled Commission staff when developing an NPRM for other mobile uses of FSS terminals, and that resulted in staff asking three pages of specific questions covering issues similar to those ViaSat is raising here, which another proponent of mobile technology was required to cogently answer. *See* Exhibit A. Those issues arose even though that provider was using an antenna that was much more sophisticated and higher-performing (*e.g.*, approximately 100 times faster in adjusting for motion) than the Row 44 antenna.

There is no basis for Row 44's suggestion that the Commission should ignore the absence of any technical support for Row 44's claims, and simply allow Row 44 to commence operations.

2. <u>Row 44's discussion of ViaSat's interference analysis is unavailing.</u>

Row 44's only response to ViaSat's December 8, 2008 interference analysis is very brief and unavailing. In fact, Row 44's claim that "the ViaSat study bears little relationship to the operations actually proposed by Row 44"[3] is demonstrably false:

- Row 44 claims that ViaSat "arbitrarily and incorrectly" assumed that Row 44's system would transmit at 12.5 watts. In fact, ViaSat's interference analysis specifically considers the impact of operations under Row 44's assertion that it would transmit at 10 watts. ViaSat separately analyzes the interference impact if Row 44 were to use the full 12.5 watts of power available on its amplifiers.

- Row 44 claims that ViaSat assumed the wrong "gain" for Row 44's proposed system. In addition to Row 44 simply being wrong, the salient factor in the interference analysis is the resulting level of transmit power (EIRP), which Row 44 does not contest. Moreover, and as Exhibit B (attached hereto) illustrates, although ViaSat and Row 44 may specify "gain" differently, any differences are readily reconciled.[4]

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44 still does not understand the power-density/pointing accuracy trade-off inherent in the design of mobile earth stations operating in FSS bands.

[2] *Cf. id.* at 4 (mistakenly comparing the impact of the fifty terminals authorized in ViaSat's experimental authorization with the impact of the twelve terminals requested in Row 44's STA application).

[3] February 11 Letter at 6.

[4] Row 44 specifies "gain" at the output of the power amplifier, while ViaSat specifies gain at the input of the antenna.

- Row 44 claims that ViaSat "ignored" Row 44's explanation that it would not exceed 0.5 degrees of mispointing. Regardless of whether Row 44's claim withstands scrutiny, ViaSat showed that Row 44 would cause harmful interference even if Row 44 were able to maintain a 0.2 degree or a 0.5 degree pointing tolerance (and would cause greater interference if were unable to do so).

Notably, there are no other responses on the record to ViaSat's interference analysis, which demonstrates that Row 44 could not operate successfully on a secondary, non-harmful-interference basis.

3. Row 44 has not substantiated its claims regarding the antenna pointing capabilities of its proposed system.

Row 44 is simply wrong in claiming that it already has submitted data corroborating the antenna pointing capabilities of its proposed system, in the form of numerous antenna gain patterns submitted to the Commission.[5] A close examination of those materials reveals that they have nothing to do with actual antenna pointing in a dynamic operating environment. Those materials allow one to assess the impact of a given level of mispointing, but they do nothing to support Row 44's pointing performance claims. In short, Row 44 has failed to produce any data with respect to the pointing and tracking capabilities of its proposed system.

Row 44 has no good reason for withholding the data it does have "from past flights that corroborate its operation on a non-harmful interference basis."[6] Contrary to Row 44's claim, even if those operations were conducted at slightly lower power-density levels than the levels at which Row 44 would like to operate, those data still are relevant in assessing the pointing accuracy of the Row 44 system.[7] If there were mispointing problems, or deficiencies in the test methods, at the lower power-density levels, those same problems would exist at the higher power-density levels as well. Row 44's fear that its data "might not be viewed as conclusive with respect to the proposal outlined in the application" reinforces the need for the Commission to ask whether Row 44 has any data to support its performance claims. Indeed, Row 44's fear that its data might be scrutinized should raise serious questions about the veracity of its claims.

4. Row 44 has not justified its STA request.

Row 44 has no response at all to ViaSat's observation, in its letter of February 9, 2009, that Row 44's in-flight testing proposal *fails to specify any methodology for assessing the antenna pointing accuracy of the Row 44 system*. Namely, Row 44's testing proposal does not explain how Row 44 would (or could) calculate whether its antenna was mispointed by as little

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5 February 11 Letter at 5.

6 *Id.* at 3.

7 Any engineer should be able to "scale" that data to reflect operations at slightly higher power-density levels.

as 0.2 degrees. This is of particular concern because Row 44's own antenna patterns show a relatively "fat" beam pattern that does not roll off much within 0.2 degrees of peak.

Row 44 has not provided the Commission with any technical demonstration of Row 44's pointing capabilities, any data from the ground-based tests that Row 44 and AeroSat claim to have conducted, or any clear path for gathering this type of pointing data while the twelve proposed aircraft are in flight. That is why Row 44's request to "test" its system on twelve commercial aircraft is unjustified: there are no identified scientific means for gathering from moving aircraft the relevant technical data needed to resolve the issues in this proceeding.

* * * * *

ViaSat urges the Commission to resolve the important issues raised in this proceeding, before granting Row any authority. Particularly because Row 44 "does not feel obligated" to respond to legitimate technical arguments advanced by ViaSat and others,[8] the Commission has no obligation to continue processing Row 44's applications.

Sincerely yours,

/s/ John P. Janka

John P. Janka
Jarrett S. Taubman

Counsel for ViaSat, Inc.

cc: Rod Porter
Bob Nelson
Fern Jarmulnek
Steve Spaeth
Karl Kensinger
Steve Duall
Scott Kotler

William Bell
Andrea Kelly
Kathyrn Medley
Sophie Arrington
Trang Nguyen
Frank Peace
Jeanette Spriggs

David S. Keir, Lerman Senter PLLC (Counsel for Row 44, Inc.)
Stephen D. Baruch, Lerman Senter PLLC (Counsel for Hughes Network Systems, LLC)

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8 *See* February 11 Letter at 7.

EXHIBIT A

WILLKIE FARR & GALLAGHER LLP

1875 K Street, NW
Washington, DC 20006

Tel: 202 303 1000
Fax: 202 303 2000

December 18, 2006 ***Ex Parte Notice***

Marlene H. Dortch
Office of the Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: In the Matter of Amendment of Parts 2 and 25 of the Commission's Rules to Allocate Spectrum in the Ku- and Extended Ku-Bands to the Vehicle Mounted Earth Station Satellite Service ("VMES") on a Shared Primary Basis and to Adopt Licensing and Service Rules for VMES Operations in the Ku- and Extended Ku-Bands, RM-11336

Dear Ms. Dortch:

On November 13, 2006, Tim Shroyer, Chief Technical Officer, General Dynamics C4 Systems, along with Jennifer McCarthy and the undersigned, counsel for General Dynamics Corporation (collectively, "General Dynamics"), met with Lisa Cacciatore, Ron Chase, Kate Collins, Howard Griboff, Scott Kotler, Paul Locke, John Martin, James Miller, and Salomon Satche to discuss the factual and legal issues, as well as the various technical parameters, described in the above-captioned Petition for Rulemaking filed by General Dynamics on May 24, 2006. Attached are the questions that were distributed by the FCC's Staff and discussed at the meeting. Also attached is General Dynamics' response to the Staff's first question regarding VMES pointing and tracking mechanisms, which supplements General Dynamics' responses to questions two through nine that were submitted for the record on November 21, 2006.

Should you have any questions regarding this matter, please do not hesitate to contact the undersigned.

Respectfully submitted,

/s/

McLean Sieverding
Counsel for General Dynamics Corporation

cc: John Giusti;

Jim Ball;
Lisa Cacciatore;
Ron Chase;
Kate Collins;
Howard Griboff;
Francis Gutierrez;
Scott Kotler;
Paul Locke;
John Martin;
James Miller; and
Salomon Satche

Questions for meeting with General Dynamics
November 13, 2006

1. Pointing and Tracking Mechanism. An earth station on a vehicle might be expected to undergo more rapid motion, changes of direction and vibration than similar earth stations on vessels (ESVs). These changes would appear to demand a larger reliance on the antenna pointing and tracking mechanism to maintain the proper pointing in VMES compared with ESVs. We'd like to understand better the technical aspects of this mechanism to ensure that it will maintain the required tolerance over the long term, and to understand better the conditions that military operational testing will require. This material currently is not a part of the petition. For example:

- *What are the parameters the VMES tracker is tested under and under what parameters is it operated?*
- *At what point does it fail (deg/sec in which axis) and what is the typical and extreme environments in which it would be used (deg/sec in which axis)?*
- *What is the typical failure rate of the antenna tracker and what are its principal failure modes?*

2. Aggregate Power Control. Our understanding is that the operator can increase the transmit power fed to the antenna potentially causing interference to near-by satellites. Additionally, we understand that the General Dynamics system, unlike the similar proposed aeronautical mobile satellite service (AMSS), does not have a central Network Operations Center (NOC) from which the aggregate power at the GSO from multiple transmitting vehicles can be controlled to protect nearby satellites.

- *We would like to understand how the operator would know if he were causing interference if he compensates for mispointing or blockage by attempting to operate at increased power, and how he might be contacted to shut off the unit?*

Additionally, the ESV systems based upon AMSS systems, such as Boeing Connexion, use dynamically controlled CDMA to increase the efficiency of transponder use. These system operators and others have argued that the EIRP-density limits should be an aggregate limit that applies to all cofrequency terminals.

- *What would General Dynamics' reaction be if the Commission rules insisted that there be a central NOC to ensure the EIRP-density limits are maintained either as individual or aggregate limits?*
- *Does General Dynamics have any comment on the current "10*Log(N)" rule applied to CDMA systems?*

3. International Recognition. As a regulatory matter, ESVs obtained international recognition by working within the ITU prior to petitioning for a Commission rulemaking. As a consequence of gaining this recognition, certain international constraints were placed on ESVs which are, generally, reflected in the ESV service rules. Without international recognition, ESVs would be restricted to operating only in the U.S.

territorial waters. Vehicle-mounted earth station proponents have not obtained international recognition through the ITU. As such, restricting vehicle-mounted earth stations to U.S. territory would appear to significantly reduce the utility of this application for the military. We would like to discuss the international aspects of earth stations on vehicles with General Dynamics. For example:

General Dynamics says that the FSS would allows for a "surge capacity" for military anywhere in the world (Petition Page 6) and [This is] "the best option to support U.S. forces in the Middle East" (Petition Page 8) and, further, the Petition (on Page 1) wants to ensure that the US military are able to adequately test and train with mission-critical VMES satellite communications.

- *Does "Mission critical" imply operational usage, thereby suggesting use on foreign soil?*
- *How will the military use VMES in or near administrations that treat ESVs as secondary MMSS (See, for example FN 5.457B, including several Middle East countries)?*
- *How will they do joint training (military exercises) in countries that don't recognize ESVs, much less VMES (see ITU-FNs 5.505, 5.506B, 5.508 and 5.509)?*
- *Does* General Dynamics *envision any efforts in the ITU to gain recognition for VMESs? If so, how long do you think this effort will take to bear fruit?*

4. Scope of VMES Technology. The General Dynamics Petition (Page ii/iii) says "...limited authority has generally only permitted to test and demonstrate Satellite on the Move (SOTM) technologies and is insufficient to meet the military's requirements to widespread domestic training with SOTM and other VMES technologies as are required."

- *What other VMES technologies are being referred to?*

5. Spectrum Efficiency. The Petition (Page 1) says that VMES will yield a more efficient use of spectrum.

- *We would like to better understand how this will happen. Is this solely by creating more users to the Ku-band FSS?*

6. Comparability with ESV, AMSS. The Petition (Page 1) says that licensing VMESs will improve access to spectrum by services with mutually compatible technical characteristics.

- *We see VMES as very different technically, i.e., motion different on VMES vs. ESVs; AMSS are centrally controlled, VMES are not proposed to be. Please explain further how does* General Dynamics *expects VMES to be similar to Ku-Band ESVs and AMSS, and how will they differ?*

7. <u>Rules For Commercial Use</u>. The Petition (Page 1) says that VMESs will result in broader market driven deployment of broadband technologies, although the application is directed to only military test and training.

> - *Does this statement "market driven" imply multiple vendors and commercial use?*
> - *If* General Dynamics *envisions commercial use of VMESs, what rules would they change to provide protection to the neighboring FSS systems?*

8. <u>Data Logging</u>. General Dynamics asserts that there should be no detailed location data-logging rules applied to VMESs because of a lack of interference experienced from ESVs and VMESs and because of the existing capabilities of FSS operators to geolocate interference sources.

> - *Noting Qualcomm's comment that existing FSS geolocation is only capable of locating fixed interferers to within a few 10's of kilometers, can General Dynamics identify another potential method that could be used to identify which mobile VMES terminal was acting as an interference source, if things should go wrong?*

9. Other questions from current record:

> How would General Dynamics react if we limited the development of the antenna-size to larger than a minimum value?
>
> How would General Dynamics react to using a pointing restriction based on the beam-width of the antenna instead of the current, fixed 2 degrees.
>
> Does General Dynamics have any alternatives to minimum antenna size & peak pointing error?

POINTING AND TRANSMIT CONTROL FOR Ku-BAND SATCOM-ON-THE-MOVE ANTENNAS IN GROUND VEHICLE APPLICATIONS

James DeBruin
General Dynamics C4 Systems
Richardson, Texas
December 2006

1.0 INTRODUCTION

This report discusses pointing and transmit control for mobile Ku-band satcom-on-the-move (SOTM) antenna systems operating on ground vehicles. The primary focus is on the prevention of adjacent satellite interference due to antenna mispointing. Though much of this discussion is applicable to on-the-move antennas on other vehicles, such as for ships or aircraft, the ground vehicle environment is considered the most challenging from a pointing accuracy viewpoint and is thus emphasized here.

Six major topics are covered. The relation between antenna pointing and adjacent satellite interference is discussed in Section 2.0. Elements of the pointing system design are detailed in Section 3.0. The detection of pointing errors and subsequent transmit control are covered in Section 4.0. Performance verification of these systems are presented in Section 5.0. An overview of the on-the-move antenna systems produced by General Dynamics is found in Section 6.0. Finally, Section 7.0 provides a discussion of the principle failure modes relevant to vehicle mounted earth station (VMES) operations.

2.0 POINTING ACCURACY AND ADJACENT SATELLITE INTERFERENCE

To be practical, the apertures of on-the-move antenna systems must be smaller than one meter in size or they will just not be practical for ground vehicle applications. This size range is smaller than traditionally used for satcom applications in the commercial Ku band. As a result, the beamwidth of these small antennas is broad enough to disperse a significant amount of energy onto a satellite parked in the next orbital slot adjacent to the target satellite. The situation is made worse if the antenna is mispointed.

These effects are shown in Table 1 below. The table shows the signal strength on a satellite located 2.0 degrees away from the target satellite, relative to the peak signal strength of the main beam. A range of pointing errors is shown. The “zero degree error” column is the nominal, “on target” level. As can be seen, these values are significant. As such, e*ven if antenna pointing was always perfect,* transmit operation using these dish sizes and standard waveforms would be (and is) allowed only by operating the transmitting on-the-move antenna at reduced power levels.

Table 1 -- Signal Strength on an Adjacent Satellite Relative to Main Beam as a Function of Pointing Error in a Small Earth Station Satcom Antenna					
Aperture Diameter	**Pointing Error**				
	0.0°	**0.2°**	**0.4°**	**0.6°**	**0.8°**
18” (0.45m)	-5.3 dB	-4.2 dB	-3.2 dB	-2.4 dB	-1.8 dB
20” (0.50m)	-6.5 dB	-5.1 dB	-4.0 dB	-3.0 dB	-2.2dB
24” (0.60m)	-10.0 dB	-7.5 dB	-5.7 dB	-4.3 dB	-3.2 dB
30” (0.75m)	-16.0 dB	-12.0 dB	-9.0 dB	-6.7 dB	-4.8 dB

Controlling adjacent interference with reduced power levels alone is generally insufficient for on-the-move antennas. Presently, all practical, cost-effective mobile antennas use electromechanical pedestals to point the aperture to the satellite. These pedestals do not point perfectly. The effect of any mispointing is shown in the table. Note that a pedestal with a pointing accuracy of one degree over its entire range is “pretty good” in many, non-satcom applications, but not here, as such a pedestal would produce adjacent power levels roughly equal to on-satellite levels, regardless of dish size (This is another reason to control antenna pointing accuracy carefully. A mispointed antenna will suffer an on-target gain loss. Often the normal reaction to gain loss is to increase transmit power, which only exacerbates the adjacent satellite problem).

Given the ill-effects of antenna mispointing, a practical on-the-move antenna must have a *very* good antenna pointing system. However, it is not cost-effective to envision a pointing system that maintains precise antenna pointing in all imaginable ground vehicle environments. Such a system would suffer a very large increase in price for very little increase in system availability. As such, the practical solution is to produce a system with a pointing system at a reasonable price-versus-performance tradeoff point, and then equip this system with a reliable, accurate transmitter control function. Such a system will (1) reliably, rapidly, and accurately detect antenna mispointing levels, (2) disable the transmitter anytime the pointing error exceeds the maximum acceptable amount, and (3) re-enable the transmitter only after the pointing error is reduced to acceptable levels.

3.0 POINTING SYSTEMS

In the broadest sense, the pointing system of an SOTM antenna is the combination of hardware and software components that keeps the line-of-sight of the antenna directed to the target satellite. In a narrower sense, the term “pointing system” is often used to refer to a servo control system that points the antenna without tracking the target satellite. Tracking systems, by comparison, use some measure of signal strength from the satellite to maintain accurate satellite pointing. Understanding certain basics of these two methods of satellite pointing control is helpful to subsequent discussions of transmit control and system verification.

3.1 Point Mode

The use of an antenna pointing system that does not use satellite tracking is called operating in "point mode". A block diagram for point mode is shown in Figure 1. A collection of various magnetic, gravitational, and/or inertial sensors are used to measure the movement and orientation of the vehicle. The system controller then uses this information to produce commands to the gimbal controllers. The feedback sensors on the gimbal measure the actual gimbal response. This response is compared to the command to produce an error signal. The antenna controller is designed to minimize these errors within the cost, weight, and power constraints of the system design.

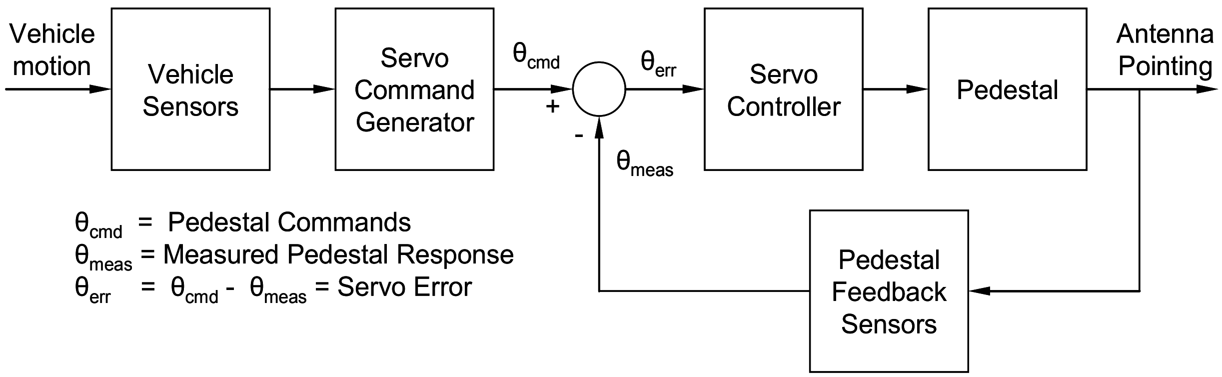


Figure 1 – Block Diagram of Open-Loop Pointing System Used in Point Mode

Operation in point mode is often referred to as *open-loop pointing*. This is because no satellite signal is used for feedback to close the pointing loop and to thus minimize errors. As such, systems that rely on point mode for on-satellite operation must be extremely well aligned and calibrated. Further, this high-degree of alignment accuracy must hold over temperature as well as wear and interchange of components. If the alignment does not hold in these circumstances, then the alignment and calibration routines must be exercised regularly to ensure to accuracy of the open-loop pointing system.

3.2 Track Mode

"Track mode" involves the use of a satellite tracker to maintain satellite pointing accuracy. Track operation begins with a point mode maneuver to position the antenna close to the satellite. When signal strength from the satellite is detected, the vehicle sensors are released and the tracking loop is engaged. A block diagram for the tracking loop is shown in Figure 2 below. Measurements of satellite signal strength are provided by the tracking receiver. The tracking processor detects any error in antenna pointing and generates pedestal commands such that the error is removed.

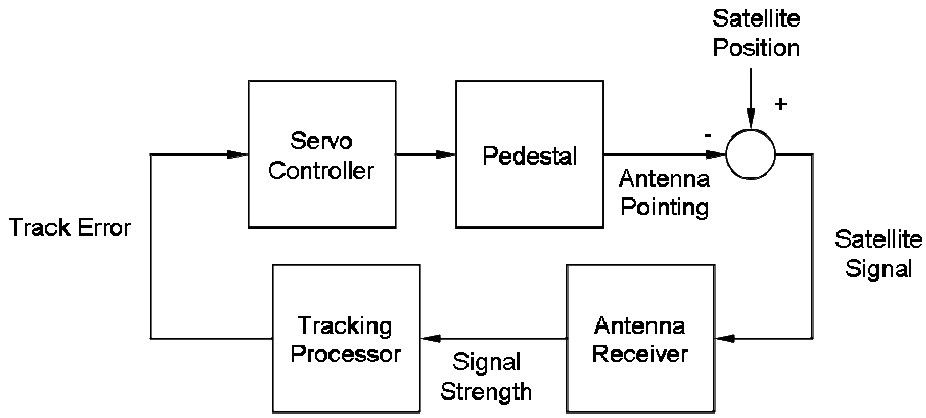


Figure 2 – Block Diagram of Tracking System

Unlike point mode, the tracking system does not require a high degree of alignment or calibration. Instead, the tracker continuously drives the pointing error to zero *regardless* of any misalignment or calibration errors. The advantage of the closed-loop tracking system over the open-loop pointing system is significant in this regard.

4.0 ERROR DETECTION AND TRANSMIT CONTROL

All antenna pedestals exhibit errors in pointing. A pedestal for a ground vehicle satcom antenna will be cost effective if the pointing errors are within acceptable limits most of the time and exceed these limits only under severe dynamic conditions, such as when hitting a pothole. This scenario is often acceptable to regulatory agencies and satellite operators if the transmitter is disabled anytime the pointing error is outside the boundaries. As it is, detection of pointing error is not all that easy. Further, some system configurations provide better observation to pointing error than others.

4.1 Error Sources and Error Detection in Point Mode

As an example, consider the pointing system shown in Figure 1. The major sources of system pointing error are as follows:

- Vehicle sensor static errors (such as offset and bias)
- Vehicle sensor dynamic errors (such as scale factor)
- Sensor-to-system alignment errors
- Pedestal alignment (boresight)
- Pedestal sensor static errors
- Pedestal dynamic errors (stabilization errors)
- Uncertainty of satellite location.

Figure 1 indicates that a servo error state, θ_{err}, exists within the system. This may at first consideration seem to be a convenient state to use for transmitter control. Unfortunately, this state does not reveal most of the errors in antenna pointing listed above for point mode. For instance, the servo error state has no observability to the alignment, boresight, or any of the sensor errors that exist in the system. As such, point mode is a useful mode only for systems in which the bulk of nominal system errors have been carefully controlled during manufacture and installation and/or accurately calibrated out. The real problem with this approach is that there is no observability within the system to the pointing errors that occur if system alignment and calibration is not accurate.

4.2 Error Sources and Error Detection in Track Mode

Tracking systems are not highly sensitive to alignment or calibration errors, so the list of major pointing error sources for tracking systems is much shorter:

- Tracking errors
- Pedestal dynamic errors (stabilization errors)

Figure 2 indicates that a track error state exists within the system. Unlike the servo error state of point mode, the track error state is a direct measurement of pointing error. As such, the track error can be used directly for transmit control. If the track error exceeds the pointing error limit, the transmitter is disabled. Since the presence of a track error drives the pedestal to move, the pointing error will be removed by the tracking feedback loop. At the point at which the pointing error is once again within the acceptable limits, the transmitter is re-enabled.

4.2.1 Limits of Using the Track Error for Transmit Control

There are two potential limits to the use of track error for transmit control. The first limit is the existence of inherent tracker error. Tracker error is mostly due to noise in the receive signal used for tracking. The second limit is the bandwidth of the tracker. Bandwidth is a measure of how quickly the tracker can respond to errors: the higher the bandwidth the faster the response. Thus, for rapid error response, the tracker bandwidth should be as high as possible. Unfortunately, high tracker bandwidths exacerbate tracker noise. As such, tracker bandwidths must be carefully set to minimize the total error.

As a result, the tracker error alone may not be sufficient for transmitter control. This is especially true for small-aperture terminals, which have a lower signal-to-noise level when compared to terminals with larger apertures. For small aperture terminals, then, additional techniques may be needed to augment the track error for transmit control. General Dynamics incorporates such techniques into their systems as necessary to provide accurate, reliable, and fast transmit control. Regardless of the techniques used, any system of transmit control must consider all error sources and must have traceable validity, as discussed in the next section.

5.0 PERFORMANCE VERIFICATION

Regulatory agencies and satellite operators are interested in the prevention of adjacent satellite interference. All systems employing a motorized pedestal for system pointing will exhibit pointing errors that exceed nominal limits. How often this occurs may be of less interest to the regulatory agencies and satellite operators than assurances that the error will be detected and that the transmitter will be shut off. If effective transmit control is the norm, then high-performance systems will have their transmitters on more often than low-performance systems, and the value of the increased or decreased availability will be left to the marketplace to decide.

Any method of transmit control will only be viable if all error sources are accounted for. Any technique that does not directly measure one or more error source must nonetheless account for this error in the control scheme. For example, a transmit control system that has no visibility to the error in a system sensor may still be viable if the pointing-error limits are tightened up to account for the errors in the sensor. The sensor error levels would have to be well characterized and controlled for this approach to work.

Verification of transmit control begins with an analysis of error sources in the system. Any error not observable by the error detection mechanism must be accounted for by calibration, alignment, or reduction in error thresholds. The effectiveness of calibration and alignment must be demonstrated, with the effects of temperature, wear-and-tear, and component replacement all considered. The error detection mechanism itself must be independently certified for accuracy. The terminal user will naturally be interested in how well the antenna holds pointing in the worst-case operational environment. In regards to verification of transmit control, however, the main issue is simply does the transmit control detection mechanism operate properly in all environment conditions.

The regulatory agencies and satellite operators are more likely than not to rely on self-reporting from the antenna equipment manufacturers to establish the viability of the transmit control mechanism within a mobile satcom antenna. The alternative is to establish guidelines for independent third-party testing of these systems. Whichever path is taken, a thorough evaluation of these systems is required to ensure compliance with the transmit control specifications.

6.0 GENERAL DYNAMICS ON-THE-MOVE SATCOM ANTENNAS

General Dynamics produces a line of ruggedized, high-performance terminals for use on military ground vehicles. These antennas were originally developed to the meet military specifications for off-road use. These specifications were defined by the operating conditions of the "Churchville B" off-road course at the U.S. Army Aberdeen Proving Grounds. (This is actually the test track that is used to determine acceptable survivability of the U.S. Army HMMWV vehicles. General Dynamics' SOTM antennas are designed not only to survive, but to operate under those conditions.) Providing a high percentage of on-satellite availability under Churchville B conditions requires a well-engineered pedestal and control system.

A computer simulation of the Churchville B course was used to drive the pedestal and control system design of the first General Dynamics on-the-move antenna. The first prototype of the antenna was shown to be compliant to the Churchville B conditions in motion table tests at Lincoln Laboratories in May of 2004. The six-axis Lincoln Lab motion table can repeatedly recreate the motion profile of the Churchville B course under instrumented conditions. The success of this test validated the General Dynamics simulation and design process. All subsequent on-the-move designs have used this same simulation technique to guide the design process.

Though military on-the-move antennas are intended for possible global deployment, the Churchville B specification is written in a way that requires the antenna to have 100% on-satellite availability when operating under Churchville B conditions within the continental United States. All General Dynamics on-the-move antennas meet this requirement.

The original on-the-move specifications used by General Dynamics contained no requirement for transmit control based on pointing error. This requirement first came from Intelsat. In August of 2005, as a condition for operating on one of the "Intelsat Americas" Ku-band satellites, Intelsat required that the transmitter of the General Dynamics on-the-move antenna system be muted anytime the pointing error exceeded 0.5 degrees in the orbital plane. General Dynamics implemented its first transmitter mute function in response to this requirement. This first transmit-control algorithm was based on the point-mode servo error, as discussed in Section 4.1. As a result, the method was blind to IMU, calibration, and alignment errors. As such, the error limits had to be tightened up to account for the unobservable errors. Though subsequent testing and operation provided acceptable availability levels, the shortcoming of this technique was immediately apparent and considered unacceptable from a competitive performance perspective.

General Dynamics has since developed an error detection technique that provides direct observability to pointing errors. This technique combines direct track and stabilization error measurements with IMU data to provide an optimum measurement of pointing error. In this way, both tracking and stabilization errors are directly accounted for. Further, the technique is highly independent of calibration and alignment issues. Essentially, the technique utilized takes into account the continuous attitude information provided by the IMU and calibrates it against the actual on-air antenna pointing information obtained through the closed-loop downlink tracking system providing both long-term and short-term perturbations. This technique provides accurate pointing error detection and transmit control without requiring that the allowable error limits be tightened to account for unobservable errors. This is the best of both worlds, as it provides effective transmit control yet gives the user the highest possible on-satellite availability.

The operation of transmit control in the General Dynamic system is shown in Figure 3. The data was taken with the antenna system mounted to a military HMMWV ground vehicle operating on-the-move in driving conditions even worse than “Churchville B”-- severe enough to cause pointing errors that exceed 0.5 degrees. The transmit control toggle is shown along with the plotted pointing error. The transmit control mutes the transmitter in under 100 milliseconds from the time the error threshold is first crossed. Note that the system responds rapidly to the error and quickly drives the line-of-sight back onto target such that the transmitter can be re-enabled.

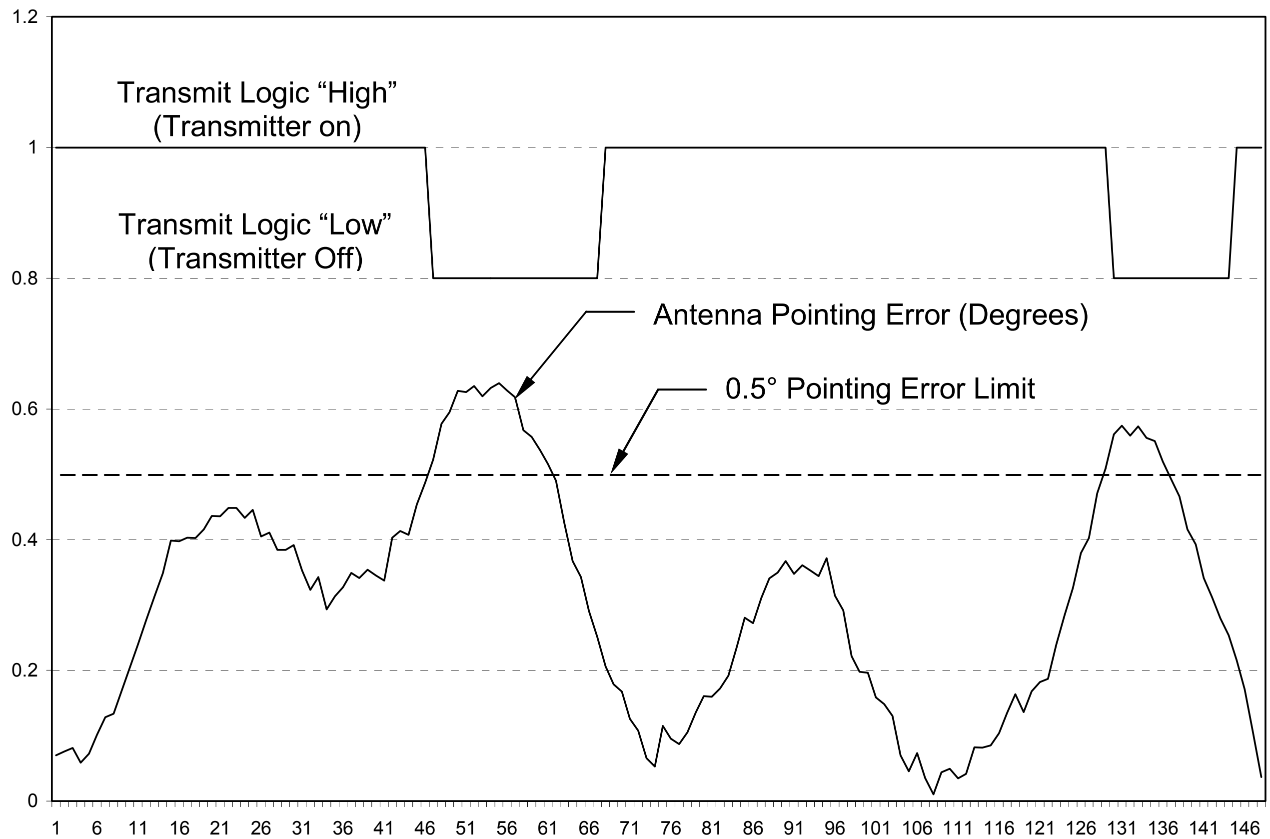


Figure 3 – Pointing error and transmit control for a General Dynamics ground vehicle antenna mounted to a military HMMWV. The lower curve is a plot of pointing error over time. The upper curve is a diagram of the transmit control logic. With logic “high” (scaled here to 1.0), the transmitter is on. With logic “low” (scaled here to 0.8), the transmitter is off. The time scale is a data packet count, not seconds. There are five data packets per second so time in seconds can be calculated by dividing the count number by five. Terrain conditions here, even worse than “Churchville B”, are severe enough to cause pointing errors to exceed the 0.5 degree limit. Pointing error is calculated 64 times per second. The transmitter is disabled within 100 milliseconds of the detection of excessive pointing error.

7.0 GENERAL DYNAMICS DISCUSSION OF FAILURE MODES

The Federal Communications Commission recently asked General Dynamics about anticipated failure modes and their frequency in this new class of Earth Station. In reality, the discussion of failure modes for such VMES terminals falls into two distinctly different areas:

- Failure of the Earth Terminal hardware or software to perform the designed function
- Failure of the Earth Terminal hardware to accurately point toward the desired satellite

An analysis of the potential operational impact of such Earth Stations should consider the ramifications of each of these different failure modes.

Probably the most straight-forward to consider is the potential failure modes of the SOTM terminal hardware. This can mainly be considered to fall into two distinct areas—failure of the hardware itself due to physical or environmentally-induced damage, or failure of the Earth Station electronics. General Dynamics has carefully designed the SOTM hardware to operate under extremely demanding environmental conditions—up to "Churchville B" shock and vibration and up to a full military temperature range of from approximately -40 to +50 Degrees C. These conditions should be considered fairly extreme in the entire range of potential operating environments. It should be noted, however, that they are not the absolute worst; temperatures could be even more extreme, and it is possible that the shock and vibration environment could be even worse than this. In such cases, it would be difficult or impossible for human operators to accompany the equipment when in operation. With this as the design environment, the terminal must demonstrate a satisfactory "Mean Time Between Failures" (MTBF) in that environment, and lesser environments could be considered fairly benign with no measurable impact on MTBF. So, there is a low probability of such an event taking place but some form of mechanical failure of the VMES assembly is possible. The potential failure modes include everything from the terminal simply locking in place and being unable to be further moved in one or more axis to individual components, like the antenna reflector, feed, or RF transceiver, physically falling off the VMES assembly. While very rare, and never experienced by General Dynamics, such events are possible. The only protection mechanism provided in the SOTM terminals to guard against the results of such failures is transmitter muting.

If the SOTM terminal does not conform, through its closed-loop tracking mechanism, to the required tracking accuracy, the transmitter is muted as described above. Virtually any failure in the downlink equipment chain should result in activation of the transmitter mute function and the transmitter should stay muted until suitable tracking accuracy is restored. (This would normally mean the equipment fault would be restored.) The only conceivable failure event that could cause the SOTM terminal to cause interference in this scenario would be the simultaneous mechanical failure of one or more elements of the terminal along with a tracking system/transmitter mute system failure. The simultaneous probability of two such events taking place is very low—likely even lower than the probability of failure of modern low-cost VSAT terminal hardware.

The other true failure mode would be an electronic equipment failure. As described above, the SOTM hardware and electronics are designed for a very hostile environment, but since all electronic equipment is less than perfect, the probability of such failures is non-zero. The most likely electronics equipment failure would result in blockage of either the downlink or uplink signal, which would tend to be self-muting because this would interrupt the SOTM terminal's ability to ensure that it is tracking the desired satellite and thereby trigger the transmitter mute function. (The probability of such an electronics equipment failure that would obstruct the transmit or receive function is exceptionally low, but is higher than the probability of failure of the Antenna Control Unit due to RF signal power levels involved.) There is also the possibility of a very low probability event that could cause a simultaneous tracking system failure accompanied by the failure of the transmitter mute function. While this is possible, it would require a significant combination of multiple faults in the Antenna Control Unit to trigger such an outcome. While this has an exceptionally low probability, it is still possible, although General Dynamics has yet to experience such a fault in any of our SOTM units, under development or operationally fielded. We believe the probability of such an event is about equivalent to modern VSAT terminal hardware failing to respond to a transmitter mute command. Such events are possible, but the VSAT industry has successfully demonstrated that they are very rare and tend not to result in significant interference complaints.

In the recent ESV rulings, the Commission wisely chose not to regulate the vast majority of specific actions that should be anticipated in the result of ESV hardware or software failure. Actual field operation of ESVs has demonstrated the wisdom of this choice, and General Dynamics believes the same approach should be useful in VMES operation.

The other “failure mode” which then must be considered is the inability of the SOTM terminal to accurately track the desired satellite. Ultimately, this has to be considered in terms of inaccurate tracking combined with satisfactory transmitter mute functionality.

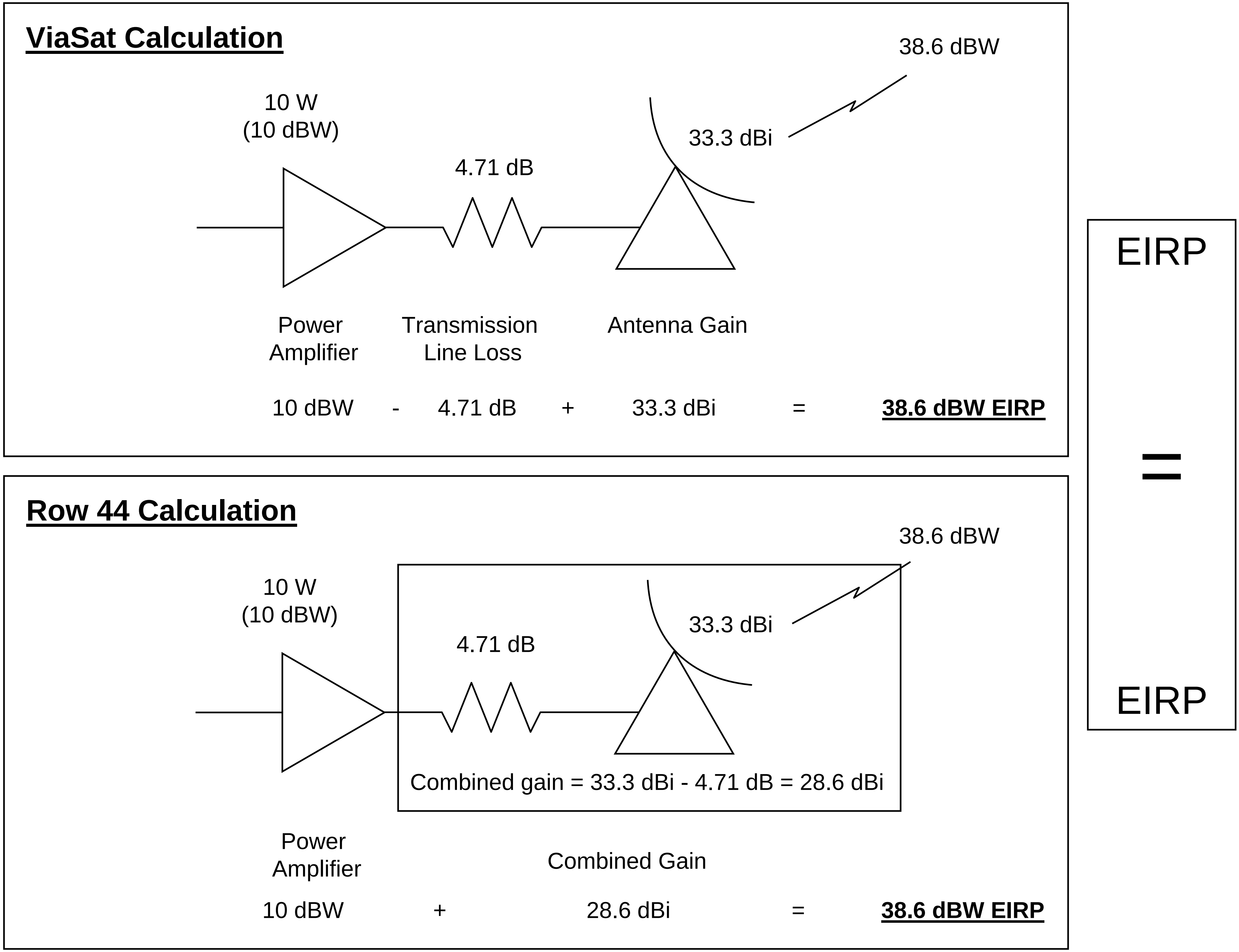
As described above, even the exceptionally difficult conditions described by the “Churchville B” shock and vibration specifications used by General Dynamics in the design of our SOTM terminals does not encompass all possible operating environments. Instead, it sets a very high standard for “most” VMES operations but recognizes that there are environments even worse to deal with. Suitable VMES operation can only be achieved by designing a terminal that can continue satellite communications even under the worst expected shock and vibration conditions. Terminals that do not meet that standard will be found by their users to be insufficient to support their communications needs. The design of a VMES terminal that could accurately track the desired satellite under any and all conditions would result in a terminal that is both too heavy and too expensive for virtually any user. Such a design would be completely impractical, so any real world system must be designed for a specific target environment, as done by General Dynamics.

Clearly, the major theoretical problem that could be encountered by VMES terminals would be an inability to achieve suitable tracking accuracy combined with improper operation of the transmitter mute function. General Dynamics has demonstrated that it is possible for the VMES antenna to be unable to move “fast enough” to satisfy extreme environments. Fortunately, we have also demonstrated that our transmitter mute function performs well enough to eliminate potential interference effects. In all the operations yet conducted by General Dynamics and our customers of our SOTM terminals, we have yet to identify a single such tracking failure that has resulted in the generation of an interference complaint. It is possible that such an event could occur, of course, but we believe the probability of such an event that is due to either an Antenna Control Unit failure or a simultaneous SOTM hardware and software failure to be low enough that it does not need to be dealt with separately.

Indeed, in the recent ESV rulings, the Commission wisely chose not to describe the anticipated failure modes or courses of action to be taken, other than local and remote transmitter mute functionality. We believe that same approach should be satisfactory in VMES operation. Since we anticipate a significant demand for VMES operation by military communications users who would be intolerable of a remote transmitter mute function, we respectfully request that the Commission consider such users in the VMES regulations. By imposing both an antenna pointing accuracy requirement and a transmitter mute function requirement, users must maintain sufficient operational control on VMES terminals such that interference to adjacent satellites could be eliminated. General Dynamics SOTM operation to date has demonstrated the wisdom of this approach, and we respectfully request that this clear standard be applied to future VMES regulations.

In conclusion, there are two distinct measures which must be considered in the evaluation of VMES terminals, and only one of these need be made a mandatory element of potential VMES regulations. Those two measures are the ability of a VMES terminal to provide satisfactory communications through an intended satellite and simultaneously the ability of the VMES terminal to avoid interference on adjacent satellites. The Commission need not include regulations pertinent to sufficient operation on the satellite of interest because the market should be free to decide the optimal solution today and adapt future technological upgrades as they become available. (As stated above, VMES terminals that do not achieve this level of performance “well enough” will likely not be embraced by users.) The other measure is inherent in one of the Commission's principal objectives: maximizing efficient use of precious RF spectrum resources while precluding interference to other users. In the ESV rulings, the Commission chose a minimal set of regulations that have demonstrated satisfactory for the various failure modes experienced by the ESV equipment itself. General Dynamics suggests that the VMES environment, while it may include higher terminal shock and vibration constraints, is essentially no different than ESV in anticipated failure modes.

EXHIBIT B


ViaSat Calculation
38.6 dBW
10 W
(10 dBW)
33.3 dBi
4.71 dB
Power
Amplifier
Transmission
Line Loss
Antenna Gain
10 dBW - 4.71 dB + 33.3 dBi = 38.6 dBW EIRP
Row 44 Calculation
38.6 dBW
10 W
(10 dBW)
33.3 dBi
4.71 dB
Combined gain = 33.3 dBi - 4.71 dB = 28.6 dBi
Power
Amplifier
Combined Gain
10 dBW + 28.6 dBi = 38.6 dBW EIRP
EIRP
=
EIRP