## Attachment 1

## Technical Description

### Network

The proposed aeronautical earth stations in motion (ESIMs) will operate in the same ViaSat-2 Ka-band network, using the same frequencies and access method, as residential customers using the fixed VSAT equipment authorized under call sign E170088. This network incorporates the functions necessary to support mobility into the management functions of the AfterBurner multi-frequency time division multiple access (MF-TDMA) waveform technology operating on the network. The network allows the aircraft to fly across the service area and seamlessly switch from spot beam to spot beam within the current operational satellite and to switch between satellites as coverage dictates. The transmitted bursts from the ESIMs use the same return link channels as used by the millions of residential terminals and represent just another burst out of many on any given return channel frequency.

Because the AfterBurner architecture employs adaptive coding and modulation, the terminals could transmit at any code and modulation point within the library of available choices. The available symbol rates are 5 mega-symbols per second, or megabaud (MBd), 10 MBd, 20 MBd, 40 MBd, 80 MBd, 160 MBd, and 320 MBd.

The AfterBurner architecture is designed to operate at the lowest power density modulation and code point that allows the link to close. The network employs adaptive power control and reduces power when conditions permit, keeping the Es/No margin at 1 dB or less above the intended operating point. When the modem has sufficient excess transmit capability, it will automatically switch to the next higher symbol rate and increase data rate, keeping the e.i.r.p. density at the minimum. This further reduces the likelihood that the system will impact traffic on other satellites.

### Antenna and Pointing Accuracy

The Mantarray antenna used in this application is a low profile waveguide horn array. The same Mantarray mechanically steered waveguide horn array antenna aperture is used for both earth stations in this application. The initial earth station using this antenna was the Mantarray M40, which uses a 4 W PA and is capable of operating over the 28.1-30 GHz band. The second generation earth station using the Mantarray aperture is the Global Mantarray GM40. This earth station has an increased power amplifier output of 31.6 W and is capable of operating over the 27.5-30 GHz range. The “40” designation in the Mantarray M40 and Mantarray GM40 model name reflects the number of feed horns across the width of the aperture.

As the GM40 and the M40 share the same Mantarray aperture design, they have the same antenna pattern, and the principal differences between the two earth stations are power output and tuning range. Due to its lower PA output power and higher loss between the PA and aperture, the M40 antenna is only capable of operating over a limited number of the available AfterBurner symbol rates, whereas the GM40 with its higher power output supports the full range symbol rates used with the ViaSat-2 AfterBurner waveform. Because the higher power of the GM40 is spread over a wider frequency range than the M40 at the higher symbol rates supported by the GM40, the resulting EIRP density of the GM40 is the same or less than the M40.

The maximum clear sky e.i.r.p. density in Form 312 for the M40 uses the 5 MBd rate and for the GM40 is the 80 MBd rate. For both antennas, this results in the same 12.5 dBW/4 kHz maximum e.i.r.p. density. However, nominally, the earth stations will use either the next step higher symbol rate—10 MBd for the M40 and 160 MBd or 320 MBd for the GM40 as conditions permit, with the 5 MBd and 80 MBd symbol rates being used primarily in beam edge of coverage conditions. In the case of the GM40, the remaining lower symbol rates will be used only when links are degraded to mitigate the effects of rain and atmospheric conditions.

Both versions of the Mantarray antenna will be fuselage mounted typically as depicted in Figure 1 and will be covered by a radome.[1]

The terminal is directed toward the intended satellite by the antenna control unit (ACU), which receives input data from the inertial reference unit (IRU) that is part of the avionics navigation system of the aircraft. This input includes information, such as the current latitude, longitude, altitude, pitch, roll and yaw. The antenna control unit uses this information to calculate the initial pointing angles and polarization for the antenna to the desired satellite. Once the required pointing angles have been determined, the ACU will drive the antenna to the desired position and the modem will attempt to acquire the receive signal from the satellite. When the signal is received and the modem is able to properly identify and demodulate the carrier, the antenna will enter a closed loop tracking mode.

[1] The same radome may also house a receive-only antenna for DBS satellite TV services. The DBS satellite receive-only antenna and service are not associated with, or part of, this application.

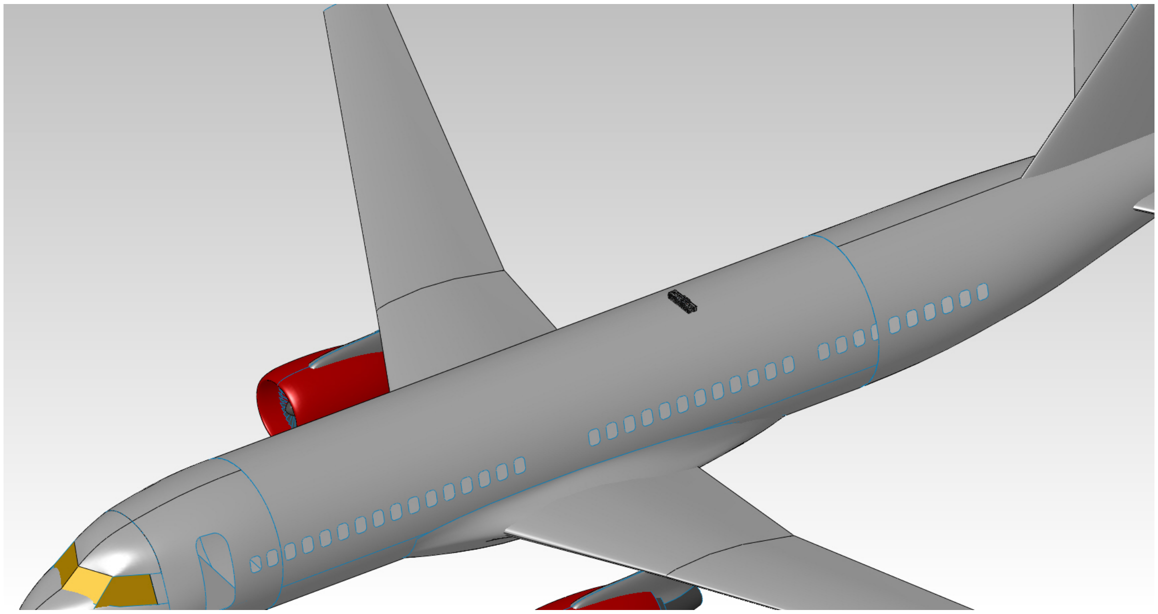

**Figure 1 – Typical Antenna Mounting Location**

By performing closed loop tracking, the ACU is able to properly account for any installation alignment differences between the IRU / airframe and antenna, as well as bending of the aircraft body on the ground or in flight. The antenna system also incorporates local rate gyros to mitigate latency between the IRU and the Mantarry ACU and further improve pointing accuracy.

The mean pointing error is 0° in both the azimuth and elevation directions and the standard deviation (σ) for each axis is given in Table 1 along with the peak pointing error (3σ or 99.73%). The pointing error values are different in the azimuth and elevation directions because the arrays are wider than they are tall. The Mantarray has a 5:1 width to height aspect ratio and accordingly the elevation beamwidth is wider than the azimuth beamwidth by the same factor. Likewise, the target standard deviation for pointing accuracy follows the same ratio.

The antenna control unit monitors the current and intended pointing directions, and if the error limit in either the azimuth or elevation axis is exceeded, the transmit output from the modem is inhibited in less than 100 ms (20 ms typical). The pointing error threshold is programmable for each axis, and Viasat proposes to inhibit transmissions should the pointing error exceed 0.5° in the azimuth direction, or 1.35° in the elevation direction. Because the 3σ pointing error is only ±0.27º in azimuth, the system should not inhibit due to azimuth pointing errors. Elevation pointing error should only cause the antenna to inhibit transmit less than 0.27% of the time.

| 1σ | | 3σ | | Limit | |
|---|---|---|---|---|---|
| Azimuth | Elevation | Azimuth | Elevation | Azimuth | Elevation |
| ±0.09° | ±0.45° | ±0.27° | ±1.35° | ±0.5° | ±1.35° |

**Table 1 – Pointing Error**

## Antenna Patterns

The antenna patterns generated by the Mantarray antenna differ from those typically encountered when considering circular or mildly elliptical reflector type antennas. The patterns are characterized by a narrow main beam and a line of sidelobes in the azimuth axis, a wide main beam and line of sidelobes in the elevation axis, and relatively low amplitude sidelobes elsewhere. Figure 2 depicts an X-Y view of the azimuth and elevation patterns when looking directly into the boresight of the antenna. The figure illustrates the lobes that exceed the Section 25.138 mask in some respects.

Notably, there are four grating lobes in the transmit antenna patterns that are well removed from the main lobe. These grating lobes are present at the geostationary satellite orbital (GSO) arc only for a limited range of skew angles centered around approximately 25º of skew. The location and amplitude of the grating lobes is a function of transmit frequency and typically are between 25 and 35 degrees off axis from the main lobe. A 25-degree skew cut pattern showing the magnitude of these grating lobes is also included in Exhibit B. While the amplitude of these grating lobes when operating at the highest clear sky e.i.r.p. is as much as 5 dB above the 25.138 off-axis e.i.r.p. density mask, the location of these lobes with respect to the GSO arc is such that the lobes do not intersect the GSO arc except when the aircraft is located in a limited number of geographic areas. Viasat has analyzed the potential impact to the spacecraft at the affected locations and found the actual level of interference to be minimal—less than 2% $\Delta T/T$ at the nominal symbol rate of 160 MBd, and less than 4% $\Delta T/T$ at the lowest clear sky symbol rate of 80 MBd, in the case of the GM40.

Figure 2 depicts the grating lobes as viewed looking into the boresight of the antenna. The three colored dotted lines represent the GSO arc from the perspective of the terminal at three different geographic locations: Red is Carlsbad, CA, Green is Denver, CO, and Blue is Germantown, MD. The dots on each line represent satellites along the GSO arc at 2 degree longitude increments.

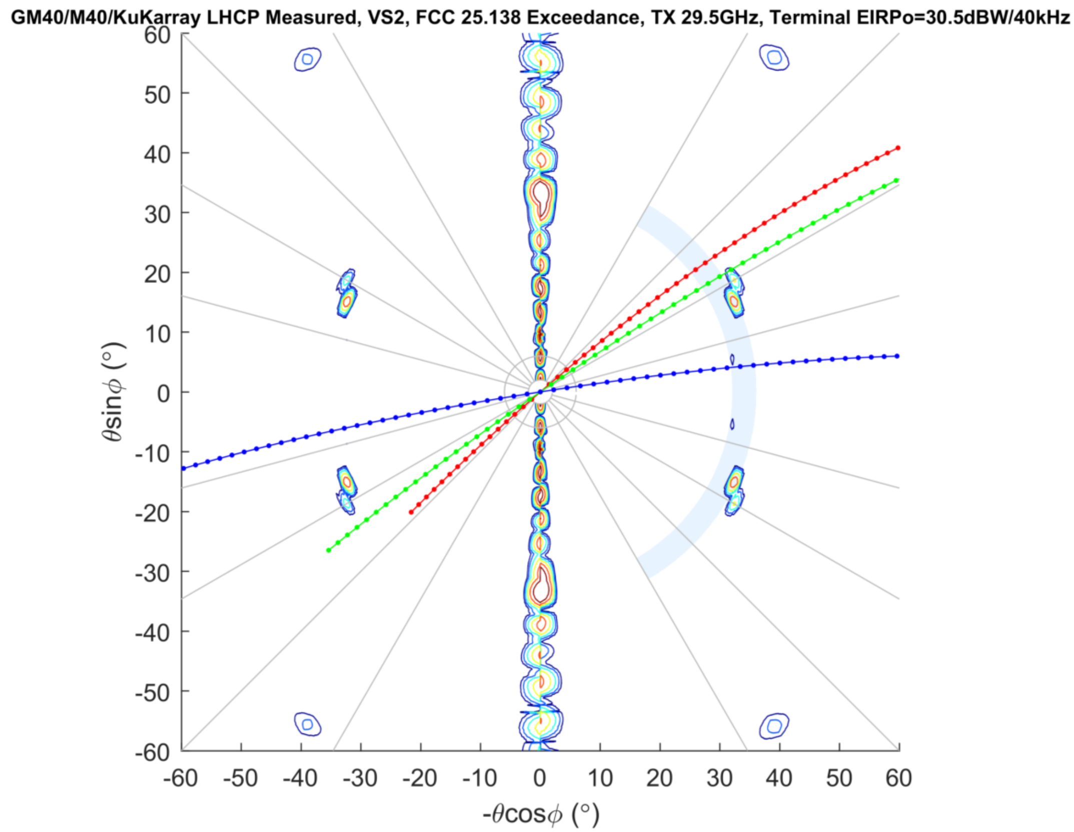


**Figure 2**

The only GSO satellites potentially affected by the grating lobes are the DirecTV satellites operating at the 99º -103º WL nominal orbital locations and are 29-33 degrees away from ViaSat-2. Viasat has previously coordinated the operation of the Mantarray M40 antenna with this satellite operator, and because the Mantarray GM40 antenna uses the same radiating aperture and operates at the same or lower e.i.r.p. density as the Mantarray M40 antenna there is no increased risk of interference. Nevertheless, Viasat is in active discussions with the operator to add the new antenna to the existing coordination agreement and does not expect any new issues.

Because the width of the main lobe of the antenna increases between the azimuth and elevation axes as the antenna is rotated around the boresight, the alignment of the major axis of the antenna with the GSO must be considered. As the geographic location of the aircraft moves away in longitude from the longitude of the satellite (69.9º for ViaSat-2), the GSO arc appears skewed with respect to the local horizon of the AES antenna. This skew angle is also affected by the banking of the aircraft while in flight. Viasat has evaluated the worst case skew angle within the operational service area of the AES antenna and determined it to be less than 50 degrees. The Mantarray antenna is fully compliant in the main lobe with the 25.138(a) mask for the GSO arc up to a skew angle of 60 degrees. Accordingly, the Mantarray antenna control unit monitors the skew and bank angle, and will automatically reduce power or inhibit transmissions if the combination of bank angle and geographic skew would result in exceeding the authorized or coordinated EIRP density at any applicable adjacent orbital locations.

**NGSO Sharing Analysis**

Because the Mantarray antenna patterns have a wider than typical radiation pattern in the elevation (90° skew) plane, and present more energy than typical in the plane perpendicular to the GSO, Viasat also conducted an interference analysis for the various NGSO systems which participated in the recent Ka band processing round.

Of these NGSO systems, the technical parameters of both Mantarray antennas are within the scope of Viasat's existing coordination agreement with OneWeb, and Space Norway does not have coverage over the license area.

Analyses were performed for Audacy, Boeing, Karousel, Leosat, O3b, Theia, Telesat, and SpaceX using the information in the Schedule S and technical narratives of the applications of the NGSO operators and using the technical characteristics of the Mantarray from this application. The analysis for each system was conducted using the Visualyse Pro analysis software available from Transfinite Systems Ltd.

In the software simulation, an ESIM was placed at the center of the NGSO's receiving beam next to a presumed gateway earth station of the NGSO system. The orbit of the NGSO was propagated over a 30 day period while the ESIM transmitted using a typical duty cycle, as required to support commercial aircraft services in order to generate I/N statistic over time.[2] While parked aircraft are technically temporary-fixed earth stations, not ESIMs, the emissions are the same as if the aircraft were flying a holding pattern around the NGSO gateway station. This simulation was performed to develop worst-case I/N and interference statistics.

When the aircraft are in flight, they will normally transit through a typical NGSO receiving beam in a relatively short period of time. A nominal cruising speed of 250 m/s represents a cruising speed of 560 miles (902 km) per hour. Accordingly, an aircraft typically spends less than an hour in any given NGSO receiving beam. To simulate the effects of an ESIM transiting an NGSO receiving beam, an ESIM was configured in the simulation to travel between two points on either side of the receiving beam. The ESIM then was then flown forth and back repeatedly throughout the simulation duration.

While long- and short-term interference criteria have not yet been established for these NGSO systems, a reasonable benchmark to check for the presence of interference is the 6% ΔT/T coordination trigger. This value is equivalent to an I/N of -12.2 dB and represents an increase in the noise floor of the receiver of just 0.25 dB. In the

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[2] Due to the large number of similar orbital planes, the SpaceX simulation was only run for 24 hours.

case of GSO networks, this is also the long-term criterion for interference from an adjacent satellite network that could be received 100% of the time. So, if received I/N levels are less than the -12.2 dB, coordination is not required in the case of GSOs. If received I/N is greater than -12.2, but only for brief intervals and for a very small percentage of time, the brief noise floor increases are generally considered short-term interference, which are typically acceptable.

The results show that for the NGSO system most sensitive to the elevation beam of the Mantarray, the time statistics for percent of time less than -12 dB I/N increases from 99.995% to 99.9994%, and the worst case I/N is reduced 3 dB in this scenario where the aircraft is flying at normal cruising speeds through the receiving beam. This is as reasonably expected because the aircraft is not in the beam full time, and when it is in the beam, it is not always at the beam center when transmitting. Received interference is reduced by the roll-off of the receiving beam pattern over the coverage area.

**Table 2: Simulation Results for the Various NGSO systems.**

| System | -12.2 dB I/N Exceeded | % Time | % of time meeting -12.2 dB | Worst I/N (dB) | Total Exceeded (s) / month | Longest Event (s) |
|---|---|---|---|---|---|---|
| Audacy | No | 0 | 100.000 | -60.00 | 0 | 0 |
| Boeing | No | 0 | 100.000 | -19.00 | 0 | 0 |
| Karousel | No | 0 | 100.000 | -23.00 | 0 | 0 |
| Leosat | Yes | 0.000965 | 99.9990 | -2.72 | 26 | 1 |
| O3b | Yes | 0.000116 | 99.9999 | -1.13 | 3 | 1 |
| SpaceX | Yes | 0.000579 | 99.9994 | -4.68 | 15 | 1 |
| Telesat | Yes | 0.000270 | 99.9997 | -6.70 | 8 | 1 |
| Theia Holdings | Yes | 0.000154 | 99.9998 | -7.46 | 4 | 1 |

These simulations use a single ESIM in either the stationary or moving scenarios, which is a realistic representation of the actual operation of a larger number of ESIM terminals in the entire network, because these networks use MF-TDMA as described below. As described above, the ViaSat-2 GSO satellite network employs MF-TDMA as an access method for the various residential user terminals and for the ESIMs accessing the satellite. In a time division multiple access system, only one station may transmit on a given frequency and polarization within a beam at a given time. Each station transmits for a brief time and then another station transmits and so on. There may be gaps or pauses between transmissions depending upon network loading, but two stations never transmit on the same frequency at the same time.

In the case of multi-frequency TDMA, a given station may dynamically change frequencies as directed by the network controller and transmit on frequency A for burst 1, frequency B for burst 2, and so on, or the station may transmit on frequency A for burst 1 and burst 2, and remain on that frequency indefinitely—choice of frequency allocation and time slots are up to the network management system. As with the residential earth stations which operate under E170088, regardless of how many aircraft are flying through the same ViaSat-2 beam at a given time, only one earth station, residential or ESIM, will transmit on the same return link channel frequency at a time. Therefore, having a single ESIM in the simulation co-located with an NGSO gateway 24/7 is representative of the highest possible interfering power because no two earth stations, and certainly no two aircraft, will burst at the same time and aggregate their energy. Thus, the I/N recorded in the simulation for an aircraft in the beam center of the NGSO receiving beam represents the highest expected at any time

While ViaSat-2 has many beams, these beams have a frequency and polarization reuse pattern such that it is unlikely that any two adjacent beams which might fall inside the area of a given NGSO receiving beam will be both co-frequency and co-polarization. While there maybe be two ESIMs transmitting, one in one ViaSat-2 beam and one in the other ViaSat-2 beam, the two ESIMs will not be operating on the same frequency and polarization due to the frequency reuse pattern of ViaSat-2. Therefore, it is very unlikely that transmissions from adjacent ViaSat-2 beams will result in the aggregation of interference into the receiving beam of an NGSO satellite.

Lastly, as described above, while only a single ESIM may transmit at any given time, multiple ESIMs may transmit one after the other, effectively increasing the percentage of time interference is received on a given frequency—this does not, however, increase the I/N, just the percentage of time in which it might occur. With the exception of operation near airports, ESIMs are generally well distributed throughout a satellite receiving beam. The alignment between the Mantarray antenna on each aircraft and the NGSO satellite will be different give the various geographic locations of the ESIMs. Accordingly, even though multiple stations may burst one after the other in a receiving beam, the elevation beam of each ESIM will not align with the NGSO satellite and some of those bursts will not contribute toward effectively increasing the duty cycle. As noted in Table 2 above, several NGSO systems have worst case I/N values much lower than -12 dB I/N, and where a NGSO network's worst case I/N is -12 dB or greater, the percentage of time for a single aircraft is very low—in the region of < 99.999% of the time. In those cases, even a theoretical one hundred fold increase in the number of aircraft transmitting one after the other still only raises the likelihood of hitting a -12 dB I/N to < 99.9% of the time.