**Analysis of Potential Interference to Iridium Feeder Links in the frequency band 29.25-29.3 GHz from Telesat's Telstar-12V Gateway at Mt. Jackson, VA**

## Introduction

In this application, Telesat requests authority to transmit in the 29.25-29.3 GHz band. Since this band is allocated in the United States on a co-primary basis to both GSO FSS and feeder links to NGSO MSS, Section 25.203(k) requires a demonstration that the proposed earth station will not cause unacceptable interference to any other satellite network that is authorized to operate in the same frequency band.

A search of the IBFS database shows three earth stations that are authorized to use the 29.25 to 29.30 GHz band as feeder links for NGSO systems: Tempe, Arizona[1]; Fairbanks[2], Alaska; and Wahiawa, Hawaii[3]. All three stations show the Iridium constellation as a Point of Communication, and we refer to them as "Iridium-facing" earth stations.

The following analysis shows that the distance between each of these sites and the Mt. Jackson site precludes the possibility of any potential interference between the Mt. Jackson earth station and the Iridium network.

## Line-of-Sight Distance of Iridium Spacecraft

First, one must consider the maximum line-of-sight distance from an Iridium NGSO spacecraft to an earth station on the surface of the earth. This is the distance to the horizon from the spacecraft, given by the formula:

$$d = \sqrt{2Rh + h^2}$$

Here *d* is the distance to the horizon from the spacecraft, *R* is the Earth's radius, and *h* is the altitude of the spacecraft. Substituting the values *R*=6371 km, and *h*=871 km (the altitude of Iridium's NGSO orbit) gives a value of *d*=3443 km. To convert this value to the distance along the Earths' surface, *s,* from the point directly below the satellite to the horizon, the following formula applies:

[1] Call Sign E960131
[2] Call Sign E050282
[3] Call Sign E980049

$$s = R \tan^{-1}\left(\frac{d}{R}\right)$$

Substituting the values provides a value of *s* = 3157 km. This means the great-circle distance between the sub-satellite point of an Iridium spacecraft and an earth station must be less than 3157 km for there to be line-of-sight between the two.

## In-Line Event Analysis

We now consider the location of an Iridium spacecraft when it experiences an *in-line event* with the Mt. Jackson earth station. This occurs when an Iridium spacecraft passes directly between the bore of the Mt. Jackson earth station and Telstar-12 Vantage at 15°W, subjecting the spacecraft to peak interference. Simulations of the Iridium orbits in the *System Tool Kit (STK)* software package indicate that the sub-satellite coordinates of an Iridium spacecraft when experiencing an in-line event are (28.196 N, 58.773 W). This point falls over the Atlantic Ocean.

The Fairbanks earth station is located at (64.818 N, 147.724 W), Tempe at (33.342 N, 111.897 W), and Wahiawa at (21.519 N, 158.017 W).

The great-circle distances from these three earth stations to the location of the in-lineevent are, respectively, 7144 km, 5054 km, and 9742 km. This means that at the point when any Iridium spacecraft is exposed to peak emissions from Telesat's Mt. Jackson earth station the spacecraft cannot be receiving a signal from any earth station in the United States that is licensed to communicate with the Iridium constellation in the 29.25 – 29.3 GHz band. Therefore harmful interference is not a possibility.

## Interference Region Analysis

Next, we calculate an upper bound on the maximum off-bore angle, φ, from the Mt. Jackson antenna, where the interference power from Mt. Jackson is significant relative to the feeder link signal an Iridium spacecraft receives from an Iridium-facing ground station. Significant interference is defined here as having a minimum power density 30dB below that of the Iridium signal. We start with the assumption that the Iridium spacecraft has line-of-sight to an Iridium-facing ground station while passing along its orbit at the point where it is φ degrees off-bore to Mt. Jackson, and after carrying out the calculation check whether this assumption is accurate.

Since the value of φ calculated is an upper bound, it is reasonable to use upper bounds on the interference power and lower bounds on the signal power. Both of these approximations will serve to over-estimate the value of φ where the interference is significant. Below is a list of simplifying assumptions in keeping with this approach:

- The free space loss from the Iridium-facing earth station to the Iridium spacecraft at the point where it is at φ degrees off-bore to Mt. Jackson is the same as when it is at the in-line point (in reality the free space loss will be less when the spacecraft is at a position closer to the uplink)
- The spacecraft antenna will be oriented on-bore to both the Iridium-facing ground station and Mt. Jackson (in reality it would only be on-bore to the Iridium uplink, and have some discrimination angle towards Mt. Jackson)

The following is a list of values used for the Mt. Jackson earth station:

- Maximum input power density at antenna flange: -66 dBW/Hz (the value used to calculate EIRP densities in the application)
- Antenna gain at an angle φ greater than 1 degrees off-bore: below 29-25 log (φ) dBi (from measured transmit antenna patterns)
- Distance from antenna to intersection with Iridium orbit: 2191 km (from *STK* simulation)

The following values used are sourced from a technical showing by DirecTV filed with the FCC[4]

- Minimum uplink EIRP density of Iridium feeder link: -21.4 dBW/Hz
- On-bore gain of Iridium spacecraft antenna: 30.1 dBi

The following table calculates the received signal and noise power density, as a function of φ, at an Iridium spacecraft. The free-space loss for the Iridium signal is calculated for the case where the signal originates at the Tempe uplink, which is the closest one to the in-line point.

| | **Iridium Signal** | **Mt. Jackson Interference** |
|---|---|---|
| Transmitted EIRP Density (dBW/Hz) | -21.4 | -66+29-25 log (φ) |
| Path Loss to spacecraft (dB) | 195.9 | 188.6 |
| Iridium spacecraft antenna gain (dBi) | 30.1 | 30.1 |
| Power Density Received (dBW/Hz) | -21.4-195.9+30.1 =-187.2 | -66+29-25 log (φ)-188.6+30.1 =-195.5-25 log (φ) |

[4] SES-MFS-20111104-01315, Attachment Exhibit A [Mod Nar]

| | |
|---|---|
| C/I (dB): Iridium signal to Mt. Jackson Interference | =-187.2-(-195.5-25 log (φ))<br>=8.3+25log (φ) |

Setting the C/I expression to 30 dB and solving for φ, gives φ =7.4°.

This value of φ defines a circle, centered at the point of the in-line event and parallel to the surface of the Earth, where interference from Mt. Jackson is significant. The distance to a point on the circle is 871 km, the altitude of the Iridium orbit. Therefore, the radius of the circle is 871*$\varphi_{rad}$ where $\varphi_{rad}$ is the value of φ in radians. The radius is calculated as 112 km.

This means that when an Iridium spacecraft passes through any point within this circle, its distance to an Iridium earth station is reduced, by, at most, 112 km relative to the distance from the in-line event point. Subtracting 112 km from the previously calculated distances from the in-line-event point to the Iridium-facing earth stations (7144 km, 5054 km, and 9742 km), results in distances that are still well beyond the Iridium line-of-sight distance of 3157 km.

Conclusion

Any Iridium satellite passing through the area sufficiently close to the Mt. Jackson earth station where it could receive harmful interference cannot in fact be affected since the Iridium satellite within that area would be unable to receive a signal from any licensed Iridium-facing uplink.