Analysis of Potential Interference to the Iridium Feeder Links in the 29.25 – 29.3 GHz band from Boeing Satellite uplinks

1. Background

The frequencies of the Boeing system (call sign E100106) and the Iridium system overlap in the frequency band 29.25 – 29.3 GHz. Iridium's gateway earth station in Tempe, Arizona operates earth-to-space feeder links and TT&C links in this band which are co-primary with Boeing's ongoing operations. As the Iridium satellites orbit the earth at an altitude of 775 km, they will at times transit the uplink beam of the Boeing earth station directed towards a geostationary satellite.

For simplicity and consistency, some of the data used for this analysis was obtained from a similar DirecTV filing (SES−MFS−20111104−01315, November 4, 2011).

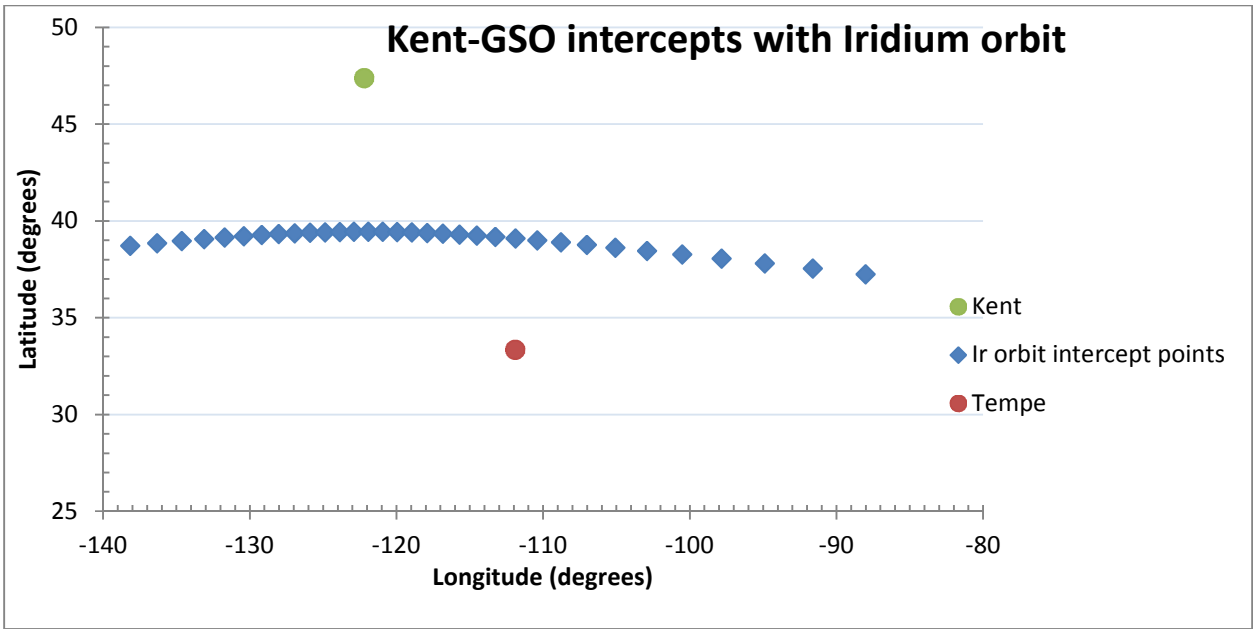
2. Analysis

The Boeing and Iridium earth stations are located are as follows:

	City	Latitude, Longitude
Boeing	Kent, WA	47.42° N, 122.25° W
Iridium	Tempe, AZ	33.34° N, 111.90° W

The Kent and Tempe earth stations are separated by 1,793 km. This contrasts sharply with the previously mentioned DirecTV analysis in which the earth stations were separated by only 168 km.

The Kent earth station can see the GSO orbital arc from about 160° E to about 45°W. The line-of-sight (LOS) from Kent to these GSO slots would intersect the 775 km Iridium orbital altitude at the latitude/longitude locations shown in the following figure, assuming a minimum elevation angle for visibility from Tempe of 5°.



(Not to scale)

Figure 1. Kent-GSO intercepts with Iridium orbit

Over this range of intercept points, the off-axis angle at the Iridium satellite ranges from 32.8° to 92.8°. These relatively large values of off-axis angles occur because Kent and Tempe are far apart. For any off-axis angle greater than 30°, the Iridium satellite antenna discrimination will be 40.1 dB, as shown in Figure 2.

For example, the LOS from Kent to a GSO longitude of -161° would intersect the Iridium orbital sphere at 39.1, -133.1 latitude, longitude. For an Iridium satellite at this orbital position, with its antenna pointed at Tempe, the ES at Kent will appear at an angle of 52.0° off the mainbeam axis of the Iridium satellite antenna. From the antenna mask graph in Figure 2, this will yield an antenna discrimination of 40.1 dB.

For this location, the C_0/I_0 can be calculated as shown in Table 1, using information from the DirecTV analysis and the current Boeing authorization. Boeing operates the transmitter in a laboratory environment for preliminary design and demonstration projects. In addition, any transmission from Kent, Washington will be subject to occasional rain fades. For these reasons, both a maximum and nominal calculation are given in the table.

	Max signal		Nominal Signal	
	Tempe signal	**Kent signal**	**Tempe Signal**	**Kent Signal**
eirp (dBW)	43.50	73.9	43.50	59.3
bandwidth (MHz)	4.00	29.0	4.00	4.4
eirp density (dBW/Hz)	-22.5	-0.7	-22.5	-7.1
Path loss (dB)	-188.8	-185.6	-188.8	-185.6
Ir satellite gain (dB)	30.1	-10.0	30.1	-10.0
power density received	-181.2	-196.3	-181.2	-202.8
C_0/I_0	15.1	--	21.5	--

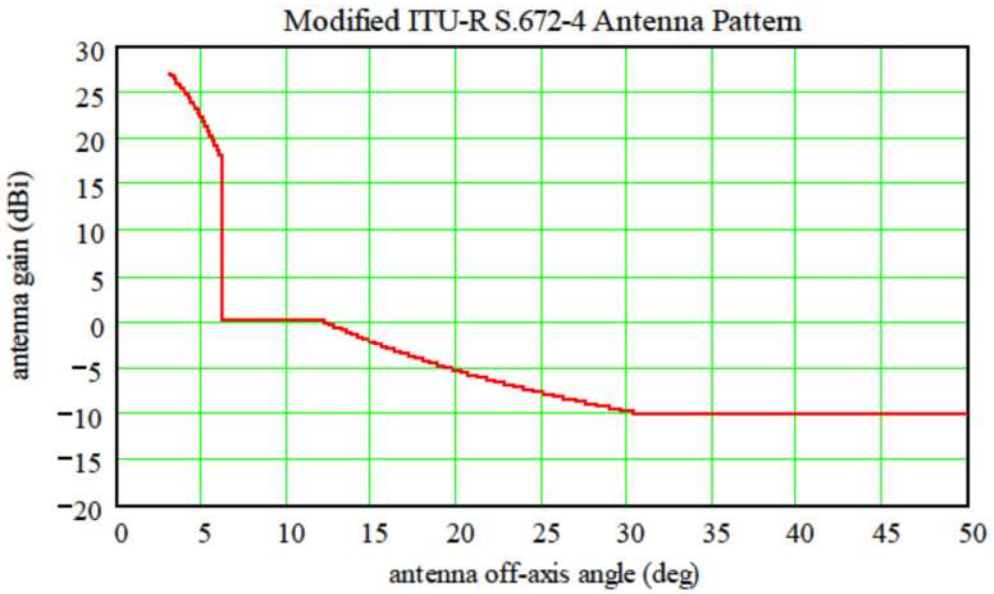
Table 1. Example C_0/I_0 calculation

As can be seen, for this location, the C_0/I_0 is 15.1 and 21.5 dB for the max and nominal cases. These are the minimum values for these two cases experienced over the range of orbital longitudes. Similar to the DirecTV study, even this level would occur for only a very small fraction of the time as the Iridium satellite quickly traverses the Kent earth station's narrow antenna beam.

Over the range of orbital slots visible to Kent, the C_0/I_0 changes little because the relative geometries change very little. The values are shown in the Table 2 for selected GSO orbital locations. As can be seen, the proposed ALSAT designation is compatible with the Iridium system for all of the possible orbital locations.

GSO Longitude	Latitude, intercept	Longitude, intercept	Off-axis angle(deg)	Discrimination	Co/Io, max	Co/Io, nominal
-173.0	38.7	-138.1	41.7	-10.0	15.2	21.6
-169.0	38.8	-136.3	45.1	-10.0	15.2	21.6
-165.0	39.0	-134.6	48.5	-10.0	15.1	21.5
-161.0	39.1	-133.1	52.0	-10.0	15.1	21.5
-157.0	39.1	-131.7	55.5	-10.0	15.1	21.5
-153.0	39.2	-130.4	59.0	-10.0	15.2	21.6
-149.0	39.3	-129.2	62.5	-10.0	15.3	21.7
-145.0	39.3	-128.0	66.0	-10.0	15.4	21.8
-141.0	39.4	-126.9	69.4	-10.0	15.6	22.0
-137.0	39.4	-125.9	72.7	-10.0	15.8	22.2
-133.0	39.4	-124.9	76.0	-10.0	16.0	22.4
-129.0	39.4	-123.9	79.1	-10.0	16.3	22.7
-125.0	39.4	-122.9	82.0	-10.0	16.6	23.0
-121.0	39.4	-121.9	84.8	-10.0	17.0	23.4
-117.0	39.4	-120.9	87.2	-10.0	17.4	23.8
-113.0	39.4	-119.9	89.4	-10.0	17.8	24.2
-109.0	39.4	-118.9	91.1	-10.0	18.3	24.7
-105.0	39.4	-117.9	92.3	-10.0	18.9	25.3
-101.0	39.3	-116.8	92.8	-10.0	19.4	25.8
-97.0	39.3	-115.7	92.6	-10.0	20.0	26.4
-93.0	39.2	-114.5	91.5	-10.0	20.6	27.0
-89.0	39.2	-113.2	89.3	-10.0	21.2	27.6
-85.0	39.1	-111.9	86.0	-10.0	21.7	28.1
-81.0	39.0	-110.4	81.6	-10.0	22.2	28.6
-77.0	38.9	-108.8	76.3	-10.0	22.5	28.9
-73.0	38.8	-107.0	70.2	-10.0	22.6	29.0
-69.0	38.6	-105.1	63.8	-10.0	22.6	29.0
-65.0	38.5	-102.9	57.5	-10.0	22.5	28.9
-61.0	38.3	-100.5	51.4	-10.0	22.2	28.6
-57.0	38.1	-97.8	45.9	-10.0	21.9	28.3
-53.0	37.8	-94.9	41.0	-10.0	21.5	27.9
-49.0	37.5	-91.6	36.6	-10.0	21.1	27.5
-45.0	37.2	-88.0	32.8	-10.0	20.7	27.1

Table 2. C_0/I_0 for the visible GSO arc



Source: Figure 3A of the DirecTV analysis, (SES−MFS−20111104−01315, November 4, 2011)

Figure 2. Modified ITU-R Recommendation S.672-4 Iridium Spacecraft Antenna Pattern