Adjacent Satellite Interference (ASI) - Effects and Causes on Ku-band DTH Network

AsiaSat Engineering Department – White Paper

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Review of the relationship between adjacent satellite interference and dish size, space separation and throughput, and how to mitigate interference.

Overview of Adjacent Satellite Interference

The geostationary orbit arc is increasingly crowded, with average longitudinal orbit separation getting close to 2.5° or less. For Ku-band direct-to-home (DTH) TV service, a small dish of 65cm is typically preferred for ground reception, yet the beamwidth of such a small dish is wide and so unavoidably picks up unwanted signals from adjacent satellites with co-coverage, co-frequency & co-polarization, resulting in different levels of ASI.

The on-axis to 2.5° off-axis gain delta of 65cm is about 11.5dB only. If there is no EIRP delta between the satellites, this means the downlink carrier-to-adjacent satellite interference is 11.5dB. This number is small and has significant implications on the achievable performance of DTH service. For example, if the adjacent satellites do not have any carriers or are operating at back-off mode for data services at the frequency and co-coverage with the DTH service, then the DTH service can have high throughput capacity with good signal quality. However, if the carrier of an adjacent satellite is saturated, the quality of DTH service will suffer. A prudent approach would therefore be to reserve an appropriate margin for ASI.

In addition is the common issue of mis-pointed DTH dishes, due to the inherent weakness of the clamp mounting design and the lack of professional tools like the spectrum analyzer to refine the dish pointing. Installers usually point the dish by observing the signal strength of set-top-box (STB). Even with a perceived good signal, the dish pointing may be biased toward one direction without satellite interference at the time of installation, but will pick up more interference when adjacent satellite from the other side loads up its carrier. This mis-pointed dish will also pick up significantly more adjacent interference when the carrier of an adjacent satellite is varied (e.g. more carriers are turned-on on the adjacent satellite).

A proper understanding of the current and future plans of adjacent satellites and a good understanding of selected satellite operator's coordination agreements and filing priority with neighbour satellites are therefore important. They can be used as input for the network design to determine the interference environment, possible throughput, and service level.

Effects and Causes of ASI

As mentioned, ASI manifests via neighbouring satellites with co-coverage, co-frequency and co-polarization. It is better to understand what the EIRP coverage of adjacent satellites looks like, the transponder bandwidth, frequency plan, modulation and what the downlink EIRP density of adjacent satellites is allowed based on co-ordination agreements. If the adjacent satellite has not been launched or is not operational yet, then an adequate margin for potential ASI should be reserved in the budget, including the consequences of a mis-pointed dish. Using the information about allowed downlink EIRP density from adjacent satellites, DTH network engineers should be able to determine the DTH quality of service (e.g. link availability and required system C/N) in accordance with DTH service provider's technical requirement.

For a Ku-band DTH service a small receiving dish is usually employed, yet this can easily pick up unwanted signal from adjacent satellites due to the wide beamwidth. A commonly employed antenna pattern template is shown in Figure 1.

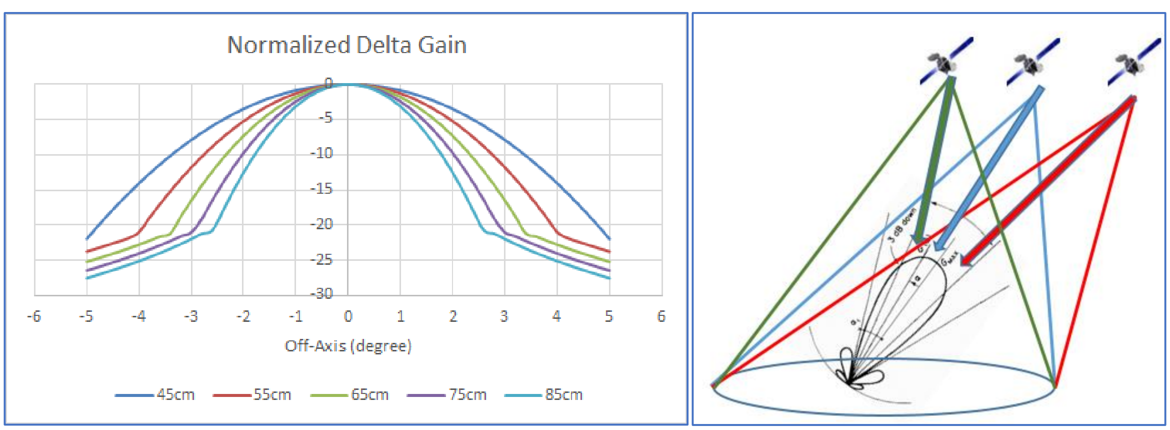

Figure 1. Normalized Delta Gain of Small Dish[1]

[1] *Recommendation ITU-R BO.1213.*

From the figure, it can easily be seen that the delta gain of a 45cm dish between peak and 2.5° off-axis is about 5.5dB. If the aggregated adjacent satellite downlink EIRP density is the same as the satellite to be used, then a 45cm dish will pick up significant ASI and the total carrier-to-noise plus interference ratio will be less than 5.5dB. If 65cm is used, then it can provide 11.5dB delta gain. The larger the dish used, the higher the delta gain can be obtained and ASI will be picked up. However, larger dishes have incremental equipment, installation and site selection costs.

Apart from dish size, dish pointing to target satellite can also have significant effect on the total carrier-to-noise plus interference ratio. During installation, once a good signal strength is obtained the screws are usually fastened immediately. However, slight movement in the azimuth or elevation direction of these small dishes will cause a large variation, so optimum pointing is almost impossible to achieve.

If the significant ASI source is from only one direction, the dish pointing is likely biased toward the other direction. It is easy to get 0.5dB mis-pointing loss when the dish is mis-aligned by 0.6°. If there is no adjacent satellite with co-coverage, frequency & polarization, then the service quality is good at the point in time. However, significant performance degradation may be experienced when a new adjacent satellite is launched with carriers turned on at the same coverage, frequency & polarization.

Both dish size and pointing should be taken into account during network design to avoid significant quality degradation.

Downlink ASI: Relationship with Dish Size, C/N+I, Space Separation, & Throughput

In DTH network link budget, the dominating factors commonly considered are the downlink thermal C/N and downlink ASI. There is also cross-polarization interference (assuming both polarizations are available), intermodulation, and terrestrial signal interference. For simplicity, it is assumed thermal C/N and downlink ASI are used in C/N+I calculations in the following:

For **45cm**, the beamwidth is very wide and the delta gain between main lobe and the side lobe at 2.5° off-axis is about 5.5dB only (based on the model of ITU-R BO. 1213) so the C/N+I is totally dominated by the ASI. Even though the adjacent satellites are located 3° away, the delta gain is about 8dB only so it is difficult using 45cm dishes for Ku-band when space separation of co-coverage, frequency & polarization adjacent satellite with same downlink EIRP density is less than 3° away.

This is also challenging for a **55cm** dish with a 2.5° separation because the delta gain is about 8dB only. In the scenario of multiple adjacent satellites with the same downlink EIRP density, the ASI term becomes the dominating factor in the link unless space separation with those multiple satellites is greater than or equal to 3°.

For **65cm** dishes, the delta gain at 2.5° is about 11.5dB and the downlink C/N is about 14dB at -25dBW/Hz downlink EIRP density so the C/N+I by considering the same aggregated downlink EIRP density (i.e. -24.5dBW/Hz) from adjacent satellites at 2.5° away is about 9.6dB. The required C/N of DVB-S2 8PSK 3/5 is about 6dB[2] and it can provide about 4dB margin on the link so 65cm dish is typically used in Ku-band DTH. The relationship of C/N+I among different dish size, adjacent satellite space separation and downlink interference ratio between wanted and interfered satellite is shown in Figure 2.

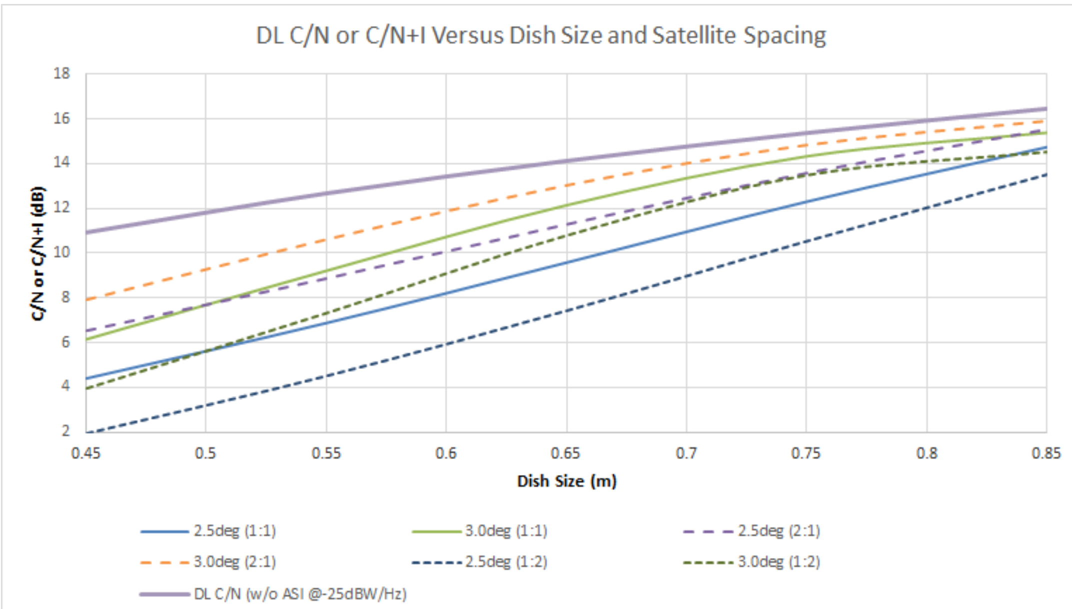

Figure 2. DL C/N or C/N+I versus Dish Size and Space Separation

Notes:
"1:1" means the aggregated downlink EIRP density from adjacent satellites are same as wanted satellite.
"2:1" means the aggregated downlink EIRP density from adjacent satellites are half of wanted satellite.
"1:2" means the aggregated downlink EIRP density from adjacent satellites are double of wanted satellite.

The relationship of C/(N+I) among different dish size, different aggregated downlink ERIP density of interfered satellite and adjacent satellite space separation is shown in Figure 3.

[2] *Throughput rate calculation is based on Newtec DVB-S2 calculator.*

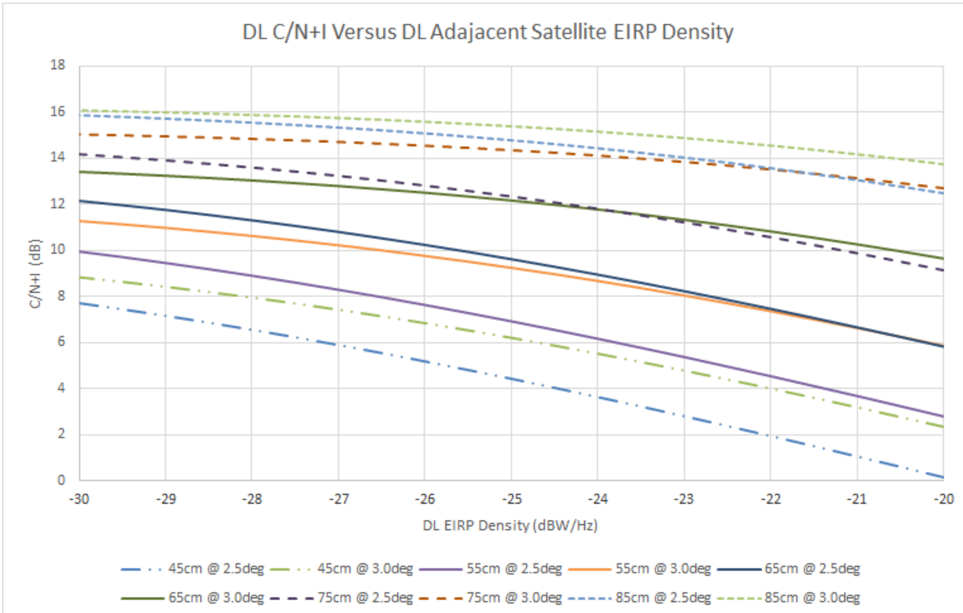

Figure 3. DL C/N+I versus DL Adjacent Satellite EIRP Density

The relationship of throughput rate of a 54MHz transponder among different dish size, different aggregated downlink EIRP density of interfered satellite and adjacent satellite space separation is shown in Table 1a.

C/N+I	Orbital Separation (deg)				
Dish Size (cm)	2.0	2.5	3.0	3.5	4.0
45	2.8	4.4	6.2	7.8	9.2
55	4.5	6.9	9.2	11.0	12.1
65	6.5	9.6	12.1	13.4	13.6
75	8.7	12.3	14.3	14.6	14.8

Table 1a. C/N+I versus different dish size and orbital separation

	Maximum throughput rate (Mbps) to fill up a 54MHz transponder with 7dB margin or greater														
Aggregated DL EIRP Density of Adj SAT (dBW/Hz)	45cm @ 2.5deg	45cm @ 2.8deg	45cm @ 3.0deg	55cm @ 2.5deg	55cm @ 2.8deg	55cm @ 3.0deg	65cm @ 2.5deg	65cm @ 2.8deg	65cm @ 3.0deg	75cm @ 2.5deg	75cm @ 2.8deg	75cm @ 3.0deg	85cm @ 2.5deg	85cm @ 2.8deg	85cm @ 3.0deg
-20.0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	55.8	41.7	83.6	94.1	94.1	104.6	133.5
-20.5	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	33.3	62.7	55.8	83.6	104.6	94.1	133.5	133.5
-21.0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	41.7	66.9	62.7	94.1	104.6	104.6	133.5	139.2
-21.5	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	50.1	69.8	66.9	94.1	104.6	104.6	139.2	139.2
-22.0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	55.8	69.8	69.8	94.1	104.6	104.6	139.2	139.2
-22.5	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	62.7	69.8	69.8	104.6	133.5	133.5	139.2	139.2
-23.0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	62.7	83.6	69.8	104.6	133.5	133.5	139.2	139.2
-23.5	#N/A	#N/A	#N/A	#N/A	#N/A	33.3	41.7	69.8	83.6	83.6	104.6	133.5	139.2	139.2	148.6
-24.0	#N/A	#N/A	#N/A	#N/A	#N/A	41.7	41.7	69.8	83.6	83.6	104.6	139.2	139.2	148.6	148.6
-24.5	#N/A	#N/A	#N/A	#N/A	#N/A	41.7	50.1	69.8	83.6	94.1	133.5	139.2	139.2	148.6	174.1
-25.0	#N/A	#N/A	#N/A	#N/A	33.3	50.1	55.8	83.6	94.1	94.1	133.5	139.2	139.2	174.1	174.1
-25.5	#N/A	#N/A	#N/A	#N/A	41.7	55.8	62.7	83.6	94.1	94.1	133.5	139.2	139.2	174.1	174.1
-26.0	#N/A	#N/A	#N/A	#N/A	41.7	62.7	66.9	83.6	94.1	94.1	139.2	139.2	148.6	174.1	174.1
-26.5	#N/A	#N/A	#N/A	#N/A	50.1	62.7	69.8	83.6	94.1	104.6	139.2	139.2	150.5	174.1	174.1
-27.0	#N/A	#N/A	#N/A	27.7	55.8	66.9	69.8	94.1	94.1	104.6	139.2	139.2	174.1	174.1	174.1
-27.5	#N/A	#N/A	#N/A	41.7	62.7	69.8	69.8	94.1	104.6	104.6	139.2	139.2	174.1	174.1	174.1
-28.0	#N/A	#N/A	#N/A	41.7	62.7	69.8	83.6	94.1	104.6	104.6	139.2	139.2	174.1	174.1	174.1
-28.5	#N/A	#N/A	#N/A	50.1	66.9	69.8	83.6	94.1	104.6	133.5	139.2	139.2	174.1	174.1	174.1
-29.0	#N/A	#N/A	33.3	50.1	69.8	69.8	83.6	94.1	104.6	133.5	139.2	148.6	174.1	174.1	174.1
-29.5	#N/A	#N/A	41.7	62.7	69.8	69.8	83.6	104.6	104.6	139.2	139.2	148.6	174.1	174.1	174.1
-30.0	#N/A	33.3	41.7	62.7	69.8	83.6	94.1	104.6	104.6	139.2	139.2	148.6	174.1	174.1	174.1
-30.5	#N/A	41.7	41.7	62.7	69.8	83.6	94.1	104.6	104.6	139.2	139.2	148.6	174.1	174.1	174.1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 1b. Maximum throughput per 54MHz transponder

Notes:

a) "#N/A" means that MODCODE cannot be found to meet required C/N+I requirement.
b) Downlink EIRP 52dBW, thermal C/N, DL adjacent satellite interference C/I and 7dB margins reserved for other potential interference and uncertainty are assumed in the throughput calculations.

How to Mitigate Adjacent Satellite Interference

To mitigate ASI, the following suggestions are recommended:

1) Ask your satellite capacity provider about the coordination status of the offered satellite capacity. The status information shall include, but not be limited to, coordination agreement status with adjacent satellite operator; ITU filing status within respect to the adjacent satellite operators; coordinated/filed emission level, filed received antenna size.

2) Obtain the EIRP coverage of the satellite to be used and gather the EIRP coverage of adjacent satellites with co-coverage, frequency & polarization so that adjacent satellite interference assessment can be carried out.

3) Obtain the maximum allowed downlink EIRP density of adjacent satellites from satellite operator. If the satellite to be used completes co-ordination with adjacent satellite operator, this information can be obtained from co-ordination results.

4) If the adjacent satellite has not been launched yet, it is better to reserve margin for potential adjacent satellite interference.

5) Reserve sufficient system margin based on quality of service and determine the appropriate dish size to be used.

6) Do antenna pointing assessment based on the information obtained from (2) & (3) to find out the optimum pointing position. The typical dish mis-pointing loss is about 0.5dB.

7) Verify the actual adjacent satellite interference of frequency band to be used by using spectrum analyzer. If significant interference is observed, report to the satellite operator for resolution.

8) Verify the receive pattern of the dish to be used from the manufacturer to characterize the variation of the delta gain and adjust the parameters used in the link calculations.

9) Install the dish with appropriate tools so that good pointing can be obtained.

Conclusion

Prior to deploying Ku-band DTH service, it is recommended to do some investigations on the coverage performance and maximum allowed EIRP density of the satellite to be used and adjacent satellites in the target service region. Make a balanced assessment between dish size and potential adjacent satellite interference so that issues related to ASI can be minimized.