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APT SATELLITE

Case Study:

Sharing Schemes for Closely Spaced Satellites

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- Adjacent Satellite Interference (ASI) Status in Asia Pacific Region
- Loading Match Type 1
- Loading Match Type 2
- Comparison

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- **Adjacent Satellite Interference (ASI) Status in Asia Pacific Region**
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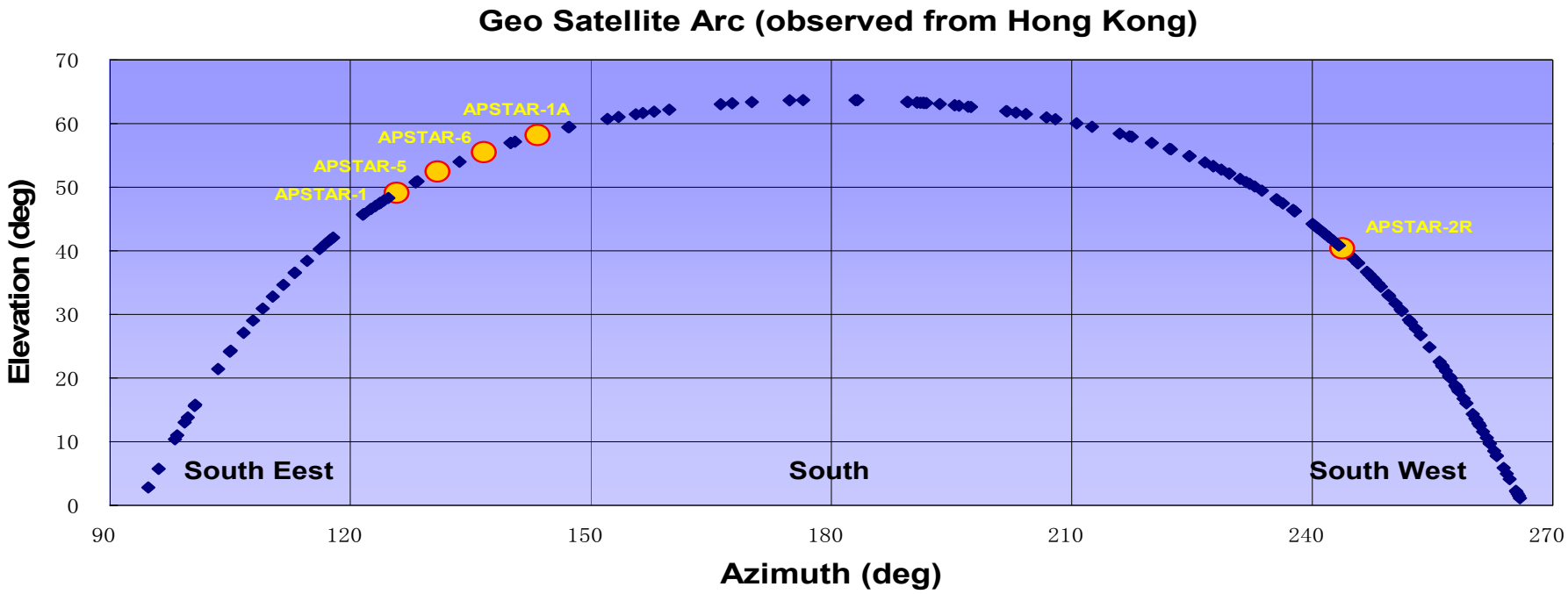
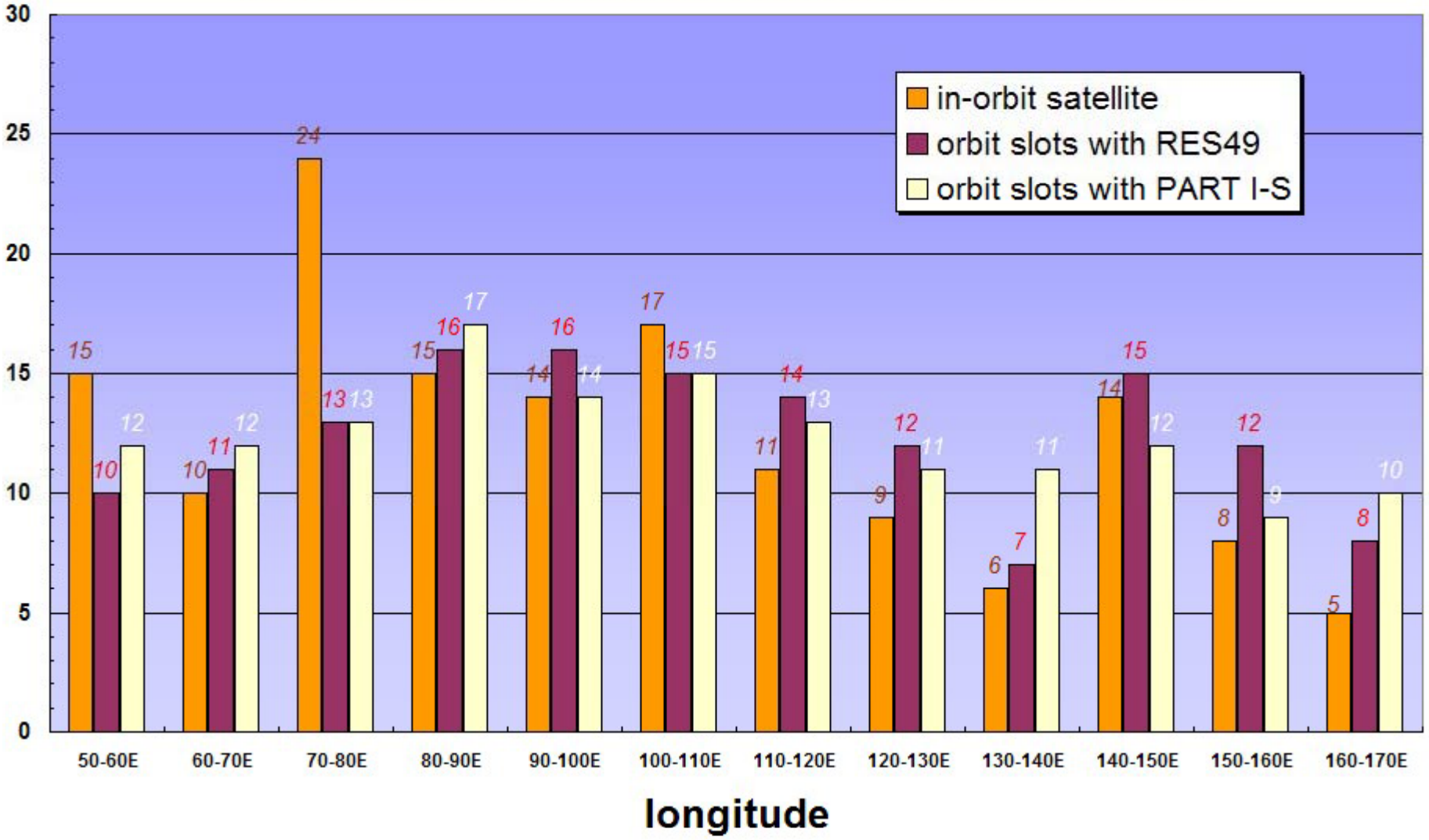
GEO arc in Asia Pacific Region



In orbit satellites and their RES49, PART I-S filings



Causes of ASI for Closely Spaced Satellites

- **Orbit Congestion**

  Although the GSO arc is highly congested, satellites from different countries often share overlap coverage and frequencies with orbital separation of 2 degrees or even less in many cases, there is no uniform minimum antenna size requirement or power level constraints adopted across the region. The single entry 6% criteria is usually not applicable for these cases.

- **Small Antennas**

  The increasing use of small size antennas for SNG, mobile VSAT, and fly-away etc, causes more ASI. Even for 2 degree or less spaced cases, more and more links adopt 1.5 to 1.8 meter C-band, 0.45 to 1 meter Ku-band antennas for transmission use. Big antennas are much less likely to cause or receive ASI due to its higher gain and better off-axis discrimination.

- **Side effects of DVB-S2**

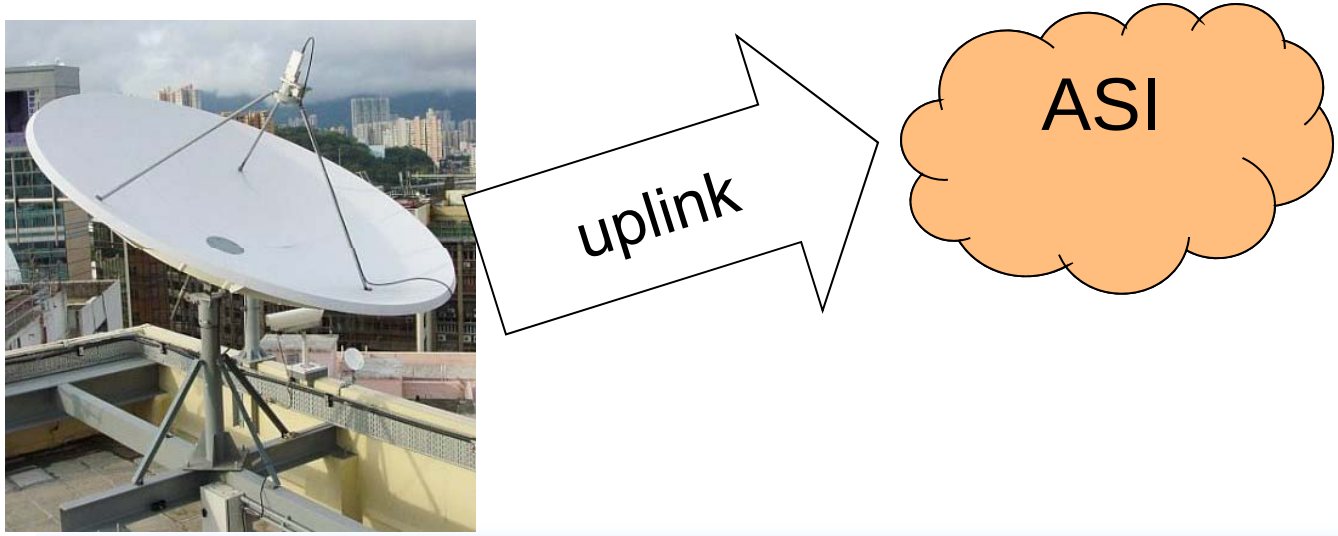
  Advanced modulation and forward error correcting code (FEC) techniques (DVB-S2) has been worsening the ASI situation either when the users tend to use smaller antenna for same order of modulation, or when the users tend to use higher order of modulation for much more information throughput, which ends up less C/N link margin instead of more in many cases.

Causes of ASI for Closely Spaced Satellites (cont'd)

- **Main culprit of ASI: small antenna and its uplink transmission**

- It is found in operation experience that, 90% ASI is caused by the uplink transmission of small size antennas, the small terminals usually operate in pair with a big hub antenna to form an asymmetric VSAT network.

- Only a few percentage of ASI happens to the downlink route of the satellite link when the reception of the small size antennas is interfered by transmission from adjacent satellites which falls in its sidelobe or even mainlobe in closely spaced cases.



Math Model of ASI

For ASI evaluation, the C/I for a given C/N objective at the receiver demodulator input can be written as below, the bigger C/I is, the less link performance is affected,

$$C/I = (C_0*B_C)/(I_0*B_I) = (C_0/I_0)*(B_C/B_I) = (C_0/N_0)/(I_0/N_0)*(B_C/B_I) = (C/N)/(I/N)*(B_C/B_I)$$

Or,

$$10\log(C/I) = 10\log(C/N) - 10\log(I/N) + 10\log(B_C/B_I), \text{ (dB)}$$

The equation shows that, for wanted signal "C" which has a noise bandwidth of B_C being interfered by interference "I" which has a bandwidth of B_I, there is an improvement in C/I performance as given by "Delta",

$$\text{Delta} = 10\log(B_C/B_I), \text{ (dB)}$$

"Delta" is a benefit factor brought by the bandwidth difference between the wanted carrier and the interfering carrier. The bigger the difference between two bandwidths is, the more it improves the C/I performance.

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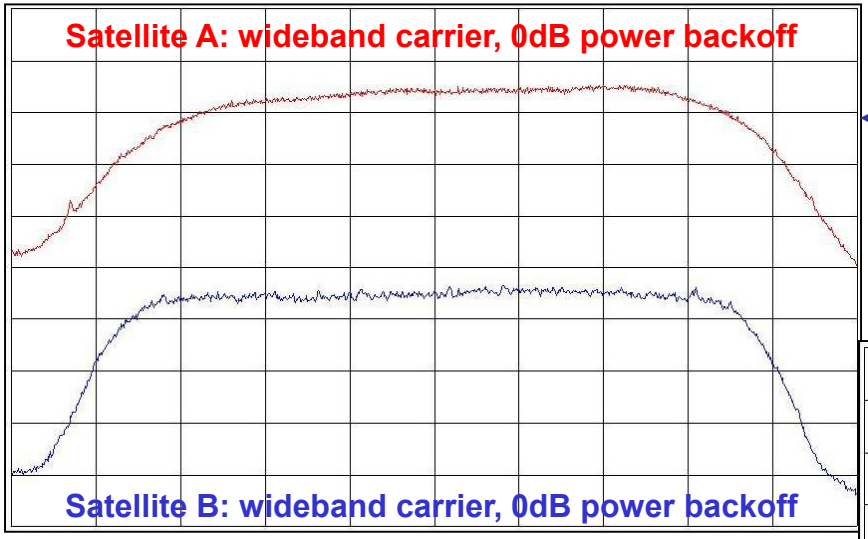
Preemptive Solution to ASI — Loading Match — Homogeneous Match

- Loading Match Type 1, Homogeneous Match

  In order to achieve compatibility between closely spaced satellites networks, the satellite operators adopted a loading match method which allocates same type of loadings in their corresponding frequency bands, i.e. high power transmissions (MCPC) to high power transmissions, and low power transmissions (SCPC or VSAT) to low power transmissions.

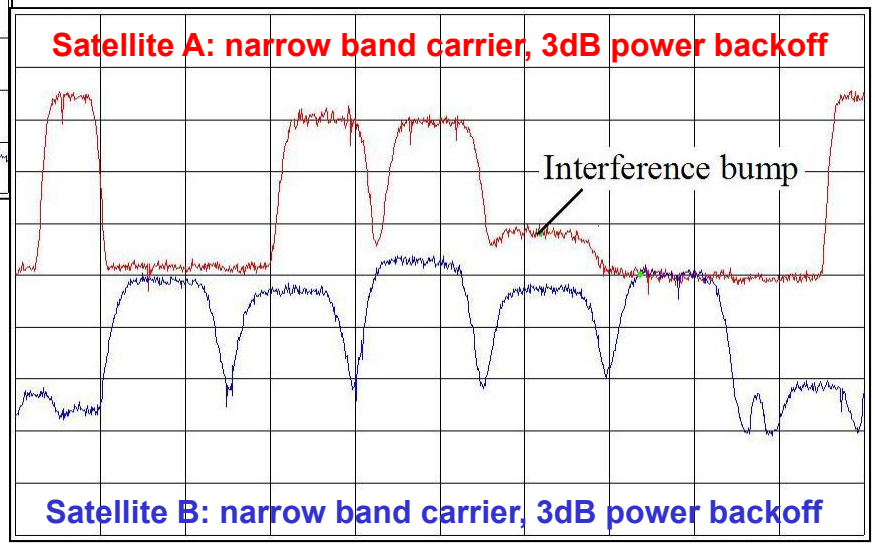
  Power level constraints are usually introduced for the carriers to help define the operation conditions.

Preemptive Solution to ASI — Loading Match — Homogenous Match (cont'd)



MCPC to MCPC

SCPC to SCPC



Pros and Cons to the Homogenous Match

Pros:

Two satellites enjoy equitable operation conditions in the overlapping frequency bands, which creates balance in the coordination between satellites networks with interleaved regulatory priorities.

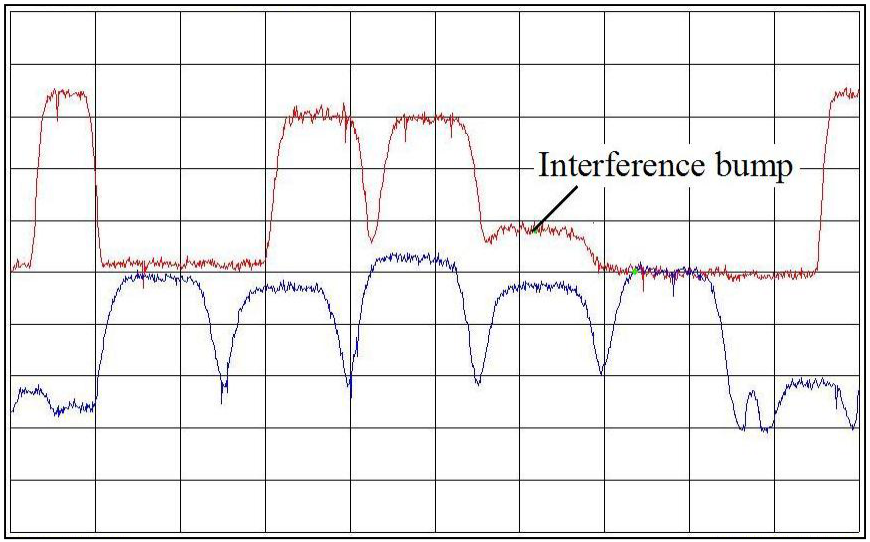
Cons:

For the low power match of VSAT carriers, it is found in operation experience that the inbound carriers transmitted by small size antennas have brought a great deal of ASI to the other satellite and vice versa.

Reason for the Cons

- No obvious improvement brought by bandwidth factor for the VSAT-to-VSAT pair

The bandwidth of the wanted carrier and interfering carrier, i.e. B_C and B_I, is in comparable level, the benefit brought by the bandwidth factor (Delta) is not obvious for the wanted carrier.



Delta = $10\log(B_C/B_I)$, (dB)
= $10\log(1.2\text{MHz}/1.0\text{MHz})$
= 0.79 dB

Reason for the Cons

- No obvious improvement brought by bandwidth factor for the VSAT-to-VSAT pair

  The bandwidth of the wanted carrier and interfering carrier, i.e. B_C and B_I, is in comparable level, the benefit brought by the bandwidth factor (Delta) is not obvious for the wanted carrier.

- Small size uplink antenna for the VSAT-to-VSAT pair

- Operation experience has shown over 90% ASI comes from the small size antenna's VSAT-type uplink transmission. In other words, the VSAT to VSAT pair in the homogeneous loading match scheme can not effectively protect links from ASI.

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Heterogeneous Loading Match

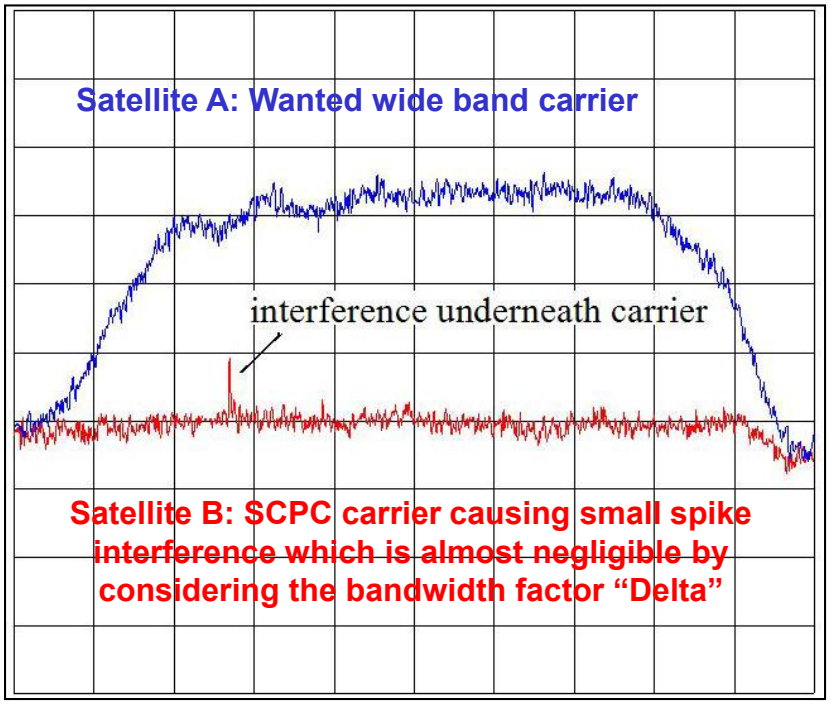
- Loading Match Type 2

For the purpose of making better use of the bandwidth benefit in ASI mitigation and avoid VSAT to VSAT matches, type 2 loading match scheme is introduced so as to allocate heterogeneous transmissions in corresponding bands, i.e. high power transmissions (MCPC) to low power transmissions (SCPC).

MCPC to SCPC

Improved ASI Status

- If the wanted transmission is a wide-band MCPC which is interfered by a narrow band VSAT carrier, the C/I link performance can be greatly improved by a "Delta" of more than 10 dB (i.e. 10 times bandwidth difference) in most case, and at least 3 dB in the worst full packed case.



ASI Scenario One:

MCPC interfered by SCPC

Delta = $10\log(B_C/B_I)$, (dB)
= $10\log(33MHz/1.0MHz)$
= 15.2 dB

Improved ASI Status (cont'd)

ASI Scenario Two: SCPC interfered by MCPC

If the wanted transmission is a narrow band VSAT carrier which is interfered by a wide band MCPC carrier,

- The bandwidth benefit factor would not deteriorate to be negative since the receiver demodulator can only filter in ASI power within the bandwidth of the wanted carrier. When B_C is less than B_I, then "Delta" is equal to zero

- Most MCPC carrier is transmitted by large size antenna which has better off-axis discrimination, it is not likely to cause ASI as consequence. Generally speaking, only a few cases of this type happened before and it was easily settled down by correcting the big antenna's pointing or tracking function

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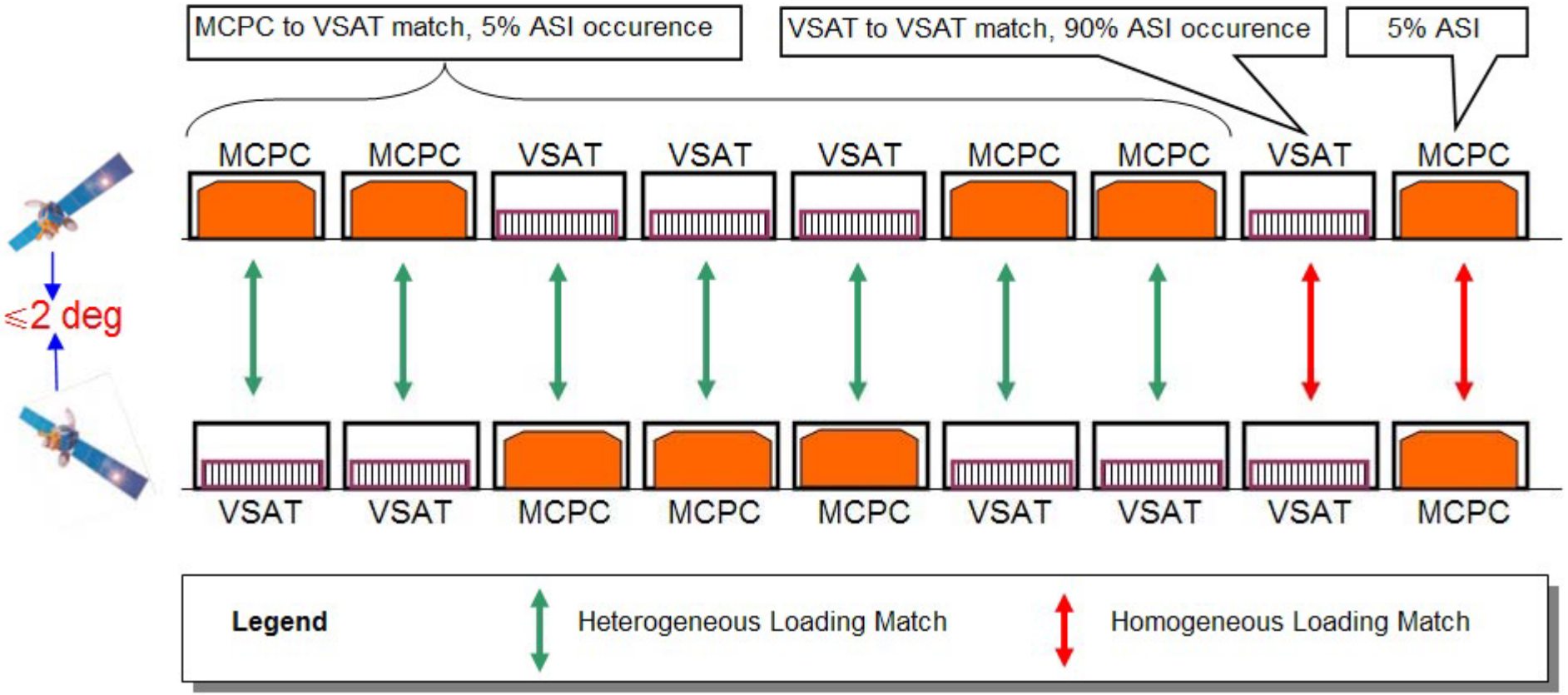
Comparison between Two Loading Matches



Question?