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Reaching Further, Bringing You Closer

Efficient usage of spectrum orbit resources and efficient satellite usage (WRC-15)

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Reduce “Unnecessary” Coordination

WRC-15 Agenda Item 9.1, Issue 9.1.2

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Today's situation

- Congestion in the arc
  - "Paper satellites"
  - "Virtual satellites"
  - Real operational satellites (every 2°-3° around the GSO arc)
- Congestion in particular serious in unplanned C- and Ku-band
  - Well established and mature technology and applications
  - Relatively homogeneous technical parameters have evolved (due to the maturity of the technology and applications and out of necessity due to the congestion)
- Interference completely dominate by first co-frequency, co-coverage adjacent network
  - Little impact from further away networks
- The need to be able to live with first adjacent network will;
  - limit operation and capability in causing/receiving interference to/from others
  - facilitate compatibility with farther away networks

Coordination requirements

- **Extreme** coordination requirements
  - E.g. ASIASAT-105.3T
  - 1802 networks identified
  - 49 administrations
  - Orbital separation to identified networks up to 157.8°
- Coordination to be completed within 7 year of API
  - i.e. within ≤ 6.5 years of coordination request
  - Force administrations to notify without completing coordination (RR 11.41)

Need to Avoid Unnecessary Coordination!

Attempt in addressing the issue

WRC-12 (Agenda Item 7, Issue 2A)

- Decided to reduce the coordination arc for C- and Ku-band by 2°
- Decided to further study this issue under WRC-15 Agenda Item 9.1, Issue 9.1.2 (Resolution 756 (WRC-12))

WRC-15 (Agenda Item 9.1, Issue 9.1.2)

- *resolves 1* of Resolution 756 (WRC-12)
  to consider alternative types of criteria used in the coordination and notification process
- *resolves 2* of Resolution 756 (WRC-12)
  to consider further reduction of the size of the coordination arc for C-, Ku- and Ka-band
- instructs the Director BR to include in his Report to WRC-15 the results of these studies

Two separate issues under Issue 9.1.2 (WRC-15):

- Type of coordination triggers and protection criteria used (resolves 1)
- Size of coordination arc (resolves 2)
- Independent

Why and how to address *resolves 1*?

WRC-2000 introduced coordination arc concept

- Aiming at reducing unnecessary coordination

WRC-12 reduced the size of the arc by 2° for unplanned C/Ku-band

- Again aiming at further reducing the unnecessary coordination

However….

- Inclusion under RR 9.41 increases
  - 1854 networks requested included between 01.01.2013 and February 2014
  - 33 networks requested included on average per coordination request (20 before 01.01.2013)
- Root cause: Unrealistic filing parameters
  - Criteria under RR 9.41 and RR 11.32A are still based upon filed parameters
  - Filings can be designed with parameters that are artificially sensitive to interference, triggering coordination and unduly blocking access for other networks
  - The Bureau has confirmed that there are several filings with artificial parameters already in the Master Register
- Solution: Need to seek criteria that are independent of parameters of individual filings, but which at the same time give adequate protection

Consideration on ensuring adequate protection

- Requires fairly stable technology and relatively homogeneous parameters
  - C and Ku-band? (Mature, highly congested band)
  - Ka-band not mature yet?

- Possible protection criteria independent of parameters contained in individual filings
  - **Coordination arc**
    (like under RR No. 9.7)
  - **Pfd masks/thresholds**
    (has already been implemented in Appendix 30 and 30A (WRC-2000) and for BSS in 21.4-22 GHz band (WRC-12)

Goal

- Adequately protect satellites with technical parameters within a reasonable range
  - No additional protection for networks with parameters outside this range
  - Avoid overprotection stemming from unrealistic parameters contained in filings

Current types of coordination triggers/protection criteria in commonly used unplanned frequency bands

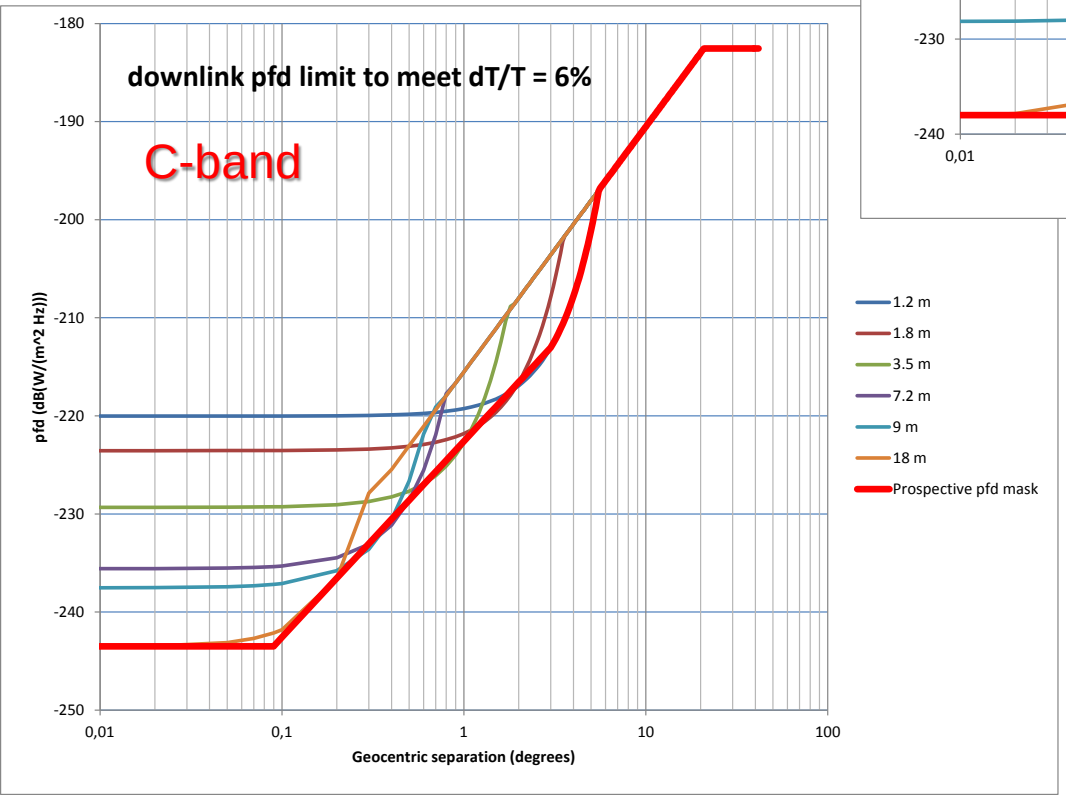
Provision	Stage	Criterion
RR 9.7	Identification of coordination requirements	Coordination arc Independet of filed parameters
RR 9.41	Inclusion in coordination of networks outside the coordination arc	$\Delta T/T = 6\%$ Calculated from filed parameters
RR 11.32A	Determination of probability of harmful interference (in case of outstanding coordination requirements)	$C/I = C/N + 12.2$ $(\Delta T/T = 6\%)$ C/N calculated from filed parameters

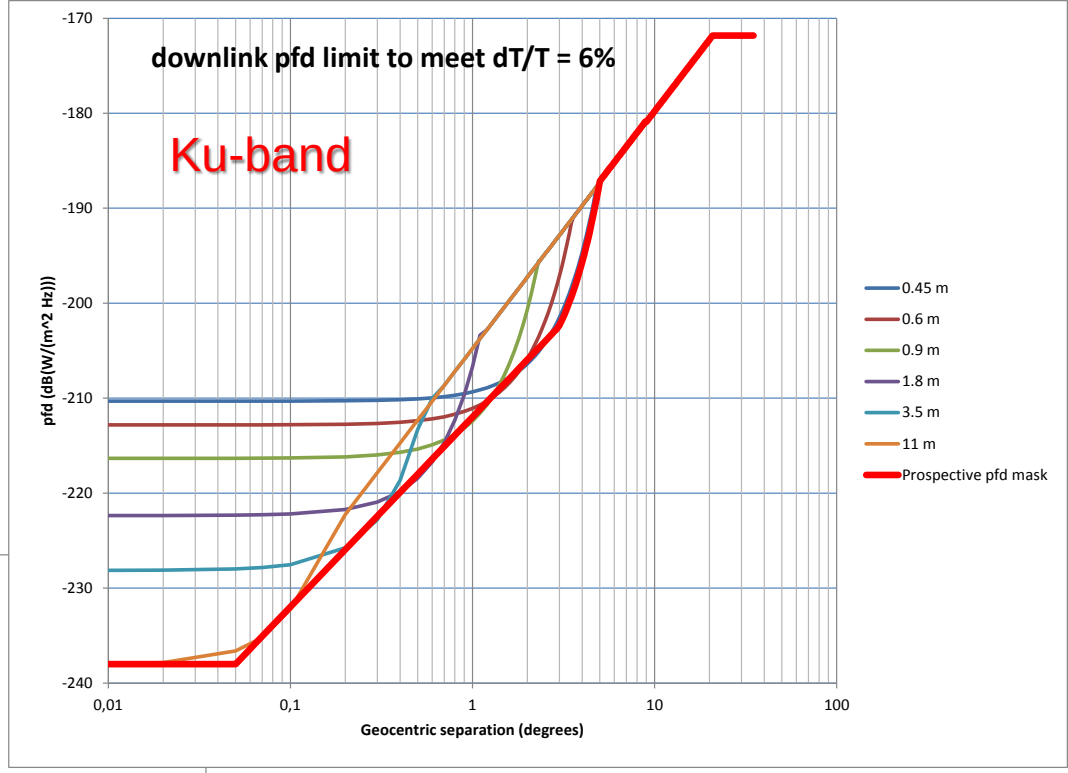
Representative parameters required for determining the PFD Mask/Threshold and prospective parameters (from ITU study)

Equivalent ΔT/T	6%	6%
Downlink		
Frequency (GHz)	4	12
Range of antenna diameters (m)	1.2 – 18	0.45 – 11
Thermal Noise T_s (K)	95	125
Antenna efficiency (%)	70	70
Uplink		
Frequency (GHz)	6	14
Space station G/T (dB/K)	≤ 0	≤ 11

resolves 1

Example of pfd criteria based upon interference levels equivalent to ΔT/T = 6%





Uplink pfd thresholds:

C-band: – 204 dB(W/(m^2 · Hz))

Ku-band: – 208 dB(W/(m^2 · Hz))

Advantage of pfd criteria and its implementation

Advantage

- Defined protection inside and outside coordination arc
- Independent of filed parameters
- Artificial parameters will not unduly block coordination of other networks
- No need to define allowable range for parameters to be contained in a filing

Implementation

- Could be introduced at different stage prior entering into MIFR
  - RR No. 9.7
  - RR No. 9.41
  - RR No. 11.32A

Propose to introduce at RR No. 11.32A in CPM Report

Reduction of coordination arc in C/Ku-band?

Current coordination arc (WRC-12)

- 8° (C-band)
- 7° (Ku-band)

Reality

- C- and Ku-band satellites every 2° - 3° apart
- First adjacent satellite networks (co-frequency, co-coverage) on either side will dominate adjacent satellite interference
- Further away networks will have little impact

Current Arc	Reality
7/8 °	2-3 °

⇨ Room for further reduction of the arc!

Proposal in the CPM Report

- 6° (C-band)
- 5° (Ku-band)

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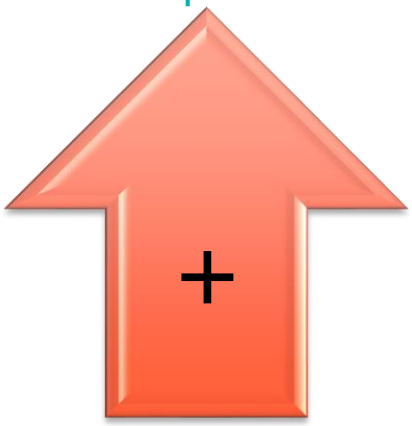
Reduction of coordination arc in Ka-band?

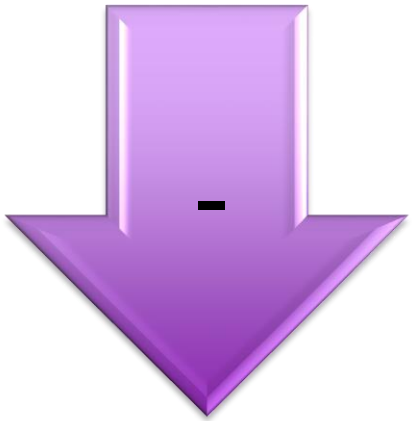
What about Ka-band?

- Proposals in CPM Report to reduce size of Ka-band coordination arc 8° → 6°



Would reduce of coordination requirements identified under RR No. 9.7

Due to higher frequency, a smaller coordination arc might appear logical



Criteria independent on filed parameters requires somewhat homogeneous satellite implementations

Although there are many Ka-band filings, there are

- fewer satellites with significant commercial Ka-band payloads and

- applications and technical parameters would seem to diverge more than at C- and Ku-band

Has Ka-band reached the level of maturity and homogeneity required to justify a further reduction of the coordination arc?

Potential issues with coordination arc reduction

Would reduce amount of unnecessary coordination identified under RR No. 9.7

Could lead to a corresponding increase of identification of coordination requirements under RR No. 9.41

With no changes to the types of criteria used under RR Nos. 9.41 and/or 11.32A, much of the gain from the reduction of the coordination arc could be lost!

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Balancing up- and downlink spectrum

WRC-15 Agenda Item 1.6.2 and possibly future Agenda Item

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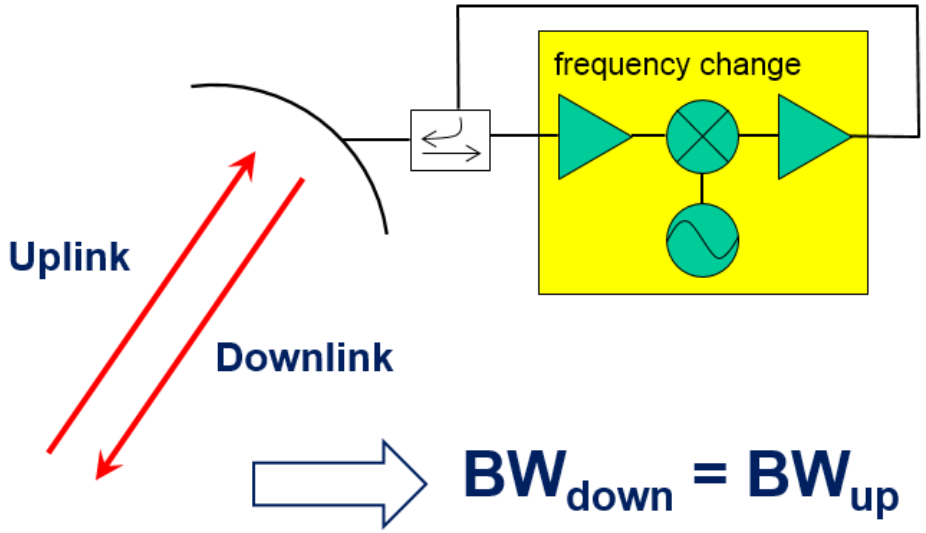
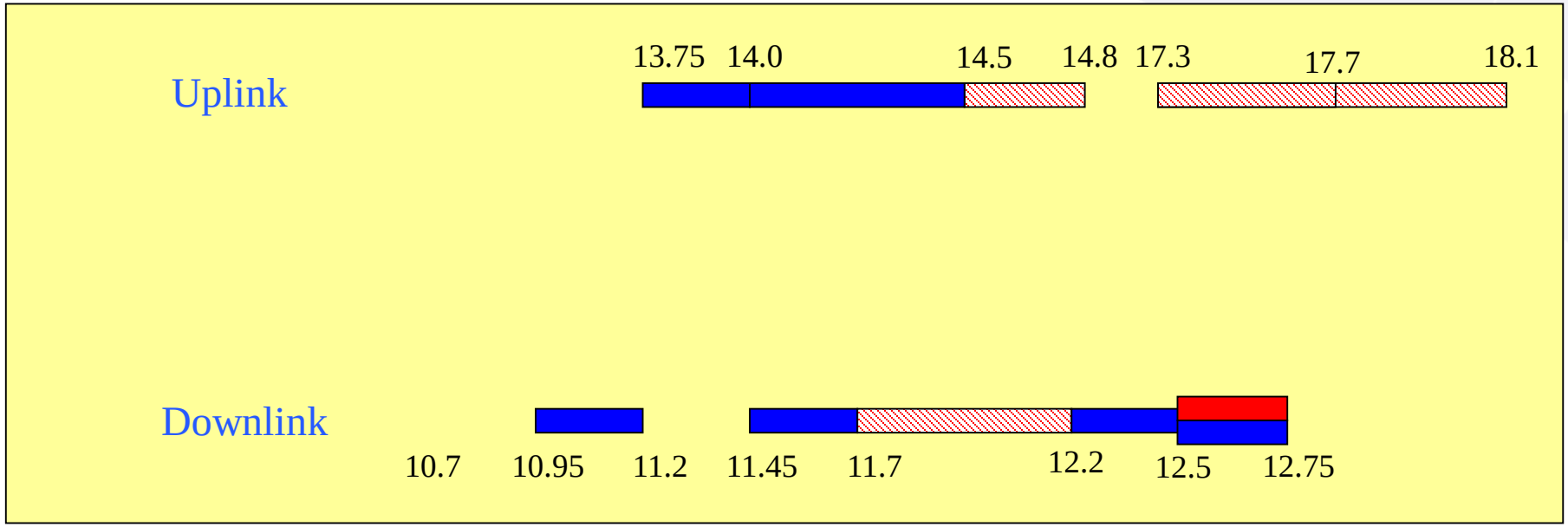
Balancing up- and downlink spectrum

Commercial communication satellites normally use "bent-pipe" technology:



- Amount of spectrum for up- and downlink should match
- Due to satellite antenna design, waveguide and OMTs etc., it is normally most efficient to have up- and downlink in frequency bands in the vicinity of each other

Example 1: Current ITU-R Region 3 table of allocations, Ku-band



FSS (unplanned)

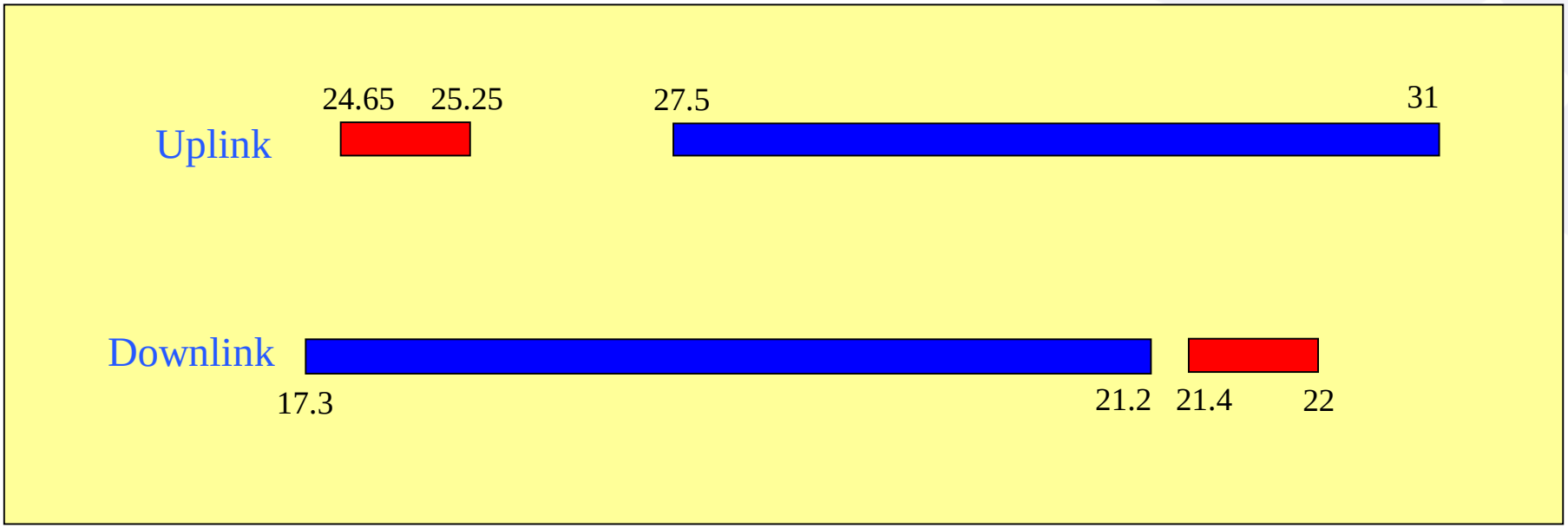
BSS (unplanned/planned) and uplinks limited to only feederlinks for BSS

Uplink	Downlink
750MHz	1050 MHz
1100 MHz	750 MHz

300 MHz of downlink capacity cannot be efficiently used due to lack of uplink capacity

350 (600) MHz of uplink capacity cannot be efficiently used due to lack of downlink capacity

Example 2: Current ITU-R Region 1 table of allocations, Ka-band



FSS (unplanned)

BSS (unplanned) and uplinks limited to only feederlinks for BSS

Uplink	Downlink
3500 MHz	3900 MHz
600 MHz	600 MHz

400 MHz of downlink capacity cannot be efficiently used due to lack of uplink capacity

Up until corrected by WRC-12, no uplink assignments existed

Balancing up- and downlink spectrum

- To facilitate efficient spectrum usage, up- and downlink spectrum should be balanced
- WRC-15 Agenda Item 1.6.2 is addressing spectrum imbalance in Ku-band for unplanned FSS in Regions 2 and 3.
- Spectrum imbalance in other frequency bands remains to be addressed…
  - Potential Agenda Item for future WRC?

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Steerable beams

Spectrum hoarding or efficient use of satellites?

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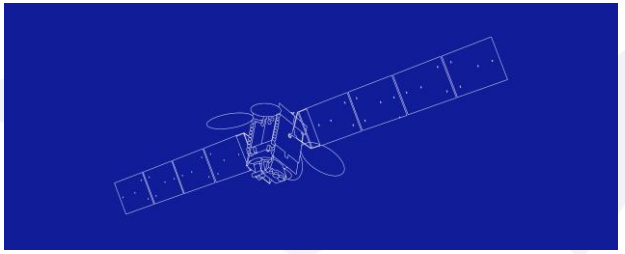
Why steerable beams?



- Many satellites have steerable beams, why?
- Satellites are expensive

- To be financially viable
  - Serve several countries and several application
  - Adapt to changing markets and requirements
  - In particular important for small satellite operators and newly started operators
- Allow operators to serve new customers, e.g. when:
  - Existing customer are moved to other satellite operator
  - Replacement satellites are launched
  - Additional satellites are co-located

→ Facilitates efficient usage of the spectrum resources on-board each satellite

Criticism towards steerable beams

- Warehousing of orbit spectrum resources?
  - Simultaneously laying claim on the frequency band / polarization within the entire steerable area, e.g. an ITU-R Region or the entire visible earth
- A steerable beam may end up serving one area for many years
  - e.g. due to a stable market situation, no additional satellite being brought in, ….
- Ideas has been formulated to block steerable beams
  - e.g. after a certain time period after bringing the filing into use ([3 years])

Legitimate use of steerable beams

- Comply with the concept of the latest BIU definition (No. 11.44B)

> 11.44B A frequency assignment to a space station in the geostationary-satellite orbit shall be considered as having been brought into use when a space station in the geostationary satellite orbit with the capability of transmitting or receiving that frequency assignment has been deployed and maintained at the notified orbital position for a continuous period of ninety days. The notifying administration shall so inform the Bureau within thirty days from the end of the ninety-day period. (WRC-12)

- Physical reality in real satellites for operational and financial reasons
  - Will continue to be so irrespective of whether the Radio Regulations recognize this or not
- Prohibiting such use would lead to overfilling, because
  - Operator simply has to continue filing to keep the right to cover areas that the satellite is built for and capable of covering

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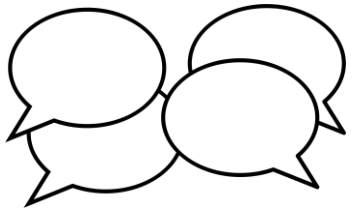
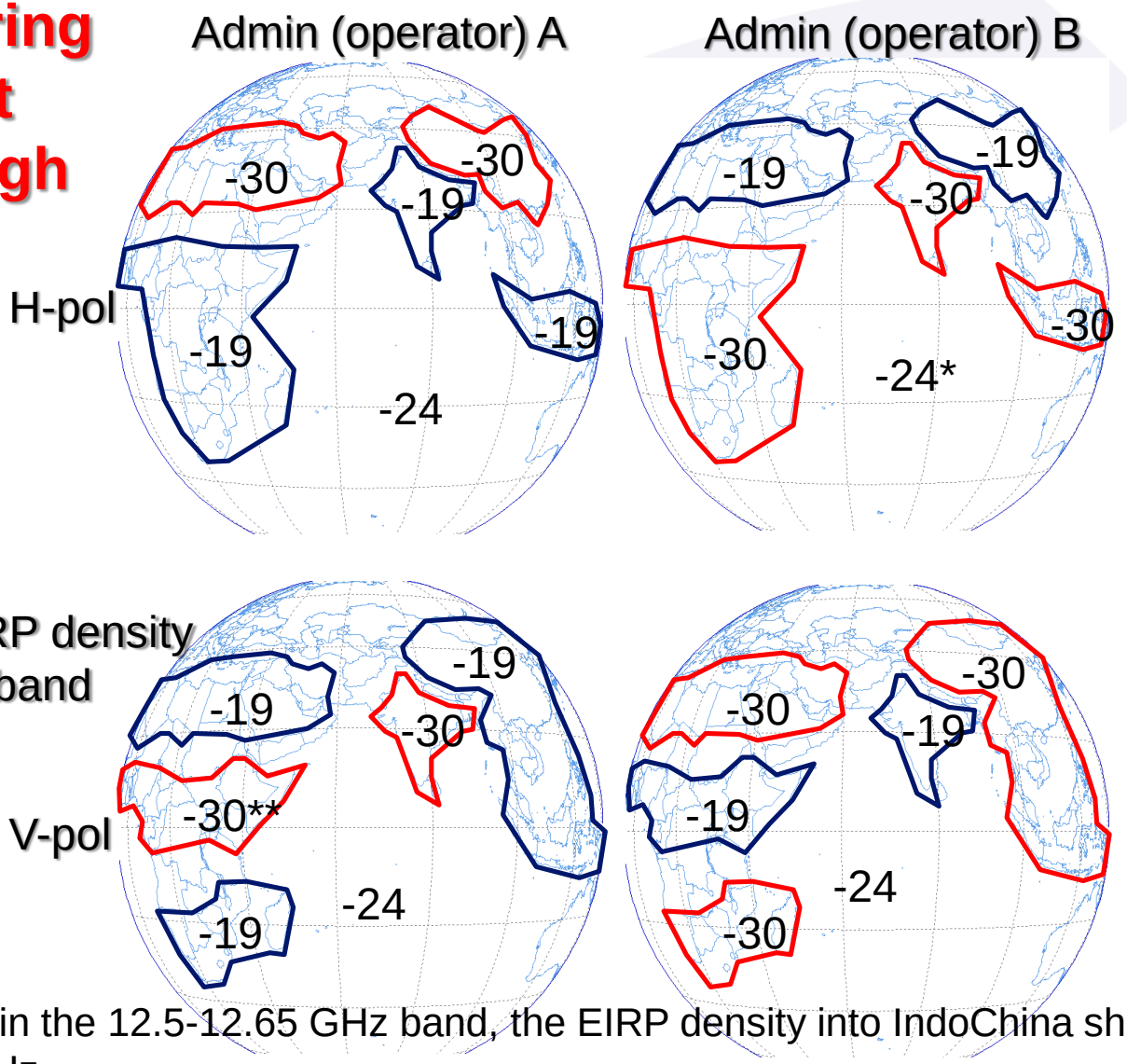
Today's practice

- Sharing of spectrum resources is done through bilateral agreements or agreements between satellite operators
- Such agreements will normallly address several elements to enable efficient operation of the satellite networks
  - Pointing/coverage of steerable beams, but also elements like;
  - Shape/coverage of fixed beams
  - EIRP levels
  - Frequency bands
  - Polarization
  - Different applications
  - Time limitations
  - Procedures in case of interference
  - Procedures regarding fleet renewal
  - Procedures to revise the agreement
- Details of such agreements are rarely brought to the attention of ITU



Example of sharing of common orbit resources through coordination agreements between two administrations (or operators)

Maximum downlink EIRP density in the 12.5-12.75 GHz band

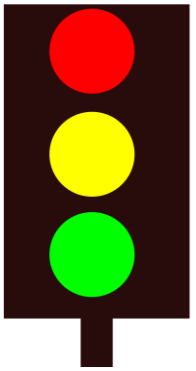


* After 01.11.2017, in the 12.5-12.65 GHz band, the EIRP density into IndoChina shall not exceed -26 dBW/Hz

** In the 12.6-12.75 GHz band, the EIRP density into Nigeria and west of Nigeria shall not exceed -38 dBW/Hz

Should steerable beams be allowed in filings?

- Blocking access to use of steerable beams would significantly threaten efficient use of a satellite and the economic viability of a satellite
- Steerable beams will remain a reality in physical satellites
- Prohibiting steerable beams in the Radio Regulations blocks ITU databases from reflecting the real spectrum orbit occupancy
- Prohibiting the Radio Regulations from reflecting steerable beams will not enhance efficient use of spectrum resources and would lead to overfilling



Steerable beams:
Spectrum hoarding or efficient use of satellites?

- Today, sharing of spectrum resources is done through bilateral agreements or agreements between satellite operators
- Is it realistic to believe that ITU can capture the detailed arrangements for sharing of orbit spectrum resources currently established bilaterally?
- Is it at all desirable that ITU should get involved in such bilateral matters?
- Does reflecting steerable beams in ITU filings unduly block access to orbit spectrum resources of others?

Maybe it is better to keep things as today and leave such matters to be resolved directly between administrations on a case-by-case basis?

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Use of mobile applications with FSS satellites

ESVs, ESOMPs,
WRC-15 A.I. 1.8 (ESVs)

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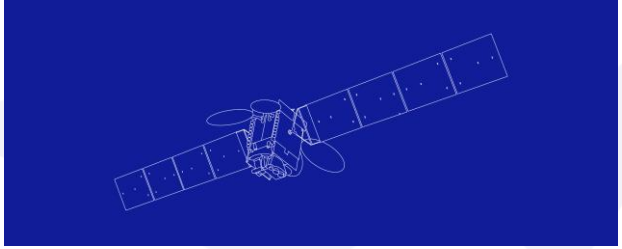
Characteristic of FSS

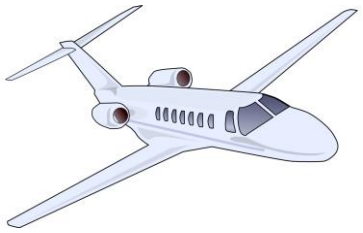


- Inherent qualities of satellite include:
  - Point to multi-point (broadcasting)
  - No requirements for terrestrial infrastructure
  - Mobile applications
  - Remote locations (oceans or sparsely populated areas)
  - Disaster relief
- Large number of satellites and large bandwidths currently only through FSS satellites
- Technically well suited to provide services to mobile terminals (VSAT-like applications)
- Applications (bandwidths) offered through FSS satellites cannot realistically be provided by other means now, or in the foreseeable future
- Use of FSS satellites to serve mobile terminals is a cost efficient way to provide applications and an efficient way to utilize satellite resources

ITU consideration

- ESVs (Earth-Stations on-board vessels)
  - Studied in the 1997-2000 and 2000-2003 study periods, resulting in Resolution 902, specifying conditions under which ESVs may operate in portions of C- and Ku-band
  - Studied in the 2012-2015 study period (under WRC-15 Agenda Item 1.8) with a view to potentially review the conditions for operation of ESVs in these ba

- ESOMPs (Earth Stations On Mobile Platforms)
  - Studied in the 2007-2012 and 2012-2015 study periods (no specific WRC-15 Agenda Item).
  - Maritime, Land and aeronautical applications fore
  - Considered for Ka-band applications



- UAS CNPC
  - Control links for UAS (Unmanned Aircraft stations)
  - Studied in the 2007-2012 and 2012-2015 study periods (currently under WRC-15 Agenda Item 1.5)
  - Principally different from ESVs and ESOMPs since the main issue not the mobility of the terminals, but the requirements for safe operation and the linkage to RR 4.10 outlining the special requirements for such operation
  - Payload communication of UAS would be comparable to ESVs and ESOMPs, but this is not studied under WRC-15 Agenda Item 1.5

Technical reality, potential issues and challenges

Technical reality:

- FSS satellites are technically well suited to serve mobile terminals
- No technical issue in respect of other satellite networks if operated within the coordinated envelope

Potential issues and challenges:

- Challenges to distinguish between “mobile VSAT” and traditional MSS terminals with low directivity antennas
  - Traditional MSS parameters used in FSS bands would significantly increase the required spacing between satellites and would be detrimental for efficient use of the FSS bands
- Care needs to be taken to ensure the integrity and protection of terrestrial services of other countries in same frequency band
  - In particular in respect of maritime and aeronautical mobile applications
- The Radio Regulations, through its definitions are creating difficulties to offer mobile applications through FSS satellites

Mismatch with Radio Regulations definitions

1.21 *fixed-satellite service:* A *radiocommunication service* between *earth stations* at given positions, when one or more *satellites* are used; the given position may be a specified fixed point or any fixed point within specified areas; in some cases this service includes satellite-to-satellite links, which may also be operated in the *inter-satellite service*; the fixed-satellite service may also include *feeder links* for other *space radiocommunication services*.

1.25 *mobile-satellite service:* A *radiocommunication service:*

– between *mobile earth stations* and one or more *space stations*, or between *space stations* used by this service; or

– between *mobile earth stations* by means of one or more *space stations*.

This service may also include *feeder links* necessary for its operation.

1.68 *mobile earth station:* An *earth station* in the *mobile-satellite service* intended to be used while in motion or during halts at unspecified points.

Appropriateness of mobile earth stations operating in the FSS

Should the ITU and the Radio Regulations aim at enabling efficient and desirable use of spectrum and satellite resources (while ensuring the integrity of other services)?

or

Should applications be limited to what fits into the (current) Radio Regulations?

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Thank you!

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