

ITU Seminar in St. Petersburg

MEO Constellations



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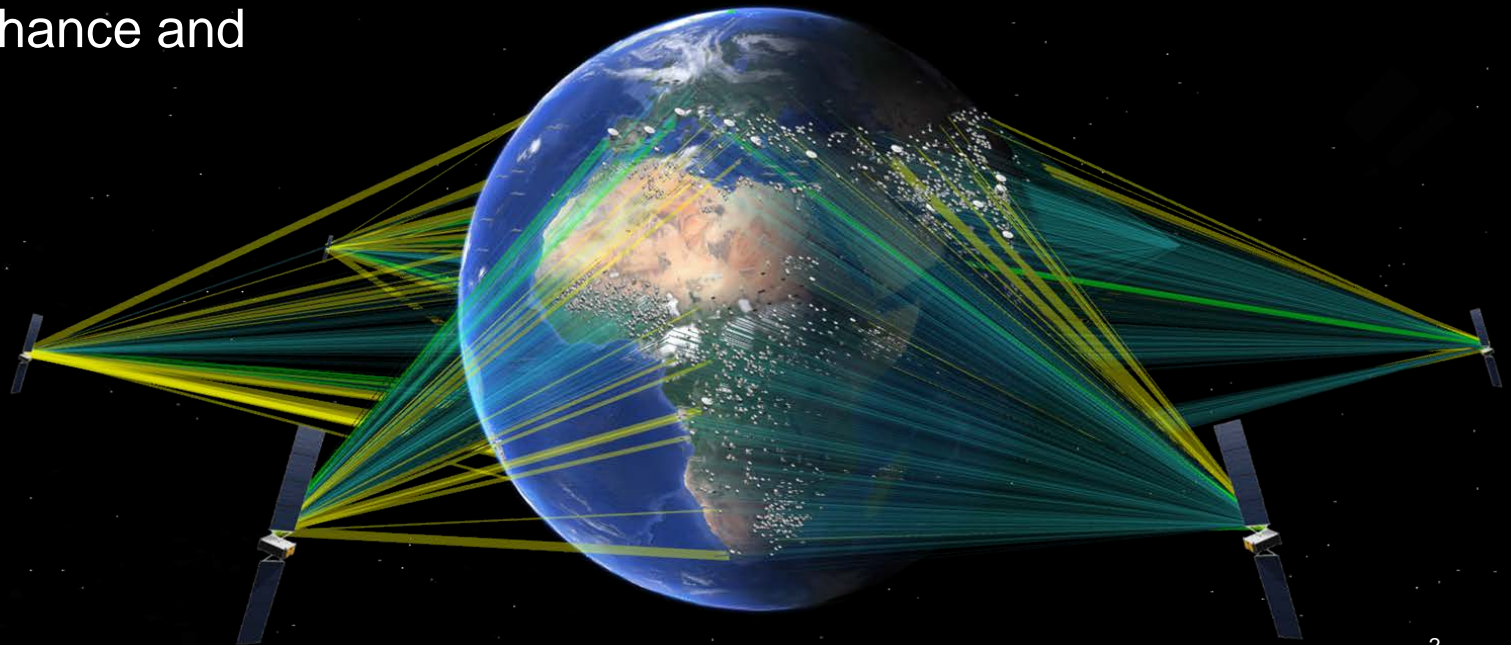
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SES/O3b MEO Constellation

At a glance



- ▲ NGSO constellation at MEO equatorial orbit (8000km) providing a global service to a majority of the world's population
- ▲ SES current generation of NGSO satellites deliver fibre-like service with satellite reach
 - Enabling connectivity to 4G/LTE MNOs, maritime, aeronautical, government, and other network operators
- ▲ SES mPower will substantially enhance and extend the existing capabilities
 - 1000s of beams per satellite
 - 100s of GHz of spectrum reuse
 - Flexible and efficient delivery of capacity where it is most needed



Video

EPFD limits

Defined in Article 22 of RR in certain frequency bands

- ▲ In Article 22 of the Radio Regulations, EPFD limits are specified as the sum of total PFD from all visible NGSO satellites or earth stations into a single GSO earth station or satellite, respectively
- ▲ Expressed dBW/m²/40 kHz (or MHz) as a function of time percentage
- ▲ Key NGSO parameters to evaluate EPFD (all provided by the administration of an NGSO system):
 - PFD mask per NGSO satellite
 - Exclusion zone angle
 - NGSO orbital parameters
 - Uplink: NGSO earth station density



CHAPTER VI – Provisions for services and stations

RR22-1

ARTICLE 22

Space services¹

Section I – Cessation of emissions

22.1 § 1 Space stations shall be fitted with devices to ensure immediate cessation of their radio emissions by telecommand, whenever such cessation is required under the provisions of these Regulations.

Section II – Control of interference to geostationary-satellite systems

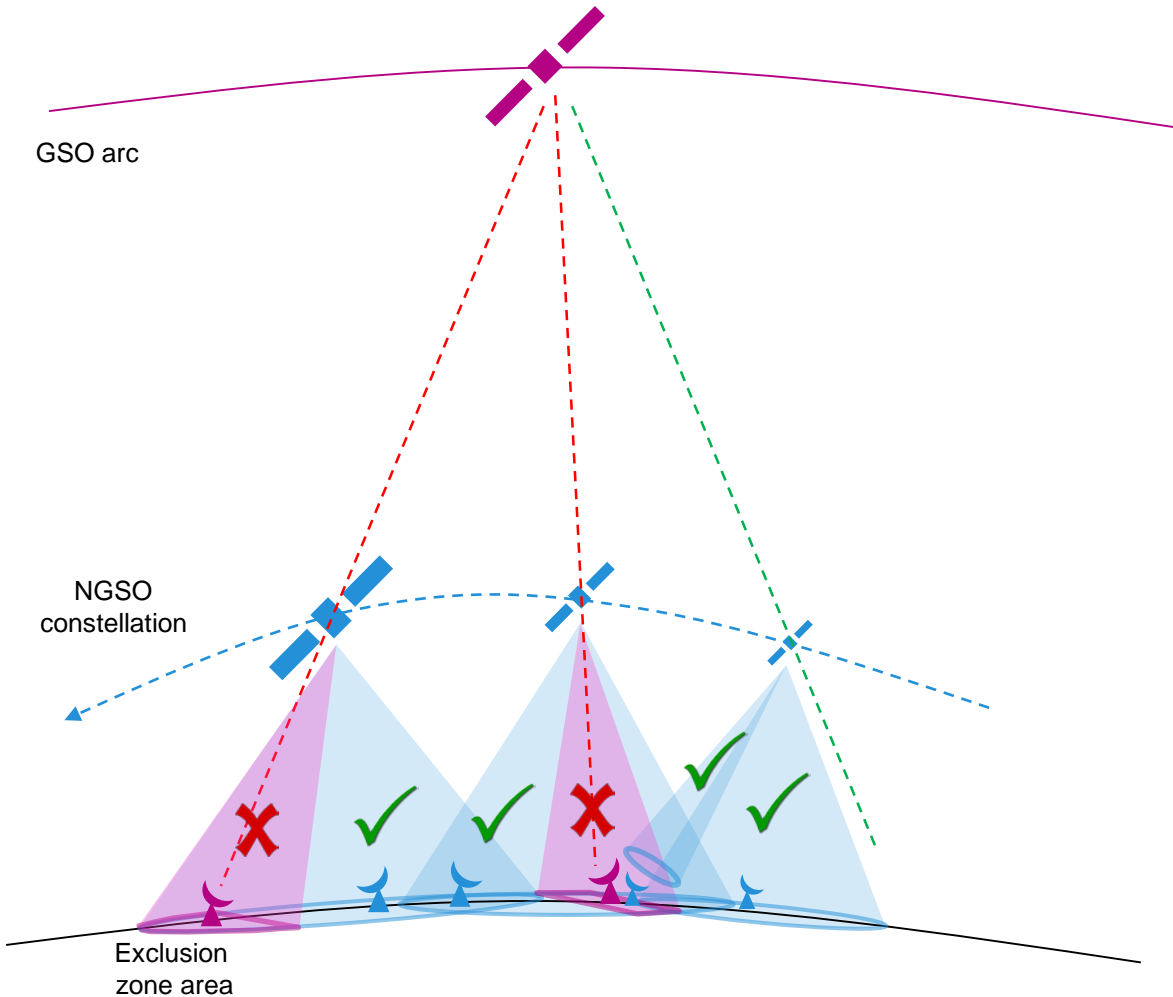
22.2 § 2 1) Non-geostationary-satellite systems shall not cause unacceptable interference to and, unless otherwise specified in these Regulations, shall not claim protection from geostationary-satellite networks in the fixed-satellite service and the broadcasting-satellite service operating in accordance with these Regulations. No. 5.43A does not apply in this case. (WRC-07)

22.3 2) Whenever the emissions from geostationary satellites in the inter-satellite service are directed towards space stations at distances from Earth greater than that of the geostationary-satellite orbit, the boresight of the antenna mainbeam of the geostationary satellite shall not be pointed within 15° of any point on the geostationary-satellite orbit.

22.4 § 3 In the frequency band 20 05,30 GHz space stations in the Earth exploration,

EPFD limits

Illustrated NGSO protection of the GSO downlink



- ▲ The **shaded area** (shown with red ✘) under these NGSO links cannot be served because they will align with the GSO arc
 - Either the NGSO satellite must turn off those beams covering that area or, in the case of steerable beams, point their beams to serve other areas not in-line with the GSO arc
- ▲ The **shaded area** (shown with green ✓) under these NGSO links has no intersection with the GSO arc and the surface of the Earth
 - These NGSO links may transmit without impacting the GSO
- ▲ Ideally, NGSO constellations will have satellite diversity for their earth stations within the GSO exclusion zone such that a continuous service may be offered to NGSO earth stations in that area

EPFD limits

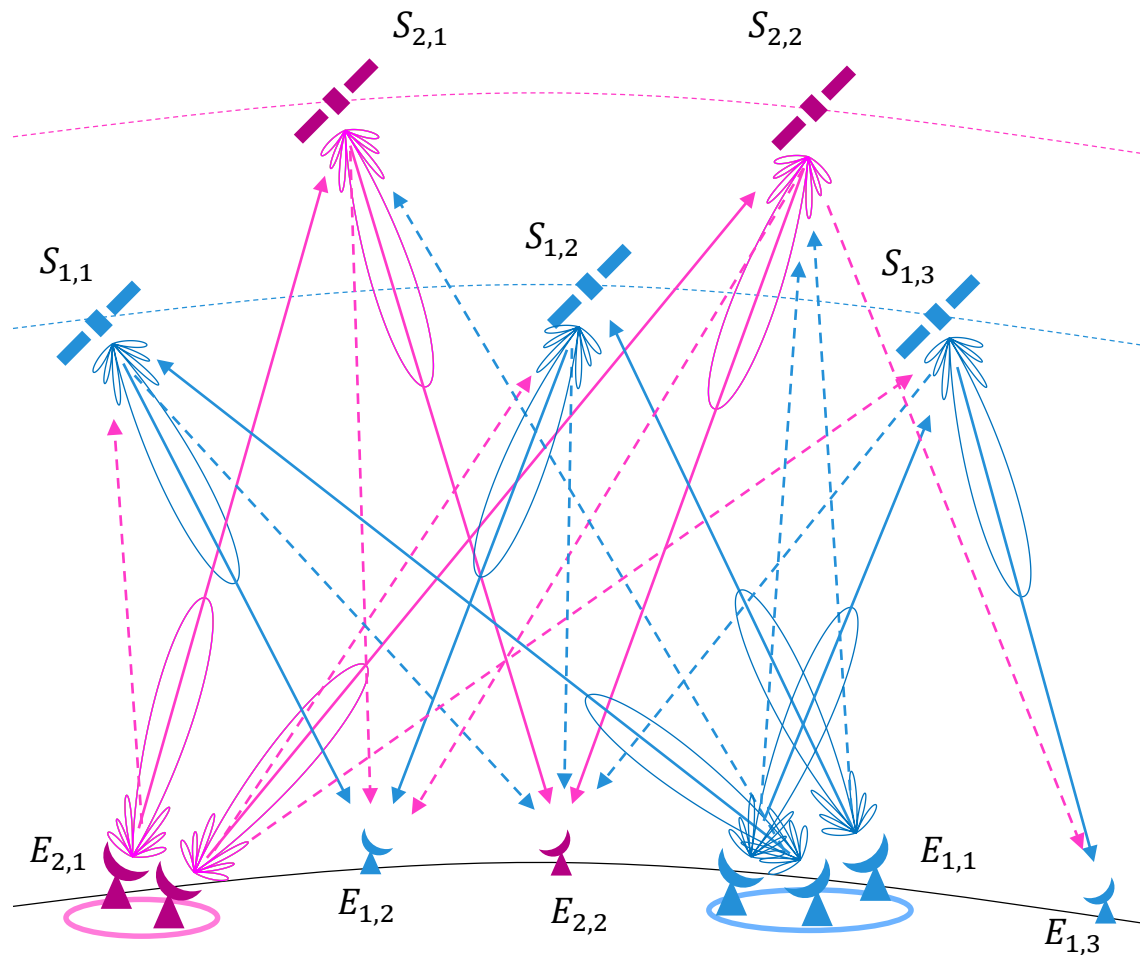
Illustration of SES MEO constellation and exclusion zone



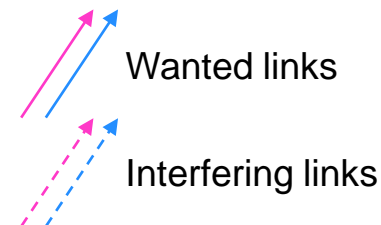
- ▲ This video illustrates the visible area of SES MEO satellites and the protection of the GSO arc by way of an exclusion zone (shown as a gap along the equator)
- ▲ SES provides service in this equatorial region using non-EPFD limited frequencies

NGSO-to-NGSO coordination

Managing the likelihood and magnitude of interference



- ▲ Compatibility is driven by the likelihood and magnitude of interference
- ▲ Key input parameters
 - NGSO orbital parameters
 - Geographic separation of their earth stations
 - Earth station tracking strategy
 - EPFD limits
- ▲ Key output
 - Likelihood & magnitude of the time-varying interference
- ▲ Interference mitigation
 - Orbital avoidance, frequency diversity, geographic avoidance, etc.



Equatorial Arc in Sky



NGSO-to-NGSO coordination

Illustration of time varying orbital parameters



- ▲ Illustration of a LEO satellite constellation with SES MEO equatorial constellation
- ▲ Viewed from earth station in polar coordinates
 - Azimuth angles 0 – 360°
 - Elevation angles 0 – 90°
- ▲ In this example, orbital avoidance may be an alternative to ensure compatibility between the NGSO constellations

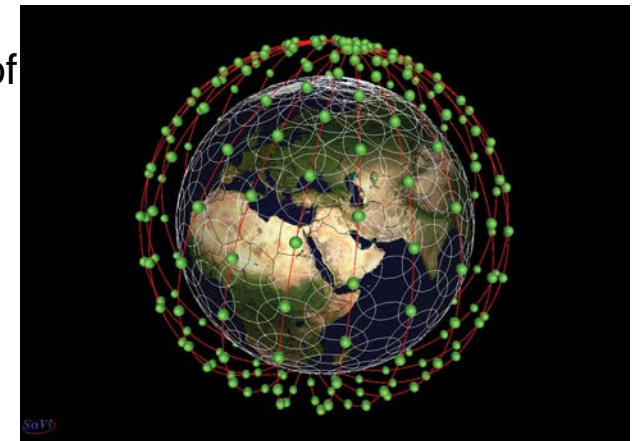
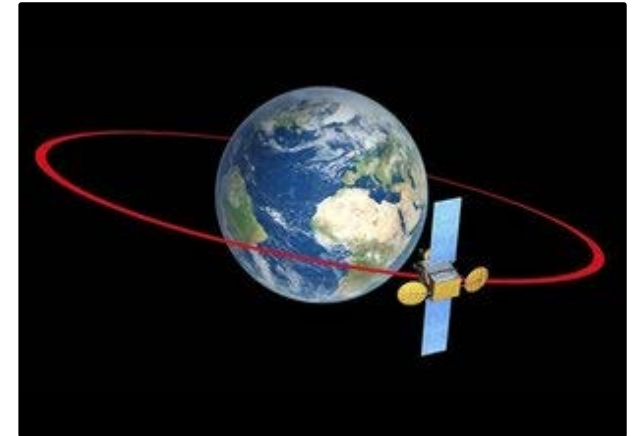
WRC-19

Focus on regulatory issues: **Bringing into use**

- ▲ WRC-19 will consider NGSO bringing into use and maintenance of the MIFR
 - Identified by BR Director before WRC-15 as potential issue contributing to spectrum warehousing

- ▲ WP 4A, under Agenda item 7, is studying the issue and preparing methods for a regulatory solution
 - Currently, 1 satellite deployed in one of the notified orbital planes can satisfy BIU of all frequency assignments
 - Deploying the full constellation takes time so milestones are needed to ensure the MIFR matches reality

- ▲ **Goal:** establish a regulatory solution to minimize spectrum warehousing by ensuring an accurate MIFR while allowing reasonable flexibility to deploy an NGSO constellation



Focus on spectrum issues: [Agenda item 1.6](#)

- ▲ WRC-19 will consider a regulatory solution to protect GSO from NGSO FSS operations in the V-band (40-75 GHz)
 - Studies include NGSO-to-NGSO sharing and protection of passive services from NGSO OOB

- ▲ WP 4A is studying the issue and preparing methods for a regulatory solution
 - Currently, there are 4 methods to satisfy the Agenda item based primarily on establishing EPFD limits or an allowable increase in the GSO unavailability
 - Also considers revisions to Resolution 750 for limits on NGSO transmitting earth stations and coordination provisions between NGSO systems under Article 9

- ▲ **Goal:** establish a regulatory solution that defines certainty between the GSO and NGSO operations while ensuring GSO protection

Future Work

Looking ahead at NGSO topics

- ▲ Improving S.1503 (conformity of NGSO to limits) and EPFD evaluations
 - Should dynamic EIRP allocation be considered as part of the improvements for EPFD algorithm?
- ▲ Aggregate EPFD evaluation
 - Currently no software to ensure the aggregate EPFD limit is met when there are more than 3.5 systems deployed
 - How to ensure the aggregate is met if/when more than 3.5 systems are operating in a band?
- ▲ Modifications to NGSO systems between coordination and notification stages
 - At least one modification published by the BR where an NGSO systems emission and orbital parameters are changed while maintaining the original date of receipt
 - Should a universal procedure be established?

Thank you



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