MEO

The Enabler Orbit

Presented by

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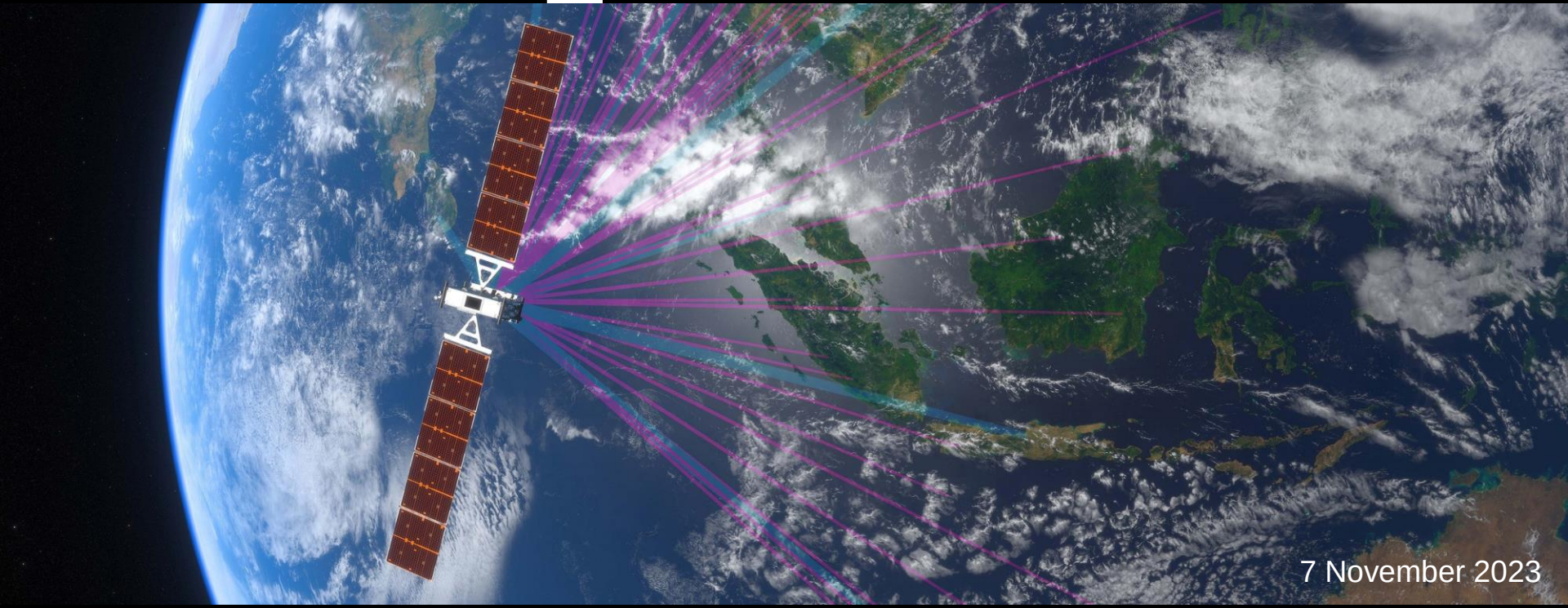
KIVI Satellite Communications Seminar – ESTEC



7 November 2023

SES

O3b mPOWER

Leader in Global Content Connectivity Solutions

Delivering Global Content Connectivity Solutions

We broadcast almost 8,200 TV channels that reach over 1 billion people

We deliver HD & Ultra HD content to any platform, on any device

We ensure that customers have full access to the cloud, from any location

We help restore connectivity after natural disasters

We connect over 300 customers in 130 countries and on planes, ships, oil rigs

We support telcos with their 3G/4G/5G roll-outs and connecting remote areas

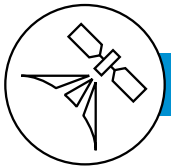
Our Assets in Space

GEO wide beam

Over **48** satellites in service and **1** being built

Reaching **366 million** TV households worldwide

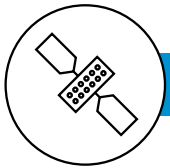
Providing comprehensive reach to deliver **data connectivity**



GEO HTS

Expanding GEO HTS satellites; **4** launched and **2** being built

Improving value proposition for **data applications**



MEO HTS

24 satellite constellation plus **2** more launching in 2023

High throughput, **Low** latency

Our Medium Earth Orbit (MEO) Journey – Part 1

O3b
Current MEO Communications System

2009 — SES starts its MEO journey with an initial investment in O3b Networks

2013 — First four O3b MEO satellites launched

2014

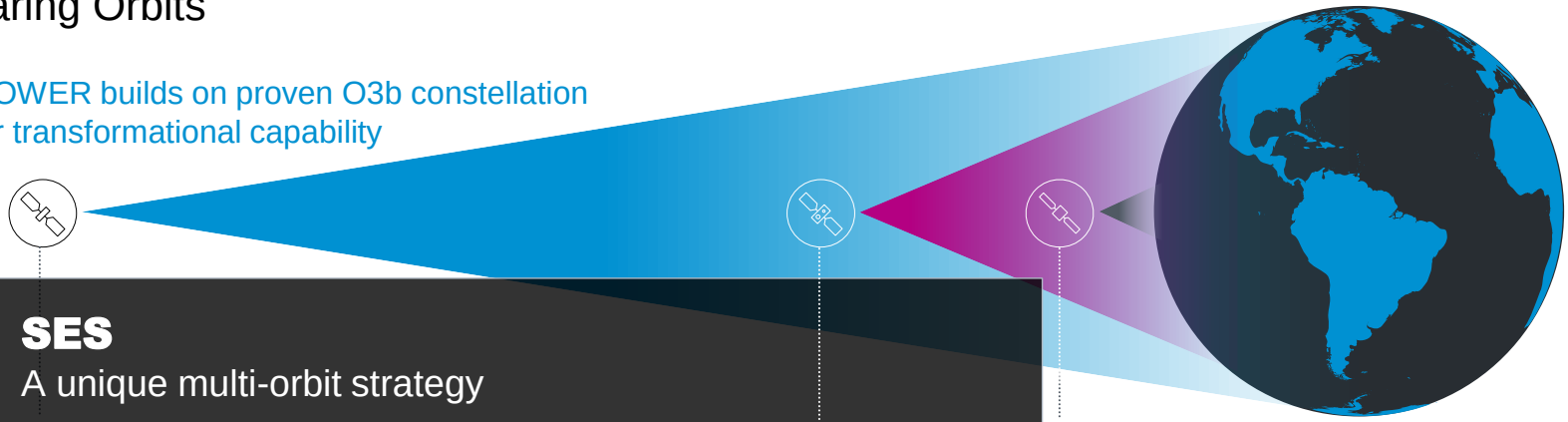
2015 — First telco, cruise, energy, and government customers

2019 — The O3b constellation is completed with 20 satellites in orbit

Source: Thales

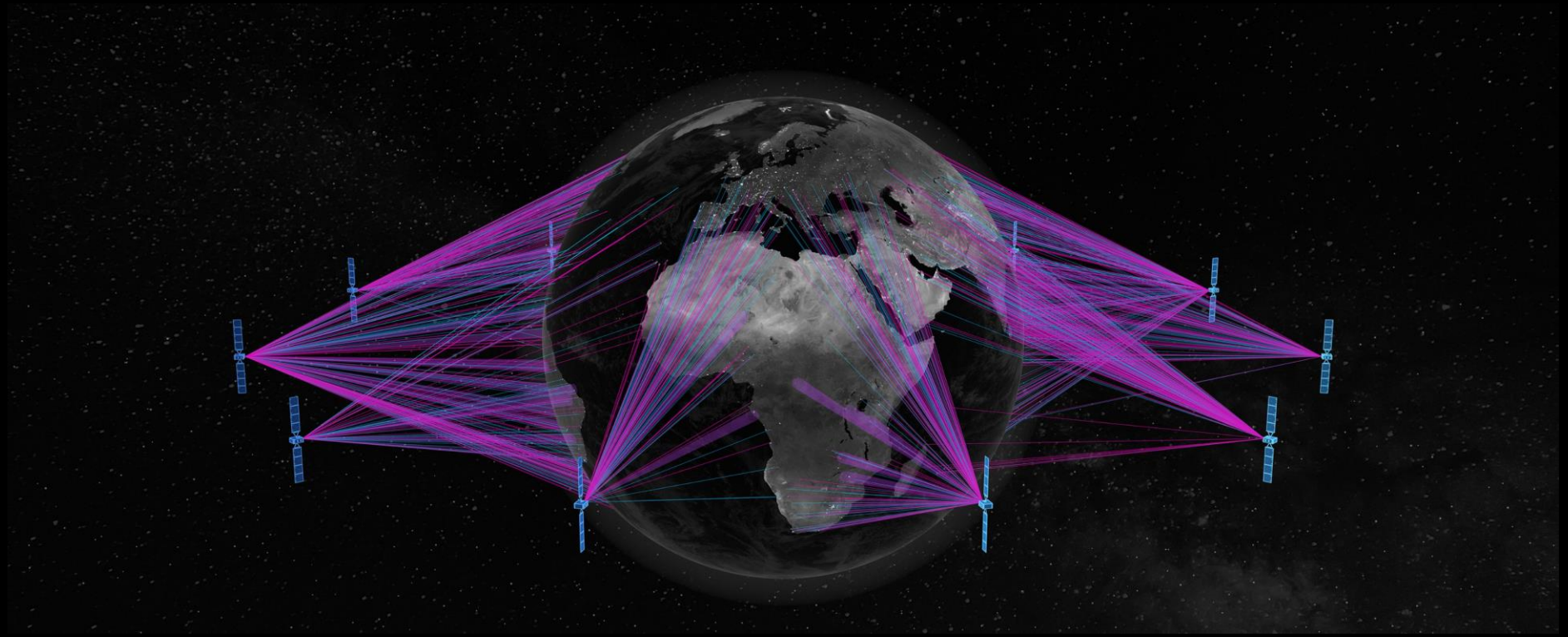
O3b mPOWER
Comparing Orbits

O3b mPOWER builds on proven O3b constellation
to deliver transformational capability



SES
A unique multi-orbit strategy

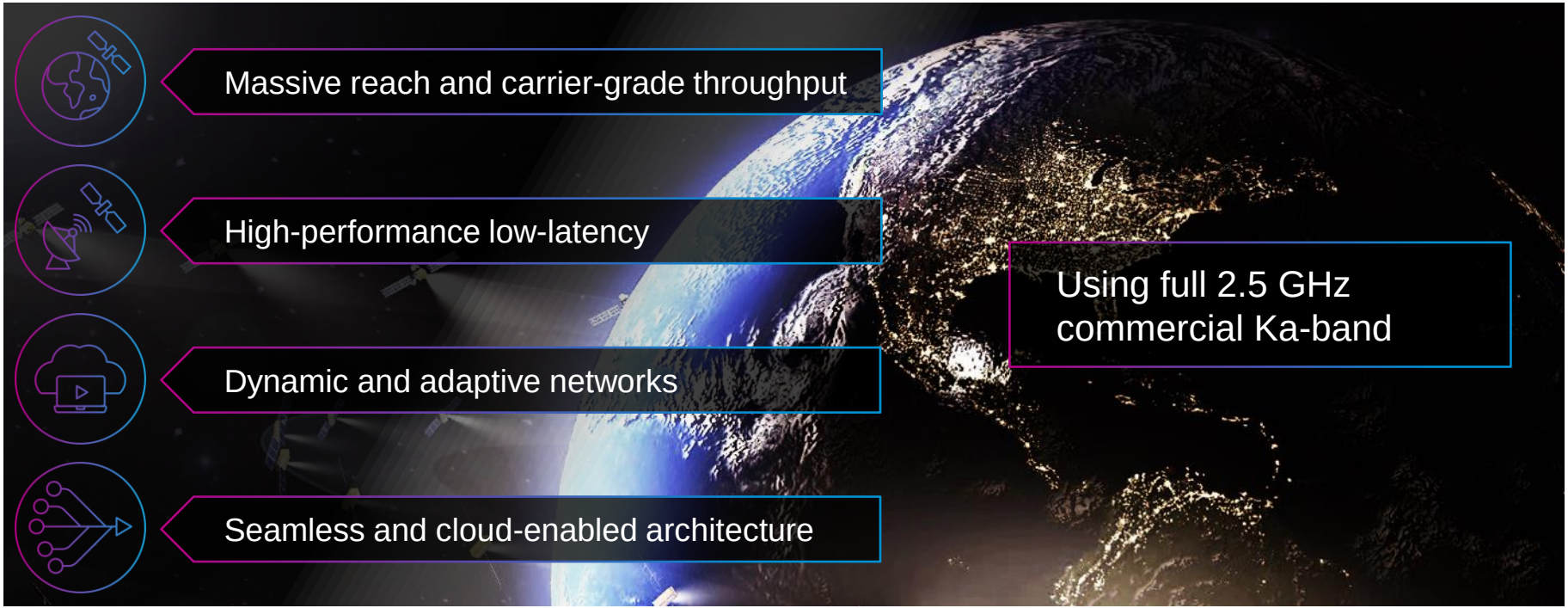
GEO	MEO	LEO
36,000km	~ 8,000km	~ 1,000km
E.g., Wideband global system	E.g., O3b mPOWER	E.g., Starlink
Broad coverage—3 satellites	Extended reach—6 satellites, scalable	Limited view—hundreds of satellites
High latency—operationally simple	Low latency—operationally simple	Low latency—operationally complex
Expansive coverage	High throughput, high flexibility, high performance	Low, contended bandwidth, requires operator's nearest gateway



O3b mPOWER constellation artist impression

O3b mPOWER

Enables a new era of satellite-based network services



Expanding Capabilities

O3b MEO - CURRENT

UP TO 1.5 Gpbs
Throughput per terminal

MECHANICALLY
Steered beams

TEN
User beams per satellite

2
Gateway beams per satellite

700km
Coverage per beam

~150ms
MEO low latency

NEXT GENERATION - O3b mPOWER

MULTIPLE Gpbs
Throughput per terminal

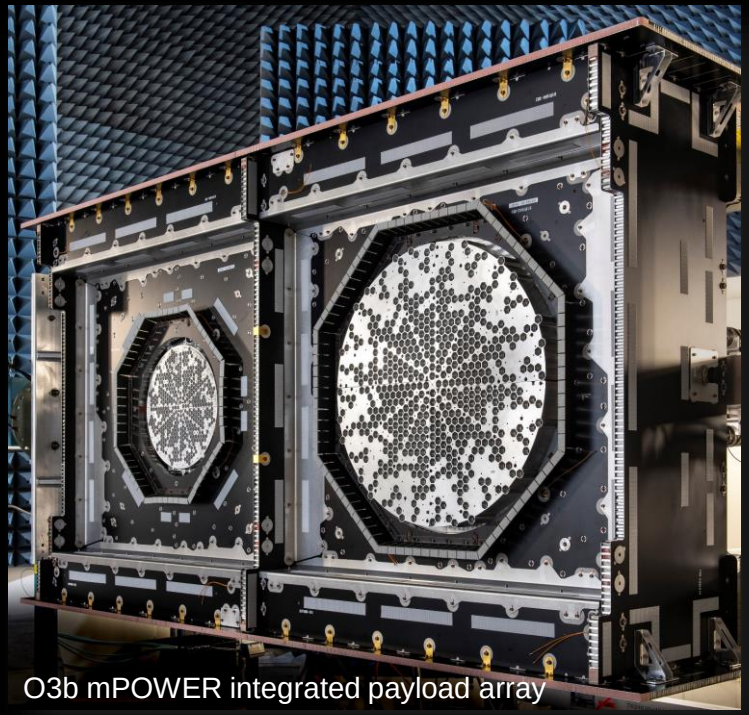
ELECTRONICALLY
Generated shapeable beams

THOUSANDS
of beams per satellite

ANY BEAM
Can be used as a gateway

250km
Coverage per beam

O3b mPOWER satellite artist impression



O3b mPOWER integrated payload array

O3b mPOWER 2 satellites stacked

O3b mPOWER gateway (Greece)


JLG
193
HercRental

SES

O3b mPOWER

Our Medium Earth Orbit (MEO) Journey – Part 2

O3b mPOWER

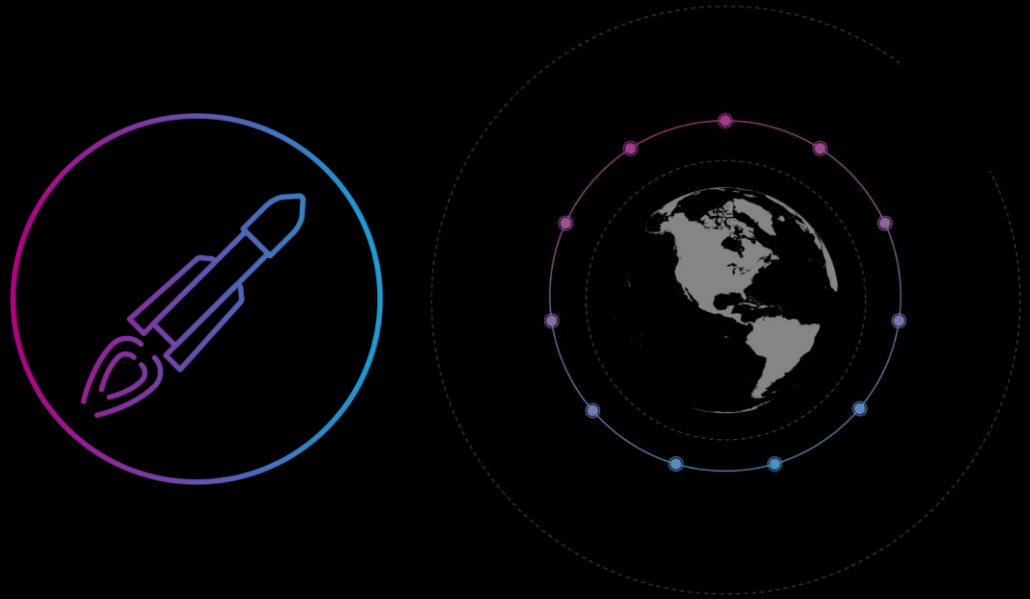
Second-generation MEO Communications System

- **2017** – Seven O3b mPOWER satellites ordered from Boeing
- **2020** – First telco and cruise customers signed – Orange and Carnival
- **2020** – Four additional O3b mPOWER satellites ordered
- **2020** – Construction of co-located O3b mPOWER gateways with Microsoft data centres begins
- **2022** – SES co-develops ground ecosystem with 30 software and technology partners
- **2022** – SpaceX launched the first batch of O3b mPOWER satellites

LAUNCH TIMELINE AND START OF SERVICE

O3b mPOWER Satellite	Launch Date
1 – 2	Launched!
3 – 4	Launched!
5 – 6	Q4 2023
7 – 8	H2 2024
9 – 11	2025
12 – 13	2026

Enter into Service Q2 2024



Telco & Enterprises

Empowering Enterprise, Energy, and Mining

MNOs

Empowering LTE & 5G networks

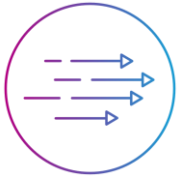
Cruise operators

Empowering Cruise

Military / Governments

Empowering network security and safety

MEO Use Case : LEO Data Relay

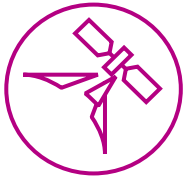


REAL TIME DELIVERY

- Continuous, virtual contact channels within each O3b mPOWER MEO region
- Send imagery immediately any time
- No Gaps: no waiting for ground station pass

OCEAN COVERAGE

- 70% of globe is ocean
- Instantly downlink Ocean imagery
- Eliminate gaps due to ocean flyover
- Offer real-time naval/maritime value



NO CONTACT GAPS

- Always-available MEO-to-ground relay.
- Overcome contact gaps over ocean, huge inaccessible landmasses (regulatory)

SCALE GLOBALLY

- Virtual Downlink contact while imaging anywhere over inhabited earth – all with a single service
- Add regional or global real-time downlink capability
- Time-to-market: Bypass in-country delays & barriers

IN-THEATRE REAL-TIME

- Overcome lack of in-theatre/near-theatre downlinks
- SES MEO Relay extends real-time connectivity to LEO during In-Theatre fly over, without need to rely on nearby ground assets for downlink

What about the regulations?

- ITU Radio Regulations contain the international agreements concerning the use of frequency bands by different services, e.g.
  - Satellite
  - Mobile (yes, our phones)
  - Navigation (e.g. GALILEO, GPS, also on your phones)
  - Radio Astronomy
- O3b mPOWER constellation built to operate in the Ka-band
  - 17.7-20.2 GHz downlink
  - 27.5-30.0 GHz uplink
  - FSS (Fixed-Satellite Service)
- **Currently no regulations** for data relay links between MEO/GEO and LEOs in Ka-band!
  - Operations possible on “non-interference basis” → not ideal
- **Enter: World Radiocommunication Conference**

1. Harmonize global spectrum to create economies of scale, roaming and interoperability

3. Creating certainty requires consensus: time, efforts and patience

WRC PURPOSE

2. Create regulatory certainty for a multi-trillion dollars industry playing an increasingly important role in the development of our societies

WRC preparatory process – 3 to 4 year cycle

National level

National proposals

LUX, HOL, Sweden, USA, Brazil, Singapore…

Regional proposals

Europe - CEPT
Americas - CITEL
Asia Pacific - APT
Arab group - ASMG
Africa - ATU
CIS - RCC

Regional level

Radio Regulations in force

WRC-23

20 November - 15 December

Updated Radio Regulations

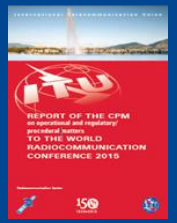
+

Agenda for WRC in 2027

Agenda for WRC-23

Study Groups
& their Working Parties
of global experts

CPM Report



Conference Preparatory Meeting
March 2023

International level

Is it big?

568 documents

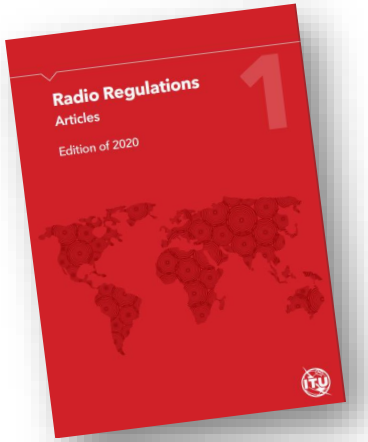
3420 delegates

230 Heads of delegations

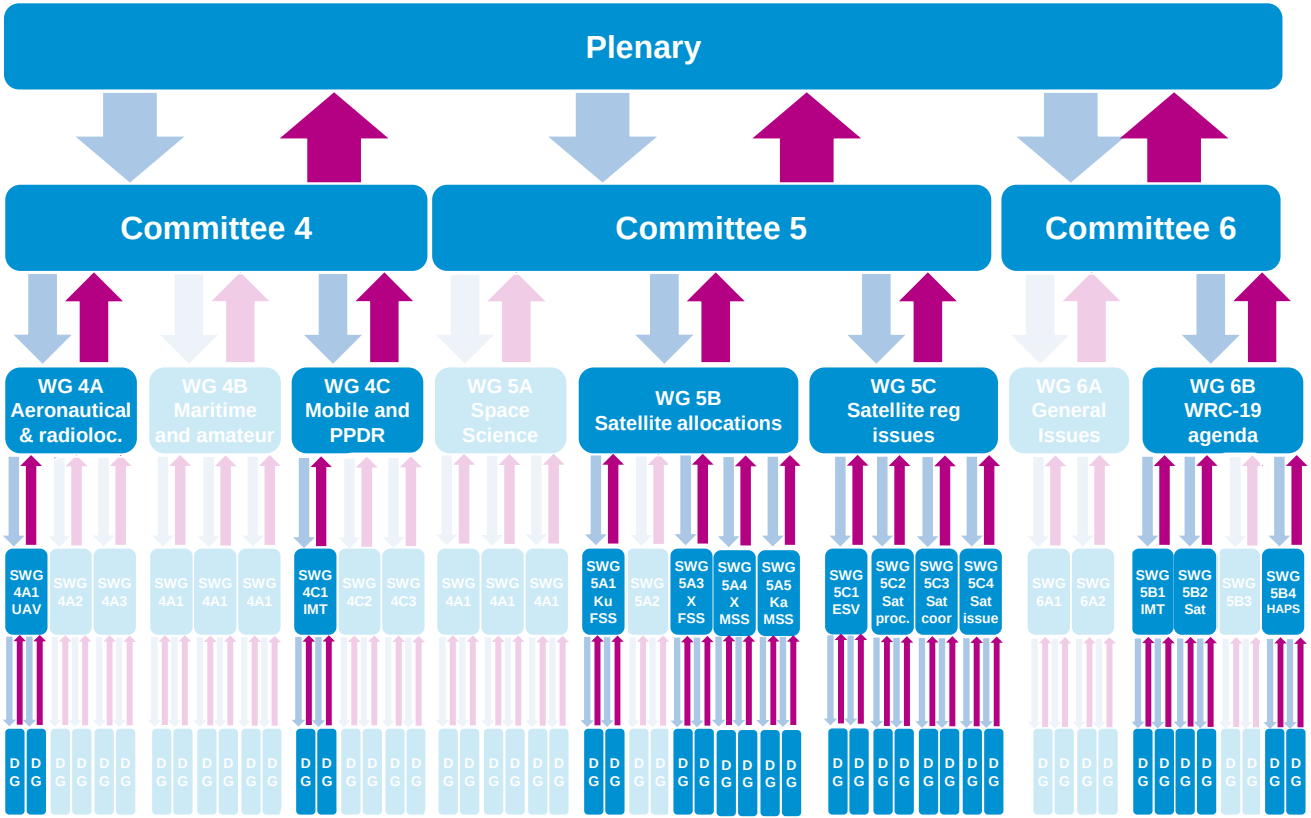
163 admins, industry, observers

25 agenda items

103 new & changes Resolutions



WRC Structure (or… why does it take 4 weeks?)



So how do we get LEO data relay in Ka-band in the Radio Regulations?

WRC-23 Agenda Item1.17:

"to determine and carry out, on the basis of ITU-R studies in accordance with Resolution **773 (WRC-19)**, the appropriate regulatory actions for the provision of inter-satellite links in specific frequency bands, or portions thereof, by adding an inter-satellite service allocation where appropriate"

Resolution **773 (WRC-19)**

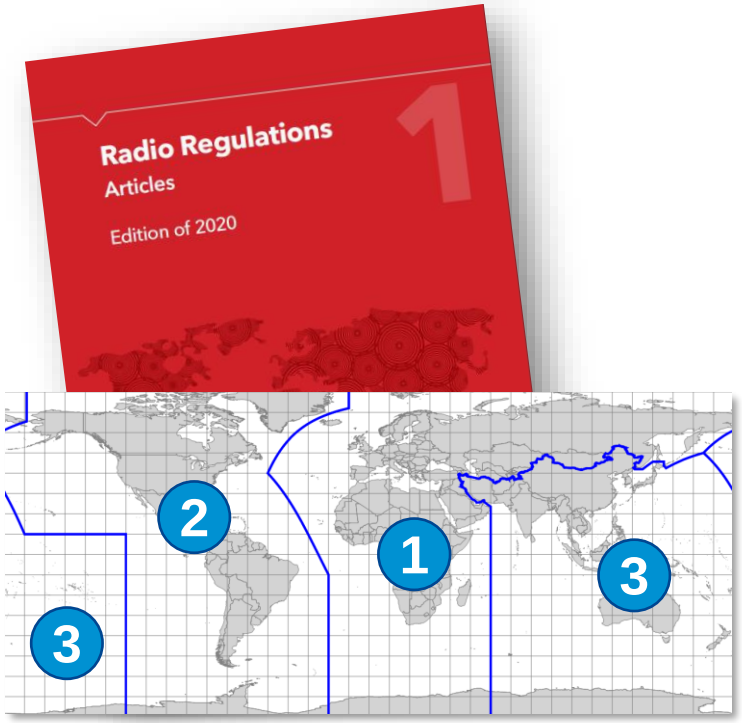
"Study of technical and operational issues, and regulatory provisions for satellite-to-satellite links in the frequency bands 11.7-12.7 GHz, 18.1-18.6 GHz, 18.8-20.2 GHz and 27.5-30 GHz"

So how do we get LEO data relay in Ka-band in the Radio Regulations?

"Typical" language in the Resolution:

"to study sharing and compatibility between satellite-to-satellite links intending to operate between space stations in the frequency bands 11.7-12.7 GHz, 18.1-18.6 GHz, 18.8-20.2 GHz and 27.5-30 GHz and current and planned stations of the FSS and other existing services allocated in same frequency bands and adjacent frequency bands, including passive services, with a view to ensuring protection of the primary services"

What other services?

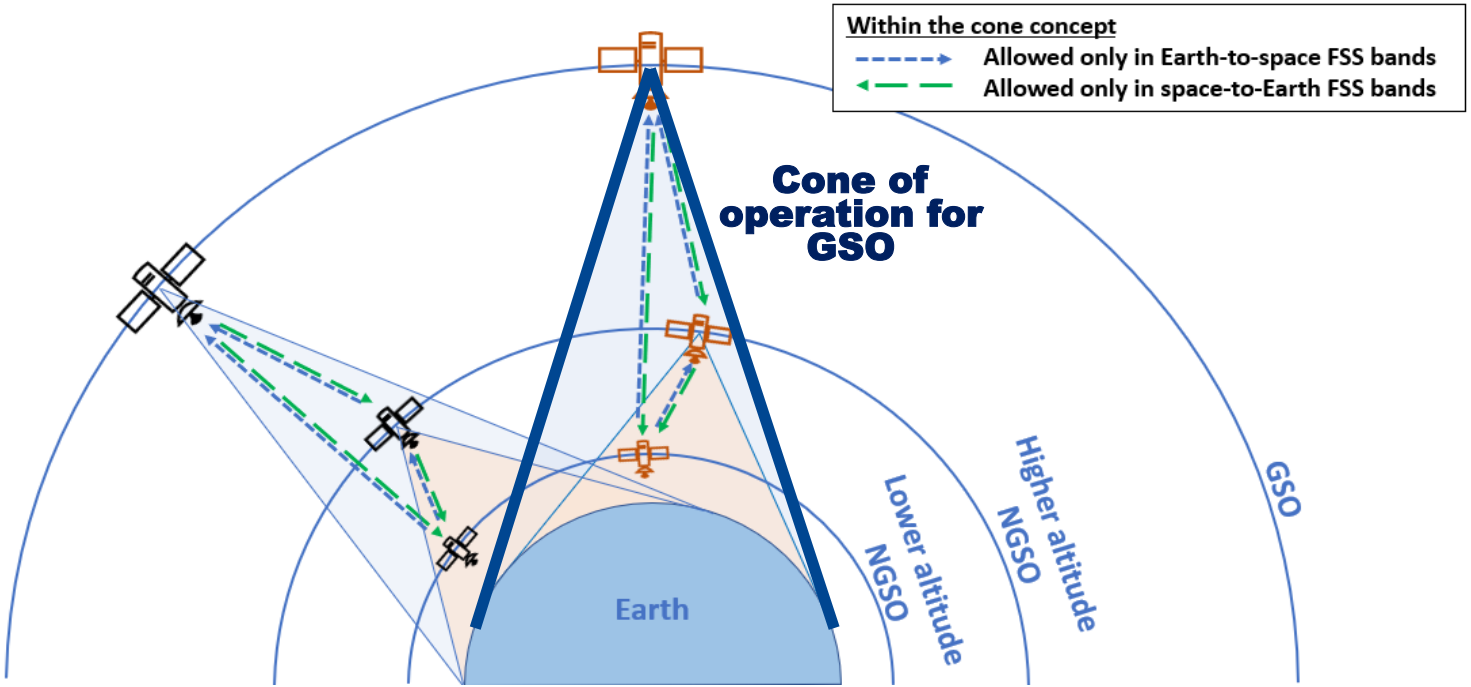


24.75-29.9 GHz

Allocation to services		
Region 1	Region 2	Region 3
27.5-28.5	FIXED 5.537A FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.517A 5.539 MOBILE 5.538 5.540	
28.5-29.1	FIXED FIXED-SATELLITE (Earth-to-space) 5.484A 5.516B 5.517A 5.523A 5.539 MOBILE Earth exploration-satellite (Earth-to-space) 5.541 5.540	
29.1-29.5	FIXED FIXED-SATELLITE (Earth-to-space) 5.516B 5.517A 5.523C 5.523E 5.535A 5.539 5.541A MOBILE Earth exploration-satellite (Earth-to-space) 5.541 5.540	
29.5-29.9 FIXED-SATELLITE (Earth-to-space) 5.484A 5.484B 5.516B 5.527A 5.539 Earth exploration-satellite (Earth-to-space) 5.541 Mobile-satellite (Earth-to-space) 5.540 5.542	**29.5-29.9** FIXED-SATELLITE (Earth-to-space) 5.484A 5.484B 5.516B 5.527A 5.539 MOBILE-SATELLITE (Earth-to-space) Earth exploration-satellite (Earth-to-space) 5.541 5.525 5.526 5.527 5.529 5.540	**29.5-29.9** FIXED-SATELLITE (Earth-to-space) 5.484A 5.484B 5.516B 5.527A 5.539 Earth exploration-satellite (Earth-to-space) 5.541 Mobile-satellite (Earth-to-space) 5.540 5.542

27.5-30 GHz

Concept of the operations



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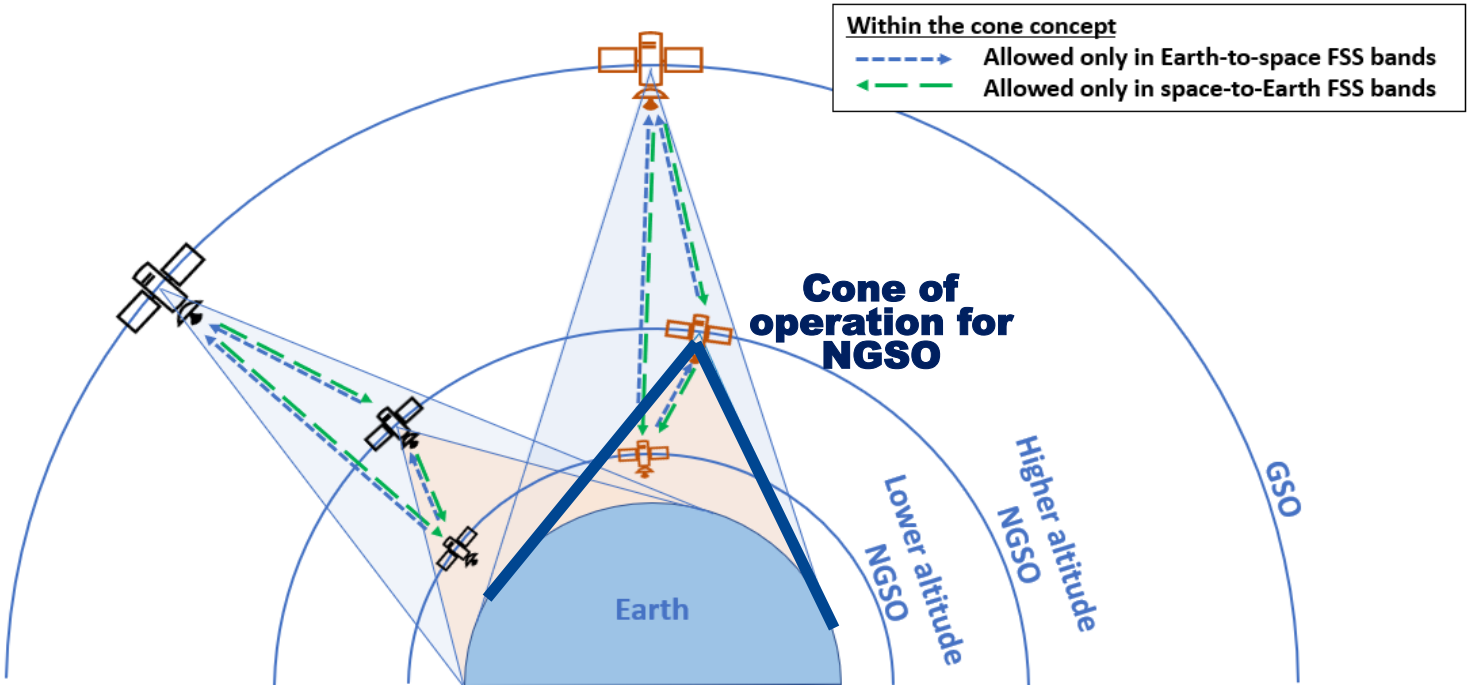

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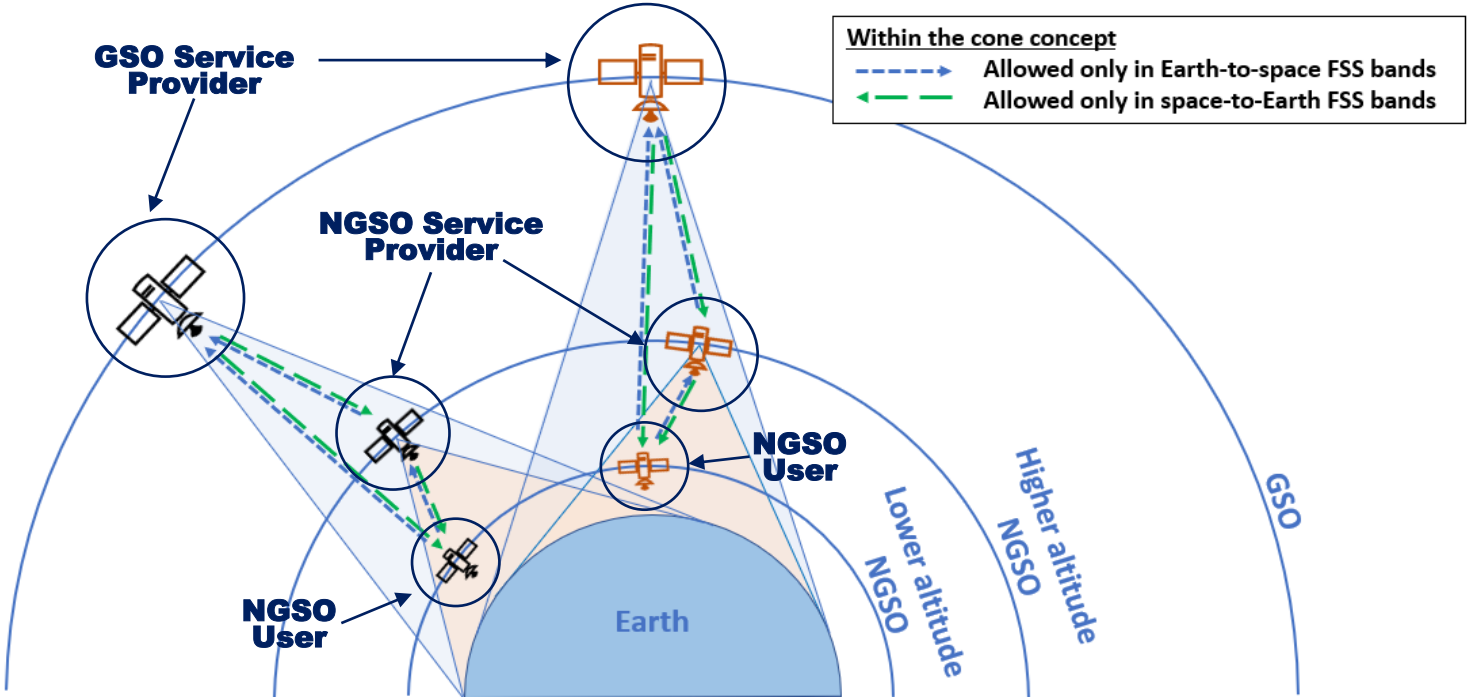

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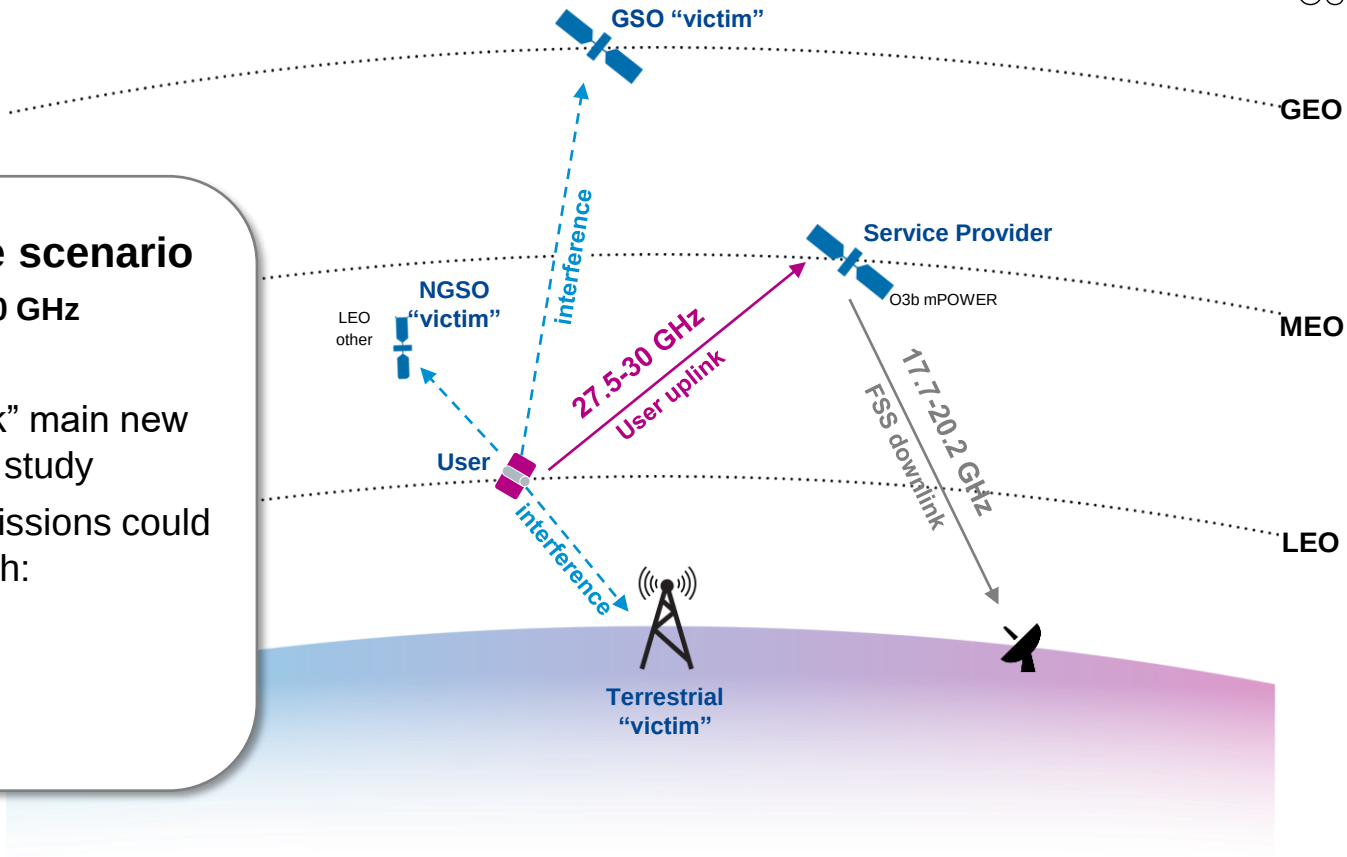
O3b mPOWER

Interference scenario

Ka-band 27.5-30 GHz

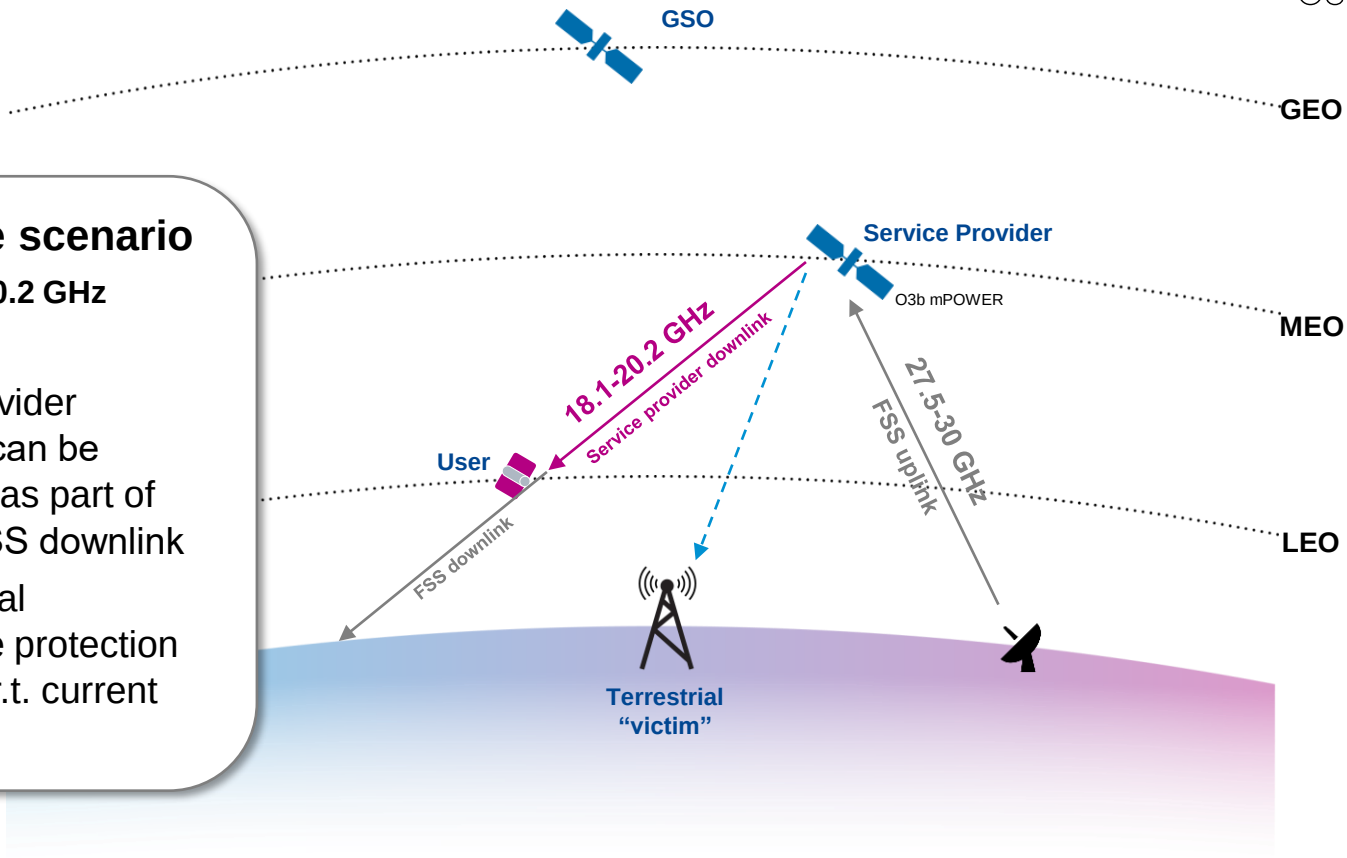
- User “uplink” main new element for study
- Off-axis emissions could interfere with:
  - GSO
  - NGSO
  - Terrestrial



Interference scenario

Ka-band 18.1-20.2 GHz

- Service provider “downlink” can be considered as part of “normal” FSS downlink
- No additional interference protection required w.r.t. current regulations



What compatibility scenarios did we have to study?

TERRESTRIAL SERVICES

- Needs to be protected in 27.5-29.5 GHz range as there can be fixed broadband applications
- **Solution** is for the User uplink to meet certain pfd (in dBW/m^2/MHz) on the Earth surface

EARTH EXPLORATION SATELLITE SERVICE

- Needs to be protected in the frequency range 18.6-18.8 GHz
- **Solution** is for the Service Provider downlinks to meet certain pfd (in dBW/m^2/200MHz) on the Earth surface or over Oceans

GEOSTATIONARY SATELLITES

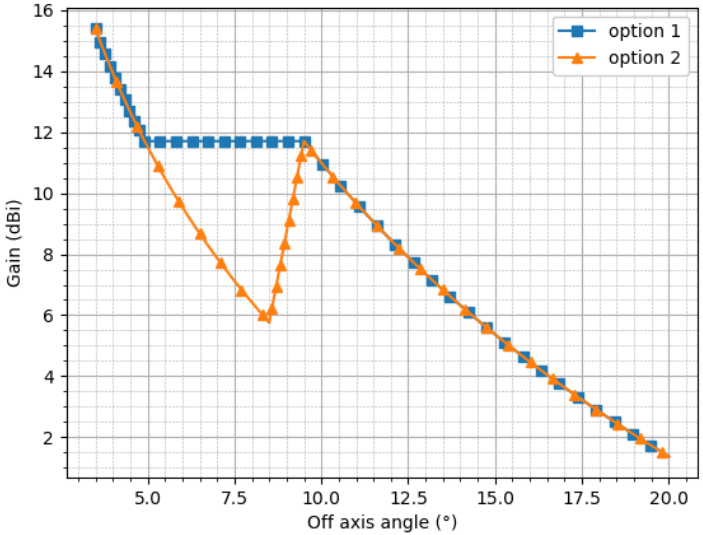
- GSO satellites receiving in 27.5-30 GHz need to be protected
- Depending on the sub-band, the **solution** is to operate under the coordination agreements that already exist w.r.t. Service provider, or
- The user uplink needs to meet a certain pfd (dBW/m^2/40kHz) at the GSO orbit

NGSO SYSTEMS

- NGSO satellites receiving in 27.5-30 GHz need to be protected
- **Solution** is for the User uplink to comply with on-axis eirp spectral density limit (in dBW/Hz), potentially in combination with aggregate eirp value (in dBW)

So what will happen next?

- The Conference (WRC) has been provided with a number of ‘options’ to solve a the various elements (CPM Report)
  - What “type” of allocation? FIXED-SATELLITE SERVICE or INTER-SATELLITE ?
  - What pfd level to protect terrestrial services?
  - What antenna pattern for the ‘user’ satellite
- Different Regions or (groups of) Administrations have submitted to the Conference their preferred options
- Proposals will be presented and discussed, from plenary level to small drafting groups, and back up and then a result will normally follow through a ‘delicate compromise’



Thank You !

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