



Orbit/Spectrum ITU International Regulatory Framework

**ITU Regional
Radiocommunication Seminar
for the ASIA&PACIFIC
Apia, Samoa
19-23 September 2016**

Mitsuhiro Sakamoto

The poster features a scenic background of a rocky beach at sunset with palm trees and a large island in the distance. The ITU logo is prominently displayed in the center, overlaid on a blue circular graphic. Text on the poster includes the ITU name at the top, the seminar title, location, and dates. At the bottom, there is a QR code, a website URL, and logos for PITA and ITU.

International Telecommunication Union

ITU

ITU/PITA REGIONAL
RADIOCOMMUNICATION SEMINAR
FOR ASIA PACIFIC

**APIA, SAMOA
19-23 SEPTEMBER 2016**

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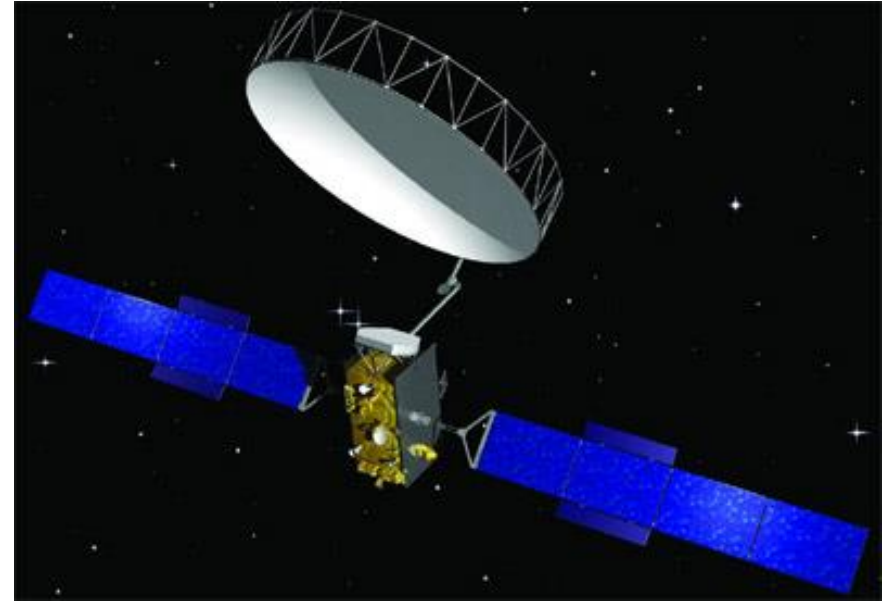
1957.... 1965

development of
communication
satellites

Sputnik 1 (Спúтник-1) was the first artificial Earth satellite launched on 4th October 1957 with external radio antennas to broadcast radio pulses

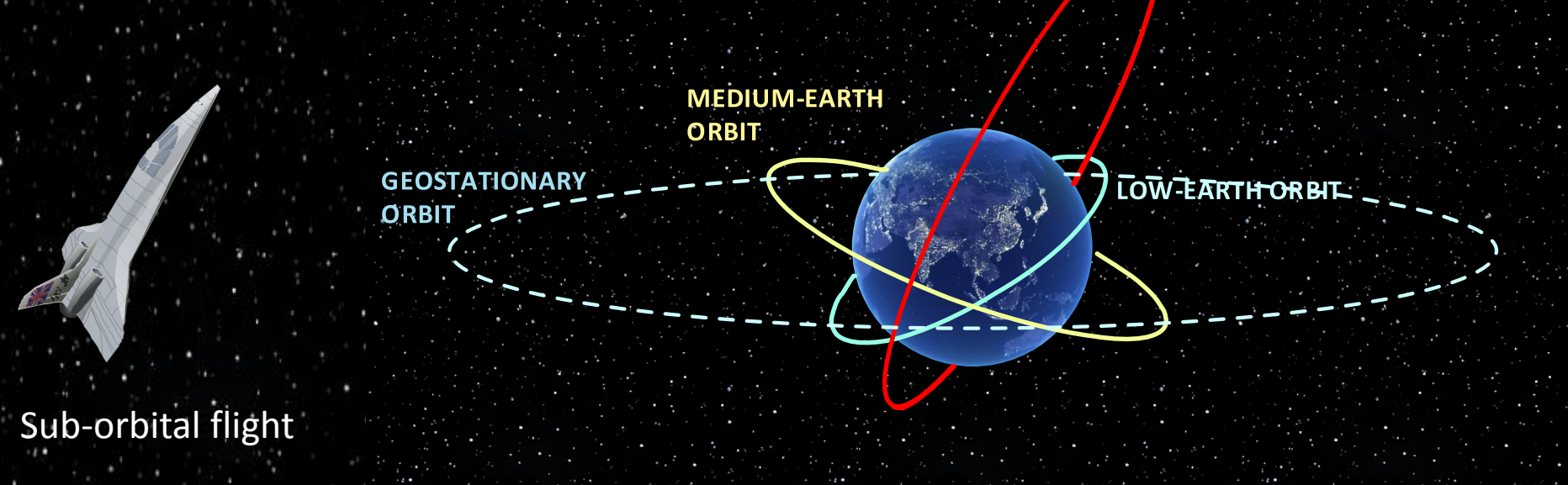
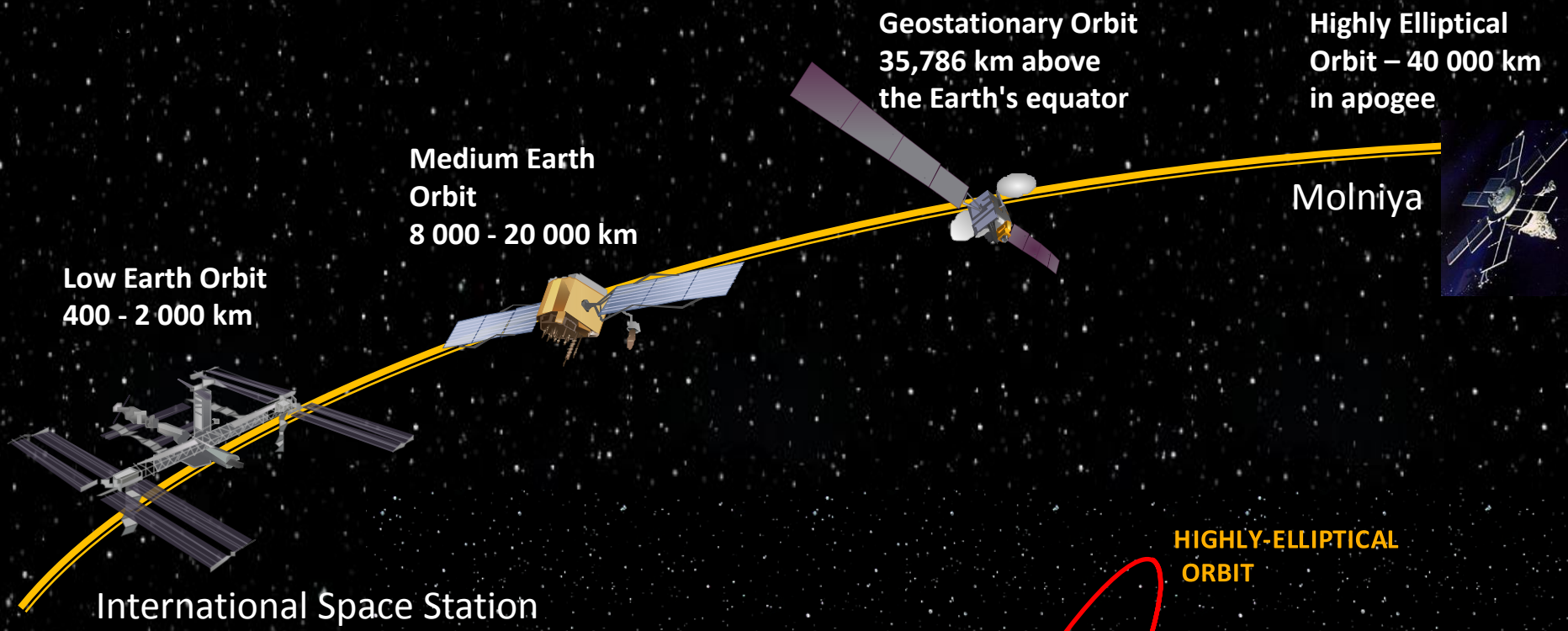
58 cm metal sphere
83 kg launch mass
1W TX 20.005 / 40.002 MHz

© D. van Ravenswaay



INMARSAT ALPHASAT

- Size of a London double-decker bus
- Total mass of more than 6.6 ton
- Solar arrays – wing span of 45 m
- 12 kW total power
- Operational life time 15 years
- L band and 2 Gbit/s laser (opt.link)
- 9 wide beams and
- more than 200 narrow spot beams



United Nations Outer Space Treaties

1. Principles Governing the Activities of States in the Exploration and **Use of Outer Space**, including the Moon and Other Celestial Bodies – 1967
 2. The Agreement on the **Rescue of Astronauts** -1968
 3. The Convention on International **Liability for Damage Caused by Space Objects** (States retain jurisdiction and control over objects they launch into outer space) - 1972
 4. The Convention on **Registration of Objects** Launched into Outer Space - 1976
 5. The Agreement Governing the Activities of States on the **Moon and Other Celestial Bodies** – 1984
-

Legal Framework

■ ***United Nations Outer Space Treaty (1967)***



Outer space free for exploitation and use by all states in conformity with international regulations



States retain jurisdiction and control over objects they have launched into outer space



States shall be liable for damage caused by their space objects

ITU Legal Framework

- ***ITU Constitution***

Article 1

Purposes of the Union

“The Union shall effect **allocation of bands** of the radio-frequency spectrum, the **allotment of radio frequencies** and the **registration of radio frequency assignments** and, for space services, of any associated orbital position in the geostationary-satellite orbit or any associated characteristics of satellite in other orbits, in order **to avoid harmful interference** between radio stations of different countries.”

- **ITU Constitution**



Article 44

Use of the Radio-Frequency Spectrum and of the GSO-Satellite and other Satellite Orbits

Radio frequencies & satellite orbits are *limited natural resources*



Rational, Efficient, Economical Use



Equitable Access

- **ITU Constitution**



Article 45
Harmful Interference

All stations must be established and operated in such a manner as not to cause harmful interference to the radio services of other member states

• **Radio Regulations**

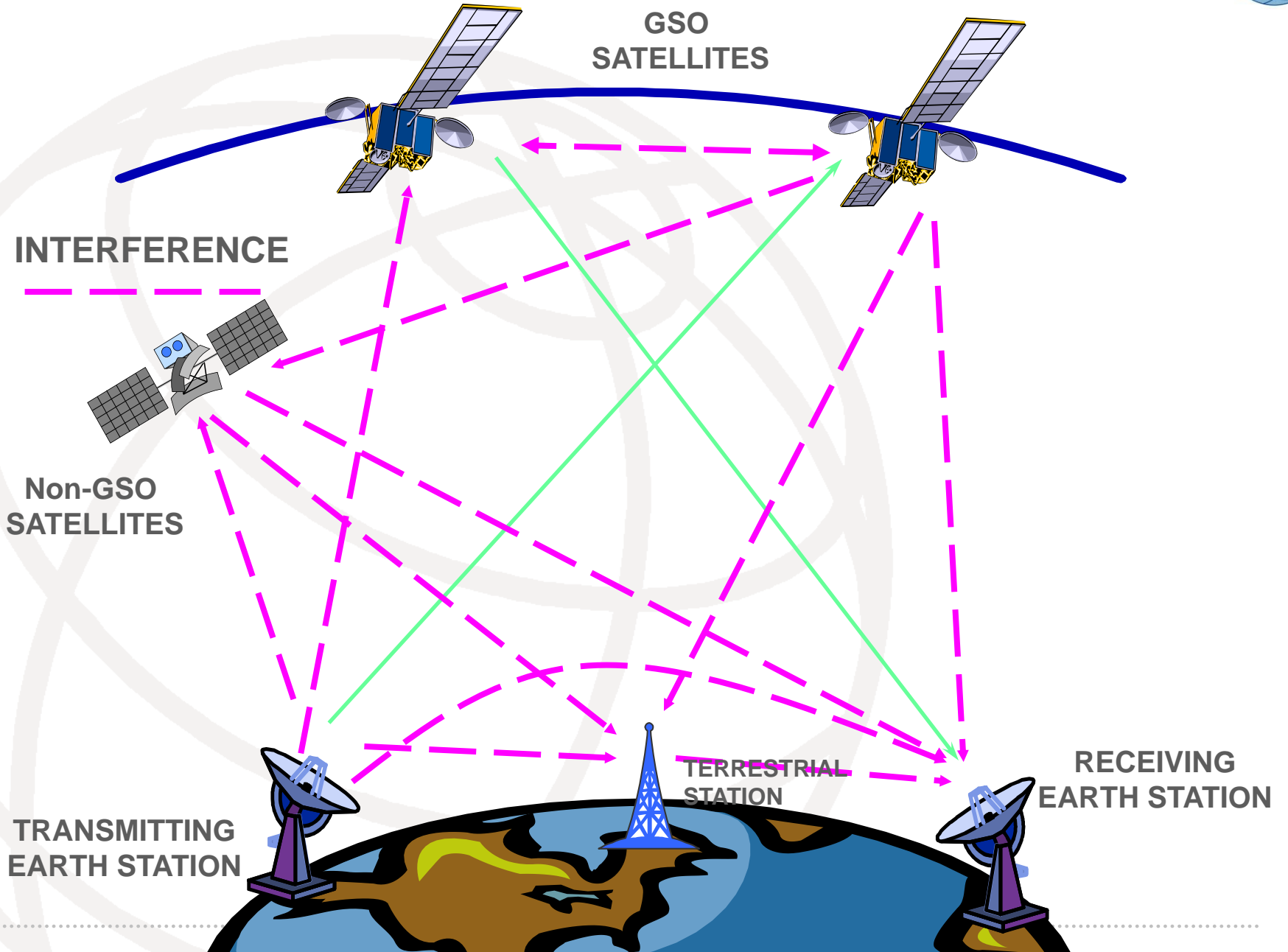
- ✓ Intergovernmental Treaty, Administrative regulations complementing ITU CS and CV – legal binding on all Member states, governing the use of spectrum/orbit resources by administrations (CS31)
- ✓ Define the **right** and **obligation** of Member States in respect of the use of these resources
 - Mechanism to facilitate rational, efficient and economical use and equitable access
 - Mechanism to ensure interference-free operation
- ✓ Updated every 3-4 years by

World Radiocommunication Conference, (WRC)
**Extraordinary Administrative
Radio Conference EARC-63**

to allocate large amount of frequency bands
for **space radiocommunication purposes**

So called, **FIRST Space** Radiocommunication Conference
(Geneva, **1963**)





Propagation of Radio waves

- 
- Laws of physics
 - Radio waves do not stop at national borders

Interference

- 
- possible between radio stations of different countries
 - This risk is high in Space Radiocommunications

➤ ***Radio Regulations (RR)***

- One of its main purposes - **Interference-free operation of Radiocommunications**

Control of Interference

ALLOCATION

Frequency separation of stations of different services

POWER LIMITS

PFD to protect TERR services / EIRP to protect SPACE services / EPFD to protect GSO from Non-GSO

MONITORING

International monitoring system

COORDINATION

between Administrations to ensure interference-free operations conditions

RECORDING

In the Master International Frequency Register (MIFR)
International recognition

Radio Regulations Mechanisms - 2



- Two mechanisms of sharing orbit / spectrum
- Rights & obligations + applicable procedures



Coordination Approach

First come, first served for actual requirements

Planning Approach

Equitable access \Leftrightarrow Plan for future use

Coordination Approach

First come, first served for actual requirements

- Rights acquired through coordination with administrations concerning actual usage
 - Efficient spectrum / orbit management
 - Dense/irregular orbital distribution of space stations
-

Elements of Coordination Approach

- **Publish a planned use of satellite network**
- **Fulfil requirements mentioned in the RR**
- **Negotiate with concerned administrations and get agreements**
- **Record the coordinated assignments in the MIFR (Master International Frequency Register) to be taken into account by other administrations**

Elements of Coordination Approach

Elements	Relevant Provisions
Procedures	Articles 9 & 11
Submission format	Appendix 4
Technical & operational limits	Article 5, Articles 21&22 etc.
Criteria and methods to identify coordination requirements	Appendix 5 (Appendices 7 and 8)

Coordination Approach

Satellite networks Not subject to Coordination Procedure

Advanced
Publication
Information

Notification

**Start the clock
(7 years to bring into use)**
Inform all administrations of any
planned satellite network (mostly
Non-GSO) and its general
description
No priority, No examination

Recording in
Master
Register
(international
recognition)

(Bringing into
use)

Coordination Approach

Satellite networks Subject to Coordination Procedure

Coordination

**Advanced
Publication
Information**

Notification

Inform all administrations of any planned satellite network (GSO & Non-GSO) and detail description
Obligatory negotiation
(Goal: interference-free operation)

Start the clock
(7 years to bring into use)

**Recording in
Master
Register**
**(international
recognition)**

**(Bringing into
use)**

Forms of Coordination

No.9.6: Before BiU or Notify in cases below shall effect coordination (No.9.27/AP 5 -Table 5-1)

Cases	Provision
GSO to GSO	9.7, Art7 AP30/30A
Certain ES of GSO to NGSO	9.7A
NGSO to Certain ES of GSO	9.7B
BSS (GSO/NGSO) to Terrestrial Services	9.11, Res.539
NGSO to NGSO	9.11A/9.12
NGSO to GSO	9.11A/9.12A
GSO to NGSO	9.11A/9.13
NGSO/GSO to Terrestrial Services	9.11A/9.14
the requirement to seek the <u>agreement</u> of other administrations is included in a footnote to the Table of Allocation	9.21

Publication : CR/C, CR/F

Special Sections

The BR publishes the information (network data) in a Special Section of BR IFIC on DVD-ROM as well as

RADIOCOMMUNICATION BUREAU COMMENTS

- Relating to the Findings with respect to No.11.31 (No.9.35 examination)
- Relating to the coordination examination with respect to No.9.36
 - **Administrations identified under all Forms of Coordination**
 - **List of Satellite networks (9.36.2)**
 - **Potentially Affected Administrations for some (9.36.1) for information only**

Comment on CR/C, CR/F

- **An administration** having received a request for coordination (through publication of CR/C, CR/F) shall examine the matter with respect to interference which may be caused to, or caused by, its own assignments
- inform the requesting administration and the BR within four months from the date of publication of the BR IFIC of either:
 - its agreement to the proposed use, or
 - its disagreement, giving reasons for the disagreement

Final Coordination Requirement

Special Section	Provision	Methods	Final/Subject
List of Adms in CR/C	9.7, Art7 of AP30/30A	$\Delta T/T$, pfd mask	Final
List of Adms in CR/C	9.7 (9.7A, 9.7B)	Coordination Arc (Band Overlap, EPFD)	Subject to request for inclusion or exclusion under Nos.9.41/9.42
List of Adms in CR/F	9.7	Coordination Arc, pfd mask	Final, 9.41 does not apply
List of Adms in CR/C	9.11 to 9.14, 9.21	Band Overlap, eirp, pfd mask	Subject to comment under No.9.52

CR/D Publication (No.9.53A)

- **An Adm informs its disagreement under No.9.52 using SpaceCom within 4 month**
- **No disagreement within 4 month means agreement to the proposed assignments in CR/C (No.9.52C)**
- **CR/D contains list of administrations having submitted their disagreement (No.9.53A)**
- **Final List of coordination requirements (Adms) published in CR/D**

CR/E Publication (No.9.42)

- **An Adm requests for inclusion or exclusion of adm/network as coordination requirement under Nos.9.41 using SpaceCom within 4 month**
- **No request within 4 month means agreement to the requirements published in CR/C (No.9.43)**
- **CR/E contains list of administrations/ satellite networks, requested and confirmed by the Bureau for inclusion (No.9.42)**
- **Final List of coordination requirements (Adms and networks) published in CR/E + CR/C**
- **During coordination additional networks can be included with mutual agreement (No.9.42.1)**

Coordination Approach



Earth stations

Coordination

Inform administrations concerned of any planned earth stations and their detail description

Earth stations should be associated with a satellite network for which API and/or CR have been published

Obligatory negotiation
(Goal: interference-free operation)

Notification

Recording in Master Register
(international recognition)

(Bringing into use by the planned date)

Article 11 Notification

- **Assignments (final characteristics) have to be notified under Article 11 to be recorded in the MIFR for international recognition within the regulatory period**

- **In order to be recorded in the MIFR Assignments shall**
 - **Be in conformity with Allocation Table and Other provisions listed in RoP under No.11.31 (No. 11.31 examination)**
 - **Complete required coordination requirements (No. 11.32 examination)**

Or

- **Be favourable in examination on probability of harmful interference (C/I) (No.11.32A examination)**

Planning Approach

Plan for future use

- Congestion of the GSO
 - Frequency / orbital position plans
 - Guarantee for equitable access to the spectrum / orbital resources
 - Spectrum set aside for future use by all countries
 - Predetermined orbital position & frequency spectrum
-

Some features of Plans Procedures

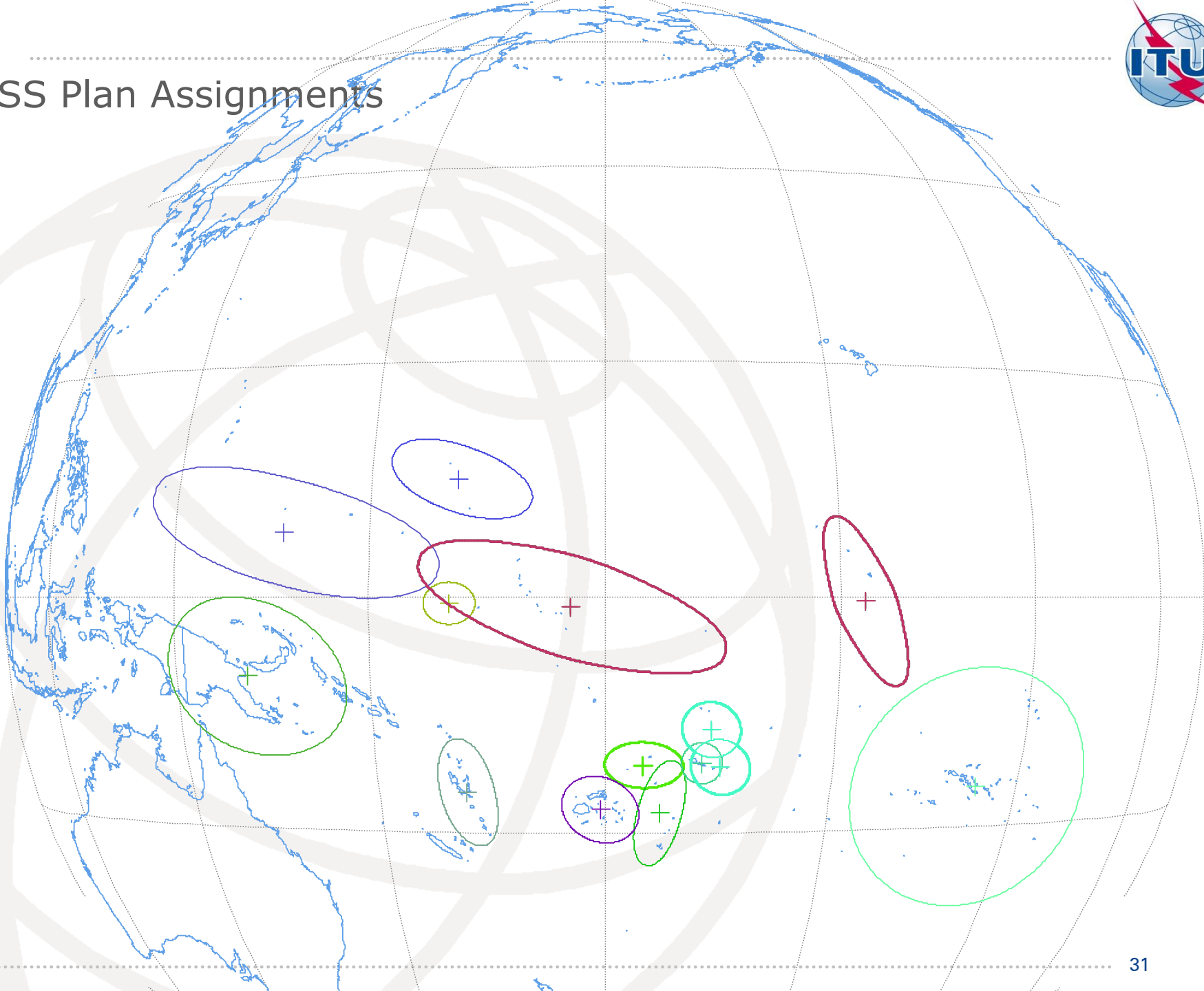
- Guarantee of equitable access
 - Beam to cover national territory
- Reservation of capacity for future use
 - In many cases Plan assignments are not in operation but will not be cancelled
 - Standard parameters (assumption) are required
- Aggregate C/I is used to maximize capacity
- Protection is given based on Plan characteristics (not characteristics in MIFR)

Standard parameters

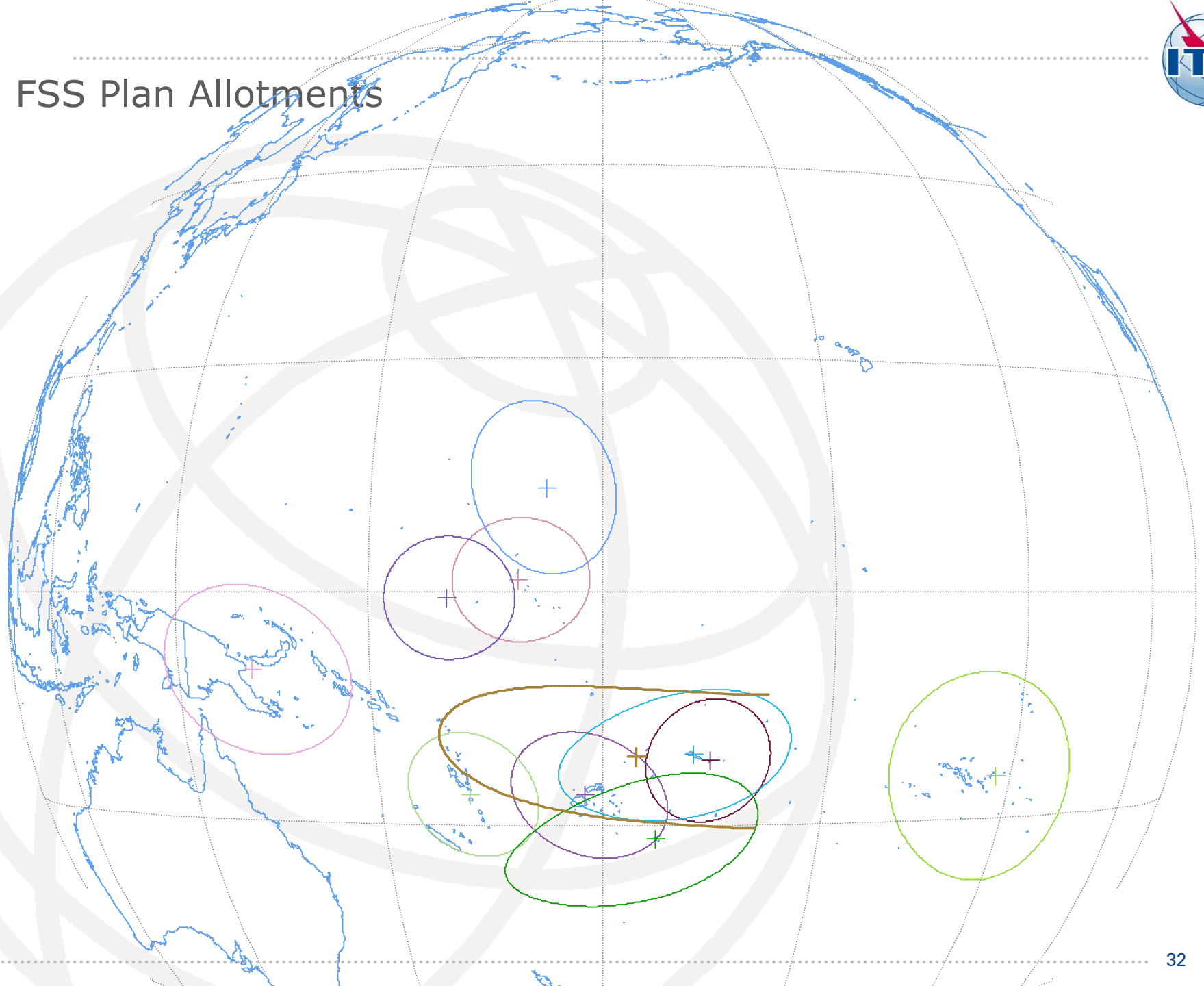
Main assumptions (with some exceptions)

- **Same amount of frequency band for each beam**
- **National coverage**
- **Elliptical beam using defined space station antenna pattern**
- **Defined C/N**
- **Same values of system noise temperature**
- **Similar power level**
- **Defined earth station antenna size and pattern**
- **Defined Aggregate C/I**

BSS Plan Assignments



FSS Plan Allotments



Plan and Non Plan procedures



Non Plan FSS/BSS GSO

AP30/30A

AP30B

Sec I of Art 9 of RR

API

Sec II of Art 9 of RR

CR/C & API

Art 11 of RR

Part IIS
MIFR

Assignment
Plan

Art 4 of AP30/30A

Part A

Art 4 of AP30/30A

Part B
List (R1&3) / Plan
(R2)

Art 5 of AP30/30A

Part IIS
MIFR

Art 7 of AP30B

A7
Allotment
Plan

Art 6 of AP30B

A6A

Art 6 of AP30B

A6B
List

Art 8 of AP30B

Part IIS
MIFR



Comparison between Plan and Non Plan procedures



	-Non Plan GSO BSS/FSS	-AP30/30A	-AP30B
Regulatory Period	7 years	8 years	8 years
Res. 49	All	Not all	All since WRC-07
API	Yes	NA	NA
Inclusion in the List	NA	Part B	A6B
Notification	Yes	Yes but not for protection	Yes but not for protection
To be compatible with	Previously filed	Plan, List, previously filed	Allotment, List, previously filed
Identification	- Affecting and affected - Single entry criteria	- Affected only - Aggregate criteria	- Affected only - Single entry and aggregate criteria
No comment within 4 m	Assistance No.9.60	Assistance for R1&3 Agreement for R2	Assistance §6.13

WRC-15 Outcome?

Some decisions related to
Space services





Fixed satellite service (FSS)

(agenda items 1.6, 1.7, 1.8)





Allocations to the fixed-satellite service in 10 – 17 GHz



agenda item 1.6

Background

- Before WRC-15, for unplanned FSS in the Ku band:
 - *Region 1: 750 MHz of spectrum both for uplink and downlink*
 - *Region 2: 1000 MHz of spectrum for downlink, only 800 MHz for uplink*
 - *Region 3: 1050 MHz of spectrum for downlink, only 750 MHz for uplink*

Results of WRC-15

- New allocations for the FSS
- in the space-to-Earth direction (Downlink)
 - *13.4-13.65 GHz in Region 1*
- in the Earth-to-space direction (Uplink)
 - *14.5-14.75 GHz, limited to 30 countries in Regions 1 and 2*
 - *14.5-14.8 GHz, limited to 9 countries in Region 3*



Better balance between uplink/downlink and between Regions

- *1000MHz (UP/Down) in **Region 1**; 1050MHz (UP), 1000MHz (Down) in **Region 2**; 1050MHz (UP/Down) in **Region 3***

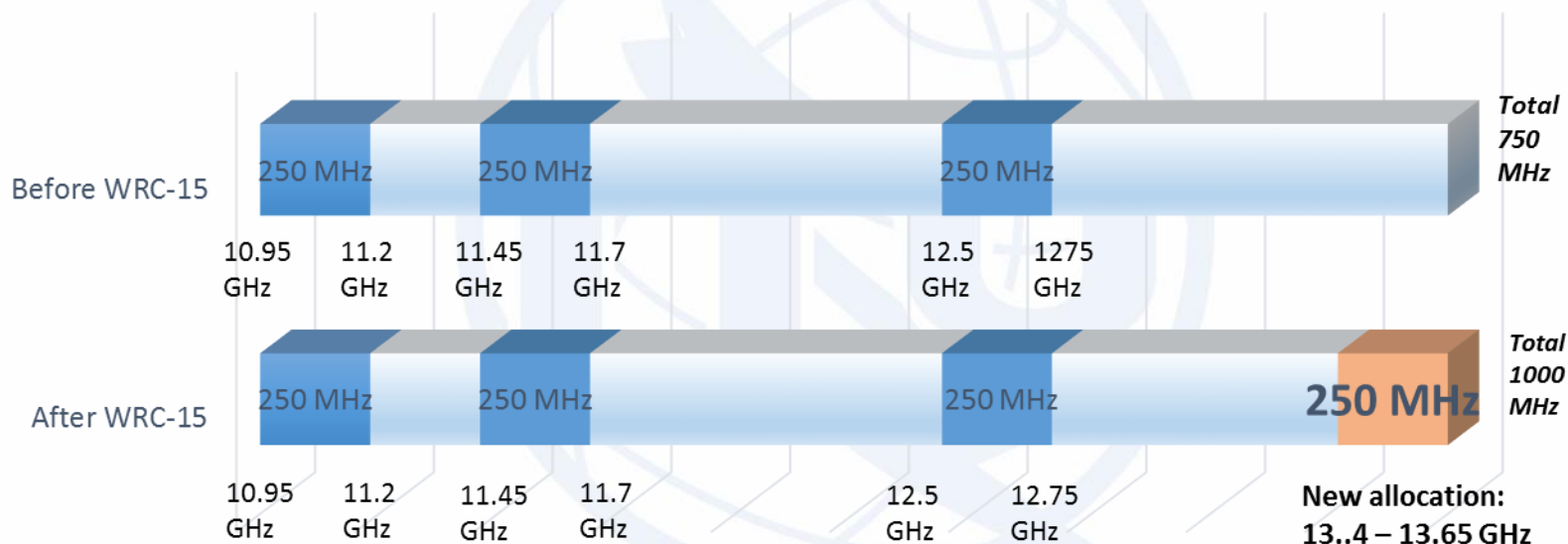


Ku-band frequency allocation for unplanned FSS Downlink (R1)



agenda item 1.6

Downlink 33% increase



 Existing allocation

 New allocation

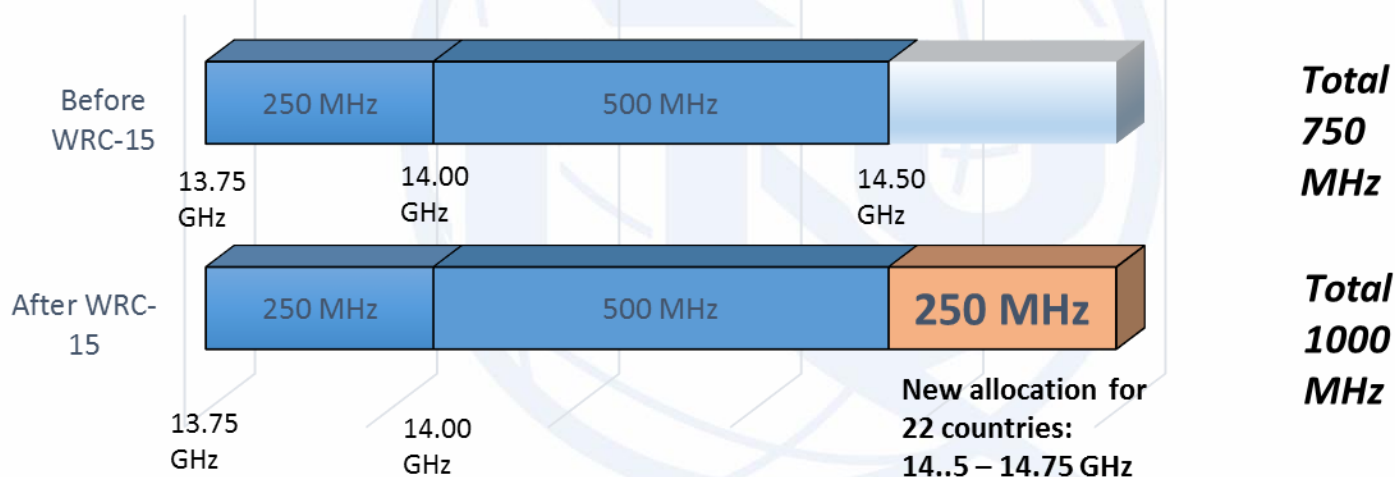




Ku-band frequency allocation for unplanned FSS uplink (R1)



agenda item 1.6

Uplink 33% increase



-  Existing allocation
-  New allocation

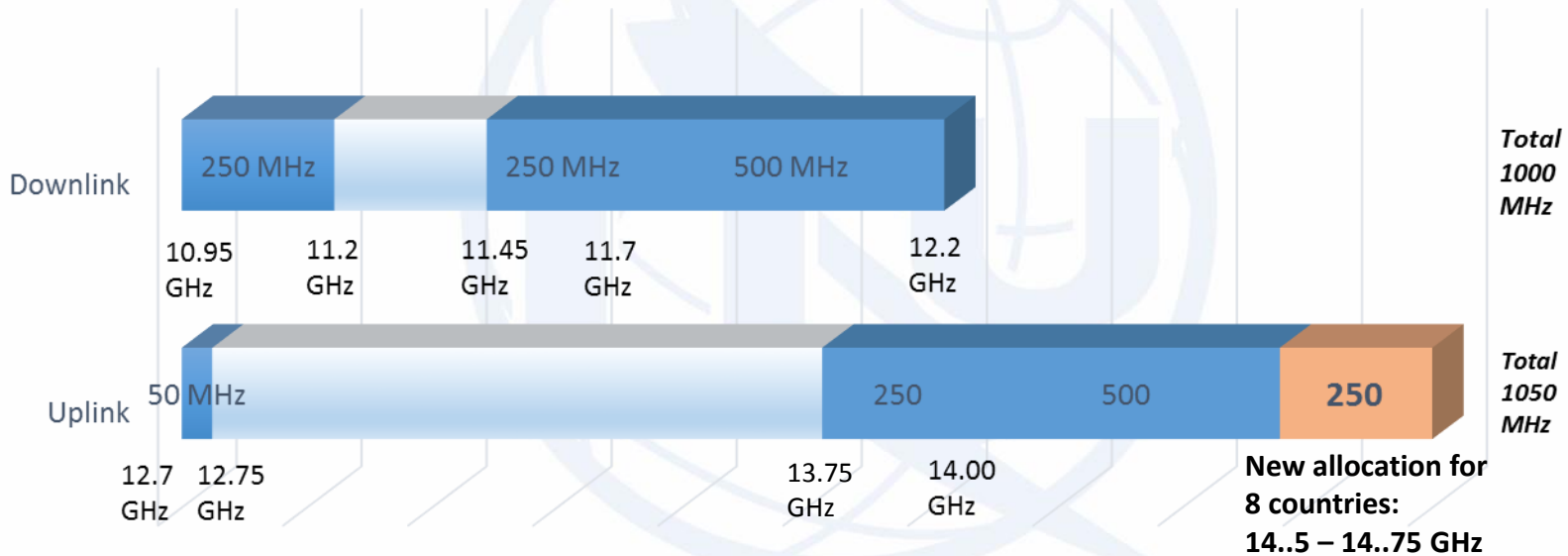




Ku-band frequency allocation for unplanned FSS (Region 2)



agenda item 1.6

Improved balance between uplink and downlink



-  Existing allocation
-  New allocation

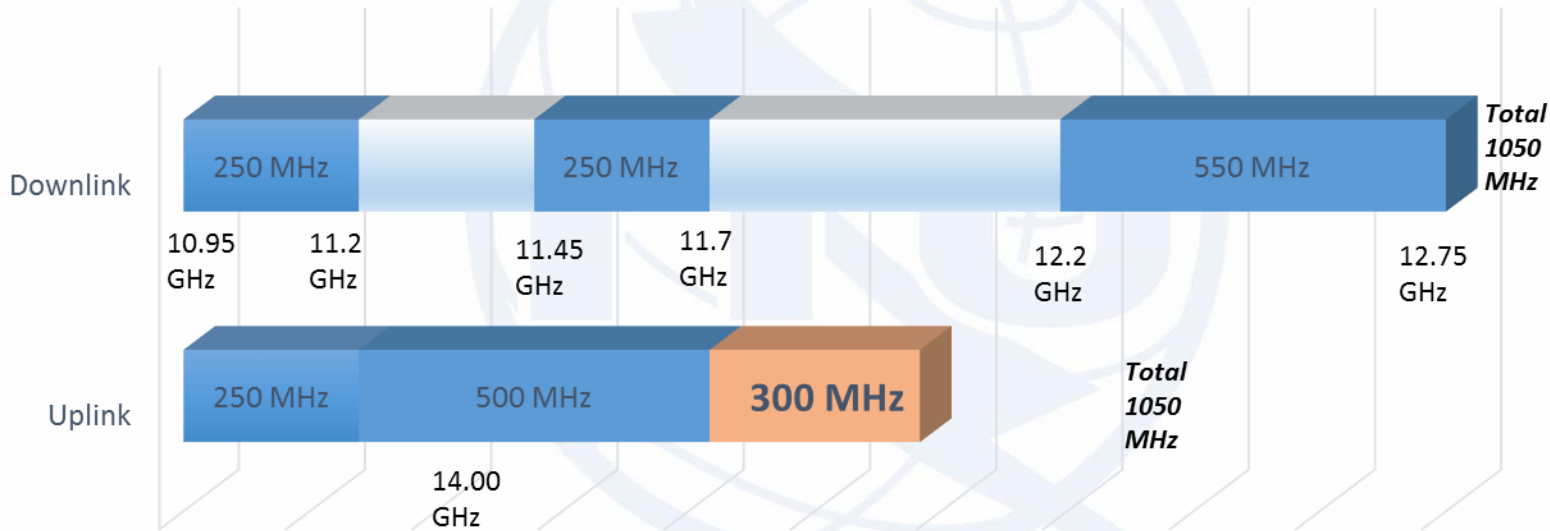


Ku-band Frequency allocation for unplanned FSS (Region 3)





agenda item 1.6

Improved balance between uplink and downlink



**New allocation for 10 countries:
14..5 – 14..8 GHz**

-  Existing allocation
-  New allocation



Allocations to FSS in 10 – 17 GHz



agenda item 1.6

➤ Conditions of utilization (to protect incumbent services)

- Downlink: 13.4 – 13.65 GHz
 - *Limited to GSO*
 - *power flux density limits specified in No.21.16*
 - *Coordination procedures under Nos.9.7 and 9.21*
- Uplink: 14.5-14.8 GHz in Region 3, 14.5-14.75 GHz in Regions 1 and 2
 - *Limited to GSO*
 - *Limited to specific countries, subject to several limitations, e.g.:*
 - minimum earth station antenna diameter, power spectral density limits, power flux density limits towards the coast, power flux density limits towards the geostationary-satellite orbit, minimum separation distance of earth stations from the borders of other countries.
 - *Coordination procedures under No.9.7 and Article 7 of AP30A*

➤ Implications

- Increased and balanced allocations will facilitate development of various applications e.g. VSAT, video distribution, broadband networks, internet service, satellite news gathering, backhaul link etc.



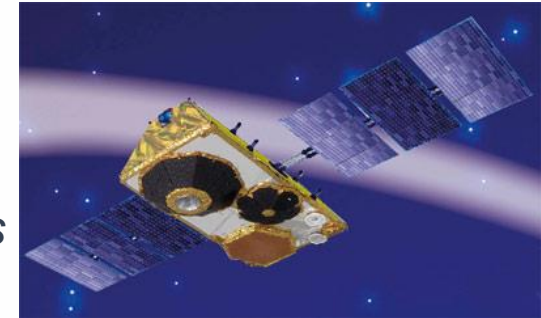
Use of the band 5 091-5 150 MHz by FSS



agenda item 1.7

Background

- 5 091-5 150 MHz was allocated to FSS (uplink) for feeder links of MSS non-GSO systems on a primary basis up to 1.1.2018 with the conditions:
 - *it becomes secondary to ARNS after 1 Jan 2018*
 - *no new assignments shall be made to earth stations providing these feeder-links after 1 Jan 2016.*



Results of WRC-15

- From 28.11.2015 this allocation is primary without any time limitation.
- Subject to Resolution **114 (Rev.WRC-15)**
- New coordination requirement for FSS earth stations within 450 km from the territory of an administration operating ARNS ground stations

Implications

- The long term availability of the spectrum for feeder links of non-GSO systems in MSS with sufficient protection to existing ARNS stations



Earth stations located on board vessels (ESVs)



agenda item 1.8

Background

- **5.457A** and Res. **902 (WRC-03)** provide technical, regulatory and operational conditions under which ESVs may communicate with space stations of FSS in bands 5 925-6 425 MHz and 14-14.5 GHz



Results of WRC-15

- Possibility to use smaller (1.2m) antenna for ESVs transmitting in the frequency band 5 925-6 425 MHz
- Resolution **902 (WRC-03)** continues to apply

Frequency band	Before WRC-15		After WRC-15		
	5 925-6 425 MHz	14-14.5 GHz	5 925-6 425 MHz	14-14.5 GHz	
Minimum diameter of ESV antenna	2.4 m	0.6 m	2.4 m	1.2 m	0.6 m
Minimum distance from the low-water mark as officially recognized by the coastal State beyond which ESVs can operate without the prior agreement of any administration	300 km	125 km	300 km	330 km	125 km

Implications

- Increased use and further development of ESVs in the frequency band 5 925-6 425 MHz with sufficient protection to the terrestrial services



Maritime-mobile satellite and science services (FSS)

(agenda items 1.9.2, 1.11, 1.12, 1.13 and
1.14)





7375-7750/8025-8400 MHz for maritime-mobile satellite



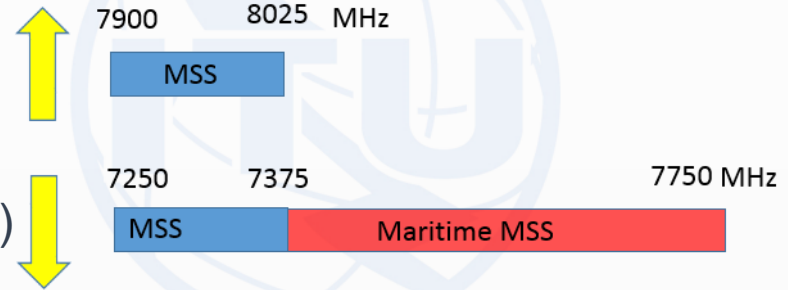
agenda item 1.9.2

➤ Background

- spectrum shortfall for current and future applications in 7/8GHz

➤ Results of WRC-15

- New allocation to MMSS in 7 375 – 7 750 MHz in the space-to-Earth direction
- No allocation for uplink in 8025-8400 MHz (traffic demand in uplink is much less and sharing with incumbent services is difficult)



Increase of 400% of spectrum in the downlink!

➤ Conditions of utilization

- Limited to GSO
- Earth stations in MMSS shall not claim protection, nor constrain use of fixed and mobile stations, except aeronautical mobile. **5.43A** does not apply.

➤ Implications

- Additional bandwidth for downlink data transmissions of the next-generation satellites in the MMSS



Earth exploration-satellite service (EESS) in 7-8 GHz



agenda item 1.11

Background

- The need for uplink large amounts of data for operations plans and dynamic spacecraft software modifications, which might not be accommodated by heavily used 2 025-2 110 MHz and 2 200-2 290 MHz TT&C bands



Results of WRC-15

- New primary EESS up link allocation limited to tracking, telemetry and command (TT&C) in the 7 190-7 250MHz band (34% increase)
- Provision to protect existing and future stations in the fixed, mobile and space research services from the new allocation

Implications

- In combination with existing EESS downlink allocation in 8 025-8 400 MHz this new allocation will lead to simplified on-board architecture and operational concepts for future missions of EESS



Earth exploration-satellite service (active) in 8-9 GHz



agenda item 1.12

➤ Background

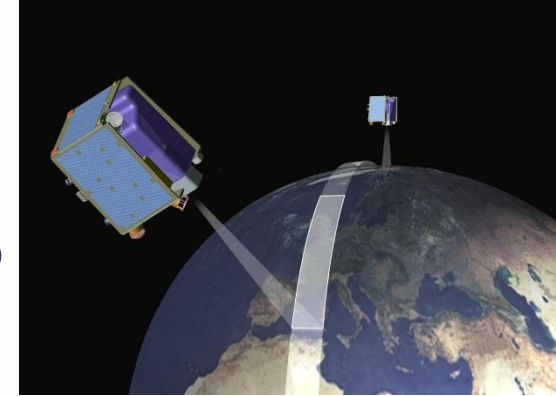
- EESS (active) bandwidth in 8-9 GHz was 600MHz. Growing demand for higher resolution to satisfy global environmental monitoring raised the need to increase the bandwidth up to 1200 MHz in total.

➤ Results of WRC-15

- New primary EESS(active) allocations totally of 600 MHz in the 9 200-9300MHz, 9 900-10 000MHz and 10.-10.4GHz bands (100% increase)
- Provision to protect existing and future fixed and mobile stations

➤ Implications

- Development of modern broadband sensing technologies and space-borne radars on active sensing EESS that provides high quality measurements in all weather conditions with enhanced applications for disaster relief and humanitarian aid, large-area coastal surveillance





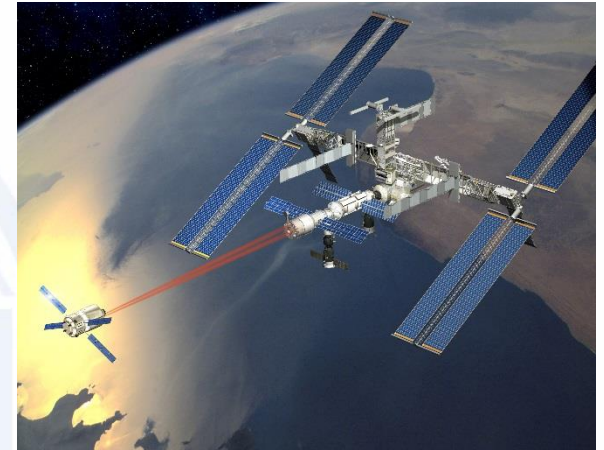
5 km distance limitation in space research service



agenda item 1.13

➤ Background

- Use of 410-420MHz band for Extra Vehicular Activities was limited to communication within 5 km of an orbiting, manned space vehicle. Rendezvous and docking maneuvers required the use of the band over larger distances.



➤ Results of WRC-15

- Removal of the 5 km distance limitation in No. **5.268**

➤ Implications

- Facilitation rendezvous and docking maneuvers which leads to safety of human life in a manned vehicle



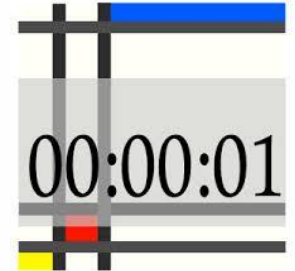
Reference time scale



agenda item 1.14

➤ Background

- The Coordinated Universal Time (UTC) adjusts atomic time and ephemeris time based on Earth rotation time by the insertion or deletion of leap seconds. Digital systems are highly dependent on keeping very precise time synchronization and thus can be disrupted when a leap second is introduced.



➤ Results of WRC-15

- The current implementation of UTC to insert leap seconds will continue until WRC-23 where the issue will be discussed again.

➤ Implications

- Further studies by the International Bureau of Weights and Measures (BIPM) and ITU on various aspects of the current and potential future international reference time scale



Satellite regulatory procedures

(agenda item 7)





Satellite regulatory procedures



agenda item 7



➤ Background

Articles 9, 11 and 13 provide the regulatory procedures for advance publication, coordination, notification and recording of frequency assignments pertaining to satellite networks

➤ Results of WRC-15: various improvements of the procedures, e.g.:

- *Mod. 11.49 to reduce regulatory period of suspension day-by-day when the information of suspension is received beyond 6 month after suspension*
- *Sup. Requirement for submission of Advance Publication Information for networks subject to coordination*
- *New Res. 40 (WRC-15) to increase transparency when one space station is used to bring into use assignments to GSO networks at different orbital locations within a short period of time*
- *Mod. 13.6 to include reason for BR' query and specify period for BR to inform administration of its conclusion in response to administrations' replies*

➤ Implications

- Facilitate the rational, efficient and economical use of radio frequencies and any associated orbits, including the geostationary-satellite orbit.

Suspension

- Frequency Assignments **can be suspended for a period of 3 years** under No.11.49.
- BR should be informed of suspension of use, **no later than 6 months** from the date of suspension.
- Regulatory period of suspension will be **reduced day-by-day** when the information of suspension is received beyond 6 month after suspension
- Frequency Assignments are considered brought back into use **only if conditions of No.11.49.1 are met**



Reduction of the coordination arc



agenda item 7

➤ Background

- Appendix **5** provides technical conditions for identification of administrations to coordinate with under Article **9**.



➤ Results of WRC-15

- Reduction of coordination arc in App. **5** from 8 to 7 degrees in C band and from 7 to 6 degrees in the Ku band
- New Res. **762** with pfd for uplink in C band and up/downlinks for Ku band outside coordination arc to consider no potential for harmful interference
- These pfd criteria in the Resolution shall be used in No. **11.32A** examination. A new footnote was added to No. **11.32A**

➤ Implications

- The reduction of the coordination arc and new Resolution **762 (WRC-15)** will facilitate the rational and efficient use of, as well as the access to, radio frequencies and associated geostationary-satellite orbit.



Earth Stations in Motion (ESIM)



➤ Background

- **5.526** provides conditions for ESIM communications with GSO FSS space stations in 19.7-20.2 GHz and 29.5-30 GHz in Region 2 as well as 20.1-20.2 GHz and 29.9-30 GHz in Regions 1 and 3.



➤ Results of WRC-15

- New **5.527A** and new Res. **156** to set conditions for ESIM communication with GSO FSS space stations in 19.7-20.2, 29.5-30.0 GHz in all Regions
- This Res. extends the possibility offered for ESIM by **5.526** in the bands 19.7-20.2 GHz and 29.5-30 GHz in Region 2 and in bands 20.1-20.2 GHz and 29.9-30 GHz in Regions 1 and 3.

➤ Implications

- Increased use and further development of ESIM in the frequency bands 19.7-20.2 and 29.5-30.0 GHz in all Regions with sufficient protection to other GSO satellite networks and terrestrial services

Key ITU documents *free* on-line



- **The ITU Constitution:**
<http://www.itu.int/pub/S-CONF-PLEN-2011>
 - **ITU Radio Regulations @ 2012:**
<http://www.itu.int/pub/R-REG-RR-2012>
 - **ITU-R Recommendations:**
<http://www.itu.int/publ/R-REC/en>
 - **WRC-15:**
<http://www.itu.int/en/ITU-R/conferences/wrc/2015>
-



Thank you !

Mitsurhio SAKAMOTO

Head, Space Systems
Coordination Division ITU-BR
mitsuhiro.sakamoto@itu.int