AsiaSat

Reaching Further, Bringing You Closer

GSO FSS and terrestrial operating in the same frequency bands

ITU Workshop on Efficient Use of
the Orbit/Spectrum Resource

Bangkok
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Use of wireless solutions for various terrestrial applications is increasing:

- User friendly applications
  (wireless broadband, remote controls, …)

- Applications that require radio frequencies to function
  (mobile phone/broadband, ITS, collision radars, ….)

- Several attractive and promising applications

- Applications different from those supplied by satellites
  => Generally no commercial competition

- Satellites in some cases provide supplementary services or is an integral part of the application
  (e.g. cellular backhaul or services to remote locations)
  => Creating business for satellites

Radio Spectrum is a limited resource

Several applications are eying use of frequency bands that are used or allocated by ITU for satellite applications:

- IMT (C-, Ka-, Q-, V-band)
- BWA/WiMax (C-band)
- RLAN (C-band)
- HAPS (Ka-, Q-, V-band)
- ITS (C-, Ka-, W-band)
- UWB/SRD (C-, Ka-band)
- …..

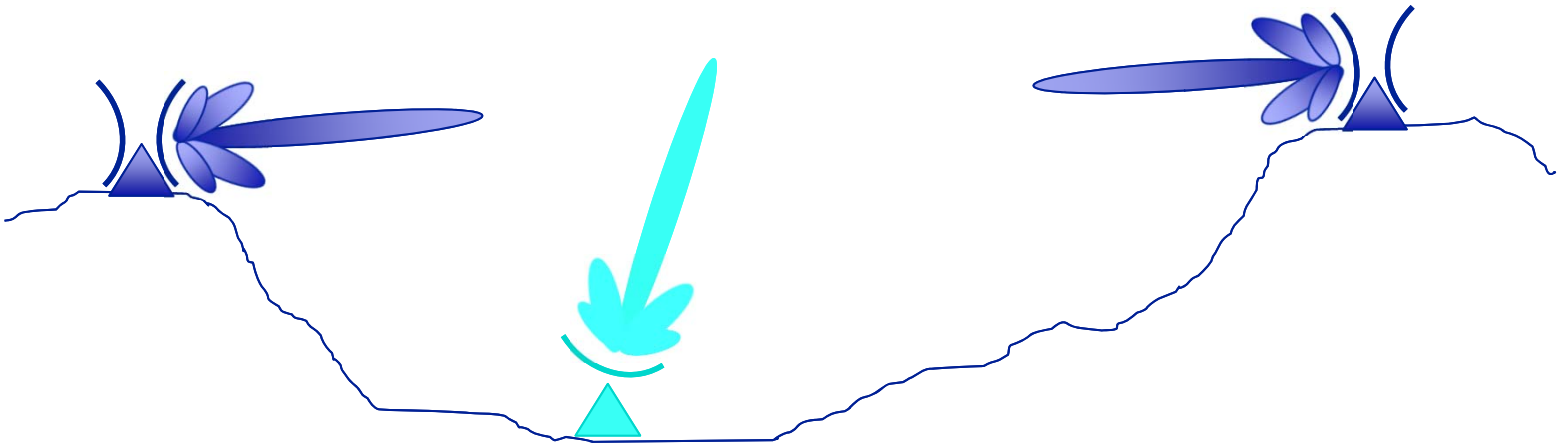
Frequency bands are commonly broadly allocated by ITU to several services, e.g. FSS, FS and MS

- This does NOT indicate technical compatibility between the services!!!
- ITU provide mechanisms to obtain technical compatibility between countries
- Individual administrations decide on frequency use within its own country

FSS and FS microwave links have for many years successfully shared the band

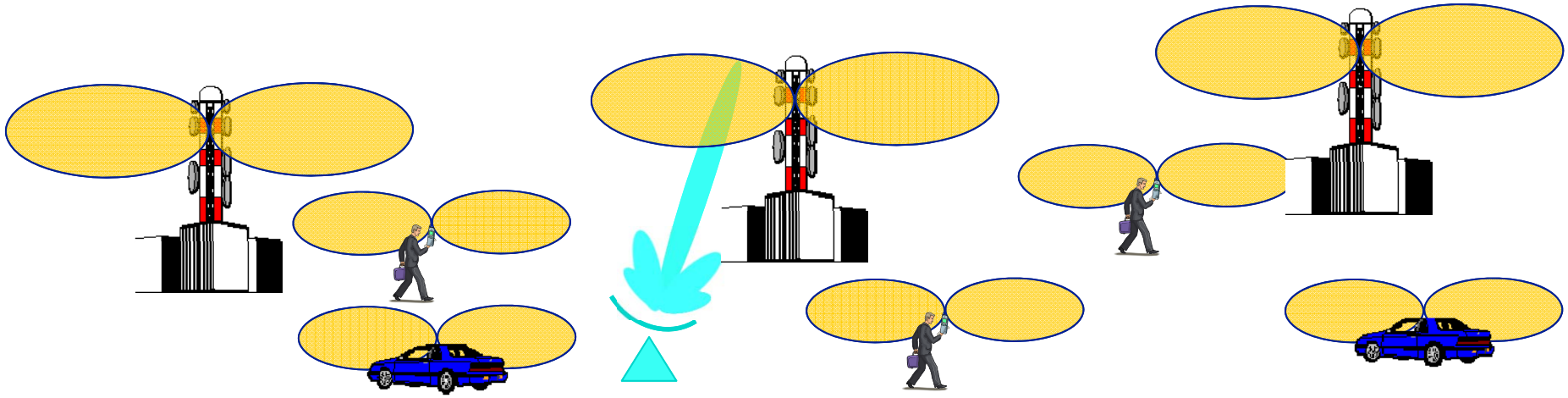
- Both services use highly directional antennas
- Transmitting stations on ground for FSS and FS are limited in number

- Transmitting FS stations are at fixed, known locations
- FS stations often are located on top of mountains or hills to increase line-of-sight distance
- Fairly static deployment scenario



Many (new) MS, FS (and FSS) applications are different in nature

- One or both services use antennas with low directivity
- Large number of transmitting stations on ground for FSS and FS
- Location of transmitting stations on ground are unknown (some times mobile transmitting stations)
- Terrestrial transmitting stations could be anywhere
- Highly variable deployment scenario



Different interference scenarios in bands for satellite downlinks and bands for satellite uplinks

Interference in satellite downlink bands

- Interference into receiving Earth stations from one or multiple terrestrial transmitters
  - In-band
  - Adjacent band
    - Unwanted emissions (out-of-band and spurious)
    - LNB overdrive

- Interference into receiving terrestrial receivers from aggregation of all transmitting satellites
  - In-band

Different interference scenarios in bands for satellite downlinks and bands for satellite uplinks (2)

Interference in satellite uplink bands

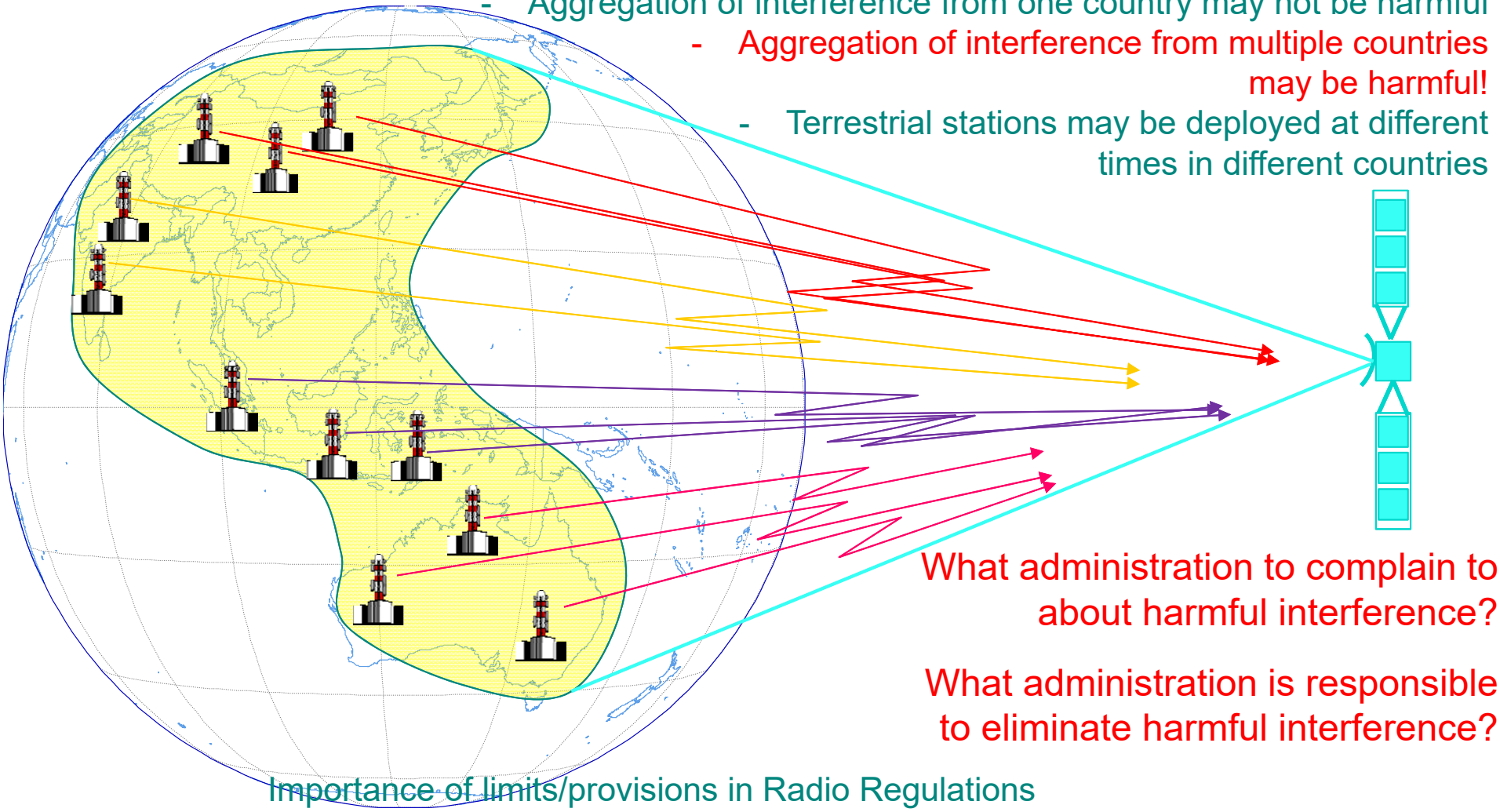
- Interference into receiving satellites from aggregation of interference from all terrestrial stations within satellite beam
  - In-band

- Interference into receiving terrestrial receivers from transmitting Earth stations
  - In-band
  - Adjacent band?
    - Unwanted emissions (out-of-band and spurious)
    - Front-end overdrive

Uplink interference into receiving satellite

Transmitting terrestrial stations will have emissions also in the direction of receiving satellites

- Individual stations may not cause harmful interference
- Aggregation of interference from one country may not be harmful
- Aggregation of interference from multiple countries may be harmful!
- Terrestrial stations may be deployed at different times in different countries



What administration to complain to about harmful interference?

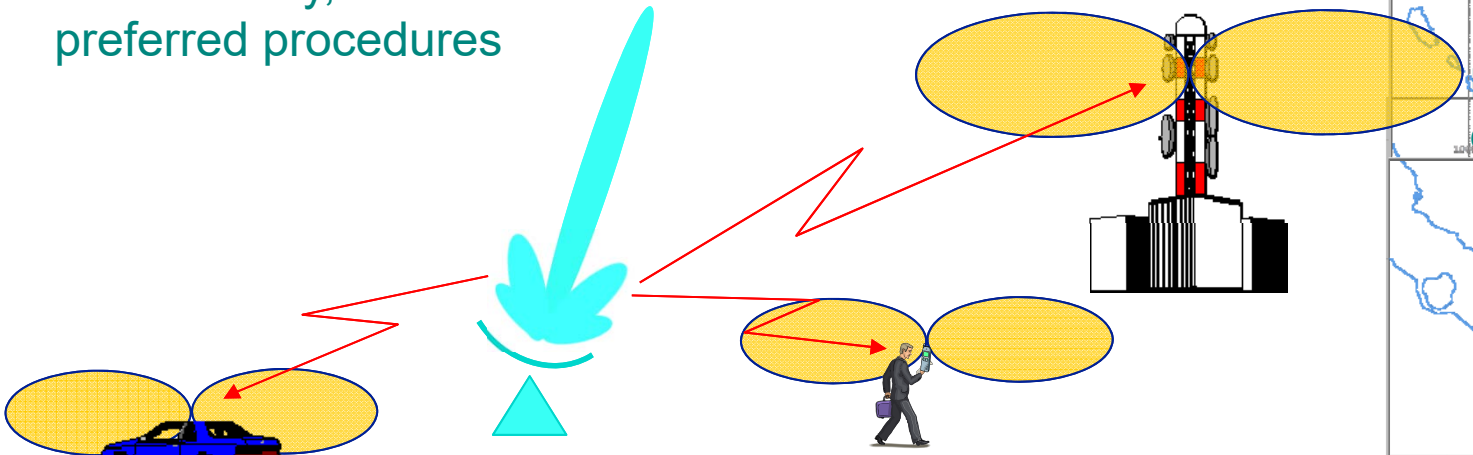
What administration is responsible to eliminate harmful interference?

Importance of limits/provisions in Radio Regulations
(even if analyses indicate that with current expected characteristics, aggregation of interference from the terrestrial stations will not be harmful)

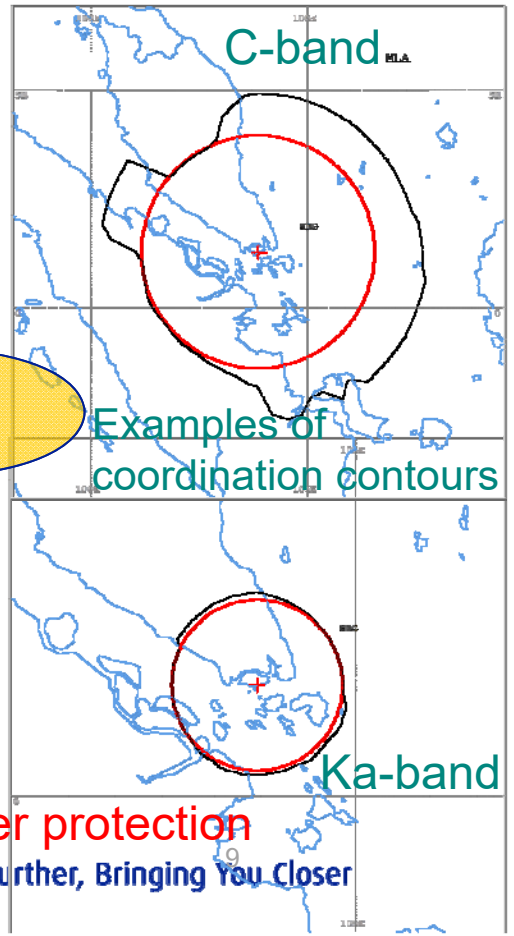
Uplink interference into receiving terrestrial stations

Transmitting Earth stations will have emissions also in the direction of receiving terrestrial stations

- Area around Earth stations where terrestrial receivers will receive harmful interference
- Existing Earth stations at known locations can be taken into account
- New Earth stations, VSATs, transportable Earth stations (e.g. SNG) difficult to take into account
- Coordination contours allow neighboring countries to object to deployment of transmitting Earth stations
- Domestically, administrations can determine their own preferred procedures



In sharing studies, ITU normally does not consider protection of newcomer (terrestrial applications)



ITU studies normally do not consider limitations on incumbent service required to protect the newcomer

Is this the best approach for the incumbent?

- Licensing of new transmitting (Earth) stations
  - To protect new service/application:
    - in the same country
    - in adjacent countries

- Unregistered transmitting (Earth) stations
  - Can cause interference to new service/application

- Later tightening in the Radio Regulations for incumbent
  - Once adopted by a WRC, both services/applications will be incumbent and later WRCs can consider tightening hard limits
    (*WRC-2000 identified the 2 500-2 690 MHz band for IMT without making any changes to the Art 21 pfd limits for the incumbent satellite services in this band. Then, when both services were incumbent, WRC-07 tightened the Art 21 pfd limits for satellite services by 8 ↔ 12 dB (depending on elevation angle), rendering the satellite services unable to close the links for the intended applications*)

Maybe it would be safer for the incumbent services to see the full picture before making a decision on whether or not to introduce a new service/application rather than later being faced with an unpleasant surprise?

Examples of terrestrial applications considered for operating in satellite bands

IMT and BWA/WiMax in satellite downlink bands

ITU and other studies all conclude that co-existence within the same geographical area is not feasible

=> I. e. one or the other

- Required separation distances to protect receiving earth stations depending on frequency range, type of deployment, technical parameters etc.
  (at C-band, required separation distances between some kilometres up to > 100 km were demonstrated for various deployment scenarios and interference mechanisms)

- FCC established 150 km separation distance at shared C-band.

- Within one city, only one of the services can be offered

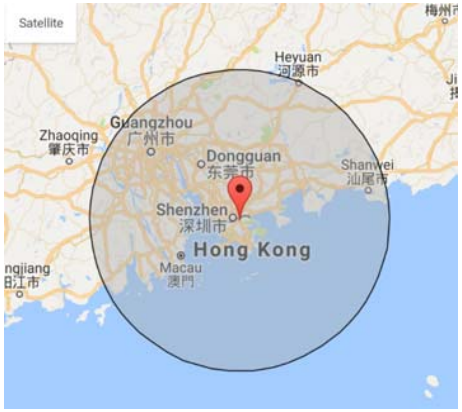
- Pfd limits in RR at borders to protect FSS reception in other countries

- FSS reception also affected by IMT or BWA deployment in adjacent bands

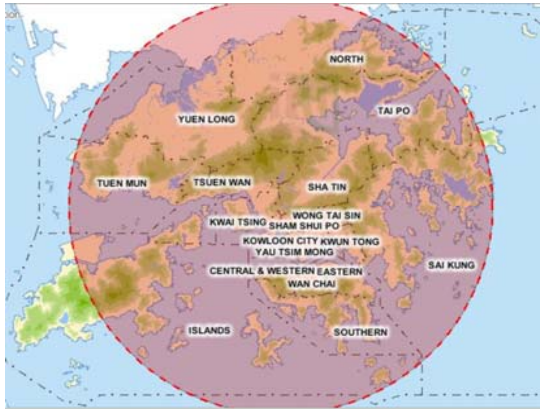
- Protection of terrestrial services in respect of current Art 21 limits has so far been addressed very little in studies
- Later demand for tightening of Art 21 limits for FSS?

Examples of C-band separation distances

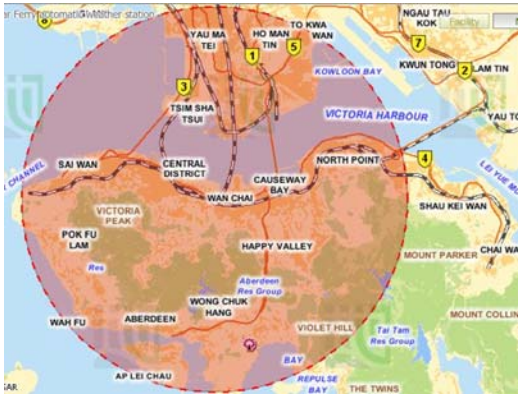
150 km separation distance
In-band (FCC)



25 km separation distance
Adjacent-band, outdoor
macro-cell IMT deployment



5 km separation distance
Adjacent-band, outdoor
small-cell IMT deployment



1 km separation distance
Adjacent-band, indoor
small-cell IMT deployment

Even small-cell indoor IMT deployment in adjacent bands would be incompatible with general FSS reception in the same city!

Would the satellite community be satisfied with a service which only can be offered in rural and remote areas?

Trends to favor IMT

- Licensing embargo on satellite earth stations in certain frequency bands
  (even on uplink earth stations to avoid complaints on interference in the corresponding downlink)

- Prohibiting filings for certain frequency bands

- Removing its own country from service area of satellite filings in certain frequency bands

- Including guardbands

- Removing or downgrading satellite allocations in national tables of allocation

IMT in satellite uplink bands

C-band

- Considered by WRC-15, but so far no identification

“26 GHz” (24.25-27.5 GHz)

- 27.0-27.5 GHz allocated for FSS uplinks in Region 2 & 3
- 24.65-25.25 GHz the uplink band for 21.4-22 GHz BSS downlinks (WRC-12)
- Many administrations seems prepared to identify these bands for IMT
- The satellite community appears very quiet (may be seen by ITU as silent acceptance)
- Region 1 satellite operators do not have access to 27.0-27.5 GHz (could reduce the satellite unity on this band) (satellite community sleeping or accepting loss)
- 24.65-25.25 GHz not much used yet since the 21.4-22 GHz band was only opened up for BSS in 2007 and definitive procedures were not established until 2012
- These bands could prove very valuable when Ka-band is being widely deployed

IMT in satellite uplink bands (2)

"28 GHz" (27.5 – 29.5 GHz)

- Existing MS allocations in Radio Regulations
- Identification (or consideration) for IMT country-by-country
  - USA (27.5-28.35 GHz)
  - Japan (27.5-28.28 GHz)
  - Korea (27.5-29.5 GHz)
  - UK
  - Other countries considering identification
- No consideration or studies on impact on incumbent services (e.g FSS) by ITU
- No particular provisions in Radio Regulations to protect FSS or FSS deployment
- "28 GHz" is a key band for FSS Ka-band deployment and development of HTS and gateways for ESIMs.
- Large number of transmitting Earth stations foreseen

- How to ensure that consideration of IMT in "28 GHz" band will not be to the detriment of FSS deployment?

IMT in satellite uplink bands (3)

Q and V-band

- Little current FSS deployment
- Will become important for future satellite networks (e.g. UHTS)
- WRC-19 A.I. 1.13 consider IMT identification in several FSS bands in Q- and V-band (ITU-R Study Group 5, TG 5/1)
- Predominantly uplink bands, but also some downlink bands considered

How to ensure that later satellite deployment is not hampered by consideration and decisions by WRC-19?

WAS/RLAN – Wireless Access Systems including radio local area networks

WRC-19 A.I. 1.16

to consider issues related to wireless access systems, including radio local area networks (WAS/RLAN), in the frequency bands between 5 150 MHz and 5 925 MHz, and take the appropriate regulatory actions, including additional spectrum allocations to the mobile service, in accordance with Resolution **239 (WRC-15)**

Considered in 5725 – 5850 MHz and 5850 – 5925 MHz MHz which is a part of C-band uplink

RESOLUTION 239 (WRC-15)

considering

h) that the frequency bands between 5 725 and 5 850 MHz are allocated worldwide on a primary basis to the radiolocation service and, in Region 1, to the fixed-satellite service;

i) that the frequency band 5 850-5 925 MHz is allocated worldwide on a primary basis to the mobile service, the fixed service and the fixed-satellite service;

invites ITU-R

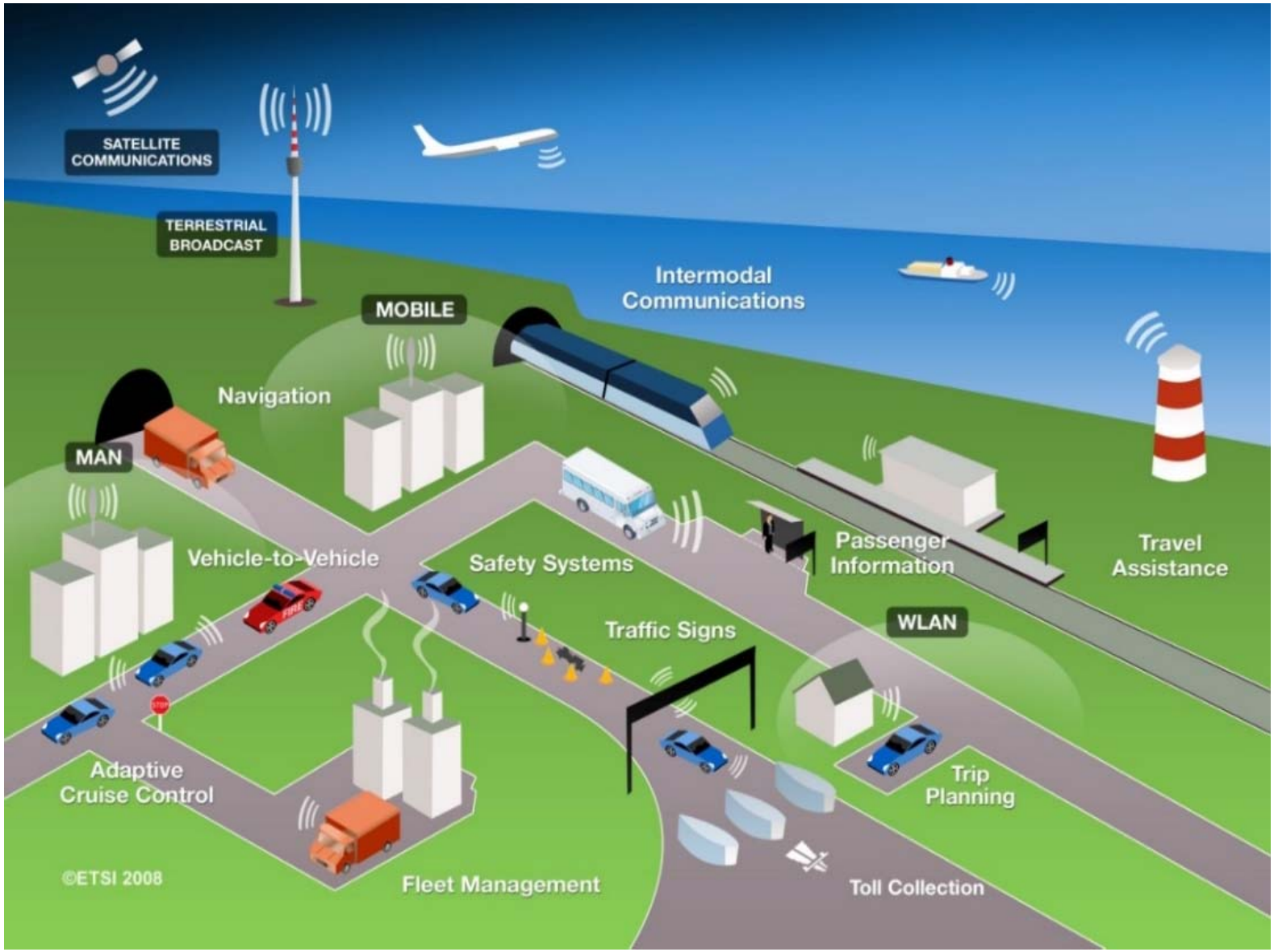
b) to conduct studies with a view to identify potential WAS/RLAN mitigation techniques to facilitate sharing with incumbent systems in the frequency bands 5 150-5 350 MHz, 5 350-5 470 MHz, 5 725-5 850 MHz and 5 850-5 925 MHz, while ensuring the protection of incumbent services including their current and planned use;

f) to also conduct detailed sharing and compatibility studies, including mitigation techniques, between WAS/RLAN and incumbent services in the frequency band 5 850- 5 925 MHz with a view to accommodating WAS/RLAN use under the existing primary mobile service allocation while not imposing any additional constraints on the existing services,

WAS/RLAN – Wireless Access Systems including radio local area networks (2)

- 5 725-5 925 MHz considered for RLAN under WRC-19 A.I. 1.16
- 5 725-5 850 MHz already used for RLAN in some countries
- Studies under WRC-19 A.I. 1.16 indicate potential for harmful interference
- On-going studies regarding the affordability and feasibility of proposed mitigation techniques to fix the harmful interference which WAS/RLAN could potential create into incumbent services
- How to ensure that no harmful interference is inflicted upon receiving satellites?
- Interference from transmitting Earth stations into RLAN receivers not studied under WRC-19 A.I. 1.16 (?)
- How to avoid negative impact on future deployment of transmitting Earth stations due to interference into RLAN receivers?

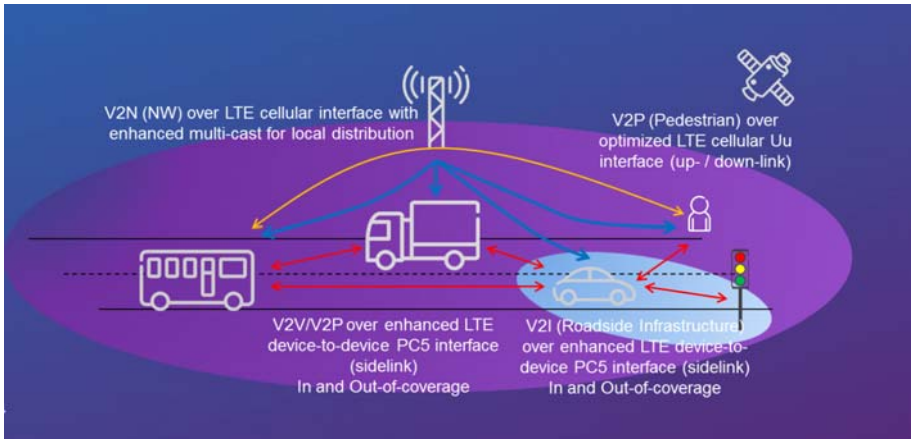
ITS (Intelligent Transport Systems)



From **Annex 32 to Document 5A/469-E**

ITS – Intelligent Transport Systems (2)

- Systems within the 5 725-5 850 MHz range already deployed in several countries for Electronic Toll Collection (ETC)
- 5 850-5 925 considered (and deployed in some countries) for vehicle communication systems[1], to assist safe driving and potentially supports automated driving, etc.



From **Annex 32 to Document 5A/469-E**

- "24 GHz" band (22-29 GHz) for automotive radars to be phased out by CEPT except for 24.05-24.25 GHz ISM band
- 77-81 GHz for automotive radars

[1] Including vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I) communications, vehicle-to-network (V2N) and vehicle-to-pedestrian (V2P)

ITS – Intelligent Transport Systems (3)

WRC-19 AI 1.12

to consider possible global or regional harmonized frequency bands, to the maximum extent possible, for the implementation of evolving Intelligent Transport Systems (ITS) under existing mobile-service allocations, in accordance with Resolution **237 (WRC-15)**

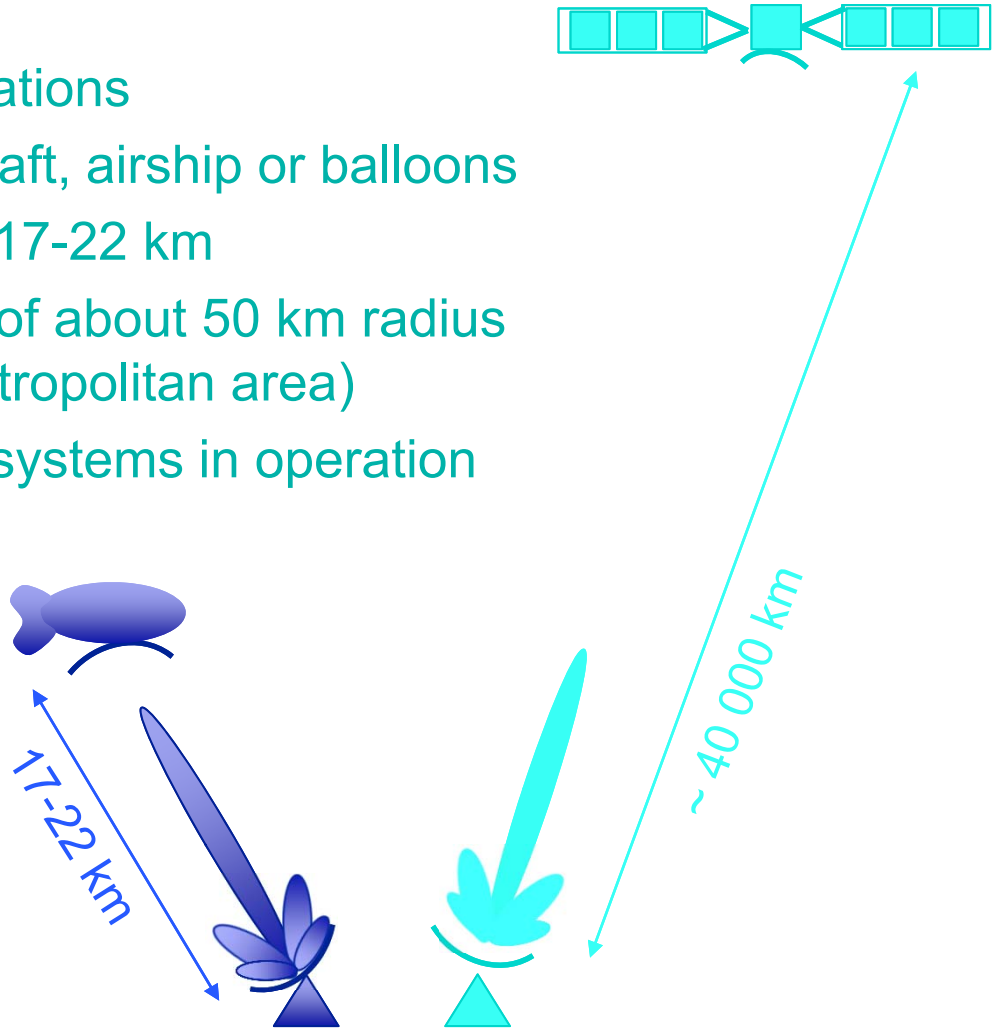
- 5 725-5 925 MHz is a part of the C-band uplink
- 24.25-25.25 GHz & 27-29 GHz are parts of the Ka-band uplinks
- ITU expect, but this is not yet confirmed, that interference into receiving satellites is not an issue with current parameters
- How to ensure that ITS is not implemented with parameters that cause harmful interference into receiving satellites?
- Concerns on Safety aspect
  - Resolution **237 (WRC-15),** emphasizing,

    b) that the provisions of Nos. 1.59 and 4.10 do not apply to ITS applications,
  - Preliminary Draft CPM text (Annex 8, Doc 5A/469**,** emphasizing,

    administrations should ensure that the ITS receivers are designed in such a way as to accommodate the potential interference created by FSS earth stations and other incumbent co-primary services
  - No change to Radio Regulations
- How to ensure that individual administrations may not impose limitations on deployment of (new or transportable) Earth stations?

HAPS - High-Altitude Platform Stations

- Stratospheric stations
- Unmanned aircraft, airship or balloons
- Altitude around 17-22 km
- Covering areas of about 50 km radius (e.g. greater metropolitan area)
- No commercial systems in operation



HAPS - High-Altitude Platform Stations (2)

- HAPS is now seeking providing broadband systems WRC-19 (A.I. 1.14)
- Existing and possible new bands being studied
- Several bands shared with FSS
  - Predominantly uplink
  - Possible new band an FSS downlink band

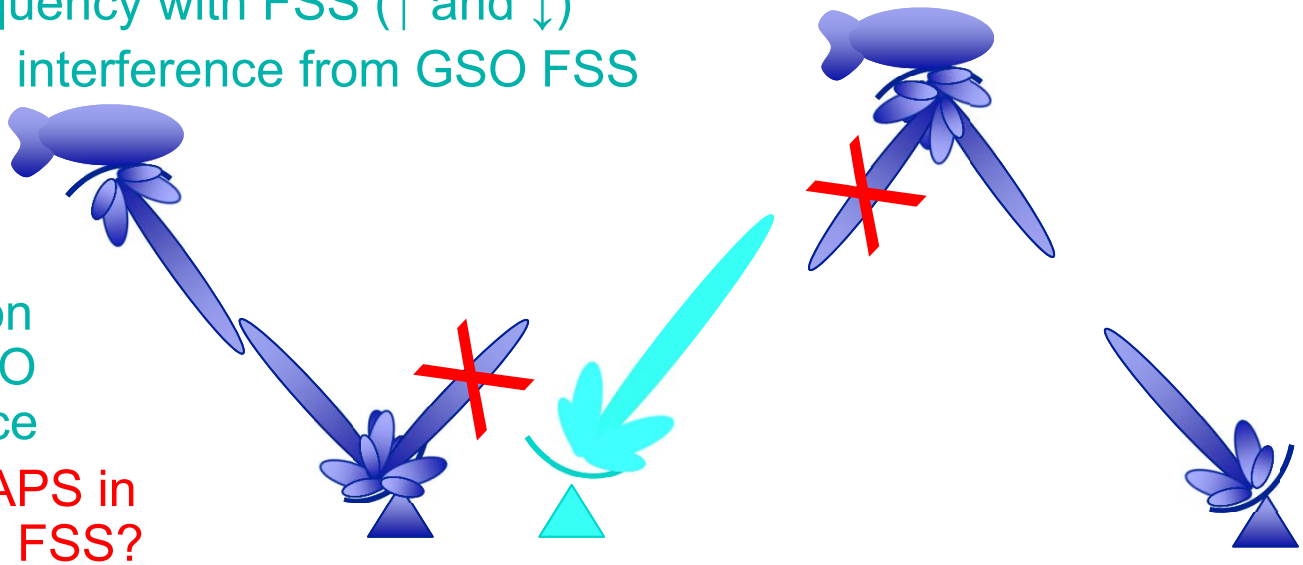
		Direction of transmission		Protection of FSS
		HAPS	FSS	
Current HAPS identifications	6 440-6 640 MHz	↓	↑	EIRP limit at GSO
	6 560-6 640 MHz	↑	↑	
	27.9-28.2 GHz	↓	↑	Non-interference, non-protected
	31.0-31.3 GHz	↑	N/A	N/A
	47.2-47.5 GHz	↑↓	↑	
	47.9-48.2 GHz	↑↓	↑ (↓)	EIRP limit (at specified elevation angle ranges)
Possible new bands	38-39.5 GHz		↓	
	21.4-22 GHz (Region 2)		N/A	
	24.25-27.5 GHz		↑*	

* 24.75-25.25 GHz & 27-27.5 GHz

HAPS - High-Altitude Platform Stations (3)

HAPS and GSO FSS sharing the band

- Res 150: C-band EIRP limit to protect receiving GSO satellite
- Extend to all HAPS bands shared with FSS ↑?
- GSO arc over equator only
- All GSO Earth stations pointing towards GSO
- HAPS might make use of this limited GSO geometry to mitigate interference
- By avoiding GSO geometry, HAPS might;
  - operate co-frequency with FSS (↑ and ↓)
  - avoid receiving interference from GSO FSS
  - Avoid creating interference to GSO FSS
- Similar to mitigation techniques for GSO NGSO co-existence
- "Epfd limits" for HAPS in bands shared with FSS?



UWB/SRD – Ultra Wide-band/Short Range Devices

- Used virtually everywhere for a very wide range of applications
  - *data collection, item management in warehousing, retail and logistic systems, baby monitors, garage door openers, home security systems, wall radars, ITS (addressed earlier), keyless automobile entry systems, medical implants, collision radars, distance measurements ……*
- Consumer and professional equipment
- Operated by end user
- Often not a part of a network
- Normally no service provider
- Transported and used across borders with little or no control or monitoring

UWB/SRD – Ultra Wide-band/Short Range Devices (2)

- Operate on a wide range of frequencies, inside and outside the ISM bands
- Some in bands allocated to FSS
- Generally operate on a non-interference, non-protected basis (supposedly operating at such low levels that they are not noticed by radiocommunication services in the band)

- UWB/SRDs demonstrated to interfere with FSS downlinks

- FSS uplinks may interfere with UWB/SRDs

UWB/SRD – Ultra Wide-band/Short Range Devices (3)

Interference UWB/SRD → FSS downlinks

Field trial in Hong Kong

UWB Consumer grade wireless computer port, bought locally in computer arcade
Operating frequency: 3.1 - 4.8 GHz
Power mask: - 41.3dBm/MHz (FCC standard)

Satellite reception
Frequency: 3.4 - 4.2 GHz
Antenna diamter: 1.8m

Results/Conclusions

1. UWB – FSS receiver distance: 10-20 m
   FSS antenna pointing: towards satellite, receiving UWB in sidelobes
   => Raise of noise floor > 3 dB (permissible value is 0.04 dB)

2. Need to increase exclusion zone to hundreds of meters to provide adequate protection of FSS downlinks

3. The UWB power mask of -41.3 dBm/MHz does not offer adequate protection of FSS receiving Earth stations

UWB/SRD – Ultra Wide-band/Short Range Devices (4)

Interference FSS uplinks → UWB/SRD

- Not safety service under RR 1.59 and 4.10
- Some UWB/SRDs associated with safe operation or important functions (medical implants, collision radars, …)
- How to avoid that individual administrations impose limitations on deployment of transmitting Earth stations?

Interference UWB/SRD → FSS downlinks

- Some administrations have standards and limits for some UWB/SRD applications
- Consumer grade products sold on the open market, brought between countries and used everywhere
- Normally no service provider involved
- How to avoid UWB/SRDs being used with parameters which can cause harmful interference to FSS?

- How to enforce exclusion zones around receiving Earth stations?

- Who to complain to and how to identify interfering UWB/SRD device if harmful interference occurs?

Wrap up

- Satellite and terrestrial sharing frequency bands within the same geographical area offers efficient spectrum utilization if technically feasible
- The Radio Regulations generally allocate frequency bands broadly for several services (e.g. FSS, FS and MS)
  This does not indicate technical compatibility between the services
- Terrestrial use at the detriment of FSS does not mean efficient spectrum utilization
- FSS can be interfered by terrestrial applications
  - FSS reception not feasible within the same geographical area
  - Interference from adjacent band emissions through unwanted emissions and LNB overdrive
  - FSS receiving satellites can be interfered by the aggregation of emissions of several terrestrial transmitters
- Terrestrial applications can be interfered by FSS
  - Tightening of downlink pfd limits for FSS
  - Limitations on deployment of transmitting Earth stations
- Mitigation techniques may work in some cases

How to ensure that introduction of terrestrial services in new frequency bands is not at the cost of satellite services?

Thank you for the attention!

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