CRITICAL USE OF C/L BAND FOR SATELLITE SAFETY SERVICES & PROTECTION OF THE L-BAND SPECTRUM FOR LAND, SEA, AND AIR

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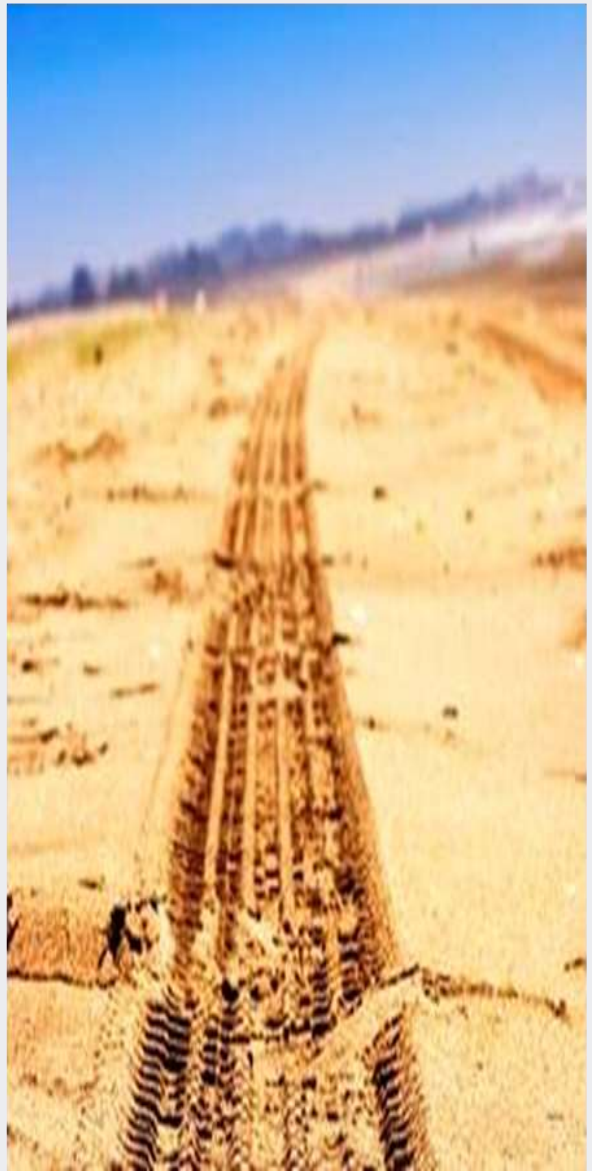
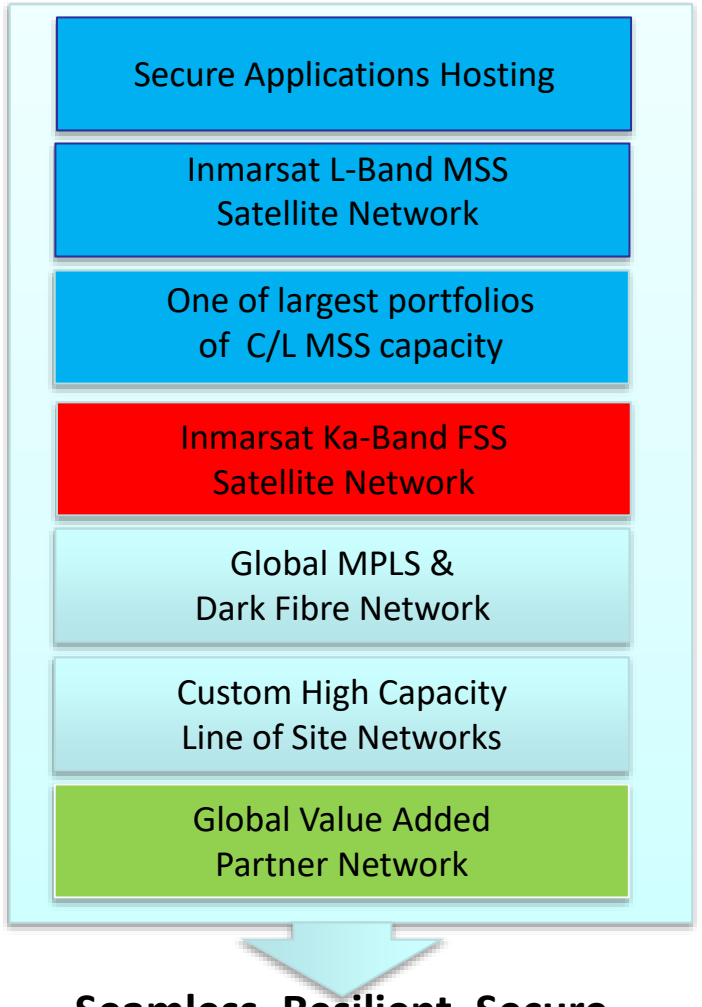


Contents

1. Overview of Inmarsat MSS L Band Services

- Formed in 1979 as an International Government Organization – 'owned' by 42 nations of IMO.
- Major provider of Maritime & Aeronautical Safety Services as a public service Globally
- Market leader in Mobile Satellite Services (>50% Market share)
- One of the largest global providers of Mobile Satellite capacity
- Network Availability >99.9%.
- Globally Support 24x7 NOC, throughout the year



Inmarsat's Heritage is all about Saving Lives

Inmarsat MSS L Band Services

Core Markets - Customers on land, at sea and in the air

Land/ Enterprise

Global, integrated communications solutions tailored for a broad range of enterprise markets

Voice, M2M and broadband data services

Maritime

The broadest portfolio of global voice and data solutions for all types of vessel

Global satellite safety services provider for the maritime industry

Aviation

Global voice and data connectivity for all types and sizes of aircraft now, and in the future

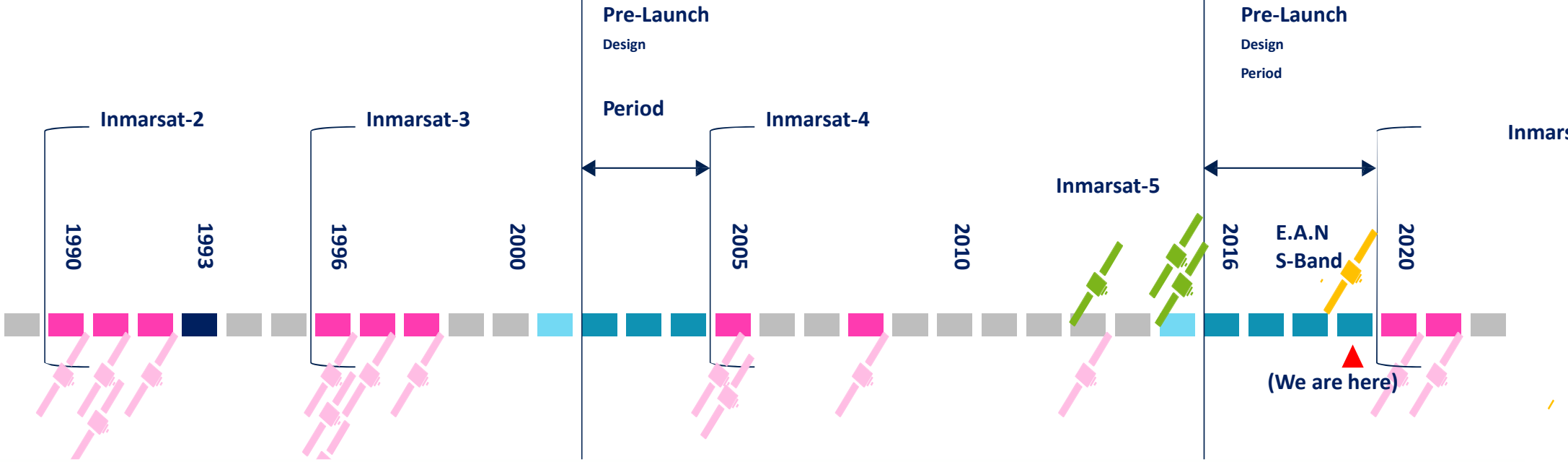
The leading satellite safety services provider for the aviation industry

Government

Secure, end-to-end telecommunications solutions for US Government operations worldwide.

Assured, end-to-end satellite communications solutions for the global government user

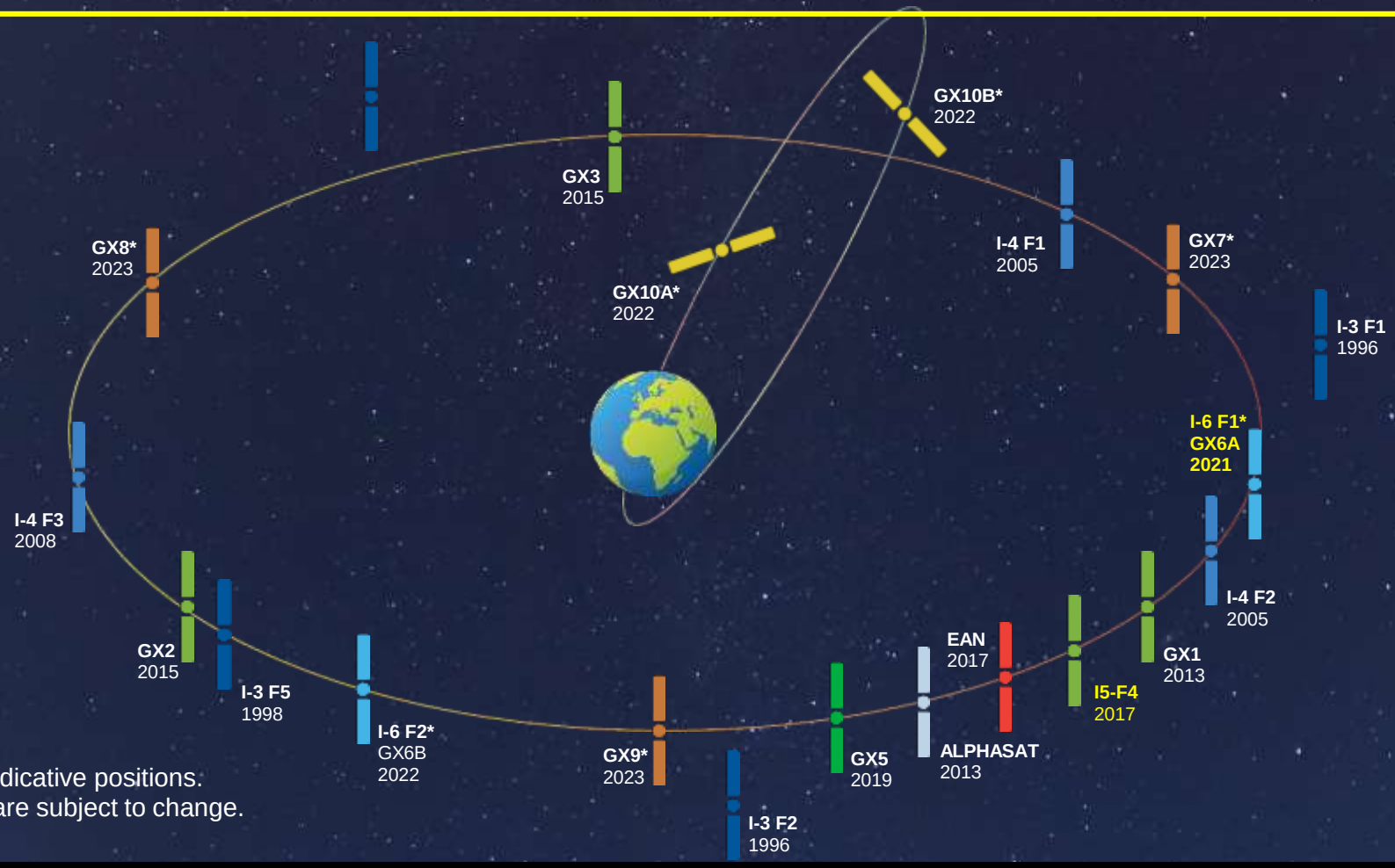
Evolutionary Development – Space Segment with advances in technology in L, S & Ka bands



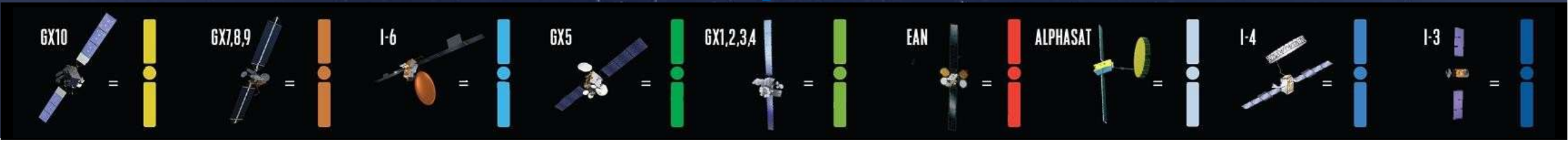
Coverage	Global Beam	Global Beam+5 Wide Spots	Global+19 Wide Spots+228 Narrow Spots	
Mobile Link EIRP	39 dBW	49 dBW	67 dBW	
Power Generation	1.2 kW	2.8 kW	14 kW	22 kW
Channelisation	4 channels of 4.5-7.3 MHz bandwidth	46 channels of 0.9-2.2 MHz bandwidth	630 channels of 200 kHz bandwidth	750 channels of 200 kHz bandwidth
Solar Array Span	14.5 m	20.7 m	45.0 m	
Satellite Dry Mass	700 kg	1000 kg	3000 kg	
Total Launch Mass	1500 kg	2050 kg	5960 kg	6600 kg

Growing Satellite Fleet

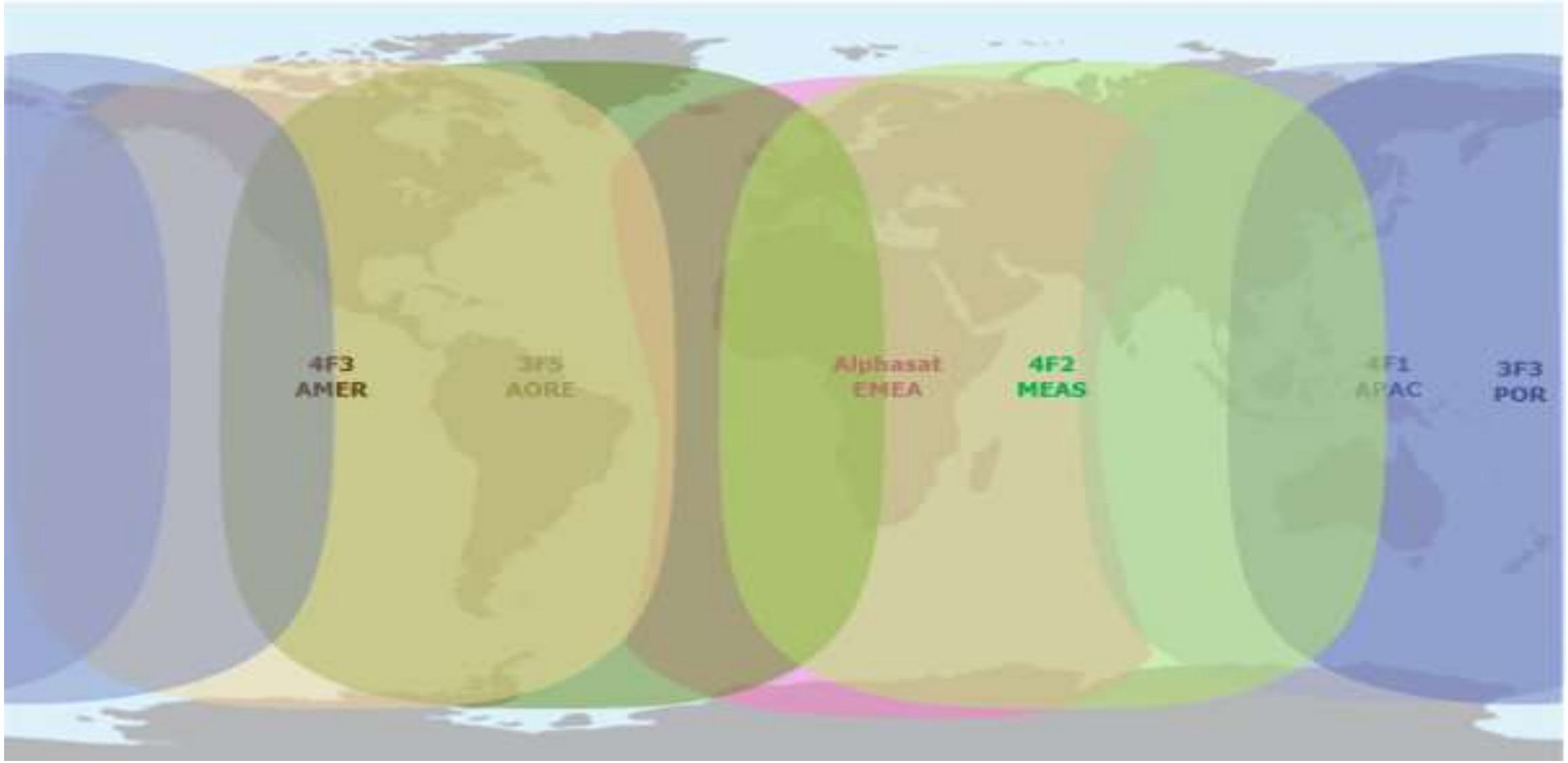
Committed Programmes - 2024



Please note that these are indicative positions.
*Future locations and dates are subject to change.



Inmarsat's Global Coverage



Powering Connectivity for safety at Sea and in the Air

Maritime

Maritime safety & mission-critical communication

- Modernising satellite communication between ship and shore, and enabling autonomous rescue vessels to revolutionise search and recuse operations
- Provide real-time data both on and off the ship whenever its needed most

Communication

- Powers advanced vessels monitoring and catch reporting systems for fishing industry
- Deliver communications across oceans and along the most rugged coastlines, optimises business operations and minimise in-port maintenance time with better monitoring and reporting (through IoT technologies)

Aviation

Air traffic management

- Provide voice and data services allowing aircraft to communicate with Air Traffic Control (ATC) and its Airline Operation Centre (AOC) when outside coverage of conventional ground radar and VHF stations
- Non-ATC use, satellite voice communications still require standard radio discipline procedure

In-flight connectivity

- Transforming business aviation by increasing speed, capacity and throughput to business jets
- A-ESIM operating in the Ka-band enable gate-to-gate in-flight communications. Improve Wi-Fi user journey and experience – to get their inflight Wi-Fi connectivity on-board the aircraft, departing from any airport

GLOBAL MARITIME DISTRESS SAFETY SYSTEM

GMDSS

1999

1 February the final implementation of GMDSS became fully effective

300T

Required on all passenger and cargo ships over 300gt on international voyages

99.9%

Consistent availability of Inmarsat's satellite & ground network which meets the GMDSS standards

INTERNATIONAL CIVIL AVIATION ORGANIZATION

ICAO APPROVED

Inmarsat supporting GADSS through Search and Rescue Operations (SAR)

90%
Of wide-bodied trans-oceanic commercial aircraft have Inmarsat safety services installed

100K
We support 80,000 air traffic service messages per day

14K
Aircraft are connected by Inmarsat all over the world

Land Mobile Emergency Communications

Emergency Response

Emergency response
- Provide made communication possible in disaster situations, enabling governments and organisations to coordinate emergency response

Continuity of communication
- Enable community communication (calls and Wi-Fi) to victims of natural disasters help reconnect families

Pre- and post disaster monitoring
- Use satellite images over time to determine shifts in ecological activity, such as lakebed flooding

Enabling connected media
- Provide reliable internet connection, enabling it to share and download content more quickly and easily across multiple sites

Government / Defence

Daily operation
- Provide critical communications link
- Provide service continuity when no other communications are available

Emergency response & disaster recovery agency
- Provide communications between disaster areas and regional response offices
- Increasing impact of climate change

TÉLÉCOMS SANS FRONTIÈRES (TSF)

OFFICIAL PARTNER

2000
Inmarsat became the very first official partner of TSF

400K
People have been helped through the partnership

100K
Free priority humanitarian telephone calls for those affected

L-band Network Services

Voice and broadband data communications

GSPS / BGAN

- Portable, fixed and vehicular
- Simultaneous voice
- Broadband data up to 650kbps
- Portfolio of guaranteed on-demand IP streaming rates

Fleet Safety / Broadband

- Broadband data up to 492kbps
- Simultaneous voice
- Guaranteed data rates up to 256kbps
- Accessible through a compact antenna
- Approved by IMO for GMDSS

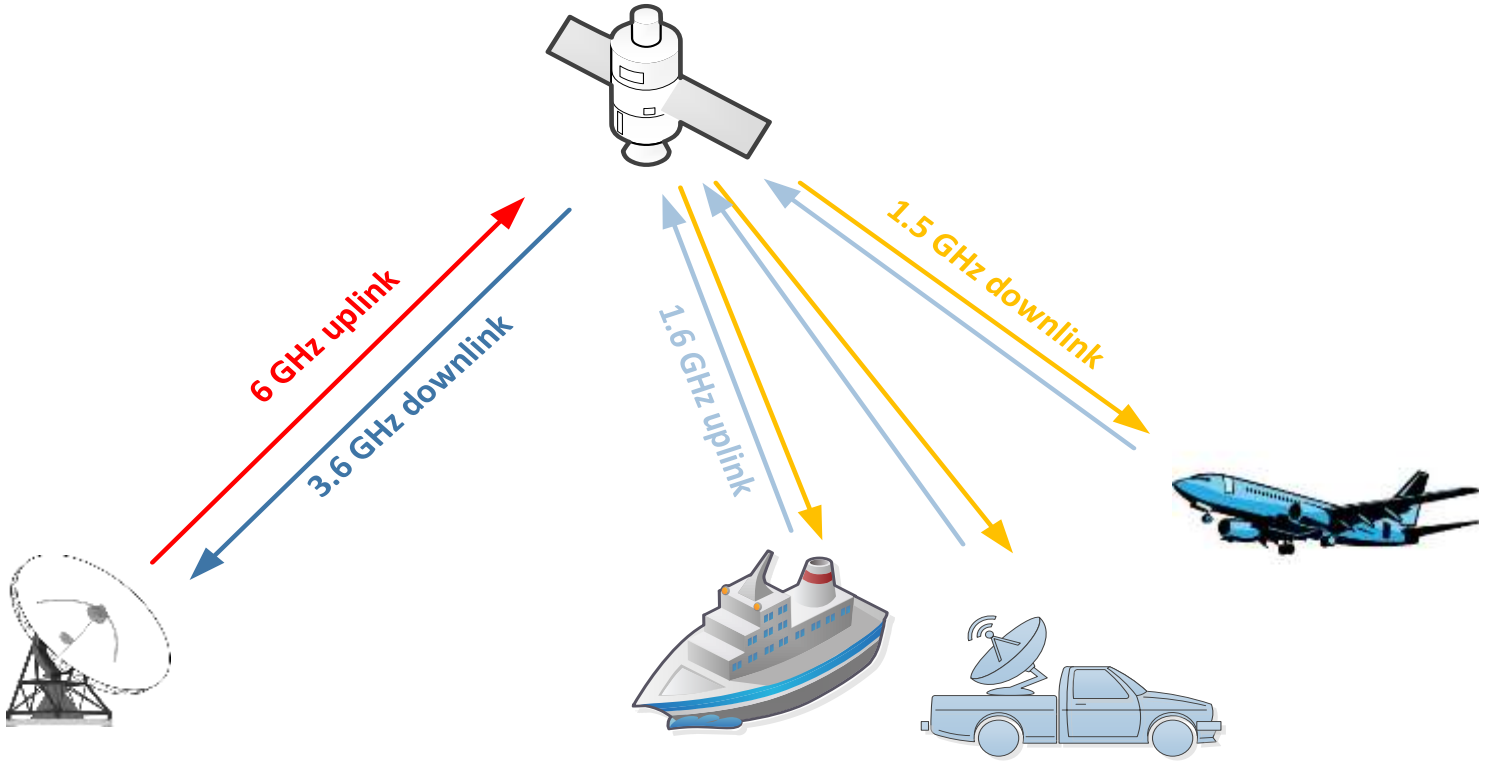
SwiftBroadband

- Broadband data up to 432kbps per channel
- Simultaneous voice
- Guaranteed data rates up to 224kbps
- SB-Safety accepted by ICAO for meeting aero Safety Requirements
- Cornerstone of EC IRIS (traffic control) system

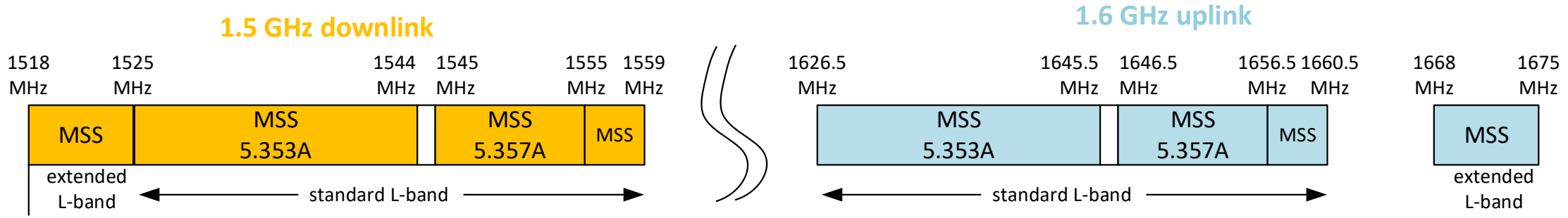
2. Inmarsat L Band in India

- Government of India was one of the founding members at IMO of Inmarsat in 1979 and operated a Land Earth Station for L band services through VSNL @Arvi.
- Today, Inmarsat Services are offered through locally established service providers, BSNL; offering a variety of critical L-band services on land sea and air to various users within India, regionally and globally.
- As of today:
  - India has one of the strategic NAVAREA identified covering the India Ocean, and a major traffic route connecting east and west for aeronautical and maritime operations.
  - India has one of the busiest sea lanes on its doorstep, with an RCC operations footprint
  - Large number of Indian Flag vessels are equipped with L-band maritime terminals registered by Indian Shipping corporations, Indian Navy and Coast Guard are users of L-band services.
  - Increasingly Aviation Carriers are demanding Inflight Connectivity (IFC) that uses L-Band spectrum including Government for overflight.
  - Viasat provides a number of L-band systems in India for government and non-government use, in accordance with India's authorization regime. Some of these systems are GSPS, FBB, SBB, BGAN, LRIT, and GMDSS.

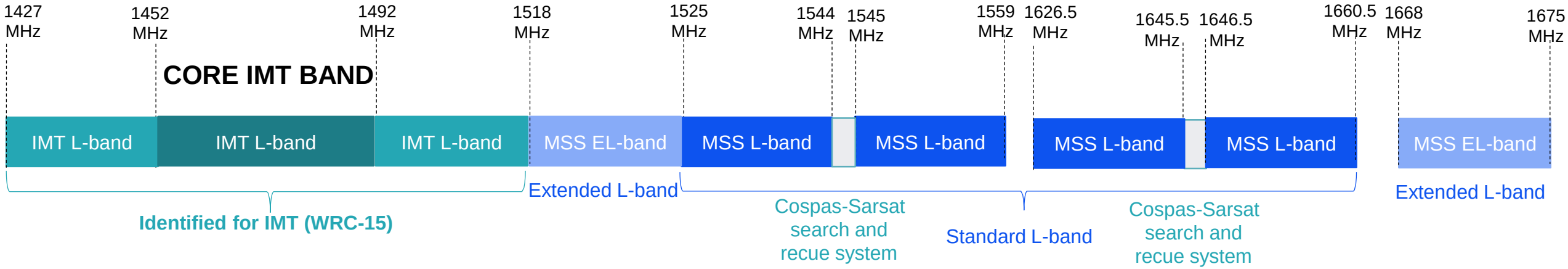
C/L-band Global Architecture



- L-band used by Inmarsat and other GSO MSS operators for ~50 years
- "Extended L-band" allocated in 2003, and brought into use in 2013 with Inmarsat Alphasat
- Inmarsat-6 satellites, launched in 2022 and 2023, operate in Standard L-band and Extended L-band



L-Band Spectrum Overview

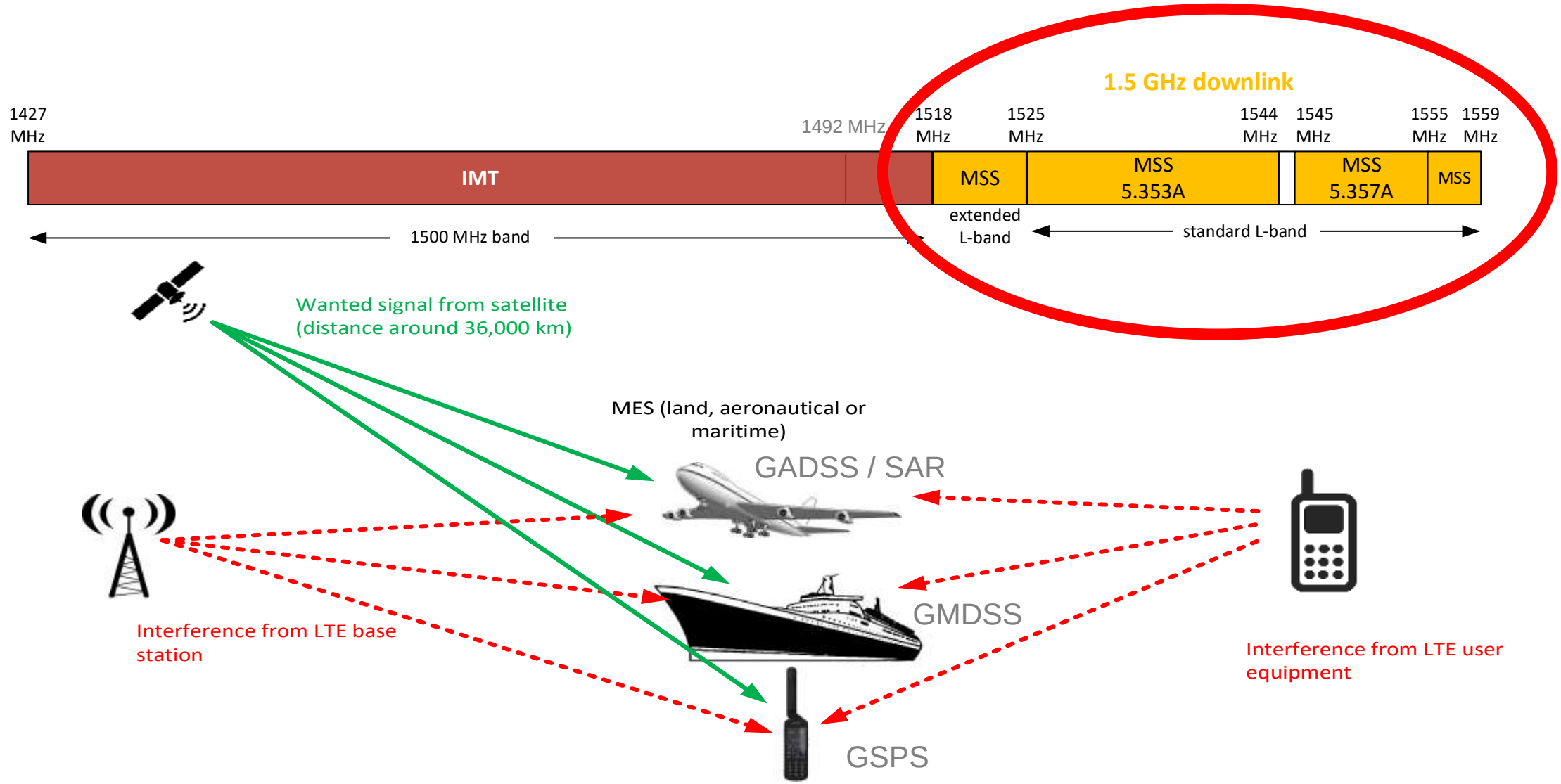


Critical band for current & future satellite services (including safety services e.g. GMDSS)

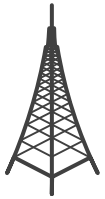




3. Interference issue

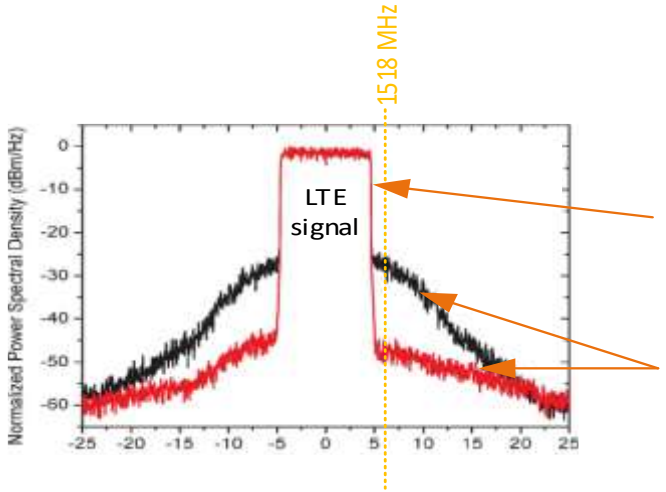


Interference Mechanisms from IMT into MSS



- MSS MESs receive in the 1518-1559 MHz band
  - Older terminals operate in the standard L-band (above 1525 MHz) and most new terminals receive in the whole band (1518-1559 MHz). **All are impacted**.
- IMT BS transmission below 1518 MHz can cause:
  - MES receiver blocking from IMT in-band emission
  - MES receiver interference from IMT out-of-band emission

- IMT UE transmission below 1518 MHz, if TDD-IMT is considered
  - MES may receive interference from IMT UE OOB emission



Blocking interference (LTE signal received by MES on adjacent frequencies, including terminals operating above 1525 MHz)

Out-of-band emissions (LTE OOB emissions received by MES within the MSS band)

Only improving IMT filters can reduce interference to MES from OOBE

Affected Satellite Terminals

Maritime terminals

- Inmarsat-C (SOLAS vessels for GMDSS compliance)
- Fleet-77 (GMDSS for voice)
- Fleet Safety (recently approved for GMDSS)
- Fleet broadband
- Used by many shipping companies based in India and by numerous visiting ships along the vast Indian coastline

Safety use required in Ports & Harbours

MARITIME OPERATIONAL REQUIREMENTS IN AND NEAR PORTS

- A number of mandatory communication requirements are commonly carried by Inmarsat-C or Fleet-Safety.
  - Long-range Identification and Tracking (LRIT):
  - Maritime safety information (MSI)
  - Search and Rescue (SAR)
  - Fishing Vessel Monitoring System (VMS)
  - International Ship and Port Facility Security (ISPS) Code
  - Common European Reporting System (CERS):
- Many applications require operation while in port (stationary) and on approach (e.g. LRIT). GMDSS communications must be tested before departure.
- Other operational communications use SatCom.
- As of 2024, the country has 14 major ports and 217 non-major ports
- **Conclusion: Terminals should be usable when stationary at port, on approach to port, and in waterways.**

More to

inmarsat
The mobile satellite company™

GMDSS Distress calls map

IMT Interference to the C- Satellite Receivers & L-band terminals near the coast could prevent Safety services

Affected Satellite Terminals

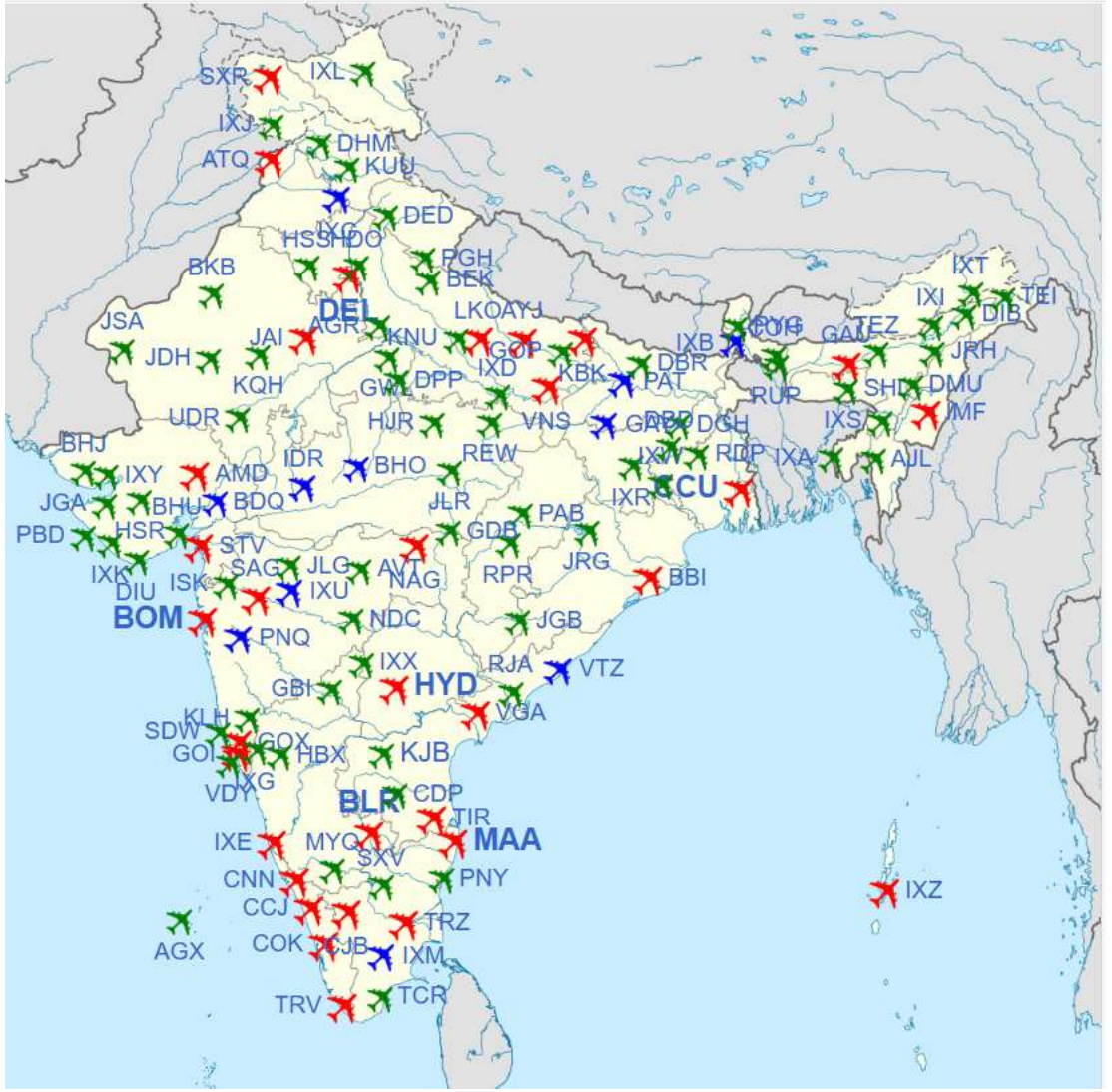
Aeronautical terminals

- Classic Aero
- Swift Broadband
- Swift Broadband Safety (GADSS ready)
- Used by most commercial airlines + government users

Safety use required at Airports

AERONAUTICAL OPERATIONAL REQUIREMENTS AT AIRPORTS

- Studies show risk of interference from IMT is only significant to aircraft on the ground.
- Operation of AMS(R)S compulsory in oceanic airspace as required in the FANS mandate, Master Minimum Equipment List and European Commission Datalink Implementation Rule. Requirement for the majority of large passenger aircraft.
- SatCom is used over continental airspace, e.g. to avoid switching from SatCom to VHF, to avoid VHF congestion
- Some airlines place an operational requirement to test SatCom before departure
- Other (non-safety) operational communications and passenger communications use SatCom
- India has a total of 487 airports and airstrips. 35 International, 11 Quasi Int, customs, domestic, private
- **Conclusion: Terminals should be useable at the airport and in the air**.



Affected Satellite Terminals

Land terminals

- GSPS (IsatPhone)
- IsatData Pro
- BGAN M2M
- BGAN land MESs (portable and vehicular) including BGAN HDR

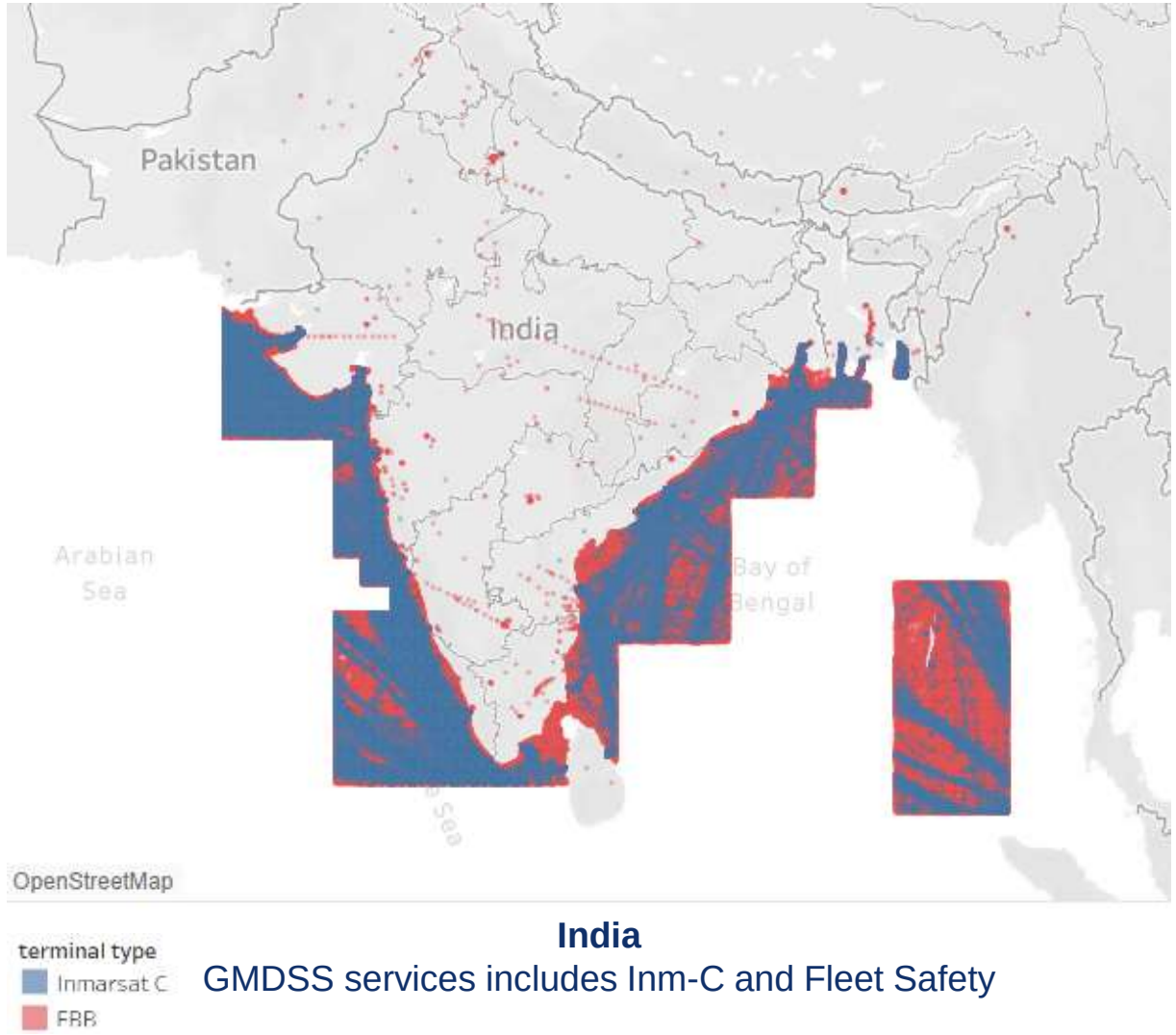
Impact on Existing Terminals

- There are hundreds of thousands of terminals deployed in the field:
  - More than 160K Inmarsat maritime terminals in the field, incl GMDSS.
  - Almost all wide-body jets are equipped with Inmarsat terminals
- These terminals could suffer overload/blocking effect from new IMT in-band emission and interference from IMT OOB emissions
- If not mitigated, IMT interference can impact on the MES receiver while 10s of km separated from the BS (for uppermost IMT channel).
- Wanted satellite signal level at same reference point may be as low as **-140 dBm**, which could be up to 110 dB lower than the IMT signal.

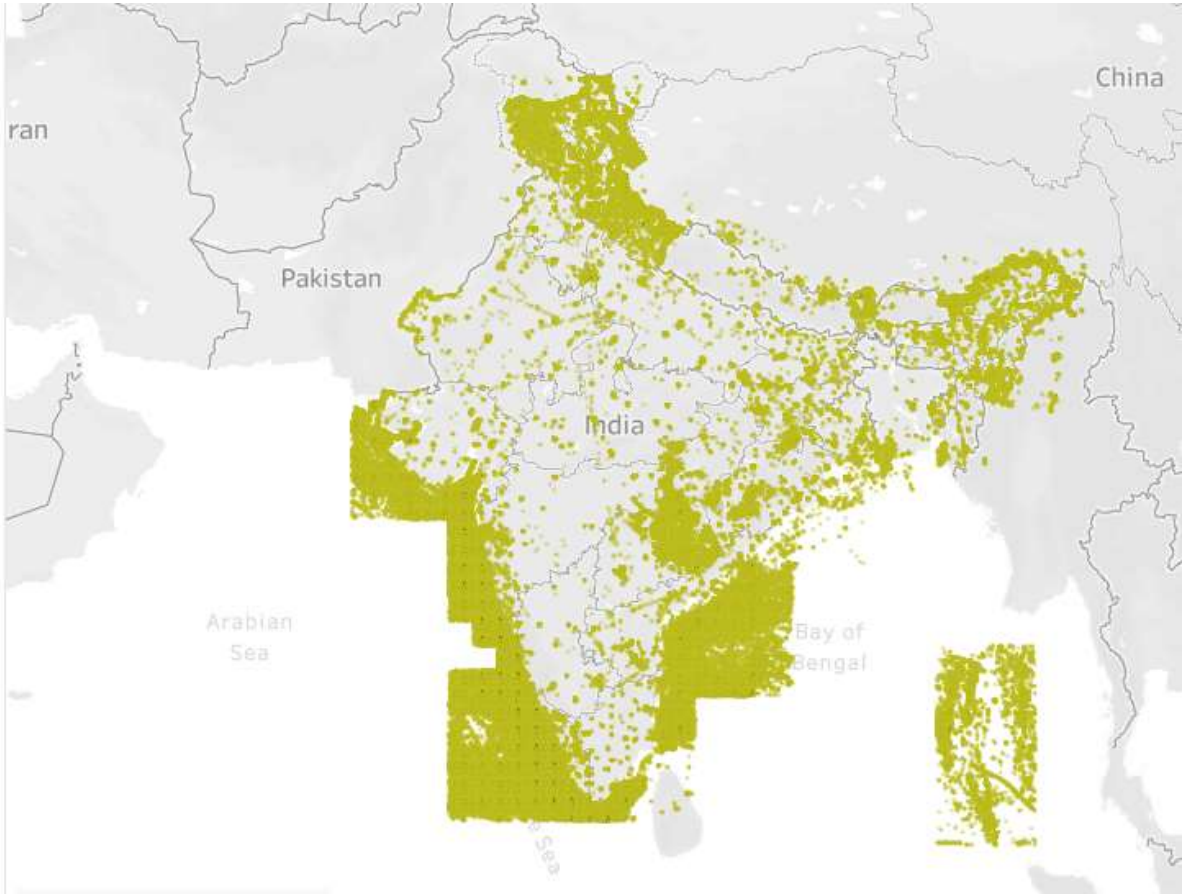
ITU Report & Recommendation

- ITU-R Recommendation M.1036:
  - Includes frequency arrangements for FDD, SDL and TDD
  - Notes including: *"Based on the current results of these studies, 1.a number of possible measures to facilitate adjacent band compatibility, is for administrations to consider **additional frequency separation** below 1 518 MHz at the upper part of G1, G2, or G3 (e.g. a total separation of different values up to 6 MHz). Moreover, when implementing these frequency arrangements, administrations are **encouraged to take into account the results of the compatibility studies, e.g. in order to address IMT-MSS coexistence in certain areas (around seaports and airports, etc.)**."*
- Technical studies were completed by WRC23, a Report ITU-R M.2529 & **Rec ITU-R M.2159**
- Complex compatibility measures developed over the 8 years in a New Recommendation, which includes:
  - Out-of-band emission limits for IMT base stations and user equipment
  - In-band EIRP limits for IMT base stations
  - Guard bands
  - PFD limits for ports, waterways, and airports, to be met by IMT base stations.
- Many countries have capped at 1492 MHz to avoid implementing complex measures

Examples of GMDSS (Inm-C/FSS) & GSPS usage



India
GMDSS services includes Inm-C and Fleet Safety



India
GSPS

Step 2 – Define PFD limits to be met by the emissions from IMT base Station outside the protected areas

- Power Flux Density (PFD) Limits based measurements of current maritime and aero terminals are shown below:

TABLE 1

pfd limits for IMT BSs transmitting a single channel

	MSS terminal antenna gain (dBi)	pfd limit for BS emissions in the band 1 492-1 502 MHz (dBW/m^2)	pfd limit for BS emissions in the band 1 502-1 512 MHz (dBW/m^2)	pfd limit for BS emissions in the band 1 512-1 517 MHz (dBW/m^2)
Ports and inland waterways	3	−60.9	−75.9	−83.9
	3-19*	−60.9 to −76.9	−75.9 to −91.9	−83.9 to −99.9
Airports	3	−28.9	−42.9	−58.2
	3-17*	−28.9 to −42.9	−42.9 to −56.9	−58.2 to −72.2

***Note**: The pfd values based on 3 dBi MES antenna gain apply in most situations, but there are locations in the world where the antenna gain towards the horizon can exceed 3 dBi (up to 19 dBi or 17 dBi). This is where there is a low elevation angle for the MES and where an IMT BS could be deployed in the direction of the MSS satellite as seen from the MES. For these cases, the actual angles to the satellite and the IMT deployment should be taken into consideration and the pfd adjusted to a value within the ranges shown.

TABLE 2

pfd limits for MFCN BS transmitting multiple channels

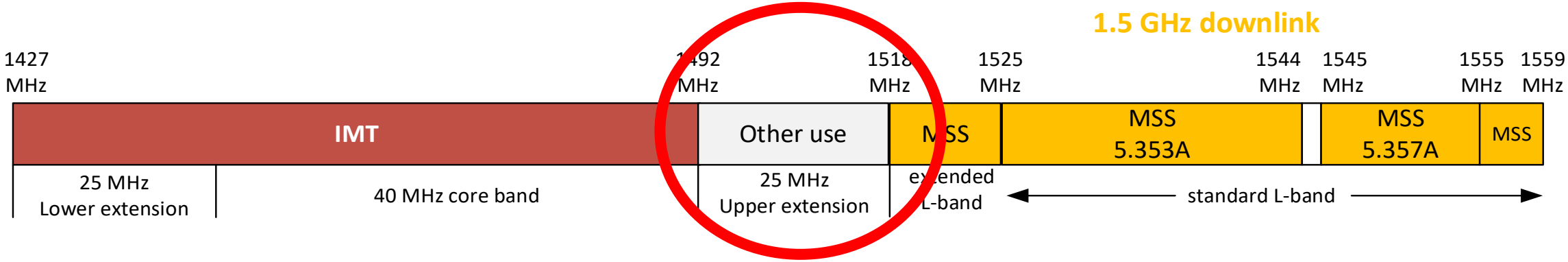
	MSS terminal antenna gain (dBi)	pfd limit for emissions in the band 1 492-1 512 MHz (dBW/m^2)	pfd limit for emissions in the band 1 512-1 517 MHz (dBW/m^2)
Ports and inland waterways	3	−74.9	−85.9
	3-19*	−74.9 to −90.9	−85.9 to −101.9
Airports	3	−53.5	−63.4
	3-17*	−53.5 to −67.5	−63.4 to −77.4

***Note**: The pfd values based on 3 dBi MES antenna gain apply in most situations, but there are locations in the world where the antenna gain towards the horizon can exceed 3 dBi (up to 19 dBi or 17 dBi). This is where there is a low elevation angle for the MES and where an IMT BS could be deployed in the direction of the MSS satellite as seen from the MES. For these cases, the actual angles to the satellite and the IMT deployment should be taken into consideration and the pfd adjusted to a value within the ranges shown.

Recommended limits in the ITU-R Recommendation – M.2159 (12/2023)

Compatibility with Land MESs

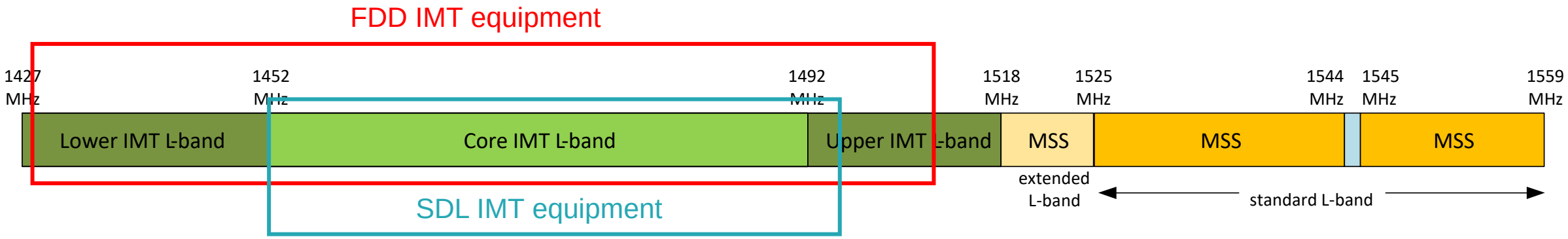
- Land MESs typically operate throughout the territory of any country without geographic restriction.
- Hence, the application of PFD limits to protect land MES operations is typically not practical unless applied for specific sites
- The most practical solution which also reduces the interference into aero and maritime: *Limits IMT operation in the upper extension part of the 1500 MHz band*
- Band may be used for military links, narrowband point-to-point, IMT limited to indoor use.
- This solution has already been adopted by the Netherlands, Malta, Italy, Germany, Romania, African Countries
- Use of 1452-1492 MHz by BSS in some countries may be needed – not compatible with IMT



IMT Equipment Availability

RECENTLY REPORTED BY THE GLOBAL SUPPLIERS' ASSOCIATION (GSA) IN AWG-29

- 382 commercial devices were supporting the frequency bands 1 427.9-1 462.9 MHz and 1 475.9-1 510.9 MHz for FDD (Bands 11 and/or 21) in 2020, and the number of devices supporting Bands 11 and/or 21 has grown to 431 devices by March 2022. Unique to Japan?
- 237 commercial devices were supporting the band 1 452–1 496 MHz for **SDL** (Band 32) in 2020, and the number of devices supporting Band 32 has grown to 319 devices by March 2022.
- **Apparently, no TDD equipment available and no SDL equipment for the band above 1496 MHz**



Future Evolution of L-band Connectivity

Urban Air Mobility - complete command and control network for the safe operation of autonomous flying taxis and personal UAVs.

Next Gen Safety – future emergency safety services, including enhanced real-time collaboration and expanded data collection.

Extending Inmarsat's services for the first time for small coastal vessels, offshore energy platforms and remote operations for autonomous vessels

Large Scale Industrial IoT

Secure, device-neutral, private networks that allow customers to integrate, connect, manage and monitor via a single cloud environment.

Secure Tactical Private Networks

Bespoke, high-speed, local area, temporary sovereign networks to connect emergency and humanitarian aid teams in the field while securely relaying critical data home for analysis.

New multi-band, low SWaP terminals will also extend Inmarsat's services for UAV, short-range ISR, HELO, and sensor/IoT.

Portfolio of L- Band Applications

L-band airborne intelligence, surveillance for Unmanned vehicles

High-throughput connectivity

L-band enhances agriculture productivity & food security

Real-time operations & monitoring

A global narrowband satellite network – ideally suited for IoT

The latest evolution of L-band network

5. Summary / Conclusion

- MSS use is at high risk of interference from IMT in the 1500 MHz band for safety related services
- Potential impact to land, maritime, and aeronautical safety services used throughout the Indian sub-continent and regionally. Also, it could impose limitations on future development of more innovative L-band services
- Critical to protecting existing L-Band spectrum allocation 1518–1559 MHz and protect C-Band uplink @ 6425 – 6575 MHz for an existing portfolio of critical services and future development.
- Continued access to sufficient spectrum for both current and future needs.
- Mitigation measures are available to protect maritime use and aircraft use through defined protection areas and power flux density (PFD) limits, however, given the complexity of implementing these measures, many countries have adopted to cap IMT at 1492 MHz.
- Effective compatibility with land MESs requires an additional guard band, limiting IMT to the band below 1492 MHz. This also avoids the need for complex measures to define protection areas.