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INDIAN SPACE ASSOCIATION

ISpA

Bhumandal Se Brahmaand Tak

Enhancing Maritime Situational Awareness with GeoIntelligence

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DG-ISpA

16th May 2024

Privatization of Space: INDIA

INDIAN SPACE ASSOCIATION
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- Triggered by Global Trends
- Very large Spectrum of ISROs activities
- Global Economy and India's meagre Share
- An opportunity for growth like the IT and Pharma sectors
- Availability of large talent pool in India

Chronology Of Events

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- 2019 – Formation of Defence Space Agency
- June 2020 - Government's declaration of its intent to open Space to private players
- June 2020 - Formation of IN-SPACe
- Oct 2020 - Issue of Draft Space and Remote Sensing Policy
- **Oct 2021 - Formation of ISpA**
- Feb 2022 -Discussions on consolidated New Space Policy
- Sept 2022 -Draft Indian Telecommunication Bill, 2022
- Dec 2023 - Release of the New Geospatial Policy 2022
- **Apr 2023 – Release of Space Policy**
- **Dec 2023- Indian Telecommunications Act 2023**
- **March 2024- New FDI Policy for Space**
- **May 2024- Norms, Guidelines and Procedure by IN-SPACe**

About INDIAN SPACE ASSOCIATION (ISpA)

INDIAN SPACE ASSOCIATION
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Hon'ble PM Shri Narendra Modi launched ISpA with the Vision

To create an enabling environment for strengthening the Private Space Industry to propel India to the forefront of the Global Space ecosystem.

Focus Areas

- **Unified Voice for ensuring enabling Policy frameworks**
- **Contribute to building a innovation driven resilient space ecosystem**
- **dynamic and robust Space Industrial Complex**
- **Energize Business Growth**
- **Capacity and Knowledge Building**
- **Interface With Defence and Security Agencies**
- **International Partnerships And Cooperation**

WORK IN CLOSE COORDINATION WITH ISRO, IN-SPACe & NSIL

National Space Enterprise

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ISRO

Focus on developing new technologies, systems, and R&D.

Provide strategic direction and guidance for India's space program.

Oversee the operational aspects of space missions.

IN-SPACe

Act as the interface between ISRO and NGEs.

Provide authorization and promotion of space activities by NGEs.

Facilitate collaboration between ISRO & private sector in space-related endeavors.

Academia

Collaborative Research

Strengthen the participation of private players in India's space program.

Handle the commercial aspects of ISRO's missions.

NSIL

End-to-end solutions

Create own IP

New LVs, Satellites & Applications

Technology Partner

Industry & Start-up

ENABLERS ⟷ ISpA ⟷ USERS

ISPA PROJECTION - DOWNSTREAM OPPORTUNITIES

SURVEILLANCE - STRATEGIC & TACTICAL APPLICATIONS

Intelligence, Surveillance and Reconnaissance (ISR)	Strategic Communications	Guidance	Space Security
Strategic Surveillance	Strategic communications, IoBT and IoMT*	Drones	Space Situational Awareness
Maritime Domain Awareness	Vehicle connectivity	Missiles and Munitions	Satellite Operations
Asset Tracking	Integrated command and control centre		
Signal Intelligence (SIGINT) Electronic Intelligence (ELINT)			

* Internet of Battlefield Things (IoBT), Internet of Military Things (IoMT)

MARITIME SITUATIONAL AWARENESS (MSA)

"AN ENABLING CAPABILITY WHICH SEEKS TO DELIVER THE REQUIRED INFORMATION SUPERIORITY IN THE MARITIME ENVIRONMENT TO ACHIEVE A COMMON UNDERSTANDING OF THE MARITIME SITUATION, IN ORDER, TO INCREASE EFFECTIVENESS IN THE PLANNING AND CONDUCT OF OPERATIONS"

(14 Jan 2008 Military committee endorsed NATO concept for MSA).

IT IS IMPERATIVE THAT MARITIME SURVEILLANCE (MS), IS THE CORNERSTONE OF MSA

MARITIME DOMAIN AWARENESS

The International Maritime Organization (IMO) defines it as "the effective understanding of any activity associated with the maritime environment that could impact upon **the security, safety, economy or environment."** *It encompasses a comprehensive view of activities and elements related to the sea, oceans, and other navigable waterways*

- **The Indian Navy** has described MDA as "an all-encompassing term that involves being cognisant of the position and intentions of all actors, whether own, hostile, or neutral, in all dimensions of a dynamic maritime environment, across the areas of interest."

MARITIME DOMAIN AWARENESS

- The Indian Maritime Security Strategy (2015) highlights that MDA is central to the **Information–Decision–Action (IDA)** cycle, and is also a **key enabler for maritime security across the conflict spectrum.**
- Broadly, MDA entails the **collection, fusion, analysis, display and dissemination of actionable information and intelligence**.

MARINE DOMAIN AWARENESS

- **Objective and Scope**:

  - MDA aims to collect maximum information and intelligence about ships, vessels, and related activities within a country's waters.
  - By analyzing this data, authorities can draw inferences about potential risks to safety, the ecosystem, and the economy.
  - The goal is to achieve "actionable intelligence" that enables proper maritime law enforcement.

CONVENTIONAL METHODS FOR MARITIME SURVEILLANCE

- **Automatic Identification System (AIS)**: Tracks vessel movements and provides real-time information.
- **Long-Range Radars**: Detects vessels beyond visual range.
- **Long-Range Unmanned Aerial Vehicles (UAV)**: Aerial surveillance for enhanced awareness.
- **Smart-Boxes**: Containers with built-in sensors to screen for unlawful items carried onto ships.

CONVENTIONAL METHODS FOR MARITIME SURVEILLANCE

CONVENTIONAL METHODS FOR MARITIME SURVEILLANCE

- AIS – SHIP/ MR AIRCRAFT/ UAV (DRONE)
- COMINT – INTERCEPTION OF COMMS SIGNALS IN THE 30-6000 MHz BAND
- ELINT – INTERCEPTION OF RADAR SIGNALS IN L/S/X BAND
- IFF (IDENTIFICATION FRIEND OR FOE)

- OPTICAL SENSORS – CAMERAS, VISUAL/ IR/ HYPERSPECTRAL (MWIR) FOR INTERCEPTION OF SHIP THERMAL SIGNATURES/ EXHAUST PLUMES AND WAKE SIGNATURES

- SYNTHETIC APERTURE RADAR, (SAR)

- HUMINT

SATELLITE BASED METHODS FOR MARITIME SURVEILLANCE

- **Satellite Imagery and Surveillance**:
  - **Earth Observation (EO)**: Satellites equipped with optical sensors capture high-resolution images of the Earth's surface. EO imagery helps classify vessel types and monitor their movements.
  - **Synthetic Aperture Radar (SAR)**: SAR satellites provide all-weather surveillance, overcoming limitations posed by cloud cover. SAR can detect vessels even during night time.
  - **Radio Frequency (RF) Detection**: Space-based marine radars use RF signals to detect commercial fishing vessels engaged in illegal, unreported, and unregulated (IUU) fishing
- **Ocean Temperature and Sea Ice Monitoring**:
  - Spaceborne sensors track ocean temperature variations and sea ice extent. These data are vital for understanding climate change, ocean currents, and potential hazards to navigation.

SATELLITE BASED METHODS FOR MARITIME SURVEILLANCE

- **Environmental Preservation and Disaster Preparedness**: Space technology aids in monitoring oil spills, pollution, and natural disasters (such as hurricanes and tsunamis) that impact maritime safety and ecosystems.
  - Timely information from space assets helps authorities respond effectively to emergencies.
- **Global Coverage and Consistency**:
  - Space-based systems cover vast oceanic areas, including remote regions where manual monitoring is challenging.
  - Consistent monitoring ensures timely detection of illicit activities, such as piracy, smuggling, and IUU fishing.

In summary, space-based assets enhance MDA by providing real-time data, improving surveillance capabilities, and contributing to oceanic sustainability and security.

Synthetic Aperture Radar (SAR) systems

- Pros:
- Monitors ship locations regardless of whether the ship wants to be seen – Can cover large areas of over several hundred kilometers in one image
- Has a high probability of accurately detecting steel-hulled ships; analytic tools can increase the likelihood of differentiating non-steel-hulled ships from other objects like islands.
- If controlled by an operator, can “zoom in” on smaller areas to produce a higher resolution image.
- Can detect “dark vessels” that have turned off AIS

Synthetic Aperture Radar (SAR) systems

- Cons:
- – Wood and fiberglass are not as clearly reflected, requiring additional analysis to differentiate them from other reflective surfaces like islands or waves.
- Satellite SAR was first demonstrated in 1978 and has become an important source of wide-area surveillance data. Unlike AIS, SAR does not depend on the voluntary cooperation of ships; instead, it is an active satellite system that transmits pulses of radar energy and receives the radar energy reflected by ships

Radio Frequency (RF) receivers

- Pros:

– Can be used to detect ships across a wide area – Can detect “dark vessels” that have their AIS turned off

- Cons:

– Cannot provide any identification or attribution of ships, only location RF geolocation is the most recent vessel detection and tracking capability for commercial satellites. This capability uses the difference in the time it takes a signal from a ship to reach each of several satellites to calculate the ship’s position. These signals may be from navigational radar or any one of several other RF emissions. Like SAR, RF geolocation is helpful in detecting and tracking dark vessels.

- RF geolocation generally does not identify a ship, but like SAR and AIS, it is a wide-area detection capability that can be used

Radio Frequency (RF) receivers

- RF geolocation generally does not identify a ship, but like SAR and AIS, **it is a wide-area detection capability** that can be used to cue high-resolution EO imagery collection or to cue patrol vessels and aircraft to the location of the emitter.

(EO) sensors

- Pros: – Can produce photographic imagery on many scales of distance, from hemisphere-wide meteorological shots to pictures of a single ship – Produces clear photographs of specific targets which can be used as evidence of unwanted activities
- Cons: – Each EO payload can only produce images in one set resolution and over one set geographic area Satellites carrying EO payloads can produce photographic imagery of all scales, from meteorological images of entire hemispheres to high-resolution images of a single ship; however, each satellite's area coverage and image resolution are generally fixed (unlike SAR).
-

EO IMAGERY

- High resolution EO imagery is desirable because it can often show evidence of unwanted activities, such as fishing in restricted areas via visible net buoys or illegal ship to-ship transfers.
- Wide-area EO imagery serves an entirely different function: providing meteorological or oceanographic context that helps us understand ship movements. For example, ships that veer off course may be avoiding a storm. Sea colour and temperature, observable from space, are oceanographic conditions that serve as predictors of where fish are most likely to be found, and where Coast Guard vessels are most likely to find fishing vessels.

AIS – AUTOMATIC IDENTIFICATION SYSTEM

- **SAT- AIS** FROM LEO/ CUBESAT WHICH DEPENDS ON
- SATELLITE PARAMETERS LIKE ORBIT TYPE/ ALTITUDE
- RECEIVER PARAMETERS VIZ. ANTENNA GAIN (SIZE), NOISE FIG & PROCESSING ALGORITHMS
- SCENARIO PARAMETERS LIKE TRAFFIC DENSITY, RADIO-FREQUENCY INTERFERENCE SOURCES, AIS MESSAGE COLLISIONS (FROM DIFFERENT CELLS)

OPPORTUNITY

AIS MESSAGES ARE SENT 2-10s PERIODICITY. TYPICAL SYSTEMS HANDLE 2000 REPORTS/ MINUTE.
AIS-Sat-1 – 20CM CUBE NANOSAT @635 km IMPLIES VERY LARGE FIELD OF VIEW, (FOV), HENCE SIGNIFICANT LEVEL OF AIS PACKET COLLISIONS. MOST SAT-AIS SYSTEMS ARE SECONDARY PAYLOADS TO EO SATS.

THEREFORE DESIGN/DEVELOPMENT OF DEDICATED CONSTELLATIONS FOR AIS WITH COLLISION-FREE PROTOCOLS

IMAGERY Vs SAR (SYNTHETIC APERTURE RADAR)

- SATELLITE IMAGERY USING CAMERAS, VISUAL/ IR/ HYPERSPECTRAL/ MULTISPECTRAL FOR INTERCEPTION OF SHIP THERMAL SIGNATURES/ EXHAUST PLUMES AND WAKE SIGNATURES. **HOWEVER, CLOUD COVER DISRUPTS PERFORMANCE OF CAMERAS**

OPPORTUNITY

- SATELLITE BASED SYNTHETIC APERTURE RADAR, (SAR), WITH **ADVANCED SEA-CLUTTER DISTRIBUTION MODELS AND POLARIMETRIC RADAR SIGNAL PROCESSING TECHNIQUES, (POL-SAR), LIKE COSMO-Skymed CONSTELLATION OF ITALY.**
- DATA FUSION TECHNIQUES FROM VISUAL/ MULTI-SPECTRAL / HYPERSPECTRAL CAMERA IMAGERY.
- SATELLITE BASED DF SYSTEMS FOR INTERCEPTION OF
  - COMINT – INTERCEPTION OF COMMS SIGNALS IN THE 30-6000 MHz BAND
  - ELINT – INTERCEPTION OF RADAR SIGNALS IN L/S/X BAND

BEACON TRANSPONDER

- PRESENTLY BEACON TRANSPONDERS FITTED ONLY ON G-SATS FOR TRACKING CORRECTIONS FOR LARGE REFLECTOR ANTENNAS
- BEACON SIGNALS FROM LEO SATS WITH LARGER SIGNAL STRENGTH WILL FACILITATE ENHANCED CAPABILITY FOR PASSIVE TRACKING OF FLYING OBJECTS INCLUDING DRONES, HYPERSONIC MISSILES, HIGH ALTITUDE PLATFORMS (HAPS), CLANDESTINE BALLOONS AND EVEN BALLISTIC MISSILES.
- LEO SATELLITE ORBIT/ TRAJECTORIES ARE WELL DOCUMENTED, HENCE MICRO-DOPPLER PROCESSING BASED PASSIVE RADAR NETWORK CHAIN WILL SIGNIFICANTLY BOLSTER SURVEILLANCE CAPABILITIES.
- BEACON SIGNALS WITH APPROPRIATE MODULATION WILL ALSO SERVE AS ALTERNATIVE TO GEO-LOCATION THROUGH GPS AND COULD OPEN UP UNPRECEDENTED OPPORTUNITIES IN THE POSITION, NAVIGATION AND TIMING DOMAIN.

SAT – IOT TECHNOLOGIES

OPPORTUNITY

- **IOT BASED TECHNOLOGIES**
  - COASTAL REGIONS HAVE EXTENSIVE MARITIME VEHICULAR TRAFFIC PRIMARILY FISHING FLEETS.
  - LOW COST EXTENDED RANGE COMMUNICATION DEVICES, USUALLY UNDER GOVT SUBSIDY IS A COST EFFECTIVE IDENTIFICATION AND VEHICLE TRACKING SYSTEM.
  - LEO - SATELLITE CONSTELLATION BASED IOT COMMUNICATION DEVICES ARE ECONOMICALLY VIABLE OPTION UTILIZING LICENSE-FREE BANDS INCLUDING LORA, 3G, 4G BANDS.
  - **CLASSIC CASE IS LYNK.WORLD A US TECH FIRM WHICH HAS BEEN COMMISSIONED BY GOVT OF ALASKA TO PROVIDE SMART PHONE BASED DIRECT TO SAT COMMS.**

BEACON TRANSPONDER

OPPORTUNITY

- NETWORK OF PASSIVE BI-STATIC RADAR (PBR), SYSTEMS USING DVB-T SIGNALS FROM GEO-SAT HAVE THE ABILITY TO FACILITATE ALL WEATHER MONITORING OF SKIES FOR FOREIGN OBJECTS.
- VERY COST EFFECTIVE SOLUTION - NO TRANSMITTER COST AND NO EXPENSIVE TRACKER COST
- EXISTING DTH ANTENNAS CAN BE RE-PURPOSED WITH DUAL POLARIZATION FEED HORNS TO IMPROVE DETECTION AND MONITORING PERFORMANCE.
- EFFORTS TO RE-PURPOSE EXISTING SET TOP BOXES FOR SIGNAL PROCESSING , WILL RESULT IN AN EXTREMELY LOW COST READILY DEPLOYABLE SOLUTION.

AIML BASED TECHNIQUES – ARTIFICIAL INTELLIGENCE MACHINE LEARNING

OPPORTUNITY

- **AIML BASED TECHNIQUES**
  - PASSIVE RADAR NETWORKS OFFER LONG OBSERVATION TIMES WHICH IMPLIES LARGE AMOUNT OF DATA TO PROCESS, ESPECIALLY FOR GEO-SAT BASED PASSIVE NETWORKS.
  - PRESENTLY BEACON SIGNALS AVAILABLE IN KU-BAND (BETWEEN 10.7-12.5 GHz) AND KA BAND (BETWEEN 18-21 GHz).
  - EXISTING DTH LOW NOISE BLOCKS DOWN CONVERT THESE BEACON SIGNALS TO INTERMEDIATE FREQUENCY, (IF), BETWEEN 850-2150 MHZ, WHICH CAN BE DIGITIZED BY VERY CHEAP DIGITAL SIGNAL PROCESSING CHIPS (FOR eg RTL-SDR).
  - ONCE DIGITAL BIT STREAM IS MADE AVAILABLE SEVERAL AI TECHNIQUES CAN BE BROUGHT TO BEAR.

OPPORTUNITY

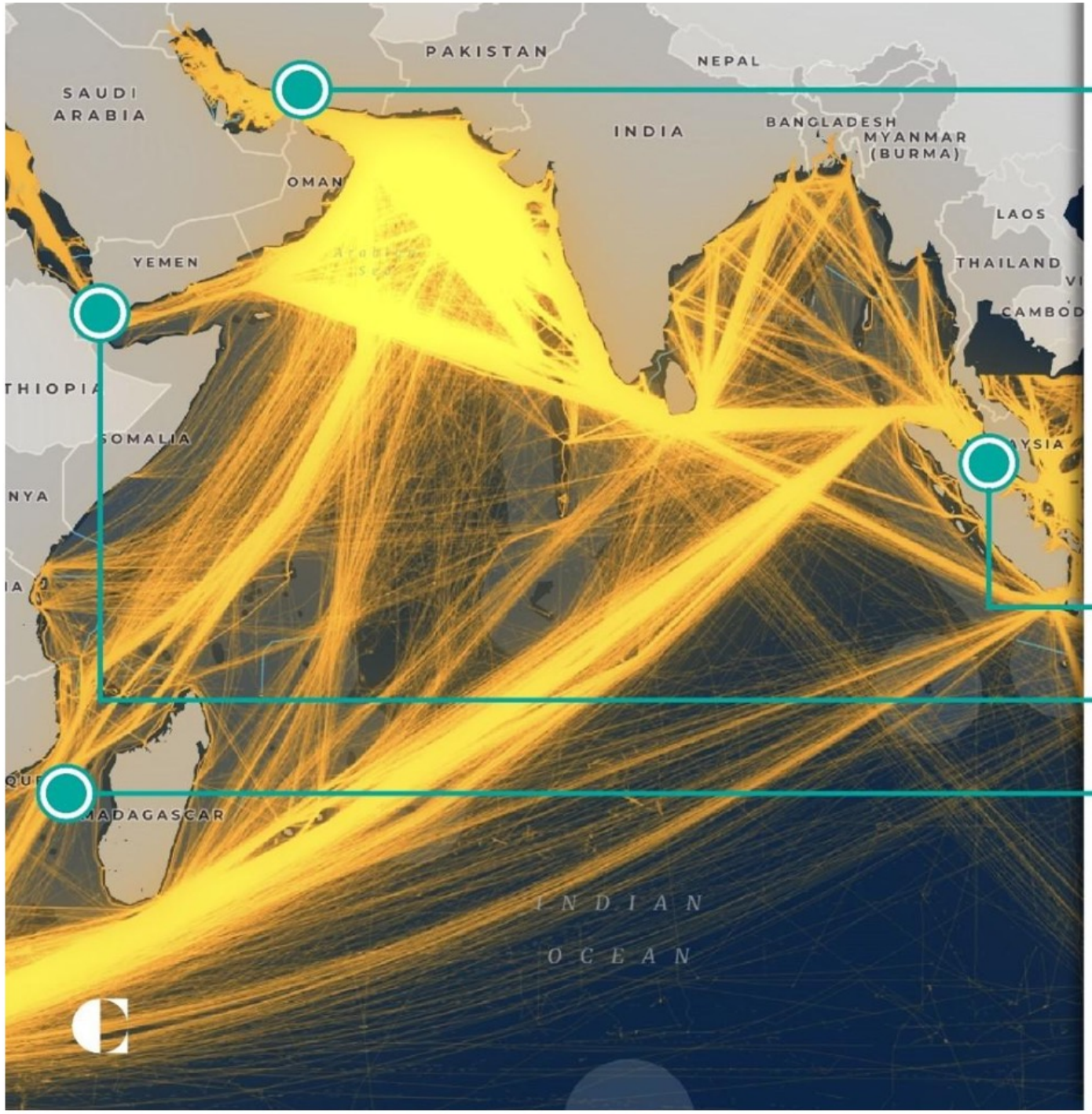
MARITIME TRAFFIC GRAPHS, (MTG)

- SATELLITE-AIS DATA CAN BE PROCESSED OVER LONG TIME DURATIONS USING TECHNIQUES CALLED TRAFFIC ROUTE EXTRACTION FOR ANAMOLY DETECTION, (TREAD). THESE TECHNIQUES ENABLE MAPPING OF SPATIO-TEMPORAL DYNAMICS OF SHIP ROUTES IN THE FORM OF MARITIME TRAFFIC GRAPHS (MTG)

- ALL THE ABOVE TECHNIQUES CONTRIBUTE TO WHAT IS CALLED

WAY AHEAD – ACTION ORIENTATION

- MARITIME DOMAIN / SITUATIONAL AWARENESS, HITHERTO HAD ONLY BEEN A KEY CORNERSTONE OF OUR NATION'S **DEFENCE POLICY** PERSPECTIVE.
- PRESCIENT CAUSE TO FORMULATE A TRANSITION OF THIS PERSPECTIVE TOWARDS A LARGER ECONOMIC POLICY.
- THIS WILL FOSTER A COMMERCE ORIENTED ACTIONABLE POLICY, WHICH WILL **ENCOURAGE PRIVATE INVESTMENT**.
- WITHOUT LARGE PRIVATE INVESTMENTS, THE DRIVERS FOR GROWTH WILL BE TEPID AND UN-SUSTAINABLE.
- IN TODAY'S INFORMATION AND DATA DRIVEN BUSINESS ENVIRONMENT, **NECESSITATES POLICY INITIATIVES TO ENABLE FREE TRADEABILITY OF SERVICES, DATA AND KNOW-HOW**.



Strait of Hormuz

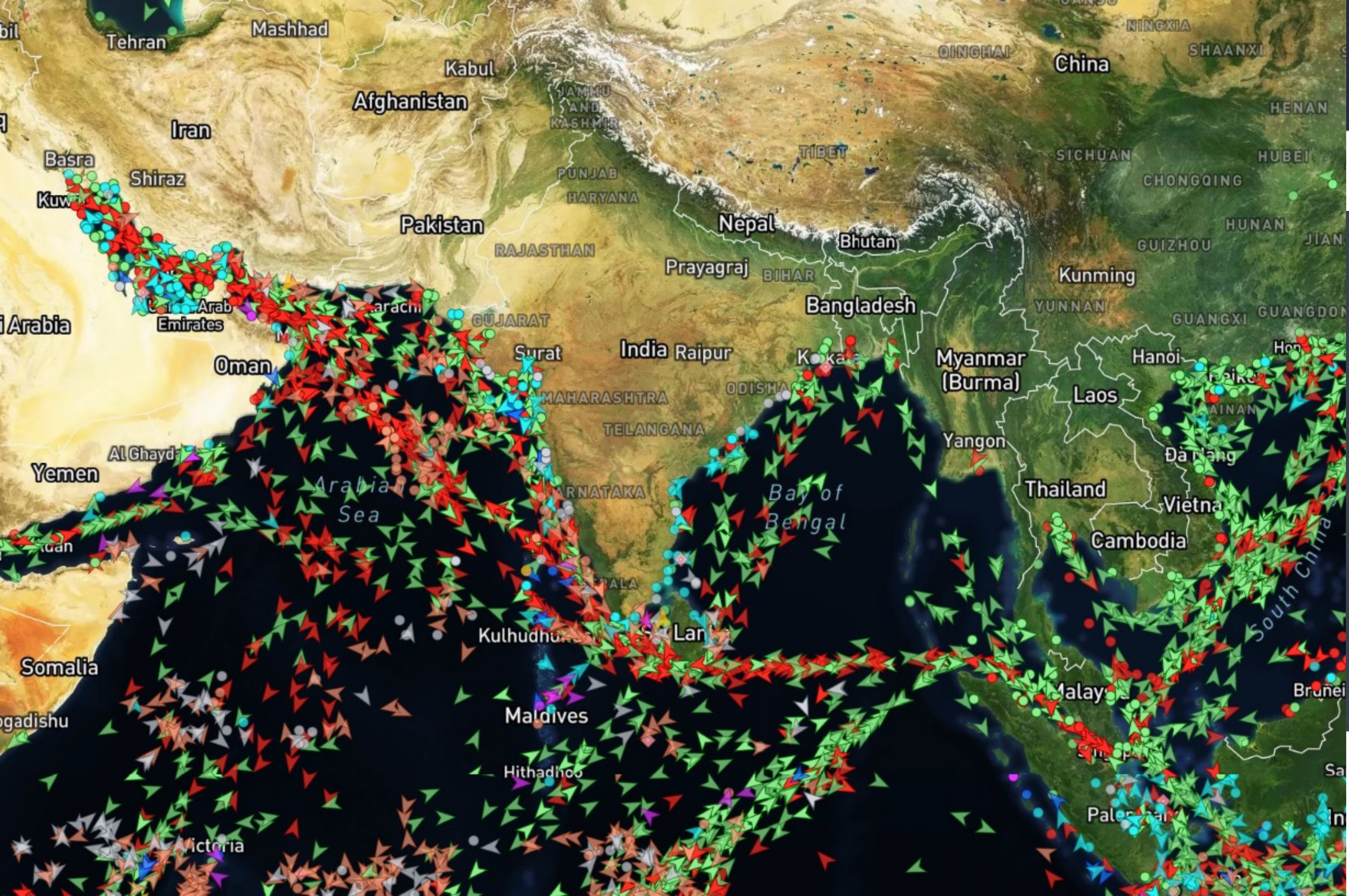
The U.S. Energy Information Administration (EIA) estimates that 20.7 million barrels of oil was transported daily through the strait in 2018.

The EIA argues that the Strait of Hormuz is "the world's most important oil transit chokepoint."

Strait of Malacca

Bab-el_Mandeb

Mozambique Channel



INDIAN SPACE ASSOCIATION

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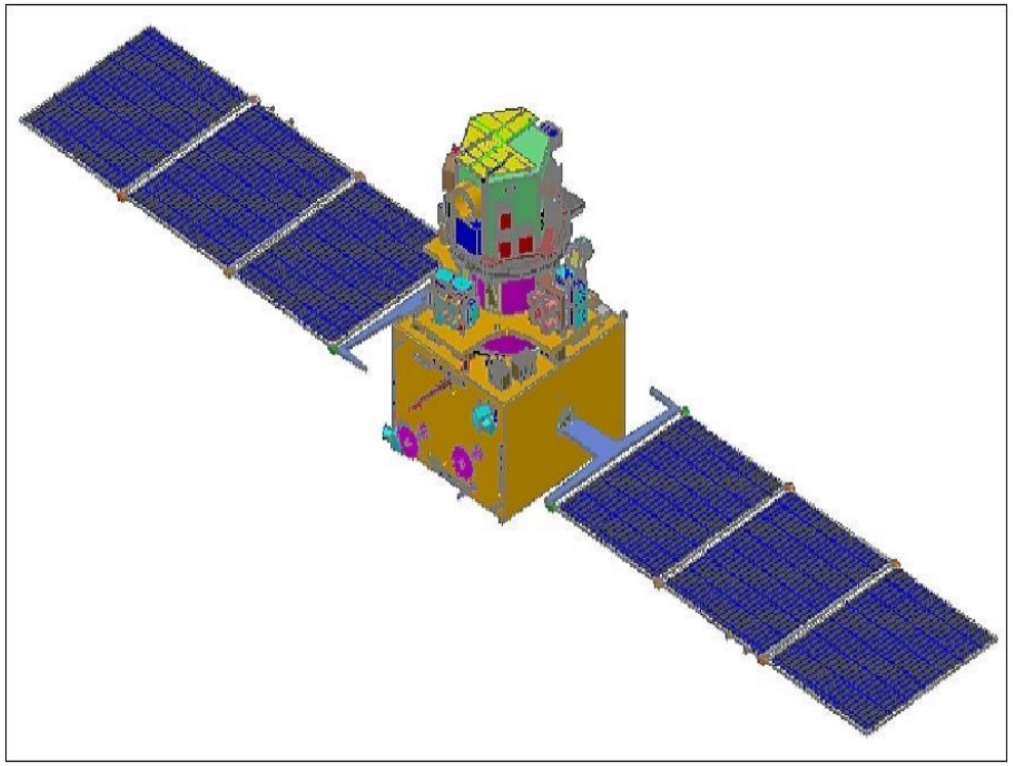
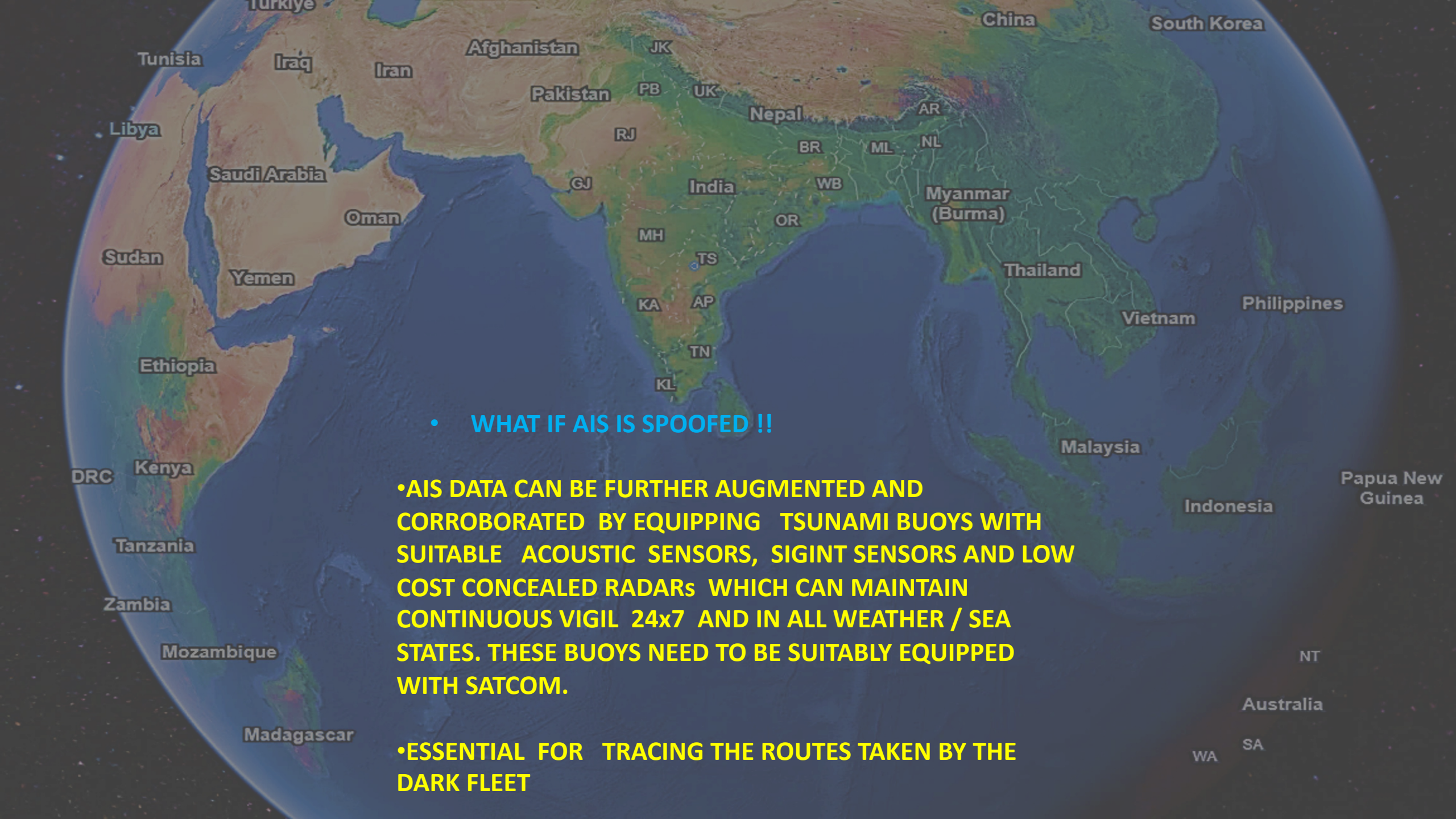
- Cargo Vessels
- Tankers
- Passenger Vessels
- High Speed Craft
- Tugs & Special Craft
- Fishing
- Pleasure Craft
- Navigation Aids
- Unspecified Ships

ResourceSat-2 /AIS-SB

- The Space Based Automatic Identification System (AIS-SB) provides timely information about seafaring vessels from space systems towards efficient monitoring of their movements.
- The programme focusses on the tracking of Indian ships across the globe and any foreign ship in the Indian Territorial waters.
- The AIS-SB provides data in the standard format to all the Indian Users especially for Maritime Domain Awareness (MDA).
- AIS-SB, developed by ComDev, was flown on-board the ResourceSat-2 (RS-2) spacecraft which was launched on 20th April 2011 by PSLV-C16.





- **WHAT IF AIS IS SPOOFED !!**

•AIS DATA CAN BE FURTHER AUGMENTED AND CORROBORATED BY EQUIPPING TSUNAMI BUOYS WITH SUITABLE ACOUSTIC SENSORS, SIGINT SENSORS AND LOW COST CONCEALED RADARs WHICH CAN MAINTAIN CONTINUOUS VIGIL 24x7 AND IN ALL WEATHER / SEA STATES. THESE BUOYS NEED TO BE SUITABLY EQUIPPED WITH SATCOM.

•ESSENTIAL FOR TRACING THE ROUTES TAKEN BY THE DARK FLEET


SATELLITE BASED METHODS FOR MARITIME SURVEILLANCE
Türkiye
China
South Korea
Tunisia
Iraq
Iran
Afghanistan
JK
Pakistan
PB
UK
Libya
BR
ML
NL
Saudi Arabia
GJ
India
WB
Myanmar
(Burma)
Oman
OR
MH
Sudan
TS
Thailand
Yemen
KA
AP
Philippines
Vietnam
Ethiopia
TN
KL
Malaysia
DRC
Kenya
Papua New
Guinea
Indonesia
Tanzania
Zambia
Mozambique
NT
Australia
Madagascar
SA
WA


THANK YOU!

ISpA PROJECTIONS – MARITIME SECTOR

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Key Characteristics of the sector and implications for SATCOM Market

Approximately 95% of India's merchandise trade is done through its 200 major & non major ports, with non-major ports contributing to 45% of the overall traffic & major ports contributing 55%	Cargo shipping emerges as a use case with massive potential for satellite communication services
Growth rate for cargo vessels in India stands at a CAGR of 2.08%	High adoption rates will drive business in the future
As of 2022, Ministry of Ports, Shipping & Waterways recorded the Indian cargo fleet at 1520 ships	The hardware component for satellite communication in cargo ships has a potential to reach USD 3.6 Mn

ISpA PROJECTIONS – MARITIME

Key Challenges

Technology

SatCom internet services have had limited bandwidth in the past, wide scale adoption & subsequent revenue has a dependency on the reliability & bandwidth of the technology

Business

In comparison to leisure, entertainment & recreational use cases, where the propensity to purchase is dependent on the pricing, commercial use cases such as cargo shipping is likely to have higher propensity to purchase

Value Drivers

- Access to reliable & quality internet services can drive efficiency in commercial use cases where communication & connectivity proves to be an essential service. While for other use cases where maritime activities are more recreational in nature, satellite-based internet services can unlock significant value through leisure & entertainment purposes

Emerging Use-Cases

- Remote ship diagnostics
- Integrated fleet management
- Precise weather monitoring
- Autonomous ship navigation
- Port operations and logistics monitoring
- Optimizing ship routes for fuel efficiency and safety

ISPA PROJECTION - DOWNSTREAM OPPORTUNITIES FOR BLUE ECONOMY

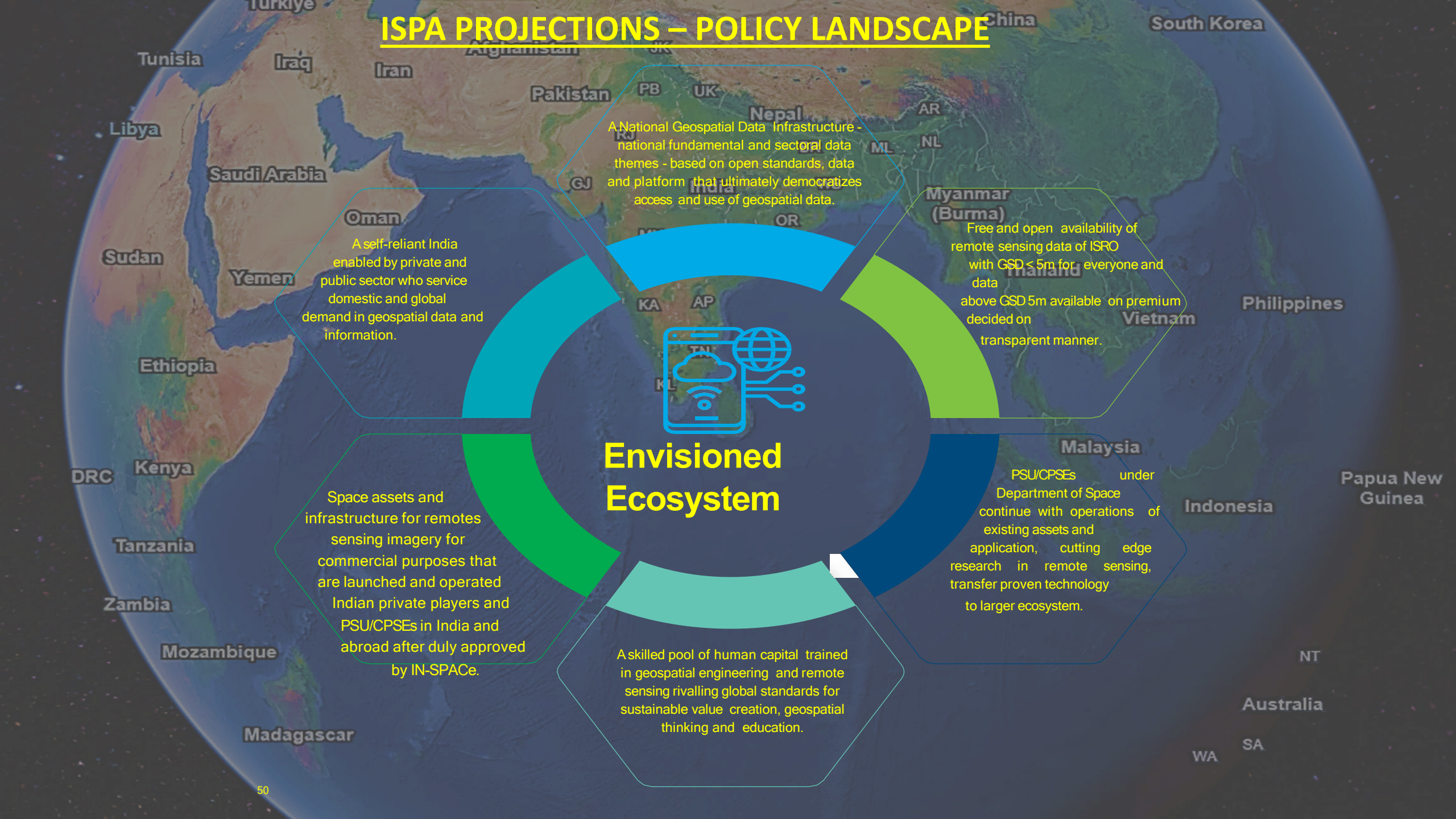
Downstream - BLUE ECONOMY

Earth observation	Satellite communications	Positioning, Navigation and Timing (PNT)
Agriculture	Commercial broadband	Navigation for enterprises and toll collection
Sustainability and biodiversity conservation	Broadcasting	Time Synchronization
Disaster management	Banking, Financial Services and Insurance	Drone Guidance
Natural resource management	Maritime communications	Railways
Fisheries	Civil Aviation	
Urban planning and development	Education	
Infrastructure planning and development	Health	

Application area

Focus sector

ISPA PROJECTIONS – POLICY LANDSCAPE



ISPA PROJECTIONS – CHALLENGES & OPPORTUNITIES - SATELLITE IMAGERY

ISpA PROJECTION - CHALLENGES & OPPORTUNITIES…. Contd

SATCOM

- **High cost of data**
- The cost of service is very high today compared to terrestrial broadband
- connections, ~5 times more, unaffordable for common man.

Limited data offering

Most of the satellite interenet service providers impose data caps on their monthly plans, and hence, data-intensive activities like video streaming, downloading large files etc., will not be feasible.

Spectrum allocation

Governing & regulatory bodies can bring spectrum allocation & adequacy in-line with global test practices allowing new players to enter the market as well as existing ones to flourish, resulting in market stabilization and lowering of cost.

Latency concerns

Satellite internet suffers from high latency issues, as it relies on signal transmission over long distances. A noticeable delay can be observed compared to terrestrial broadband services