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Comparative analysis of the maritime ISR capabilities of India and China in the IOR

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Abstract

Intelligence, Surveillance, and Reconnaissance systems (ISR) have been playing a significant role in providing robust situational awareness of the maritime domain. This paper presents a comprehensive analysis of the ISR systems of India and China in the Indian Ocean Region (IOR), a region of immense geopolitical significance and a theatre of power projection for both the countries. After tracing the evolution of ISR from ancient time to modern era, the study underscores the critical role of ISR in maritime security and strategic advantage, particularly in the IOR. The paper finds that, in accordance with its Two Ocean strategy, China has been expanding its ISR infrastructure in the IOR. Chinese naval activities, including submarine deployment, research vessels suspected of conducting covert surveillance in the eastern Indian Ocean, classified use of its satellite systems, use of air based ISR systems as force multipliers, and acquisition of bases in the IOR has potential to alter power dynamics in the IOR. These developments allow China to exert geopolitical influence and potentially challenge India's traditionally dominant position in the IOR. The paper further delves into examining factors influencing the ISR force structure of India and China, including defence expenditure, military modernisation drive, development in Defence Industrial Base (DIB), and the role of command-and-control structure. Finally, this research tries to provide recommendations for India to enhance its ISR infrastructure, emphasizing the need to invest in HUMINT and TECHINT capabilities and enhanced inter-agency coordination. Overall, the paper provides a comprehensive assessment of the ISR landscape in the IOR.

Keywords: ISR, situational awareness, IOR, India, China, HUMINT, TECHINT, satellite systems, air based assets, ocean surface and subsurface fleet, DIB.

Introduction

Information collection is critical to maritime security because it provides intelligence and situational awareness that protects maritime activities, assets, and interests. Both India and

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China, who are critical players in the Indian Ocean, have stressed on securing their maritime interests by acquiring data from all dimensions – space, air, surface, underwater and cyber. They have been expanding their situational awareness capabilities (termed as 'Maritime Domain Awareness' by India and 'Informatization' by China) for information gathering and further disseminating the data to the command-and-control structure. ISR systems offer the necessary technological assistance required for information gathering. It plays a crucial role in providing real-time information on vessel activities, navigation patterns, and potential threats. ISR systems, thus aid in safeguarding the national interests and security concerns.

The Indian Ocean Region (IOR) is spreading over seven subregions – Southern Africa, Eastern Africa, Arabian Peninsula, South Asia, Southeast Asia, Australia, and the Indian Ocean Islands (McNicholas, 2008). The region plays an eminent role in global power dynamics for several key reasons. Firstly, IOR has the highest maritime traffic globally. Nearly 80% of international oil shipments and 33% of bulk cargo traverse through this region. The region also provides transit to an estimated 90,000 cargo vessels carrying essential goods. The region had reported an overall trade of USD 7 trillion in 2022 (Rear Admiral Asthana, 2023).

Secondly, the strategic importance of the Sea Lanes of Communications (SLOCS). Malacca Strait, Mozambique Channel, Strait of Bab-El-Mandeb, and Strait of Hormuz are the major chokepoints in the region. Approximately 40% of global oil shipments traverse through these SLOCS. Even minor disturbances in maritime traffic could affect global shipping drastically. One such illustration is the Houthi attacks on commercial vessels passing through the Red Sea. More than 33 attacks have been reported since late November 2023. These attacks have disrupted a key maritime route essential for USD 1 trillion of annual merchandise and approximately 30% of global container traffic.

Thirdly, the competition among major powers for dominance and control. The US has long maintained a presence in the Persian Gulf and at the Diego Garcia base. Britain has been administering the British Indian Ocean Territory in the region since 1965. The French has its territories in the form of the Reunion, Mayotte, Crozet Archipelago, Kerguelen Islands, Saint Paul, and Amsterdam Islands. Australia and Japan engage in military exercises with regional countries. India is a dominant and responsible resident power in the region, with 7500 km of shoreline, 14500 km of accessible waterways, 217 operational ports (12 state-owned and 205 minor ports), and 2.3 million sq. km of EEZ.

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Finally, China's inroads in the region as a blue water navy. Although it is a more recent development, it has added a new strategic orientation to the region influenced by several important considerations. China's maritime interests have grown and now play a key role in its economic development. This is due to the country's increased international trade and imports of energy and raw resources. China is the world's largest exporter, with an estimated export of USD 3.59 trillion worth of goods in 2022 (Akram, 2024). To secure and safeguard its oil imports, 80% of which are shipped through the Strait of Malacca, China is expanding and improving port infrastructure in littoral countries of the Indian Ocean to develop land transport lines for vital commodities, bypassing sea-borne transportation. The oceanic leg of the Belt and Road Initiative (BRI) is a strategic vision of linking China to Europe via the Indian Ocean littoral countries. New Delhi is concerned about Beijing's strategic ambitions in the IOR, and the possibility of these ports becoming naval facilities for the People's Liberation Army Navy (PLAN). This poses a threat to India's interests.

The Chinese military, which was generally dominated by its ground forces has undergone qualitative as well as quantitative changes in the past few years. Restructuring of the Chinese military has elevated PLAN to a more prominent role, in accordance with President Xi Jinping's call to make China a 'true maritime power'. This shows a shift from the continental orientation of the Chinese military to the maritime theatre (Bommakanti, 2018). Accordingly, China has developed a wide range of maritime resources unilaterally and with some external help, mainly from Russia. Satellites, signals intelligence (SIGINT) sites, radars, unmanned aerial systems (UAS), ISR aircrafts, maritime assets, ASW sensors, are major components of China's ISR capabilities (McCabe, 2021).

Under the aegis of these advancements, China has been expanding its activities in the IOR. China has a relentless presence of nearly 6-8 warships in the region. Chinese research vessels are often suspected of carrying out covert surveillance activities. Approximately 80% of the 64 Chinese research and survey vessels active in the IOR have been suspected of having organisational links to the PLA (Funaiole, Hart, & Powers-Riggs, 2024). 13 of these vessels were sighted in the Indian Ocean, carrying out comprehensive surveys of the regions' underwater terrain. In 2018, Chinese research vessel Hai Yang Shi You 760 was spotted in the Bay of Bengal and near the coast of Myanmar. Chinese spy vessel Shi Yan 1 was spotted closer to Thailand in 2019. Between 2019 and 2021, the spy vessel Xiang Yang Hong 01 is suspected to have travelled to the region closer to Indonesia and Myanmar multiple times. Another spy vessel named Xiang Yang Hong 03 is suspected to have carried out surveillance in the region

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close to India. The docking of Chinese tracking ship Yuan Wang 05 in Sri Lanka during August 2022 and research vessel Xiang Yang Hong 03 in Maldives during February 2024 had invited strong reactions from India.

This growing influence of China in the IOR, abetted by its better ISR capabilities, requires a comprehensive adaptation of advanced ISR systems from India. As China's naval potential develops, India's ISR systems become increasingly important not just for monitoring and securing its own maritime interests, but also for getting a better grasp of the growing geopolitical dynamics in the Indo-Pacific region. Developing and deploying advanced ISR systems will enable India to acquire intelligence more proactively, monitor naval actions, and improve its situational awareness. By investing in modern ISR systems, India can effectively counterbalance its regional challengers' marine capabilities, guaranteeing a strong defensive posture in the face of changing security concerns in the maritime theatre.

Thus, this paper surveys the significance of ISR systems in information collection; various maritime ISR systems developed by India and China; and the importance of these systems to secure their interests in the IOR. Although land based ISR systems can support maritime security, they have a restricted range due to their continental orientation. They lack the mobility to cover vast ocean areas and are confined to monitoring coastal area and brown water operations. Therefore, this paper has focused on specific ISR systems from domains of space, air, ocean surface and subsurface, which can effectively conduct ISR activities in international waters and subsequently improve situational awareness. It further analyses the shortcomings of India's infrastructure relative to China and measures to overcome these challenges.

Methodology

the paper is based on secondary data analysis. It emphasizes on enhancing the current knowledge on ISR systems developed by India and China by evaluating material from various sources, such as academic literature, publications, annual reports, and online databases.

Research questions :

1) What are ISR systems?
2) What are the various spaceborne, airborne, shipborne, and underwater ISR systems developed by India and China ?
3) How does the advancements in PLAN's ISR capabilities affect India's interests in the IOR?
4) How can India enhance its ISR capabilities to address China in the IOR?

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What are ISR systems?

Intelligence, Surveillance and Reconnaissance, or ISR, is widely used in military applications. It is defined as the coordination among various data sources with the aim of acquisition, processing, and dissemination of relevant and accurate information to the command-and-control structure in a timely manner (CSMI Technology Service, n.d.). According to the US Department of Defense, ISR is defined as (DoD, 2021),

> …An integrated operations and intelligence activity that synchronizes and integrates the planning and operation of sensors, assets, and processing, exploitation, and dissemination systems in direct support of current and future operations.

Satellites, sensors, unmanned aircrafts, various ground, sea and space-based equipment, HUMINT systems are some of the ISR assets that are used to acquire and disseminate data.

a) Components of ISR systems

According to the US Department of Defense, the three main components of ISR are defined as follows:

1) "Intelligence – The product resulting from the collection, processing, integration, evaluation, analysis, and interpretation of available information concerning foreign nations, hostile or potentially hostile forces or elements, or areas of actual or potential operations" (DoD, 2021).
2) "Surveillance – The systematic observation of aerospace, cyberspace, surface, or subsurface areas, places, persons, or things by visual, aural, electronic, photographic, or other means" (DoD, 2021).
3) "Reconnaissance – A mission undertaken to obtain, by visual observation or other detection methods, information about the activities and resources of an enemy or adversary, or to secure data concerning the meteorological, hydrographic, or geographic characteristics of a particular area" (DoD, 2021).

b) Evolution of ISR systems

ISR systems have been in use since time immemorial. Their functioning is usually based on the TCPED information chain - Tasking, Capture, Processing, Exploitation, and Dissemination (Henry, 2016). The elements of the chain are described below:

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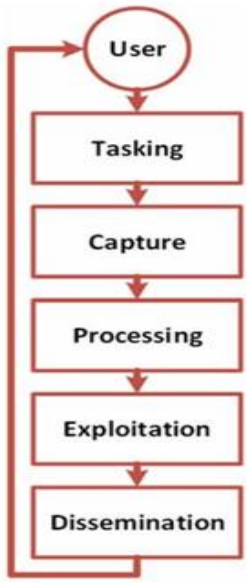
1. Tasking – tasking identifies information need and defines the mechanism for gathering information.
2. Capture – capturing is related to collecting raw data based on the mechanism laid down for information gathering.
3. Processing – during this process, captured raw data is transformed into information in compliance with operational requirements or restrictions.
4. Exploitation – analysis of the information to extract relevant intelligence in compliance with operational requirements or restrictions.
5. Dissemination – disperse the desired intelligence to the corresponding user.

Figure 1: TCPED Information Chain



Source: (Henry, 2016)

Based on this information chain, ISR systems have been used against the adversaries. In the ancient times, the adversary was hunger, hence it was used to hunt for food in a very rudimentary way. As the role of adversaries and need for information changed with time, technology evolved accordingly. Following sections describe the historical evolution of ISR since the ancient times until today and some of the corresponding techniques that are developed periodically, in relation with the elements of the TCPED chain:

Table 1: ISR progression from early age to 17th century

Tasking	• Hand motions.

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	• Primitive non- verbal communication. • Handwritten sources. • Use of maps.
Capture	• Initially with human senses. • Espionage. • Invention of telescope revolutionised capturing process.
Processing	• HUMINT
Exploitation	• HUMINT
Dissemination	• Use of humans and animals as messengers. • Long distance dissemination techniques like drums, smoke signals, signal lamps, giving alarm calls in the forests, etc.

Source: By author

Table 2: ISR progression from 18th century to World War 1

Tasking	• Use of maps. • Telegraphs.
Capture	• Espionage. • Motorized vehicles replaced animal-based transport system. • Airborne platforms (balloons, dirigibles, early airplanes). • The French used observation balloons to monitor enemy activities. • Development of K-3 aerial camera by the US during WW1 revolutionised aerial photography for surveillance. • Zeppelin airships were used by Germans for strategic reconnaissance during WW1. • Deployment of U-boats (submarines) by the Germans against the British.
Processing	• HUMINT was aided by newly developed Signal Intelligence (SIGINT) capabilities like submarine cables, telegrams (Zimmermann Telegram drafted by Germany).

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Exploitation	• The Morse system of telegraphy.
Dissemination	• Wireless Radio Communication systems. • Submarine cables.

Source: By author

Table 3: ISR progression from World War 2 to Cold War

Tasking	• Significant development in IMINT and ELINT technologies during WW2. • Use of maps. • Telegraphs.
Capture	• Espionage. • K-24 cameras were used in tactical reconnaissance aircrafts in WW2. • ASDIC (underwater) and Radar (surface) detection systems were developed by allied powers during WW2. • CORONA satellite imagery deployed during 1960-1972 was the world's first intelligence satellite program. • In 1965, USSR launched Kosmos satellites for gathering ELINT data.
Processing	• German U-boats used the coding system 'Enigma' to report the positions of their targets to the HQ. • Development of ARPANET in 1969.
Exploitation	• British intelligence launched the ULTRA project to decode Enigma encryption of the Germans. • Use of early computers for simulation and modelling.
Dissemination	• Development in SIGINT, ELINT, GEOINT and COMINT to aid HUMINT for long distance and swift distribution of intelligence. • Fibre optics.

Source: By author

Table 4: ISR progression from Cold War until today

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Tasking	• Use of GPS during the gulf war. • Use of multispectral and hyperspectral sensors.
Capture	• During the first weeks of Operation Iraqi Freedom, Coalition Air Forces conducted approximately 1,000 ISR flights, capturing 42,000 battlefield photos and more than 3,000 hours of full-motion video. • Deployment of the Yaogan satellite constellation by China to track and locate foreign warships. • Mass production of KJ-500 AEW&C aircrafts by PLAN and PLAAF.
Processing	• 13 Indian Remote Sensing Satellites in the Sun Synchronous and Geostationary satellites. • 30 Chinese Yaogan remote sensing satellites for surveillance and reconnaissance.
Exploitation	• China has at least 5 Over the Horizon (OTH) radars. • Research and development of Object Detection Algorithms like Single Shot Detectors (SSD), CenterNet and Faster R-CNN.
Dissemination	• 15 Indian National Satellite (INSAT) systems deployed for communication. • 6 dual use Zhongxing satellites deployed by China in the geostationary orbit.

Source: By author

c) Role of ISR in the Armed Forces

Primary role of ISR is to provide appropriate and precise information for threat assessment. ISR assets gather data using a wide range of capabilities. Data acquired from multiple sources is then analysed by human operators (HUMINT). Data is further transformed into information, serving as raw material for generating intelligence. The intelligence abets the analysts to envisage a potential adversary activity. If it meets the information demand of the commander, a set of actions is commenced which drives the decision-making process. Aligning with the directions advanced by the commanding officer, these systems provide 'targeting data' for

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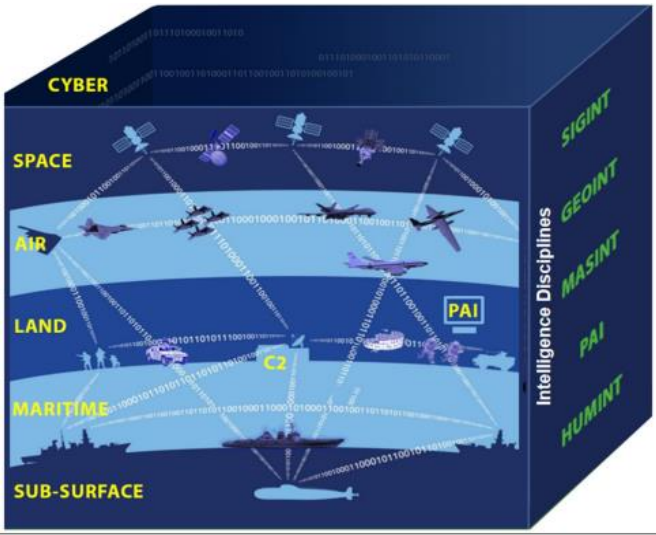
armed forces to engage enemies and 'threat data' for defence. ISR systems, thus, facilitate mission accomplishment. Various intelligence disciplines which play a significant role in ISR activities are but not limited to:

1) SIGINT – Signal Intelligence
2) MASINT – Measurement and Signatures Intelligence
3) GEOINT – Geospatial Intelligence
4) IMINT – Image Intelligence
5) PAI – Publicly Available Information, etc.

Figure 2: Array of Multi Domain ISR Capabilities



Source: (Smagh, 2020)

d) ISR in maritime domain

Maritime situational awareness (MSA) is the ability to seek and deliver essential information regarding the maritime environment to achieve an identical view of maritime security. MSA plays an important role in effective planning and conduction of maritime operations. It aids in identification and tracking of vessels, monitoring maritime borders and detection of maritime threats such as piracy, smuggling, etc. Timely information sharing enables informed decision making. This leads to effective responses to challenges and opportunities in the maritime domain. Given the significance of ISR in military operations, deployment of ISR assets in the maritime domain acts as a fundamental step in mitigating the risks from the maritime theatre and ensuring an effective MSA. ISR systems from all the domains could be used to secure the maritime interests.

As mentioned earlier, IOR is the major conduit of international trade. It is a critical route for energy transit, particularly for oil and natural gas. Nations with influence in the region can exert control over economic flow and thus gain economic leverage. To achieve this objective, major powers sought to establish and expand their military presence in the region. As a result, IOR becomes a stage for power transition. Given the significance of the region, and the rising presence of China, it becomes essential to study the significance of ISR in the IOR.

Significance of ISR in the IOR

IOR presents itself as the 'wide common', as that of a great highway across which men may travel in all directions (Capt Mahan, 1987). Maritime security in the region serves as a strategic intersection of the regional as well as global powers. It remains a widely debated topic for a several reasons (Akayima, 2018):

1) The presence of many rising economies in the region.
2) The significance of securing the SLOCS running through the region is well recognized by major economies.
3) The region is being watched from the perspective of maritime resource development.
4) The region is main arena for global power transition. Geographically, it is the rim of the Eurasian continent (Spykman, 1944).
5) Maintenance of peace and stability in the region is essential for sustaining freedom of navigation, energy transit and an open economic framework.

During the 20th century, China had little naval presence in the Indian Ocean. Recognising the significance of region, General Liu Huaqing, PLAN's third commander from 1982 to 1988, projected a three-stage development for the PLAN. In the first stage, from 2000 to 2010, China developed a naval force capable of operating along the first island chain. PLAN emerged as a regional force during the second stage (2010-2020), expanding its operation up to the second island chain. Since 2020, PLAN is in its third stage, where it aims to establish itself as a formidable blue water navy by 2049. The 2015 Defence white paper released by China states that the country aspires to gain strategic advantage in military competition and strengthen its armed forces to protect its interests abroad. Aligning with the three-stage development plan, the 2015 paper called for the naval forces to emphasize on "offshore water defences" along with "open seas operations" (The State Council - The People's Republic Of China, 2015).

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Accordingly, China is focusing on the Western Pacific as well as the Indian Ocean. In the Pacific, China's naval development is limited by US-led alliances and bases. However, the IOR provides a chance for China due to weak strategic and naval arrangements between the US, India, and Japan. China is the only country with embassies in all six Indian Ocean Island states: Sri Lanka, Madagascar, Mauritius, Maldives, Seychelles, and Comoros. Djibouti has China's first overseas military base. Hambantota and Gwadar are essentially under Chinese control. It has stepped up its efforts to build the Kyaukpyu port located in Myanmar. Moreover, China aims to increase its ties with Bangladesh as a part of its BRI. China is expanding its military presence in Maldives and boosting its investments in the island country. In Seychelles, China is investing in strategic projects. Overall, China's primary objective is to establish a new order in the region through cooperation with other littoral countries, firmly establishing itself as a dominant power.

To meet its interest, China is pursuing intelligence collection in the IOR in support of its operational requirements. China is exploiting its ties with the littoral countries in the IOR for ISR activities. In 2019, the Indian Navy (IN) ejected a Chinese civilian research vessel from the Exclusive Economic Zone (EEZ) of India near the Andaman and Nicobar Islands, a key maritime choke point. The project undoubtedly yielded valuable oceanic information for both civilian and military use for China. Chinese research vessels have visited the IOR on several occasions in the past few years and are suspected of espionage activities. The Chinese spy vessel Xiang Yang Hong 03 was slated to visit Sri Lanka in December 2023 but was unable to do so since Colombo rejected authorization to foreign research vessels for a period of one year. The vessel was later docked in Maldives on February 8, 2024. To enhance its situational awareness capabilities in the maritime domain, China could also forge maritime surveillance information sharing agreements with other littoral countries in the IOR (White, 2020). China has established an ELINT station on Great Coco Island in the Bay of Bengal, which is nearly 300 km south of Myanmar. The PLA has also established a facility on Small Coco Island in the Alexandra Channel, located to the north of India's Andaman Islands (Federation of American Scientists, 1997).

China's military modernization program might considerably improve its ability to project force in the IOR. China has significantly better ISR capabilities than India. Given the technological gulf between both the countries, it would be beneficial to investigate the ISR capabilities of India and China to draw a comparative analysis of their respective strengths and weaknesses in the IOR.

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Maritime ISR capabilities of India and China in the IOR

China has systematically moved from being an army dominated power to a force where the other arms of the PLA (PLAN and PLAAF), are now co-equal to its ground force. The CMC reforms of 2015 have resulted in massive restructuring of the PLA. Efforts were taken for streamlining of resources and tasks to improve coordination and eliminate redundancy to enhance its situational awareness capabilities. This was done to ensure quick mobilisation of resources to address any situation. Subsequently, China is developing a wide range of naval platforms and supportive systems. PLAN is being equipped with better ISR assets and communication architecture for effective information dissemination. This is China's own model of mosaic warfare, which is described as (Ryan, 2022),

> a new asymmetric advantage—one that imposes complexity on adversaries by harnessing the power of dynamic, coordinated, and highly autonomous composable systems.

Conforming with its goal of emerging as a blue water navy, China has been laying out an evolving Indian Ocean strategy (Colley, 2021). As a result, India is transforming its ISR force structure by developing and deploying advanced and robust situational awareness systems which consists of satellite systems, early warning systems, surveillance vessels and radars among others. With the rising likelihood of China adopting a two-ocean strategy, it is crucial to understand the various sorts of Chinese and Indian ISR capabilities. This paper offers a grim impression of Chinese as well as Indian ISR capabilities, even with limited availability of open-source information.

a) Space based ISR assets

China National Space Administration (CNSA) manages China's space program, including policy development, research, and planning. China Aerospace Science and Technology Corporation (CASC) looks after designing and manufacturing of spacecrafts, launch vehicles, missile systems, and ground equipment. Both CNSA and CASC are state-owned. On the other hand, the research and development arm of Indian space program is looked after by Indian Space Research Organisation (ISRO). A specialised tri-service agency called the Defence Space Agency (DSA) is tasked with the responsibility of developing a space warfare strategy and to work on SIGINT, COMINT and ELINT disciplines. India and China have developed several satellite systems to transform their respective ISR force structure.

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i) SIGINT Satellites

Signal Intelligence (SIGINT) involves collection, exploitation, and evaluation of foreign intelligence from electronic signals and networks. SIGINT includes missiles, radars, and communication networks. SIGINT satellites play a critical role in identifying adversary communication. Information gathered by SIGINT satellites is imperative for military operations and offsetting adversary's potential. SIGINT is further classified as (Scrofani, Williamson, Mimih, & Waltz, 2023) –

a) **ELINT** - Intelligence obtained from electronic signals which transmit data without speech or writing.
b) **COMINT** – Intelligence collected and analysed from foreign communication networks, excluding open sources like radio and television broadcasts, to extract relevant information.

According to military balance report 2024 (International Institute for Strategic Studies, 2024), China has 81 SIGINT and 11 COMINT satellites currently operational in the outer space. Relatively, India has only 2 COMINT and 1 ELINT/SIGINT satellite under its command. Applying contributions from military balance report 2024 (International Institute for Strategic Studies, 2024), ISRO (ISRO, 2017), and eoPortal (eoPortal, 2019), following inferences can be drawn -

Table 5: SIGINT satellite systems developed by India and China

Satellite type	Country of origin	Satellite system	Features
ELINT	China	Yaogan	• Coverage – 3500 km. • Resolution – 1m. • These satellites are deployed into orbit as triplets. • They triangulate electronic signals gathered from maritime vessels for precise positioning. The triplet can accurately zero in on the electromagnetic source which a single satellite can find hard to identify.

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		Shijian	• Serves as test beds for innovative satellite technologies. • Shijian series has raised serious concerns due to its unscheduled launches, undisclosed subsatellites deployed into orbit, and odd orbital movements.
	India	EMISAT	• Its official mission is electromagnetic spectrum measurement. • It carries the classified ELINT project Kautilya developed by DRDO.
COMINT	China	Zhongping	• It offers high-quality phone, data, radio, and TV transmission services.
	India	GSAT	• GSAT satellites are utilized for digital audio data, and video transmission for dual purposes. • It is equipped with meteorological data transmission and satellite based search and rescue services.

Source: By author

ii) IMINT satellites

Imagery Intelligence (IMINT) alludes to intelligence generated from imaging obtained by different sensors, including thermal, infrared, electro-optical, multispectral, and photographic sensors. These sensors can be land-based, sea-based, air-based or space-based (Kovarik, 2011). IMINT satellites give precise information on the location and physical characteristics of threats and their surroundings. This is the principal source of information on terrain characteristics, installations, and infrastructure for intelligence investigations, reports, and target materials. IMINT satellites are further classified into Electro-Optical (EO), Synthetic Aperture Radar (SAR), and remote sensing systems.

Gaofen (GF) is a series of IMINT satellites launched by China as a part of China High Resolution Earth Observation System (CHEOS). It seeks to construct an all-around Earth

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observation system with high spectral, temporal, and spatial resolution. It actively meets China's essential national strategic demands in national defence, natural resource survey, disaster response, and prevention. China has also launched 2 pairs of SuperView satellites (GaoJing-1 01 and GaoJing-1 02 launched in December 2016, and GaoJing-1 03 and GaoJing-1 04 launched in January 2018). India has 2 SAR satellites and 1 EO satellite. India has 2 remote sensing satellites as against 4 Chinese satellites. Based on inputs from military balance report 2024 (International Institute for Strategic Studies, 2024), CNSA (CNSA, n.d.), Hoole (Hoole, 2020), Bommakanti (Bommakanti, 2018), eoPortal (eoPortal, n.d.), and Satcom Industry Association (Satcom Industry Association, n.d.), following inferences can be drawn:

Table 6: IMINT satellite systems developed by India and China

Satellite type	Country of origin	Satellite system	Features
EO	China	GF series	• The series possesses 3 multispectral satellites, 1 optical geostationary satellite, 1 atmospheric observation satellite and 1 3D mapping satellite. • Recent models include panchromatic cameras with sub-meter resolution, as well as multi-spectral cameras with an 8m resolution.
		Gaojing	• Gaojing offers an extensive range of commercial very-high-resolution (VHR) imaging applications. • These are designed to provide images with panchromatic resolution of 0.5 m and multispectral resolution of 2 m over a 12-km swath and can image 7,00,000 sq.km. daily. • The four satellites are spaced 90 degrees apart in the same orbit and can return to the exact same location every three hours.

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	India	Carto SAT-1	• Provides Digital Elevation Models, Ortho Image products, and Value-Added Products for various GIS applications.
SAR	China	GF series	• GF-3 and GF-12 have a resolution of less than a meter.
	India	RISAT-1	• All-weather, day and night imaging capabilities with a resolution of 1m.
		RISAT-2B	• High resolution images for ISR applications with a resolution of 0.5m.
Remote-sensing satellites	China	Ziyuan	• Spatial resolution ranges from 2.5-4.5 m. • Used for stereo mapping to generate DEM for precise measurement. • Useful for countering D&D.
		Yunhai	• Meteorological satellites used for the purpose of oceanography.
		Haiyang	• Marine satellites launched for the purpose of detecting ocean colour and sea surface temperature, ocean mapping and ocean surveillance.
		Jilin	• Provide a panchromatic resolution of 0.5-0.75m and would potentially offer a full-spectrum coverage 24/7 with a 10-minute revisit time for any worldwide location.
	India	Resource SAT-2A	• Multispectral images with a resolution of 56m in visible and near-infrared band and 23.5m in shortwave infrared band.
		Carto SAT-3	• Provides images for various applications with a resolution of 0.25m.

Source: By author

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iii) Advanced satellite systems

Supplementing its space based ISR systems, China has developed various advanced satellite systems in the form of TDRS and quantum communication satellites. The Tianlian Data Relay Satellite (TDRS) is a satellite constellation system intended to enable near-real-time (NRT) communication between satellites and ground stations. As of 2024, China has 3 Tianlian satellites in Geostationary Orbit and 1 Tianlian satellite in the super sun synchronous Orbit (Bommakanti, 2018).

In 2016, China launched Micius QUESS, world's first quantum communication satellite. It utilizes quantum encryption to ensure long-distance communication. This technique has the potential to replace many traditional SIGINT capabilities. If China successfully implements quantum messaging across all systems and networks, their ISR architecture will be more durable and secure. Table 7, based on the inferences drawn from Bommakanti (Bommakanti, 2018), and eoPortal (eoPortal, 2017), depicts that India does not possess any of these advanced satellite systems.

Table 7: Advanced satellite systems developed by India and China

Satellite type	Country of origin	Satellite system	Features
Data Relay Satellite	China	TDRS	• Provides communication in all orbits, including Telemetry, Tracking, and Commanding (TTC) in low-Earth orbit. • It can transmit large amount of data efficiently in minutes rather than hours. • Data transmission rates can approach gigabits per second, with a daily capacity of terabits. • Eliminates the need for ground stations.
	India	-	-
Quantum communication	China	Micius QUESS	• Quantum encryption to secure long-distance communication.

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			• Scientists have managed communication up to 300 km. • It would enable messages that cannot be intercepted in transit, resulting in a potentially non-hackable global communication network.
	India	-	-

Source: By author

b) Air based ISR systems

Air based ISR systems are crucial in enhancing the situational awareness capabilities of a nation. They act as force multipliers and provide comprehensive understanding of the domain including adversary movement, geological conditions, and potential threats. This information plays a crucial role in power projection strategies. As a symbol of its military modernisation drive, investment in air based ISR systems enables China to demonstrate its technological prowess. As China is increasingly asserting itself as a major power in the IOR, these systems aid China in gathering intelligence on military activities, infrastructural development, and maritime activities of not only the resident powers like India, but also major players in the region including the US. India has also been investing heavily in equipping its forces with advanced ISR systems to contain Chinese assertion in its sphere of influence. Given below are the various air based ISR systems developed by both the countries.

i) AEW&C system

Airborne Early Warning and Control System (AEW&C) is used to detect and track hostile aircrafts, UAVs, and other reconnaissance systems. It enables personnel in charge of the system to identify, evaluate, and neutralize such threats. The system is entirely network-centric, with functions that provide available information via its multiple data links to the onboard operators. It further helps to develop a composite picture of the environment. Applying contributions from Dahm (Dahm, 2020), Prashant Dikshit (Dikshit, 2004), and DRDO (DRDO, 2021), following table shows several AEW&C systems possessed by India and China –

Table 8: AEW&C programs developed by India and China

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Country	AEW&C program	Range (in km)	Features
China	KJ-200	300	• Based on AESA (Active Electronically Scanned Array) radar system.
	KJ-500	300	• Based on AESA radar system. • It has one SATCOM antenna, two HF antennae and 18 UHF/VHF antennae mounted to support multiple channels of voice communications and datalinks.
	KJ-2000	470	• Based on AESA radar system. • It can track up to 100 targets simultaneously.
	KJ-600	300	• Two engine version of KJ-500.
India	Phalcon	370	• Acquired from Israel. • It can operate up to 9000m and up to a range of 500 km. • Can track up to 100 targets simultaneously.
	Netra MK-I	270	• Indigenously developed program. • 6 new versions under development by DRDO. • Advanced version will be based on AESA radar system.
	Netra MK-II	370	• Under development and are expected to be acquired by 2026-27. • The system includes an electronically scanned antenna array (ESAA), a solid-state transmitter, a dual channel mono-pulse receiver, and a signal processor.

Source: By author

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ii) ELINT aircrafts

ELINT aircrafts provide significant insights on adversaries' capabilities, intentions, and tactics, improving situational awareness and enabling effective countermeasures. Applying contributions from Dahm (Dahm, 2020), and World Air Forces 2024 report (Flight Global, 2023), following inferences can be drawn -

Table 9: ELINT aircrafts of India and China

Country	Aircraft	Country of origin	In service
China	KQ-200	China	20 +
	Y-9JZ	China	NA
India	Global-5000	USA	2
	Gulfstream-III	USA	3

Source: By author

iii) UAVs

Unmanned Aerial Vehicles (UAVs) are controlled either autonomously or remotely by pilots on the ground. UAVs play a significant role in ISR applications in situational awareness and threat perception. Drawing inferences from Dahm (Dahm, 2020), Indian Navy (Indian Navy, n.d.), and DRDO (DRDO, n.d.), following table gives insights into several UAVs developed and deployed by India and China for the purpose of ISR –

Table 10: UAVs deployed by India and China

Country	Type	UAV variant	Features
China	MALE (Medium Altitude Long Endurance)	BZK-005	• Can operate for 40 hours at an altitude up to 7000 m. • It has a mission payload of 150 kg, and a maximum level speed of 210 kmph. • Payloads may consist of EO/IR cameras, SARs, ELINT arrays, or communications relay packages.

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		BZK-007	• It has a maximum take-off weight of 750 kg, a mission payload of 70 kg, and a maximum level speed of 240 kmph. • Carries daylight/IR TV cameras, high resolution CCD cameras, remote sensors of various spectral bands, and SAR.
		GJ-1	• It can operate for 40 hours at an altitude up to 7000 m. • It has a mission payload of 200 kg, and a maximum level speed of 280 kmph. • Equipped with variety of air-to-surface bombs and missiles.
		GJ-2	• It can operate for 20 hours at an altitude up to 9000 m. • It has a mission payload of 480 kg, and a maximum level speed of 370 kmph.
	HALE (High Altitude Long Endurance)	WZ-7	• It can operate at an altitude up to 18300 m. • It has a mission payload of 650 kg, and a maximum level speed of 750 kmph. • The naval version provides tactical maritime images and builds situation awareness to provide up-to-date targeting information to anti-ship units.
		WZ-10	• It can operate at an altitude up to 15000 m for up to 20 hours. • It has a mission payload of 900 kg, and a maximum level speed of 620 kmph. • Known for its stealth characteristics.
India	MALE	Rustom	• It is the first Indian Remotely Piloted Aircraft System (RPAS) to include

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			conventional take-off and landing capabilities. • It can operate at an altitude of 6000m for a flight duration of 10 hours.
		Heron	• It is manufactured by Israel and is currently under the command of the Indian Navy. • It can operate at an altitude of 10,000m at a speed of 210 kmph.
		Searcher	• It is manufactured by Israel and is currently under the command of the Indian Navy. • It can operate at an altitude of 6000m at a speed of 200 kmph for up to 18 hours.
		Drishti-10 Starliner	• Indian navy's first indigenous MALE UAV. • It can operate at an altitude of 9000m at a for up to 36 hours and can carry a payload of 450 kg.
	HALE	-	-

Source: By author

Table 10 shows that India does not have any HALE category UAV.

c) Ship based ISR assets.

Since the past two decades, PLAN's naval fleet has tripled in size. It has now emerged as the largest naval force in the world. Although it lags its US counterpart in terms of total tonnage and capability, the gap is narrowing. In accordance with the CMC reforms of 2015 and the Chinese defence white papers of 2015 and 2019, PLAN has taken the centre stage amongst the three services to have a two-ocean strategy and expand Chinese footprint in the IOR.

It is likely that China would use its maritime militia, fishing fleet and research vessels as ISR assets to track the movements of hostile maritime activities. In March 2024, the Chinese ship Yuan Wang 03 was spotted in the Bay of Bengal when India had issued a no fly zone with a

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NOTAM for a possible ballistic missile test. Another Chinese ship Xian Yang Hong 01 was in the region during India's maiden test of the ballistic missile Agni-5 in March 2024. The Chinese research vessels are already suspected of surveillance in the eastern Indian ocean. These activities along with the Chinese acquisition of bases in the IOR (Djibouti in Africa, Gwadar in Pakistan, Kyaukpyu in Myanmar, and Coco Islands) has significantly increased Chinese presence in the region.

This development has alarmed India for two reasons. First, Chinese presence would directly impact India's interest due to China's assertive expansionist policy. Second, India's inaction would provide China an opportunity to assert its dominance in the IOR and would further its agenda of creating a 'unipolar Asia' dominated by China. As a result, IN is also enhancing its technological advancement to counter the perceived threat from its Chinese counterpart. Based on the inferences drawn from the military balance report 2024 (International Institute for Strategic Studies, 2024), following table enlists the vessel capabilities of PLAN and IN –

Table 11: PLAN and IN surface fleet

Types of surface fleet systems	Surface fleet	
	PLAN	IN
Aircraft carriers	2	2
Cruisers	8	0
Destroyers	42	11
Frigates	49	16
Patrol and Coastal combatants	142	160
Amphibious ships	11	1
Landing ships	50	7
Landing crafts	78	12
Logistics and support	167	42

Source: By author

Table 11 depicts that PLAN has invested heavily in hardware and has an edge over the IN. Although PLAN's operations as of now are mostly concentrated in the Western pacific to

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counter the US and its allies, the relative size of PLAN as compared to IN is bound to have inevitable implications in the naval balance of power in the IOR.

d) Underwater ISR assets

Underwater ISR provides support for a variety of naval activities, including amphibious operations, maritime patrols, and naval exercises. Timely and reliable intelligence acquired from underwater sensors allows naval forces to plan and execute missions more effectively, increasing operational efficiency and lowering risks. Both India and China have developed several systems to conduct surveillance under water.

i) Submarine classes.

PLAN has world's third largest submarine fleet, consisting of 59 submarines, and is very advanced. While, India, though being a major power in the IOR, quantitatively lags China as it has 16 submarines. Based on the findings from military balance report 2024 (International Institute for Strategic Studies, 2024), following inferences can be made –

Table 12: Current PLAN and IN submarines

Country	SSBN (Strategic Nuclear)	SSN (Tactical Nuclear)	SSK (Conventional)	SSB (under SLBM trials)	Total
China	6	6	46	1	59
India	1	0	15	0	16

Source: By author

China has 6 Jin class SSBNs, 6 Shang class SSNs, 17 Yuan class SSKs, and 13 Song class SSKs. The Song, Shang and Yuan submarines are equipped with YJ-18 long range cruise missiles, while the Jin class submarines carry JL-2 SLBMs (NTI, 2023). On the other hand, India has only 1 Arihant class SSN and 15 SSKs with no SSN and SSB class submarines. The Yuan class is also equipped with the advanced AIP (Air Independent Propulsion) System and is known for its non-detectability and high endurance (Bommakanti, 2018). At present, India does not have any AIP equipped submarine.

ii) Underwater sensors

China has established its ‘Underwater Great Wall Project’ to counter USA's SOSUS (Sound Surveillance System) in the Indo-Pacific region. It is a network of underwater sensors capable

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of providing precise position of maritime vessels traversing through the region (Bhuvesha, 2023). These sensors will be installed nearly 2000 m beneath the sea level. It tends to protect China from both conventional and non-conventional threats. However, it is uncertain where this undersea monitoring device will be deployed. Moreover, there is a perceived threat that China will extend this undersea monitoring network beyond its territory. Chinese researchers have developed lateral line-like mechanical sensors (LUMS) which can detect water depth and capture mechanical stimuli from water (Chinese Academy of Sciences, 2022). China is also apparently working on a new quantum radar technology that could detect stealth aircraft by generating a small electromagnetic storm (Defense Systems Information Analysis Center, 2018). Once developed, it will be the world's longest-range quantum radar.

India’s underwater deployment relies heavily on SONAR technology. It enables India to detect and monitor submarines, surface ships, and undersea objects operating in its maritime domain, as well as provide early warning against perceived threats. Various technologies developed by India include a variety of SONAR transducers, hydrophones, SONAR dome, and SONAR supporting underwater cables (DRDO, 2017). Along with this, India plans to collaborate with Japan and the US to install the SOSUS chain in India’s near seas. Japan plans to finance India’s underwater optical fibre network from Chennai to Port Blair, which would further be linked to the US-Japan ‘fishhook’ SOSUS network (Singh, 2016). It would monitor PLAN’s submarine activity in the Indian Ocean rim. DRDO in collaboration with IIT Madras has developed thin membrane based piezo MEMS technology for underwater communication (IIT Madras, 2023). This technology will provide higher efficiency than the conventional sensors possessed by the Indian Navy. However, India still lags China in terms of developing advanced technologies like quantum radar system.

iii) UUVs

Information on PLAN's Unmanned Underwater Vehicles (UUVs) is not readily accessible to the public. However, they are thought to be PLAN's force multipliers. Beijing has been researching on UUVs since the 1980s. "Hai Ren No. 1" (HR-01) is China's first cabled underwater vehicle (ROV). Weilong, Haishen, Qianlong, Haiyi, and the Sea-Whale 2000 are the various UUVs developed by China for underwater cartography (Bhuvesha, 2023). At NAVDEX 2023, China unveiled its new heavily armed extra-large unscrewed undersea vehicle (XLUVV). It is equipped with four torpedoes to boost its offensive capabilities while also serving as an anti-submarine weapon. Although there are no publicly known signs of UUVs being deployed in the Indian Ocean, it is likely to be changed in the future.

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IN subsurface fleet is devoid of any operational UUV. Considering this barrier, India has undertaken an ambitious project to indigenously design and develop XLUUV for the IN. The project aims to deliver a prototype by 2025. IN intends to procure 12 XLUUVs upon successful testing (IDRW, 2024). These XLUUVs are likely to be equipped with an array of SONAR sensors, echo sounders and sub bottom profilers for underwater surveillance and mapping, EO/IR cameras for visual intelligence and SATCOM capabilities for relaying data and command over long distances.

Factors shaping the ISR force structures of India and China

As the paper draws attention towards the quantitative and qualitative analysis of ISR systems of India and China, it is equally important to address the factors that supplement sustainability of the ISR force structure developed by both the countries. This highlights the eminent role played by these factors in correlating systematic growth of ISR infrastructure and measures taken by both the countries in refining their defence capabilities. Based on the contributions drawn from Bommakanti (Bommakanti, 2018),Bitzinger (Bitzinger, 2015), Blasko (Blasko, 1999), and SIPRI report (SIPRI, 2024) , following inferences can be drawn –

1) China's ISR infrastructure is aided by its significant military spending. In 2023, China allocated an estimated USD 296 billion to its defence sector, a 6% increase over 2022 and 29th consecutive year-on-year growth in military spending. India's military budget is USD 83.6 billion, or roughly one-quarter of that of China. As a result, China has made enormous investments in military hardware to meet the requirements of its ISR infrastructure. On the contrary, India's military modernisation remains hampered by high salaries and pension costs, as well as the relative absence of a coordinated military modernisation drive. This hardware gap propels China to steadily step up its presence in the IOR.
2) The hardware gap between India and China can also be manifested from their respective OTH-T capabilities. Although IN, like PLAN, possesses surface-based OTH-T capabilities, the former lags the latter in subsurface OTH-T capabilities. IN is not equipped with a satellite guided SLCM program, which puts limitations on India as against China's increasing ISR activities in the IOR.
3) China has also focussed on economic modernisation of its defence sector in addition to military modernisation. This has resulted in remarkable progress of China's Defence Industrial Base (DIB), augmented by free market ideas. Aligning with its aim of

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developing a new PLA force structure during the late 1990s, China opened its defence industry for private sector and implemented initiatives to promote Civil-Military Integration (CMI). Consequently, China was successful in promoting indigenous R&D solutions to military hardware requirements. China's efficient DIB has been augmenting its growing ISR capabilities in the IOR. India's DIB, however, is still grappled with relatively weaker and less competitive MIC. Any effort in the right direction is met with scepticism given the past experiences. Such longstanding discrepancies in restructuring of the DIB coupled with budgetary constraints, have been affecting India's drive for developing better ISR systems.

4) PLAN has prioritized huge investment in education and training for ISR activities as a part of its modernisation drive. Human dimension in ISR is extremely important even in a technology – intensive service. Technological advancement augmented with rigorous training can increase the probability of successful mission accomplishment. India needs to invest in effective training and education for better HUMINT capabilities.

5) China's relative strength in HUMINT and TECHINT also comes from reorganisation of its command-and-control structure and to equip it with the requirements of future warfare. The CMC reforms of 2015 transformed the military regions into Theatre Commands. This was done to create synergy between the services. Chinese armed forces are supported by dedicated Cyberspace Force, Aerospace Force, Information Support Force (erstwhile PLASSF), and Joint Logistics Support Force for coordination during ISR activities. On the contrary, India lags in inter-service prioritization. Recent initiatives like the Inter-Services Organisation Bill 2023, and theaterisation of commands are likely to strengthen India's Information Warfare (IW) capabilities and support its ISR activities.

6) China's ISR infrastructure is guided by its well organized command-and-control structure. It has the capacity to exploit adversary's information processing and decision making systems. The IN command-and-control structure is met with two major obstacles that can hinder its ISR mission accomplishment. First, the Fleet Commander (FC) and Naval HQ (NHQ) in New Delhi may prioritize safety above timely decision-making. Second, NHQ may put too much pressure on the FC or prevent them from taking initiative, which may hinder their ability to accomplish mission objectives.

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Way forward for India

1) India needs to steadily increase its military expenditure to counter China in the IOR. A major chunk of its defence budget needs to be dedicated to R&D and naval modernisation to have state-of-the-art ISR capabilities. ISR systems could also be equipped with development of strategic bases like the Andaman and Nicobar Islands in the eastern Indian Ocean and Lakshadweep in the Western Indian Ocean. Structural changes in the DIB could also augment India's growing ISR potential in the IOR. Effective budget management and prompt procurement of defence equipment would assure optimal use of funds for military preparedness.
2) India can develop high quality training programs to ensure its HUMINT is proficient in carrying out advanced ISR missions. Specialised training in new technologies and ISR systems ensures that personnel can effectively use these systems, further enhancing situational awareness capabilities. Education and training programs can include joint exercises with international players in the IOR, leadership training, and investment in exercises involving HUMINT and advanced TECHINT capabilities.
3) Finally, streamlining of the command-and-control structure can enhance India's ISR capabilities. The Inter-services Organisation Bill 2023 empowers the Commanding Officer to exercise full command and control over a unit, ship, or establishment including personnel from other services. This would provide more disciplinary and administrative powers to the officers unlike the existing structure. A potential streamlined command structure can help in successful observation of ISR mission accomplishment. Along with this, theaterisation of commands can improve operational efficiency as well as decision making process. These theatre commands can integrate their ISR systems to provide comprehensive situational awareness and real-time information. India could also create a centralised maritime command to oversee all operations in the IOR.

Limitations for Research

Besides above mentioned domains, ISR systems from land and cyber domains are equally vital for MSA. Land based systems offer critical intelligence and surveillance from inland and coastal sources. Coastal Surveillance Network, National Automatic Identification System, and Information Management and Analysis Centre are a few lands based ISR systems developed by India. On the other hand, ISR systems monitoring the cyber domain further enhance the overall MSA by monitoring threats evolving from cyberspace. Formation of nodal agencies like CERT-In and NCCC exemplifies an important step taken by India to have a robust cyber based ISR infrastructure. However, detailed study of these domains is beyond the scope of this paper. Future research could emphasize on these areas to provide a more comprehensive understanding of the topic.

Conclusion

Information collection is critical to maritime security since it provides situational awareness to protect maritime activities and interests. ISR systems have been playing a significant role in enhancing the situational awareness capabilities. Based on careful analysis, this paper has provided the historical evolution of ISR systems. The changing nature of ISR activities based on their rudimentary form in the ancient times to technologically advanced systems developed in the modern world has been briefly explained. After establishing the significance of ISR systems in the maritime domain, the paper further focused on the rising footprint of China in the IOR backed by its ISR infrastructure. The implications of Chinese assertion on India's interests were highlighted by providing a comparative analysis of the ISR systems developed by India and China in various domains.

On careful analysis, it was observed that China's robust ISR infrastructure enables it to expand its influence in the IOR. China has relatively greater number of SIGINT and IMINT satellites. They provide China with an operational advantage as they cover a wide range of geography and have better resolution. China's TDRS and Micius QUESS provide quick and robust relay communication and secure data services. India lags China in this segment. Chinese AEW&C system is technologically advanced than its Indian counterpart. Chinese ELINT aircraft fleet has a quantitative edge over that of India. Chinese UAVs can operate at higher altitudes for a longer flight duration as compared to Indian UAVs. Moreover, India does not possess any HALE category UAV. Furthermore, China is simultaneously expanding its fleet of surface warships, submarines, and naval ISR capabilities enabling it to effectively project power in the IOR. Its naval ISR capabilities are equipped with advanced technologies like quantum-based radars, nuclear submarines, AIP system for submarines, and classified network of underwater sensors among others. China has quantitative advantage over India in surface and subsurface capabilities. China's expanding ISR infrastructure raises concerns about India's maritime security, particularly freedom of navigation, SLOC protection, and EEZ defence. This further intensifies geopolitical competition between them. As a result, India is compelled to increase its naval capabilities and broaden strategic partnerships to counter China's rising stature in the IOR.

This paper further enquired into various factors shaping the ISR force structure of India and China. It discussed strategies to enhance India's ISR infrastructure to counter growing Chinese influence in the IOR. The research suggested that India should increase its military expenditure, focussing on R&D and modernisation of naval assets. India can also develop Andaman and Nicobar and Lakshadweep islands as strategic bases to support its ISR force structure. Additionally, India can improve its ISR personnel's proficiency by investing in high quality training and education programs. Finally, the paper finds that streamlining the command-and-control structure, and establishing a centralised maritime command can further strengthen India's ISR capabilities.

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Annexure A

List of tables

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Annexure B

List of figures