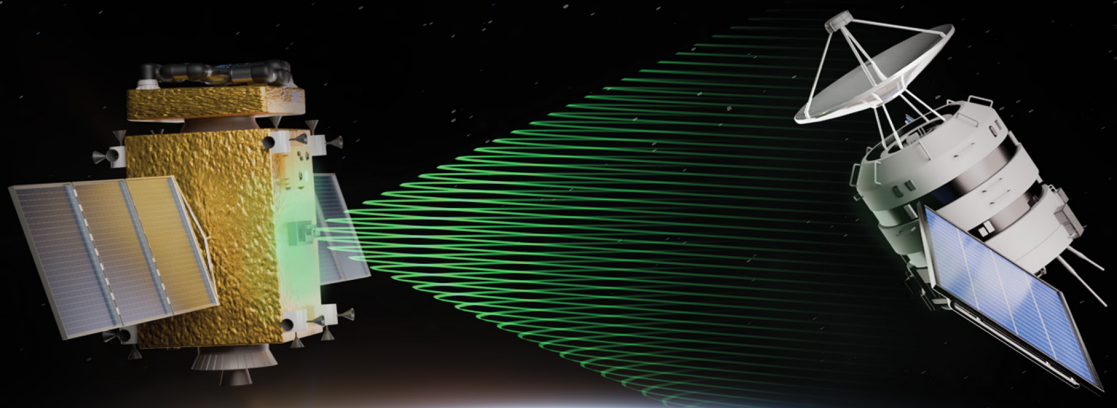
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ADVANCING ISAM:

BUILDING INDIA'S ON-ORBIT SERVICING AND REFUELING ECOSYSTEM: POLICY, PARTNERSHIPS AND PATHWAYS FORWARD



REFUELING MISSIONS. EXTENDING LIFETIMES.
REDEFINING SPACE SUSTAINABILITY.

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Foreword



Anil Prakash
Director General, SIA India

The global space sector is entering a new era. For decades, progress in space was measured by our ability to access orbit and deploy satellites. Today, as orbital infrastructure expands and dependence on space-based services deepens, attention is shifting towards a more fundamental question: how do we sustain, protect, and optimise assets once they are in space? The answer lies in building capabilities that extend beyond launch and deployment to encompass servicing, maintenance, logistics, and long-term stewardship of the orbital environment.

In this context, In-Space Servicing, Assembly, and Manufacturing (ISAM), particularly On-Orbit Servicing and Refuelling (OOSR), has emerged as one of the most consequential frontiers of the global space economy. Industry estimates suggest that the broader ISAM market could exceed USD 135 billion by 2040, driven by demand for satellite life extension, orbital logistics, debris mitigation, inspection services, and future in-space infrastructure. As space becomes more congested and strategic assets more valuable, the ability to service and sustain them will become a defining component of space capability.

For India, this presents a rare opportunity. Unlike many traditional segments of the space sector where market leadership is already concentrated, the OOSR ecosystem remains in its formative stages. India's strengths in cost-effective engineering, reliable launch systems, mission operations, and a rapidly growing private space industry position it favourably to participate in shaping this emerging domain. Recent milestones such as SpaDeX, progress under the Gaganyaan programme, plans for the Bharatiya Antariksha Station, and the rise of innovative Indian space enterprises demonstrate that the foundations for advanced in-space operations are steadily being established.

Yet technological capability alone will not determine leadership. The future OOSR ecosystem will be shaped equally by policy frameworks, technical standards, regulatory certainty, space situational awareness, and international cooperation. Countries that successfully align these elements will be best placed to influence the next generation of space infrastructure and services.

It is against this backdrop that SIA-India has undertaken this study. The paper examines the technological, regulatory, commercial, and strategic dimensions of On-Orbit Servicing and Refuelling, while also exploring avenues for collaboration with key international partners. By analysing areas of convergence in policy, governance, sustainability, and technological development, it seeks to identify pathways through which India can strengthen its domestic ecosystem while contributing meaningfully to a safe, interoperable, and commercially viable global servicing architecture.

We hope this publication will provide policymakers, industry leaders, researchers, and international stakeholders with valuable insights into one of the most promising segments of the emerging space economy. More importantly, we hope it encourages informed dialogue and collaborative action towards positioning India as a trusted partner in advancing sustainable space operations and shaping the future of orbital infrastructure.

Foreword



Sakthikumar Ramachandran
Founder and CEO
OrbitAID Aerospace

The future of space sustainability will be defined not only by how many satellites we launch, but by how effectively we preserve and extend the value of the assets already operating in orbit. Today, satellites form the backbone of the global economy, enabling communications, navigation, Earth observation, weather forecasting, disaster management, financial transactions and national security. Yet despite the immense investment required to design, launch and operate these systems, many satellites are retired not because they have ceased functioning, but simply because they have exhausted a infinite onboard resource: propellant.

This challenge presents one of the greatest opportunities in the evolution of the space economy. On-Orbit Servicing and Refuelling (OOSR) has the potential to fundamentally transform the lifecycle of spacecraft by enabling satellite life extension. Rather than replacing valuable space assets years before their systems have reached the end of their technical usefulness, operators can extend mission lifetimes, maximize returns on investment and reduce the need for replacement launches. Satellite life extension is more than a commercial advantage, it is a strategic necessity. As orbital environments become increasingly congested and launch demand continues to accelerate, extending the operational lifespan of existing satellites offers a practical pathway toward a more sustainable and efficient space ecosystem. Every year added to a satellite's life represents not only economic value for operators, but also a reduction in unnecessary spacecraft replacement and associated orbital congestion.

This challenge presents one of the greatest opportunities in the evolution of the space economy. On-Orbit Servicing and Refuelling (OOSR) has the potential to fundamentally transform the lifecycle of spacecraft by enabling satellite life extension. Rather than replacing valuable space assets years before their systems have reached the end of their technical usefulness, operators can extend mission lifetimes, maximize returns on investment and reduce the need for replacement launches. Satellite life extension is more than a commercial advantage, it is a strategic necessity. As orbital environments become increasingly congested and launch demand continues to accelerate, extending the operational lifespan of existing satellites offers a practical pathway toward a more sustainable and efficient space ecosystem. Every year added to a satellite's life represents not only economic value for operators, but also a reduction in unnecessary spacecraft replacement and associated orbital congestion.

The significance of these capabilities is becoming increasingly evident worldwide. Governments, commercial operators, and space agencies are investing heavily in servicing technologies that can refuel, inspect, relocate, upgrade, and maintain spacecraft already in orbit. What was once considered experimental is rapidly becoming an essential component of future space infrastructure. For India, this moment is particularly important. Recent achievements such as the successful SpaDeX mission have demonstrated critical rendezvous and docking capabilities that form the foundation of future servicing operations. Building on these advances, OrbitAID having launched AayulSáT, India's first orbital refueling technology demonstration and the planned AayulSat-2A & 2B missions, being India's private RPOD mission , comprising dedicated chaser and target

spacecraft, represents an important step toward validating autonomous rendezvous, proximity operations, docking and future refuelling capabilities in orbit. Together, these efforts signal India's intent not only to participate in the global servicing economy, but to help shape it. Combined with India's growing private space sector, strong engineering base, and ambitious plans for orbital infrastructure and human spaceflight, the country is uniquely positioned to emerge as a leader in the next generation of space services.

Perhaps most importantly, the impact of satellite life extension extends far beyond the space sector itself. The beneficiaries of these technologies are ultimately civilians on Earth. Every communication network maintained, every navigation signal preserved, every weather forecast improved and every disaster response enabled by operational satellites directly affects communities, businesses and governments worldwide. By extending the life of critical space infrastructure, servicing missions help ensure continuity of services that modern society increasingly depends upon. In this sense, On-Orbit Servicing and Refuelling is not merely a space technology; it is an enabler of economic resilience, public safety and societal well-being.

This paper explores the technological, regulatory and strategic dimensions of On-Orbit Servicing and Refuelling, with satellite life extension at its core. It examines how these capabilities can support orbital sustainability and contribute to the long-term viability of the space environment. As the global space economy continues its rapid expansion, the ability to service and extend the life of spacecraft will become as important as the ability to launch them. Nations and companies that recognize this shift today will help define the architecture of tomorrow's space economy. It is my hope that this paper contributes to a broader discussion on how India can seize this opportunity and play a leading role in building a more sustainable, resilient and economically efficient future in space.

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Executive Summary

Earth's orbital environment is undergoing a rapid transformation from a relatively limited domain dominated by a few state actors into a highly congested and commercially driven ecosystem supporting communications, navigation, defence, disaster management and digital connectivity. With the global space economy projected to exceed USD 1 trillion by 2034 and nearly 100,000 additional satellites expected to be launched in the coming decade, concerns surrounding orbital congestion, debris accumulation, satellite sustainability and long-term access to space have become increasingly urgent.

This paper examines the growing strategic importance of In-Space Servicing, Assembly, and Manufacturing (ISAM), with a particular focus on On-Orbit Servicing and Refuelling (OOSR). OOSR enables satellites to be refuelled, repaired, inspected, repositioned, upgraded or safely deorbited while already in orbit. These capabilities reduce the need for costly satellite replacement missions, extend operational lifespans of critical space assets, improve resilience of national space infrastructure and contribute significantly to orbital sustainability by mitigating space debris generation.The paper traces the evolution of OOSR globally from early NASA servicing missions and DARPA's Orbital Express to commercial satellite life-extension missions conducted by Northrop Grumman and emerging debris-removal initiatives led by the European Space Agency. It highlights that OOSR is transitioning from an experimental capability into a commercially viable and strategically important component of future space operations.

The paper further analyses India's current position within this evolving ecosystem. It highlights the successful completion of the SpaDeX Mission by Indian Space Research Organisation as a major milestone that established India as the fourth country to demonstrate autonomous docking capability. These developments are directly linked to India's broader ambitions in human spaceflight, lunar exploration, orbital infrastructure and the proposed Bharatiya Antariksha Station. The paper also identifies the emergence of India's private sector participation, particularly through OrbitAID Aerospace and its AAYULSAT mission focused on in-orbit refuelling and servicing demonstrations.

The study outlines the principal use-cases of OOSR, including:

- Satellite life extension;
- Active debris removal;
- On-orbit inspection and diagnostics;
- Controlled end-of-life disposal and sustainability management.

At the international level, the paper evaluates ongoing governance discussions under the United Nations framework, particularly within the Open-Ended Working Group on the Prevention of an Arms Race in Outer Space (PAROS) and the Long-Term Sustainability (LTS) discussions under the Committee on the Peaceful Uses of Outer Space (COPUOS). It highlights the growing recognition that technologies such as rendezvous and proximity operations are inherently dual-use in nature, carrying both commercial and strategic implications. The paper notes that while global consensus on binding governance frameworks remains limited, sustainability-oriented norms and operational measures are increasingly shaping future space governance discussions. Domestically, the paper reviews India's evolving regulatory ecosystem under the Indian Space Policy 2023 and recent draft guidelines issued by IN-SPACe relating to safety and space situational awareness.

While these frameworks establish an important initial foundation, the paper identifies key gaps including the absence of a comprehensive Space Activities Act, limited statutory backing for OOSR authorization mechanisms, lack of interoperability standards, and insufficient differentiation between experimental and commercial missions. The paper concludes that India possesses significant structural advantages in becoming a major participant in the future global ISAM and OOSR economy, including:

- Cost-efficient launch and mission capabilities
- Strong engineering and technical talent
- Expanding private-sector participation
- lncreasing international trust and strategic partnerships
- Existing strengths in autonomous mission operations and satellite technologies

To operationalize these advantages, the paper proposes a set of targeted policy interventions, including:

- Create Clear Space Laws for OOSR
- Develop Standard Docking and Servicing Systems
- Introduce a Tiered Approval System
- Build Shared Space Traffic & SSA Infrastructure
- Create Government Support for the OOSR Market
- Strengthen Coordination Across Government, Industry, and Defence

Finally, the paper examines bilateral collaboration opportunities with key spacefaring partners including the United States, United Kingdom, European Union, Japan, France, Germany, and Australia, identifying pathways for cooperation in areas such as interoperability standards, servicing technologies, robotics, debris mitigation, sustainability governance, and orbital logistics. Overall, the paper argues that OOSR is no longer a niche technological capability, but an emerging strategic necessity that will shape the future architecture of global space operations. India now stands at a critical juncture where timely regulatory reforms, technological investments, and international partnerships can position it as a leading actor in the future sustainable space economy.t

1. Introduction

Earth's orbital environment is entering a period of structural transformation from a relatively sparse operating domain dominated by a few state-led missions to a densely populated and commercially active ecosystem supporting communications, navigation, Earth observation, defence, climate monitoring, finance, and digital connectivity.

The global space economy has witnessed rapid expansion, with recent estimates valuing the sector at approximately USD 626 billion in 2025 and projecting it to surpass USD 1 trillion between 2032–2034, with some forecasts estimating nearly USD 1.8 trillion by 2035. This growth trajectory, driven by rising commercial investments, satellite services, launch activities, and defence-oriented space capabilities, has also resulted in a substantial increase in launches and the number of objects in orbit. Advances in miniaturization, reusable launch systems, and the increasing participation of private actors have significantly lowered the cost of accessing space, enabling large-scale deployment of satellite constellations. In 2025, 4,510 objects were launched into space across 324 launches worldwide, reflecting the accelerating demand for satellite-based services. With the proposed LEO mega-constellations, it is expected that approximately 100,000 constellation satellites will be launched in the next decade, far exceeding the total number of satellites launched since the beginning of human space activities. The Indian GEO Market for future life extension alone, stands at around USD 400 million.

This augmentation poses a severe threat to operations and long term space sustainability activities especially for the LEO satellites with an average lifespan of 5 -7 years, after which propellent depletion, subsystem degradation or component failure, atmospheric drag, and technology obsolescence render them non-operational. Ultimately after the operational lifespan, the satellites are typically maneuvered into graveyard orbits or deorbited while many remain as inactive uncontrolled objects leading to orbital debris. Earth's orbit currently holds over 40,000 tracked objects weighing approximately 7,600 tonnes, travelling at velocities exceeding 7 km per second and of size smaller than 10 cm, with the potential to cause catastrophic damage to operational satellites. The orbital congestion can activate Kessler syndrome and can disrupt future space operations.

Beyond safety concerns, satellite replacement also represents a substantial financial burden. Launching or replacing a satellite often requires substantial financial investment, with the combined costs of spacecraft manufacturing, launch services, and ground infrastructure frequently reaching hundreds of millions of dollars, particularly for large communication satellites in geostationary orbit. To combat such challenges, technologies that enable the repair, refuelling, inspection, and upgrading of spacecraft orbit have emerged as a cost-effective alternative to full satellite replacement.

The concept of In-Space Servicing, Assembly, and Manufacturing (ISAM) has gained increasing prominence as a transformative approach to sustaining space operations. ISAM encompasses a wide range of capabilities aimed at maintaining, upgrading, assembling, and even manufacturing space systems directly in orbit. A key component of this broader framework is On-Orbit Servicing and Refuelling (OOSR), which focuses on extending the operational life of satellites through activities such as refuelling, component replacement, orbit adjustment, and system inspection. By enabling satellites to remain operational beyond their designed lifespan, OOSR not only reduces replacement costs but also contributes to the long-term sustainability of the orbital environment. The development of OOSR technologies has evolved gradually over several decades through experimental and operational missions conducted by major space faring nations.

OOSR is not viewed solely as a technological capability, but increasingly as a strategic, economic and sustainability imperative for future space operations. Strategically, the ability to service, refuel, inspect and reposition satellites in orbit enhances the resilience and continuity of critical space infrastructure. Economically, OOSR reduces the need for costly satellite replacement missions by extending operational lifespans, maximizing returns on existing space assets and enabling the emergence of new commercial markets within the broader ISAM ecosystem. From a sustainability perspective, servicing and end-of-life management capabilities can significantly reduce orbital debris generation, support responsible disposal practices and help preserve the long-term usability of increasingly congested orbital environments. As satellite constellations continue to expand and dependence on space-based services deepens, OOSR is expected to become a foundational component of sustainable and resilient space architecture globally.

2. Past History of On-Orbit Servicing and Refueling Activities

On-orbit servicing and refuelling (OOSR) emerged from the broader evolution of space operations, as spacefaring nations began to recognize the limitations of single-use satellite architectures and the growing importance of maintaining operational assets in orbit. The first practical demonstration of on-orbit repair took place during Space Shuttle missions STS-41-Cin 1984. In the mission, astronauts aboard NASA's Space Shuttle Challenger captured and repaired the malfunctioning Solar Maximum Mission (SMM). Using the shuttle's robotic arm and extravehicular activity (EVA), astronauts were able to replace faulty components and redeploy the satellite back into orbit. The innovation opened new avenues leading to a series of servicing missions (STS-82) for the Hubble Space Telescope in between 1993 and 2009. The maintenance and refurbishing included installation of two technology advancements i.e., Near Infrared Camera and Multi-Object Spectrometer (NICMOS) and the Space Telescope Imaging Spectrograph (STIS). While these early demonstrations relied on astronauts and human-operated spacecraft, the next phase of OOSR development focused on autonomous and robotic servicing technologies. This leap was substantiated through the Orbital Express Mission by the United States Defence Advanced Research Projects Agency (DARPA) in 2007. This mission was a proof-of-concept with short range and long range autonomous rendezvous, capture and berthing, on-orbit electronics upgrades, on-orbit refueling, and autonomous fly-around visual inspection using a demonstration client satellite.

The concept took more than a decade to transition into commercial viability. In 2019, Northrop Grumman launched the Mission Extension Vehicle-1 (MEV-1), which successfully docked with the aging Intelsat-901 communications satellite in geostationary orbit. Rather than refueling the satellite directly, the MEV attached itself to the client satellite and provided propulsion and attitude control, effectively extending the satellite's operational life. This marked the first commercial satellite life-extension service conducted in orbit, demonstrating the economic viability of satellite servicing missions.Along with the US, other space agencies have begun participating in the initiatives with the European Space Agency's cornerstone project ADRIOS (Active Debris Removal / In-Orbit Servicing) aiming to develop essential guidance, navigation and control technologies as well as required rendezvous and capture methods. While several countries have pioneered on-orbit servicing technologies over the past four decades, India has recently begun developing the technological foundations required for future servicing missions through docking demonstrations, human spaceflight initiatives, and emerging satellite life-extension concepts.

Table 1: Major ISAM Missions

Year	Mission / Programme	Country / Organization	ISAM / OOSR Relevance
1966	Gemini 8 Docking	United States / NASA	First successful orbital docking between two spacecraft, establishing the foundational capability required for future in-space servicing, assembly, and refueling missions.
1993	First Hubble Servicing Mission	NASA	Demonstrated on-orbit repair, maintenance, component replacement, and upgrade of satellites through astronaut-led servicing missions.
1998	International Space Station Assembly Begins	International partnership led by NASA	Largest example of modular in-space assembly and long-duration orbital maintenance through robotic and crew-assisted operations.
2007	Orbital Express Mission	DARPA	First autonomous rendezvous and servicing demonstration, including satellite capture, refueling simulation, and component transfer.
2019	Mission Extension Vehicle-1 Launch	Northrop Grumman	First commercial mission dedicated to extending the operational life of satellites through in-orbit docking.
2020	MEV-1 Dockin with Intelsat 901	Northrop Grumman	First successful docking with an active commercial GEO satellite for life-extension services.
2021	Mission Extension Vehicle-2	Northrop Grumman	Demonstrated scalability and commercial viability of satellite servicing and life-extension operations.
2024	SPADEX Mission	ISRO	India's first dedicated space docking experiment, intended to develop indigenous rendezvous, proximity operations, and docking capabilities essential for future ISAM missions.
2025	AAYUL SAT	OrbitAID Aerospace	India's first commercial in-orbit refueling and docking interface demonstration mission focused on satellite life extension and orbital sustainability

3. Current Stage of India's Development

Before SpaDeX, India's first explicit mission for OOSR, Indian Space Research Organisation (ISRO) had already been developing various foundational capabilities, which includes, Rendezvous and Proximity Operations (RPO), Guidance, Navigation and Control (GNC) systems and formation flying for India's next set of missions. The Space Docking Experiment (SpaDeX), successfully completed in 2025 marked India as the fourth country to achieve this technology feat. Using the PSLV-C60, both SDX-01 and SDX-02 spacecraft manoeuvred seamlessly from the 15-metre to 3-meter hold point, initiating docking with accuracy leading to successful spacecraft capture. The technologies incorporated in the mission includes, docking mechanism, a suite of four rendezvous and docking sensors, power transfer technology, indigenous novel autonomous rendezvous and docking strategy, inter-satellite communication link (ISL) for autonomous communication between spacecrafts, GNSS-based Novel Relative Orbit Determination and Propagation (RODP) processor and simulation test beds for both hardware and software design validation and testing.

With SpaDeX's success, India's space programme has entered a more advanced phase of operational capability. Autonomous docking is a foundational requirement for complex missions, including lunar exploration, on-orbit assembly, and the sustained operation of space stations. By validating this capability, the ISRO is establishing a critical technological baseline for forthcoming missions such as Chandrayaan-4.

Moreover, SpaDeX is intrinsically linked to India's broader strategic ambitions in space, underpinning the Gaganyaan programme, prospective human missions beyond low Earth orbit, and the development of the Bharatiya Antariksha Station. India's proposed Bharatiya Antariksha Station (BAS) further reinforces the trajectory toward sustained in-orbit capabilities. Approved as part of the expanded human spaceflight programme, the first module of BAS is targeted for launch by 2028, marking the beginning of India's indigenous space station development. The station is envisaged as a multi-module platform to be operational by the mid-2030s, supporting microgravity research, long-duration human missions, and advanced scientific experimentation. These missions represent not merely a discrete technological achievement, but a systemic enabler of India's transition toward advanced, sustained, and increasingly autonomous space operations.

Building upon government-led technological advancements, commercial activities in on-orbit servicing and refuelling have begun to emerge in India, with several private players entering the domain. A notable development in this regard is the AayulSAT mission by OrbitAID Aerospace, which represents India's first dedicated on-orbit refuelling and servicing demonstration payload. The mission is designed to validate critical in-orbit capabilities, including propellant transfer, power transfer, and data exchange between spacecraft, thereby addressing key challenges associated with satellite life extension and sustainability. AayulSAT is envisioned as a miniaturized in-space servicing platform, incorporating standardized docking and refuelling interfaces that could potentially enable interoperability across satellites. Collectively, these developments position India to leverage on-orbit servicing capabilities across a range of applications, including satellite life extension, debris mitigation, in-orbit inspection, and end-of-life management.

4. Use-Cases of On-Orbit Servicing & Refuelling (OOSR)

As satellites become larger, complex and strategically indispensable, the ability to service them in orbit is emerging as a critical enabler of sustainable and resilient space operations. On-Orbit Servicing and Refuelling (OOSR) directly addresses the operational limitations imposed by fuel depletion and end-of-life management, allowing satellites to remain functional and compliant with evolving sustainability norms. The primary use-cases of OOSR include life extension, active debris removal, on-orbit inspection, and end-of-life services.

A. Life Extension

Life extension is the most immediate and high-value application of On-Orbit Servicing & Refuelling. Many operational satellites reach the end of their mission not due to failure of payloads or subsystems, but because onboard propellant is exhausted. Once fuel is depleted, satellites lose the ability to perform station-keeping, attitude control, collision avoidance maneuvers, and controlled deorbiting, even though their core mission hardware remains fully functional. Through on-orbit servicing & refueling, satellites can continue providing essential services such as Earth observation, communication, navigation, and reconnaissance for several additional years beyond their original design life. For larger, expensive satellites that require long development and replacement timelines, life extension provides clear economic and strategic advantages. By avoiding premature replacement launches, it ensures uninterrupted delivery of critical services while maximizing the value of national investments already made in space infrastructure.

B. Active Debris Removal (ADR)

Active Debris Removal is a critical use-case enabled by On-Orbit Servicing & Refuelling capabilities. Servicing spacecraft equipped with rendezvous sensors, docking ports and robotic handling systems can approach defunct satellites, rocket stages or large debris objects and actively intervene to mitigate collision risks. Through controlled docking or capture, these non-functional objects can be reoriented, refueled for disposal maneuvers, guided into designated graveyard orbits or controlled atmospheric re-entry trajectories. This prevents the long-term accumulation of debris in heavily populated orbital regions and reduces the probability of high-energy collisions that could generate cascading debris fields. ADR therefore plays a direct role in preserving the safety and long-term usability of Earth orbits.

C. Inspection

On-orbit inspection is an essential operational use-case that enables closer assessment of satellite health and structural integrity. Servicing spacecraft can be deployed to visually and diagnostically inspect satellites. This can be after the launch, during anomaly events or after close encounters with space debris. Inspection missions allow operators to detect damage to solar arrays, antennas, thermal surfaces or structural elements, as well as identify misalignments or deployment failures. This capability reduces uncertainty during anomaly resolution, supports informed decision-making on corrective actions and helps prevent unnecessary mission termination. By improving situational awareness and fault diagnosis, inspection enhances overall mission reliability and operational confidence.

D. End-of-Life Services

End-of-life servicing ensures that satellites are safely and responsibly retired once they are no longer capable of fulfilling mission objectives. On-Orbit Servicing & Refuelling enables controlled passivation, relocation to graveyard orbits, or guided deorbiting, preventing inactive satellites from becoming long-term hazards in orbit. Active end-of-life management is particularly important for large satellites operating in congested orbital regimes, where uncontrolled spacecraft pose collision and debris-generation risks. By enabling compliance with debris mitigation guidelines and responsible disposal practices, end-of-life services supported by OOSR contribute directly to long-term orbital sustainability and safe future access to space.

1. Despite their growing utility, on-orbit servicing technologies introduce new operational and regulatory complexities related to space traffic coordination, servicing protocols, liability, transparency, and interoperability between spacecraft developed by different operators and nations. As servicing missions become more frequent and technically sophisticated, the need for internationally accepted norms, technical standards, and cooperative frameworks has become increasingly important to ensure safe and predictable operations in orbit. The governance of outer space activities is primarily guided by multilateral frameworks developed under the United Nations, particularly through the Committee on the Peaceful Uses of Outer Space (COPUOS) and related working groups. In recent years, increasing attention has been directed toward ensuring the long-term sustainability (LTS) of space activities, focusing on issues such as orbital debris mitigation, safe operations, and responsible behaviour in space. Parallelly, discussions under the framework of the Prevention of an Arms Race in Outer Space (PAROS) have highlighted growing concerns regarding the security implications of emerging space technologies.

5. Domestic Policy Approach

India's evolving approach to space governance is anchored in the Indian Space Policy 2023 and the authorization framework administered by IN-SPACe through its Norms, Guidelines and Procedures (NGP) for Authorization of Space Activities. Together, these instruments establish the foundation for private sector participation in space activities while ensuring compliance with India's international obligations relating to safety, security, sustainability, and responsible conduct in outer space. Although the policy framework does not explicitly address On-Orbit Servicing and Refuelling (OOSR), several provisions create an enabling environment for the development and deployment of servicing capabilities.

The Indian Space Policy 2023 recognizes the private sector as a key stakeholder across the space value chain and assigns IN-SPACe the responsibility of promoting, authorizing, and supervising non-governmental space activities. This institutional arrangement is particularly relevant for OOSR missions, which involve complex operational activities such as rendezvous and proximity operations (RPO), satellite inspection, docking, relocation, life-extension services, and in-space logistics. By establishing a centralized authorization mechanism, the policy provides a pathway through which future servicing missions can be assessed and approved on a case-by-case basis.

Operationally, the NGP framework introduces a structured authorization process requiring applicants to demonstrate compliance with technical, safety, security, orbital debris mitigation, and mission assurance requirements. These provisions are directly relevant to OOSR missions, where close-proximity operations and interactions between space objects introduce unique operational and safety considerations. The authorization process requires mission operators to provide detailed information on spacecraft design, mission profiles, risk mitigation measures, end-of-life disposal strategies, and adherence to internationally accepted best practices. As a result, many of the foundational regulatory elements necessary for future servicing missions already exist within India's broader authorization architecture.requirements are particularly consequential for OOSR missions, which rely heavily on real-time proximity operations and coordination.

From an OOSR perspective, one of the most significant strengths of India's current framework is its flexibility. Rather than prescribing technology-specific requirements, the policy and authorization regime establish broad principles that can accommodate emerging mission architectures and business models. This allows regulators to evaluate innovative servicing concepts without requiring frequent amendments to overarching policy instruments. Such flexibility may prove valuable as technologies such as robotic servicing, in-space refuelling, debris removal, and orbital transfer vehicles mature over the coming decade.

At the same time, the growth of a domestic OOSR ecosystem will likely require greater regulatory clarity in certain areas. Future guidance could address operational standards for rendezvous and proximity operations, servicing authorization procedures, interoperability requirements, docking and refuelling interfaces, data-sharing protocols, and liability allocation between servicing providers and client spacecraft operators. The development of common technical standards will be particularly important in enabling scalable commercial servicing markets and ensuring compatibility across future satellite fleets.

Despite the progress made through the Indian Space Policy 2023, the NGP authorization framework, and emerging safety and SSA guidelines, significant regulatory ambiguity remains with respect to On-Orbit Servicing and Refuelling (OOSR) and broader In-Space Servicing, Assembly, and Manufacturing (ISAM) activities. Existing policy and authorization

mechanisms provide a general framework for mission approval but do not yet contain dedicated provisions addressing critical aspects of servicing missions, including rendezvous and proximity operations, docking procedures, ownership and control during servicing, liability allocation between servicing providers and client spacecraft, refuelling operations, and the treatment of servicing-related anomalies or failures. The absence of mission-specific technical standards and operational protocols creates uncertainty for both regulators and industry participants seeking to develop commercial servicing capabilities. Given the inherently international nature of OOSR and ISAM markets, where servicing vehicles may interact with satellites owned, operated, or registered by entities across multiple jurisdictions, international cooperation will be essential. Partnerships with established spacefaring nations, participation in multilateral standard-setting initiatives, and alignment with emerging global interoperability frameworks can help India accelerate capability development while ensuring compatibility with international servicing architectures. Such collaboration would not only reduce regulatory uncertainty but also position Indian companies to participate more effectively in the rapidly evolving global in-space economy.

Overall, India's domestic policy framework demonstrates a clear commitment to enabling commercial space activities while promoting safety, sustainability, and responsible behaviour in orbit. Through the Indian Space Policy 2023, the NGP authorization framework, India has established several of the foundational regulatory elements necessary for future OOSR activities. As servicing technologies mature and commercial demand expands, continued regulatory evolution focused on interoperability, operational standards, and mission-specific guidance can further position India as a significant participant in the global in-space servicing and logistics ecosystem.

6. Solutions enabling a OOSR Ecosystem in India

At the same time, India possesses several structural advantages that position it favourably within the emerging global OOSR ecosystem. India's cost-efficient space programme, demonstrated through comparatively low mission development and launch costs, provides a significant competitive advantage for future servicing missions, which are inherently capital-intensive and complex. The country's proven launch capability through reliable launch vehicles such as PSLV and the growing commercialization of launch infrastructure further strengthens its ability to support servicing and orbital logistics operations. India also benefits from a large pool of highly skilled engineering and technical talent across spacecraft systems, robotics, autonomy, software, and mission operations, which are critical domains for OOSR development. Internationally, India is increasingly viewed as a trusted and responsible space partner, reflected in expanding cooperation with the United States, Europe, Japan, Australia, and other spacefaring nations across civil, commercial, and strategic space activities. In parallel, the rapid growth of India's private space ecosystem supported by policy liberalization, IN-SPACe reforms, and rising investor interest has created early startup momentum in areas such as satellite servicing, space situational awareness, in-space mobility, and orbital sustainability. Collectively, these factors provide India with a strong foundation to transition from foundational capability development toward long-term participation in the global ISAM and OOSR economy. To transition from an evolving regulatory framework to a functionally enabling ecosystem for on-orbit servicing and refuelling (OOSR), India must adopt targeted policy interventions that go beyond compliance and actively shape market development, technological standardization, and institutional coherence. Create Clear Space Laws for OOSR

- Develop Standard Docking and Servicing Systems
- Introduce a Tiered Approval System
- Build Shared Space Traffic & SSA Infrastructure
- Create Government Support for the OOSR Market
- Strengthen Coordination Across Government, Industry, and Defence

A. Create Clear Space Laws for OOSR

Rather than relying on evolving guidelines, India should embed OOSR-specific provisions within the Space Activities Act, explicitly mentioning authorization pathways for servicing missions, liability regimes for in-orbit interactions and legal status of proximity operations which will enable long-term commercial and international engagement in the sector.

B. Lead Development of Servicing Interface Standards

India should initiate a national standardization programme for servicing-compatible satellite architectures, including docking interface specifications, refuelling access design and modular payload configurations. This effort should be aligned with international standard-setting bodies to ensure interoperability. By doing so, India can position itself not merely as a participant, but as a contributor to global ISAM standards, enabling future servicing markets.

C. Introduce a Tiered Approval System

Instead of uniformly applying compliance requirements, IN-SPACe should implement a graduated authorization system, where, low-risk experimental missions receive expedited approvals, commercial servicing missions follow structured compliance pathways and high-sensitivity missions undergo enhanced scrutiny allowing regulatory resources to be allocated efficiently, while supporting innovation in early-stage technologies.

D. Build Shared Space Traffic & SSA Infrastructure

Instead of placing the full burden of SSA on operators, India should develop centralized mission support services, including real-time conjunction alerts, standardized data interfaces and mission planning tools for proximity operations. This would transform SSA into a shared operational backbone, improving safety while reducing duplication of effort across actors.

E. Create Government Support for the OOSR Market

To stimulate demand for OOSR, the government should adopt a market-creation approach, including acting as an anchor customer for servicing missions, incentivizing servicing-compatible satellite design and supporting startups through grants and procurement contracts. This would shift OOSR from a technology demonstration phase to a viable commercial sector.

F. Establish a Cross-Domain Coordination Mechanism

India has already initiated important institutional reforms through the Indian Space Policy 2023, the expanding role of IN-SPACe, and ISRO's continued development of rendezvous, docking, and autonomous mission capabilities. These developments provide an initial governance and technological foundation for future OOSR activities. However, the broader ecosystem required to operationalize and scale OOSR capabilities remains fragmented and will require greater coordination across government, industry, defence, government, and academia.

Given the dual-use nature of OOSR, India should create a multi-agency coordination platform integrating civil space authorities, defence stakeholders, regulatory bodies and industry representatives ensuring alignment across security, commercial, and sustainability objectives, reducing policy fragmentation.However, given the dual-use characteristics of OOSR technologies and their implications for both sustainability and space security, domestic policy measures alone are insufficient. Advancing these capabilities will require structured bilateral cooperation with key spacefaring nations to harmonize standards, build confidence, and align regulatory approaches within an evolving global governance landscape.

Table 2: Stakeholder Analysis

Stakeholder	Key Actions	Strategic Objective / Outcome	Near Term	Mid Term	Long Term
Government of India	Enact Space Activities Act, enable international cooperation frameworks, support fiscal incentives for ISAM.	Provide long-term policy certainty and strategic direction.	Develop dedicated OOSR policy direction, accelerate Space Activities Act, support international cooperation and fiscal incentives.	Establish national ISAM/OOSR strategy and bilateral servicing frameworks.	Position India as a leading global hub for sustainable in-space operations and ISAM governance.

Stakeholder	Key Actions	Strategic Objective / Outcome	Near Term	Mid Term	Long Term
IN-SPACe	Establish dedicated approval windows for experimental servicing missions, create operational guidance for rendezvous and proximity operations, and streamline coordination between civilian and commercial operators.	Create a predictable and innovation-friendly regulatory ecosystem.	Develop authorization pathways, safety guidelines, SSA ompliance frameworks, and regulatory sandboxes for ISAM missions.	Implement tiered licensing systems, servicing standards, and interoperability protocols and establish a strong regulatory ecosystem.	Enable mature regulatory ecosystem aligned with global servicing and orbital logistics markets.
ISRO	Conduct technology demonstrations, support testing infrastructure, transfer foundational technologies to industry.	De-risk indigenous ISAM capability development.	Conduct docking, rendezvous, refuelling, and in-space technology demonstrations; support testing infrastructure.	Transfer servicing technologies to industry and support operational mission validation.	Support advanced ISAM missions including orbital assembly, logistics, and deep-space servicing.
Defence Stakeholders	Develop protocols for dual-use technologies, security coordination, and resilience planning.	Ensure secure and responsible deployment of ISAM capabilities.	Develop risk assessment and coordination mechanisms for dual-use technologies and proximity operations.	Integrate space security and resilience planning into operational servicing frameworks.	Establish secure and resilient orbital infrastructure protection capabilities.
Startups & Industry	Develop scalable servicing payloads, modular spacecraft systems, indigenous robotics, and commercial business models for life-extension, inspection, and debris-management services.	Build a competitive indigenous ISAM market.	Develop indigenous servicing technologies, robotics, autonomous systems, and inspection platforms.	Scale commercial servicing missions, debris mitigation services, and in-space mobility solutions.	Compete in global ISAM, orbital logistics, and servicing markets.

Stakeholder	Key Actions	Strategic Objective / Outcome	Near Term	Mid Term	Long Term
Investors & Financial Institutions	Provide patient capital, insurance products, and commercialization support.	Enable scaling of high-risk space technologies.	Support early-stage startups and high-risk technology development through patient capital.	Develop specialized financing, insurance, and risk-sharing mechanisms for servicing missions.	Enable large-scale commercial expansion of India's in-space economy.
Academia & Research Institutions	Advance R&D, workforce training, simulation environments, and standards research.	Strengthen long-term innovation and talent pipeline.	Expand R&D, workforce training, simulation capabilities, and servicing-related research.	Support advanced autonomy, AI-enabled servicing, cybersecurity, and standards development.	Build long-term innovation ecosystems and globally competitive research leadership in ISAM technologies.

While national regulatory frameworks and institutional mechanisms will form the foundation of India's OOSR ecosystem, the inherently transnational nature of space operations necessitates broader international coordination. On-orbit servicing missions involve spacecraft operating across shared orbital environments, often interacting with assets owned or managed by multiple stakeholders. As a result, the effectiveness of OOSR governance will increasingly depend on harmonized technical standards, interoperable servicing protocols, information-sharing mechanisms, and cooperative approaches to orbital sustainability. In this context, bilateral partnerships with established and emerging spacefaring nations can play a critical role in advancing technological capabilities, shaping operational norms, and enabling responsible growth of the global servicing ecosystem.

8. Bilateral Possibilities for Space Collaboration in On-Orbit Servicing and Refueling (OOSR)

Table 3: Bilateral Collaboration

Bilateral Partnership	**Possibility of Collaboration**	Existing Cooperation	Convergences	Divergences	Mitigation & Solutions	Future Roadmap
India – United States	India and the U.S. possess a mature civil space partnership that can naturally expand into On-Orbit Servicing and Refueling (OOSR), particularly in life-extension missions, proximity operations, debris monitoring, servicing technologies, and standard-setting. The India–U.S. Civil Space Joint Working Group (CSJWG) provides an institutional platform for incorporating OOSR cooperation.	Cooperation includes the NASA-ISRO Synthetic Aperture Radar (NISAR), satellite data-sharing arrangements, civil space cooperation frameworks, and coordination on space situational awareness (SSA). Both states also participate in multilateral sustainability dialogues and strategic space discussions.	Shared priorities include satellite resilience, protection of high-value orbital assets, debris mitigation, continuity of navigation and reconnaissance services, and sustainable space operations. Both countries support SSA, collision avoidance, and orbital sustainability norms.	The U.S. possesses established statutory and regulatory frameworks governing rendezvous, proximity operations, servicing, and commercial space licensing through bodies such as the FAA and NASA. India's regulatory ecosystem remains evolving and currently lacks dedicated OOSR-specific authorization, liability, and consent provisions.	India can leverage U.S. regulatory experience through expanded CSJWG dialogue focused on OOSR governance, including liability, mission authorization, collision avoidance, and transparency frameworks. Gradual regulatory convergence would reduce operational uncertainty and improve interoperability.	Establish dedicated India-U.S. OOSR working groups, pursue interoperability frameworks for servicing missions, develop joint standards for docking and servicing operations, and encourage public-private partnerships in satellite life-extension technologies.

Bilateral Partnership	Possibility of Collaboration	Existing Cooperation	Convergences	Divergences	Mitigation & Solutions	Future Roadmap
India – United Kingdom	India and the UK share growing cooperation in commercial space activities, regulatory governance, and sustainability-oriented space policy. The UK's private-sector-focused regulatory model complements India's expanding commercial space ecosystem, creating opportunities for collaboration in OOSR-related regulatory and commercial initiatives.	Existing cooperation includes ISRO launches of One Web satellites, the UK-DMC 3 Earth observation constellation, and PSLV-C42 British satellite launches. The UK also actively participates in international space bridge arrangements and industry partnerships.	Both countries emphasize responsible space operations, regulatory oversight, private sector participation, and sustainability-focused governance. India's space liberalization through IN-SPACe aligns with the UK's commercially oriented licensing ecosystem.	The UK maintains more mature licensing, insurance, and liability mechanisms for proximity operations and debris-related activities. India's current framework lacks detailed provisions for insurance thresholds, third-party liability allocation, and OOSR-specific risk-sharing models.	India may selectively adapt UK practices related to risk assessment, insurance, and liability management within a dedicated OOSR framework. Structured dialogue between IN-SPACe and the UK Space Agency can facilitate compatible licensing approaches.	Develop joint regulatory sandboxes for OOSR testing, establish structured dialogue on insurance and licensing standards, and move toward interoperable authorization mechanisms for future servicing missions.
India – European Union	India and the EU share strong alignment on space sustainability, Earth observation, SSA, and advanced space technologies. Cooperation in OOSR is particularly feasible in debris mitigation, interoperable servicing standards, and sustainable orbital operations.	Cooperation includes the Copernicus-ISRO Earth observation data-sharing agreement, ESA support for Gaganyaan Programme tracking operations, ESA–ISRO collaboration in human spaceflight technologies, and earlier scientific cooperation during Chandrayaan-1.	Convergences include support for orbital sustainability, interoperability standards, debris mitigation, SSA cooperation, and standardized servicing frameworks. Both sides emphasize sustainable use of orbital environments and multilateral governance.	The EU and ESA maintain highly formalized technical and interoperability standards, including docking interfaces and debris mitigation requirements, whereas India currently lacks mandatory servicing-ready satellite interface standards and binding OOSR-specific operational norms.	India can progressively adopt ECSS-style servicing and docking standards while establishing India–EU technical working groups focused on proximity operations, safety procedures, and debris mitigation guidance.	Launch India-EU interoperability forums, conduct joint servicing simulations, institutionalize policy dialogue between ESA and IN-SPACe, and expand telemetry/data-sharing arrangements for servicing operations.

Bilateral Partnership	Possibility of Collaboration	Existing Cooperation	Convergences	Divergences	Mitigation & Solutions	Future Roadmap
India – Australia	India and Australia increasingly align on SSA, sustainability, Indo-Pacific space governance, and responsible uses of outer space. Cooperation in OOSR is likely to emerge through sustainability initiatives, research partnerships, and startup-led collaboration.	Cooperation frameworks include the 2021 India–Australia civil space MoU, the Comprehensive Strategic Partnership, Space MAITRI initiatives, and industry collaboration such as OrbitAID's engagement with Australian firms. Australia also supports India's human spaceflight tracking operations.	Both countries support peaceful and responsible use of advanced technologies, science-driven innovation, and technology-led economic growth. Collaboration is reinforced through research funds, innovation programs, and Indo-Pacific strategic engagement.	India operates major sovereign orbital infrastructure while Australia's space engagement focuses more on downstream applications, facilitation, and collaborative innovation rather than large operational satellite fleets.	Cooperation can focus on ecosystem development rather than joint ownership of orbital assets. Innovation accelerators, startup partnerships, and strategic research initiatives provide flexible collaboration pathways.	Expand joint R&D programs, strengthen startup ecosystems in space sustainability technologies, deepen SSA policy coordination, and integrate OOSR discussions into broader technology and Indo-Pacific strategic frameworks.
India – Japan	India and Japan maintain a mature strategic and technological partnership with strong relevance to future OOSR collaboration, particularly in robotics, precision navigation, docking systems, and sustainability-focused missions.	Key cooperation includes the planned LUPEX Mission (Chandrayaan-5), ESA-like operational coordination between ISRO and JAXA, and growing commercial partnerships involving OrbitAID and Japanese firms in cislunar operations.	Both countries emphasize peaceful use of outer space, robotic systems, scientific exploration, SSA, and long-term sustainability of orbital environments. Shared focus on precision operations supports future servicing collaboration.	Neither India nor Japan currently possesses fully articulated OOSR-specific regulatory frameworks governing servicing authorization, proximity operations, or liability allocation. Their strategic priorities also differ in operational emphasis and mission architecture.	Structured bilateral dialogue on servicing safety, proximity operations, liability, and sustainability standards can gradually bridge these gaps. Existing cooperation frameworks such as LUPEX provide institutional foundations for expansion into OOSR domains.	Expand collaboration into robotic servicing demonstrations, involve private-sector actors in orbital sustainability initiatives, and establish bilateral frameworks for future docking and servicing standards.

Bilateral Partnership	Possibility of Collaboration	Existing Cooperation	Convergences	Divergences	Mitigation & Solutions	Future Roadmap
India – Germany	India and Germany possess strong complementarities in advanced engineering, industrial manufacturing, Earth observation, robotics, and sustainability-focused space technologies. Germany's expertise in autonomous systems, robotics, and in-orbit technologies creates significant potential for collaboration in On-Orbit Servicing and Refueling (OOSR), particularly in servicing robotics, satellite life-extension systems, and debris mitigation technologies.	India and Germany maintain longstanding cooperation through DLR and ISRO collaborations in Earth observation, remote sensing, scientific payload development, and tracking support. German institutions and industry also participate extensively in European Space Agency programmes nvolving robotics, autonomous servicing technologies, and orbital sustainability research. Commercial engagement between Indian and German aerospace industries is also increasing under broader India–Germany technology partnerships.	Both countries emphasize sustainable industrial growth, advanced engineering collaboration, responsible space operations, and climate-oriented Earth observation systems. Germany's focus on precision robotics, and space sustainability aligns closely with India's growing ambitions in indigenous satellite servicing and commercial space infrastructure. Both also support multilateral governance approaches for orbital safety and debris mitigation.	Germany operates within the broader European regulatory and technical standardization ecosystem, particularly ESA and ECSS frameworks, which are comparatively more mature and technically standardized than India's evolving servicing governance architecture. India currently lacks detailed servicing-ready interface standards and dedicated OOSR authorization mechanisms.	India and Germany can address these differences through technical harmonization initiatives focused on docking interfaces, robotic servicing systems, and debris mitigation standards. Joint technical working groups involving DLR, ISRO, and IN-SPACe could facilitate knowledge exchange on servicing regulations, robotics integration, and safety certification models.	Establish India-Germany joint research initiatives on servicing robotics and autonomous proximity operations, promote academic and industrial partnerships in orbital sustainability technologies, and expand cooperation under broader India–EU and ESA-linked frameworks for interoperable OOSR systems.

Bilateral Partnership	Possibility of Collaboration	Existing Cooperation	Convergences	Divergences	Mitigation & Solutions	Future Roadmap
India – France	India and France share one of the most mature and strategically significant bilateral space partnerships globally. This relationship provides a strong foundation for collaboration in OOSR, particularly in space situational awareness, autonomous servicing systems, orbital sustainability, and strategic satellite resilience. France's advanced capabilities in military and civilian space operations make it a valuable partner for future servicing and refueling cooperation.	India and France have decades of cooperation between ISRO and CNES in Earth observation, launch cooperation, maritime surveillance, climate monitoring, and satellite technologies. Joint missions such as Megha-Tropiques and SARAL demonstrate deep operational coordination. France has also supported India in SSA dialogue, maritime domain awareness, and broader Indo-Pacific strategic cooperation involving space security and sustainability.	Both countries strongly support strategic autonomy in space, sustainable orbital operations, SSA cooperation, and advanced satellite technologies. France's emphasis on resilient space infrastructure, orbital safety, and European space sovereignty aligns with India's goals of expanding indigenous capabilities while strengthening international partnerships. Both also support responsible behavior norms and long-term orbital sustainability frameworks.	France operates under advanced European licensing, liability, and debris mitigation ecosystems, while India's OOSR-related regulations remain under development. France additionally places stronger emphasis on military-civil integration in space operations and binding sustainability compliance measures.	India and France can deepen cooperation through bilateral SSA and servicing safety dialogues, collaborative development of docking and servicing standards, and expanded industry partnerships between Indian private space firms and French aerospace companies. Regulatory cooperation can also help India develop clearer servicing authorization and liability frameworks.	Develop India-France cooperation in autonomous servicing technologies, establish bilateral orbital sustainability initiatives, encourage joint industry-led servicing demonstrations, and integrate OOSR collaboration into the wider India–France strategic space partnership and Indo-Pacific cooperation agenda.

9. Conclusion

The global space sector is entering a transition where value creation will increasingly shift from access-to-space alone toward sustained operations and infrastructure management in orbit. In this evolving landscape, On-Orbit Servicing and Refuelling (OOSR) is expected to become a core enabling capability supporting satellite longevity, orbital sustainability, operational resilience, and future in-space infrastructure development.

For India, this presents a strategic opportunity to participate in a high-value segment of the emerging space economy at an early stage of market formation. India has already demonstrated foundational technological capabilities through missions such as SpaDeX, while the growing participation of private industry indicates that the ecosystem is beginning to mature beyond traditional satellite and launch activities. Combined with India's cost competitiveness, engineering talent, and expanding international partnerships, these developments provide a strong basis for future growth in servicing, orbital logistics, and broader ISAM-related activities.

However, the pace at which India can transition from technology demonstration to operational leadership will depend significantly on the evolution of its regulatory and industrial ecosystem. The coming years will require greater policy clarity, servicing-compatible standards, improved access to testing and mission infrastructure, stronger public-private coordination, and targeted mechanisms that encourage commercial adoption of servicing technologies. Early regulatory certainty and institutional support will be essential not only for reducing industry risk, but also for attracting long-term investment and enabling globally competitive capabilities to emerge.

At the same time, the development of OOSR should be viewed not only through the lens of sustainability, but also as a long-term industrial capability with implications for future space commerce, orbital infrastructure, and international cooperation. As global space activities continue to expand, countries that establish trusted, interoperable, and commercially viable servicing ecosystems are likely to play a defining role in shaping the next phase of the space economy. India's cost-efficient space programme, growing private sector, and expanding international partnerships provide strong advantages in the future ISAM and OOSR market.However, India still requires clear legislation, servicing standards, streamlined authorization systems, and stronger institutional coordination to scale OOSR capabilities.

Bilateral partnerships will play a critical role in accelerating India's OOSR capabilities through technology cooperation, regulatory alignment, interoperability standards, and joint sustainability initiatives. India's existing space partnerships with the United States, France, Japan, European Union, Australia, and United Kingdom provide a strong foundation for future collaboration in servicing technologies, robotics, SSA, and orbital sustainability. Such partnerships can help India bridge regulatory and technical gaps while enabling access to advanced servicing architectures, docking standards, and operational best practices. Cooperation in OOSR can also strengthen broader strategic objectives including resilient space infrastructure, Indo-Pacific collaboration, and responsible space governance.

As global discussions on space sustainability and security evolve, India has an opportunity not only to participate in the emerging OOSR ecosystem, but also to help shape future global norms and standards. With timely policy reforms and strategic investment, India can position itself as a leading hub for sustainable and advanced in-space operations.

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