Preparing to scale new heights: Enhancing private participation in India's commercial space sector

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एन्ट्रिक्स ANTRIX

Message from Antrix Corporation

I'm glad that PwC has taken the initiative to bring out a position paper on India's space sector at a time when the country's space activities are at a crossroads. Though the space-based service requirements of the country have been met by the state-owned agency ISRO thus far, the burgeoning demand from various stakeholders is far beyond the current capacity! This necessitates greater inclusion of the private sector in all areas of the space domain, including end-to-end design and manufacture of space systems. This will not only improve capacity but also result in increased economic activity, contributing to the state exchequer. However, the absence of an enabling regulatory framework is perhaps a very big challenge that needs to be ironed out. I feel that the time is ripe for an overhaul of space regulations, considering the potential of Indian companies to step up and gain a sizeable share of the growing space business, which is currently valued at USD 360 billion.

India is witnessing a start-up revolution in many segments. The space domain is also seeing an emergence of start-ups, notwithstanding the regulatory uncertainty. Today, there are about 40 start-ups in the space domain, looking to develop their own space products and services and foray into the world of space commerce. Since India is a major space-faring nation, Indian start-ups can leverage the situation for business gains, provided ISRO handholds them. In the absence of a business-friendly space law and supportive policies, these start-ups may be left in the lurch! Let's hope that the climate improves at the earliest and that Indian space commerce benefits from the contributions of these innovative and valuable players.

Rakesh Sasibhushan
Chairman and Managing Director
Antrix Corporation Limited

Message from PwC

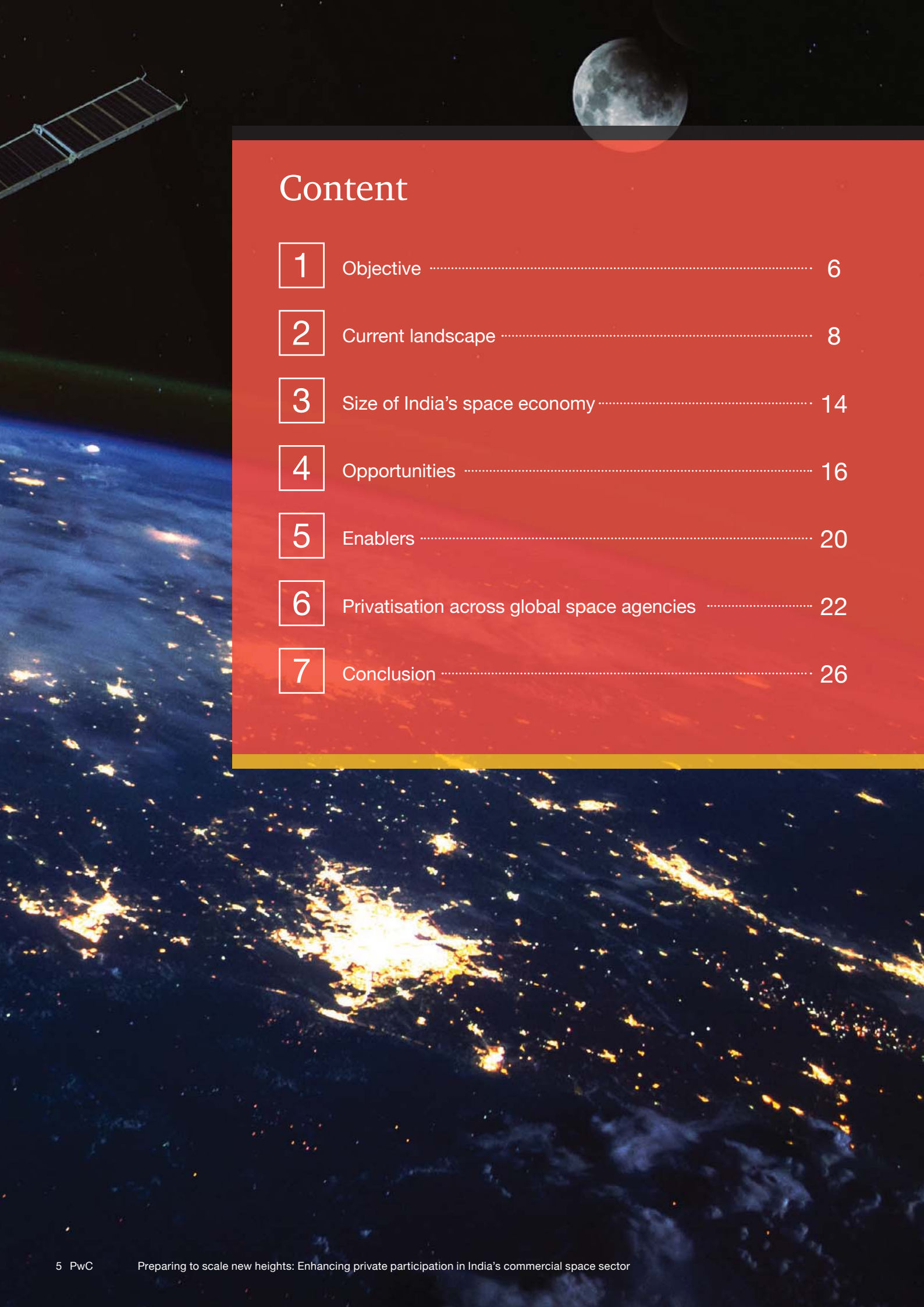
In today's age, the space sector plays a vital role in multiple facets of the global economy. Ranging from Earth observation, navigation, data analytics to defence use, the array of applications of space science is vast and the various economic as well as social impacts on humankind are well acknowledged.

The Indian space sector has a long and illustrious heritage and its space agency, the Indian Space Research Organisation (ISRO), is one of the most successful space agencies globally. Its credentials include multiple successful space missions and development of indigenous technologies in a cost-effective manner. Although ISRO has led the space sector with remarkable achievements, there is huge potential for developing the space industry in India, free from the control of the government. The participation of the private industry in the space sector will bring multiple benefits for India – development of a self-sufficient industry contributing significantly to the national income and foreign exchange reserves, technological development of smaller component suppliers and possible vertical integration, better financial provisions through a regulated and well-facilitated business environment, development of an ecosystem of many more new small manufacturers and expansion of existing ones, culminating in a greater share for India in the global space economy.

The outlook towards the participation of private industries and start-ups in India's space sector is currently favourable. The space bill is also expected to encourage private industry participation. This timely paper captures the trends in the space sector and discusses the opportunities that lie ahead. It also analyses the various challenges that will arise during the privatisation process and critical aspects like intellectual property rights (IPR), transfer of technology (ToT), financing, insurance, liability clauses and the legal framework, which need serious consideration both by the government and private industries.

India needs the private industry to grow and contribute significantly both in terms of technological development and GDP and thus become a true partner to the government on India's journey towards emerging as the leader in the global space sector.

Neel Ratan
Regional Managing Partner – North and Government Leader
PwC India



Content

1 Objective

In today's world, a nation's development is contingent on the sustainable development of its various industries, with the private sector playing a major role. A strong ecosystem of private players along with the presence of government regulatory agencies is widely held to be the recipe for successful industrialisation. Private players bring in the necessary capital, technical know-how and business acumen, which is complemented by government's policy decisions and actions towards propagating research and a scientific temperament among people as well as creating a favourable business environment in the country. Participation by private players also helps in democratising technology knowledge, which has a positive impact on the nation-building process in the long run.

India has one of the most well-developed formal space programmes in the world and has achieved numerous successes through its state-owned agency, the Indian Space Research Organisation (ISRO). Ranging from development of satellites and launch vehicles indigenously, to rendering space-based services to the nation, bringing India's own Global Navigation Satellite System (GNSS) services through Indian Regional Navigation Satellite System (NavIC) to scientific and exploratory missions to outer space – the list of ISRO's achievements is extensive. India has made commendable progress in the field of space research through organisations like ISRO and others. There is huge potential for the technological knowledge thus gained to be applied for the development of a strong commercial space ecosystem by increasing the participation of private entities.

In India, ISRO is responsible for driving the space activities. Although several private sector companies have engaged with ISRO as suppliers and component manufacturers, they have never been vested with the responsibility of end-to-end manufacturing of space systems. With the advent of New Space, many start-ups who are looking to exploit the opportunities in the growing global and Indian space markets have emerged within the Indian space domain. These start-ups are developing technologies, products and services in upstream as well as downstream space activities. While these start-ups have an ambitious vision and possess the technological capability to realise it, they lack a strong footing when it comes to financial, regulatory and policy support. The need of the hour is a law that allows the private players to participate across the Space Value Chain within the Indian territory. The government has already taken the first step towards providing this essential support by announcing the Space Activities Bill, which is currently under review. It is also trying to encourage the participation of private players in the various initiatives of ISRO. The time is ripe for strong measures to be taken to encourage and incentivise private companies for taking up a major role in the commercial space sector, with the government playing the role of regulator and facilitator.

Given the above background, this paper takes a close look at the landscape of India's private space sector, identifies opportunities for its growth, examines the challenges faced by private players and start-ups and recommends affirmative actions required. It also presents the government and industry perspective based on extensive discussions with senior officials from Antrix Corporation, members of NITI Aayog, venture capitalists, space law experts, and private companies and New Space start-ups engaged in the sector. The views shared by these stakeholders, along with the landscape study and comparison with the European space industry, have helped us arrive at a compelling viewpoint on private industry participation in the Indian space sector.

2 Current landscape

India's space programme is managed by the Government of India's Department of Space and Indian Space Research Organisation (ISRO) through its multiple centres specialising in different functions and technologies. The private ecosystem predominantly comprises companies who are subcontractors of ISRO or use basic satellite services to provide various value-added downstream services. Of late, multiple start-ups have developed diverse capabilities such as end-to-end manufacturing of satellites, design of launch vehicles and development of GIS applications.

ISRO

About ISRO

ISRO has come a long way since the establishment of the Indian National Committee for Space Research (INCOSPAR) by the Government of India in 1962. ISRO is one of the largest space agencies in the world and it maintains a large fleet of communication, (INSAT)/Geostationary Satellites (GSAT) remote sensing, navigation and scientific satellites. It provides multiple application-specific products and tools for broadcasting, communication, disaster management, weather forecasting, GIS, cartography, navigation, telemedicine, among many other functions. ISRO has completed 118 spacecraft missions and 78 launch missions till 2019.[1,2] ISRO's launch systems have earned the reputation of being amongst the most reliable and cost-effective solutions in the world and have attracted international customers. ISRO is currently working to bring in more private industry participation in both the areas of launch systems and satellite manufacturing to build capacity and reach its designated targets and goals.

With over five decades of experience in the space sector, India is investing in enhancing its capacity and expertise in space products and services. Further, these initiatives are not limited to societal applications but also extend to commercial space activities like direct-to-home (DTH), very small aperture terminal (VSAT), digital satellite news gathering (DSNG) among others.

Since the 1970s, ISRO has encouraged the participation of private organisations in the national launch vehicle programme, especially for manufacturing components and sub-assemblies, by promoting a collaborative work culture. Industries in India have invested in creating facilities and producing various sub-systems such as structures, motor cases, propellant tanks, liquid engines, control equipment, chemicals and electronic packages, while mission design, assembly and testing, quality assurance, integration, and launch have been led by ISRO. Over the last four decades, an ecosystem of approximately 500 Indian companies has been developed, consisting mainly of small and medium scale enterprises (SMEs). These organisations are heavily involved in developing space launch and ground infrastructure facilities.

ISRO reports that 80% of the Polar Satellite Launch Vehicle (PSLV) production is outsourced to private industries, while in the case of major satellite missions such as the Mars Orbiter Mission (MoM), over 120 companies have contributed to manufacturing.[4]

ISRO has also established two steering committees to create a comprehensive strategy for collaboration with the industry. The committees are engaged in discussions with industry players on transitioning from vendors to integrators of launch vehicles and satellites.

Indian space budget

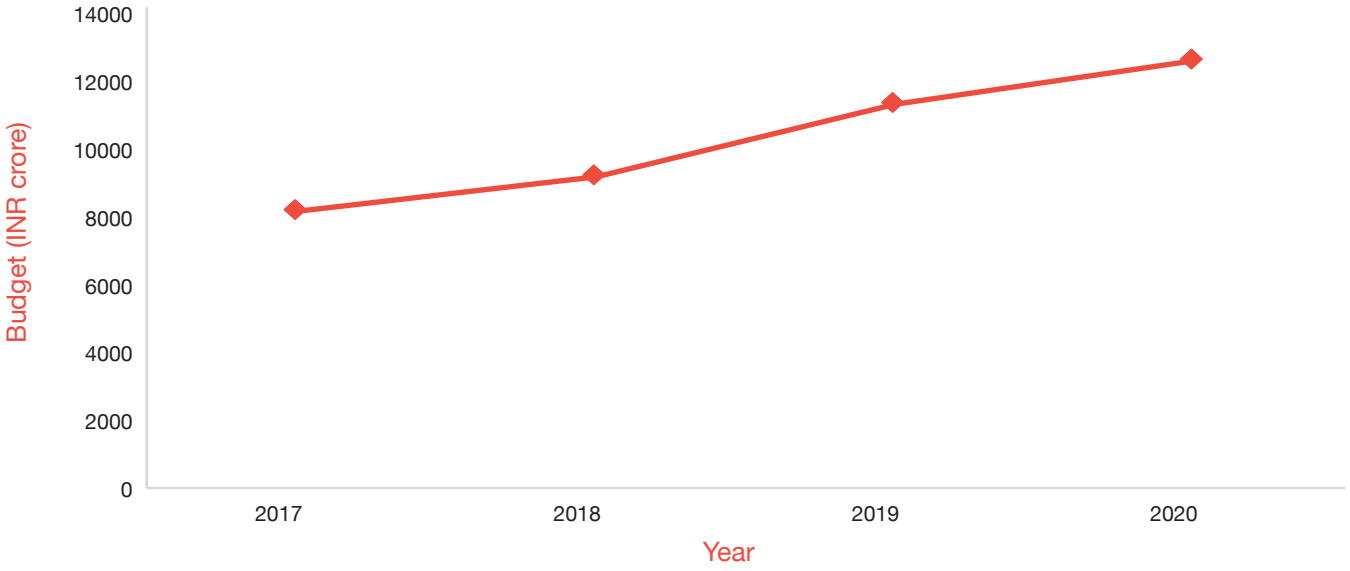


Figure 1

Source: https://www.isro.gov.in/budget-glance, https://www.business-standard.com/budget/article/budget-2019-fm-hikes-dept-of-space-outlay-pushes-for-commercialisation-119070500973_1.html

ISRO's existing space value chain mapping

ISRO's value chain mapping

Upstream

Launchers and satellite manufacturing

- Satish Dhawan Space Centre
- Vikram Sarabhai Space Centre
- Liquid Propulsion Systems Centre
- Laboratory for Electro-optic Systems
- ISRO Internal Systems Unit
- ISRO Satellite Centre
- Space Applications Centre

Midstream

Satellite operations and commercial activities

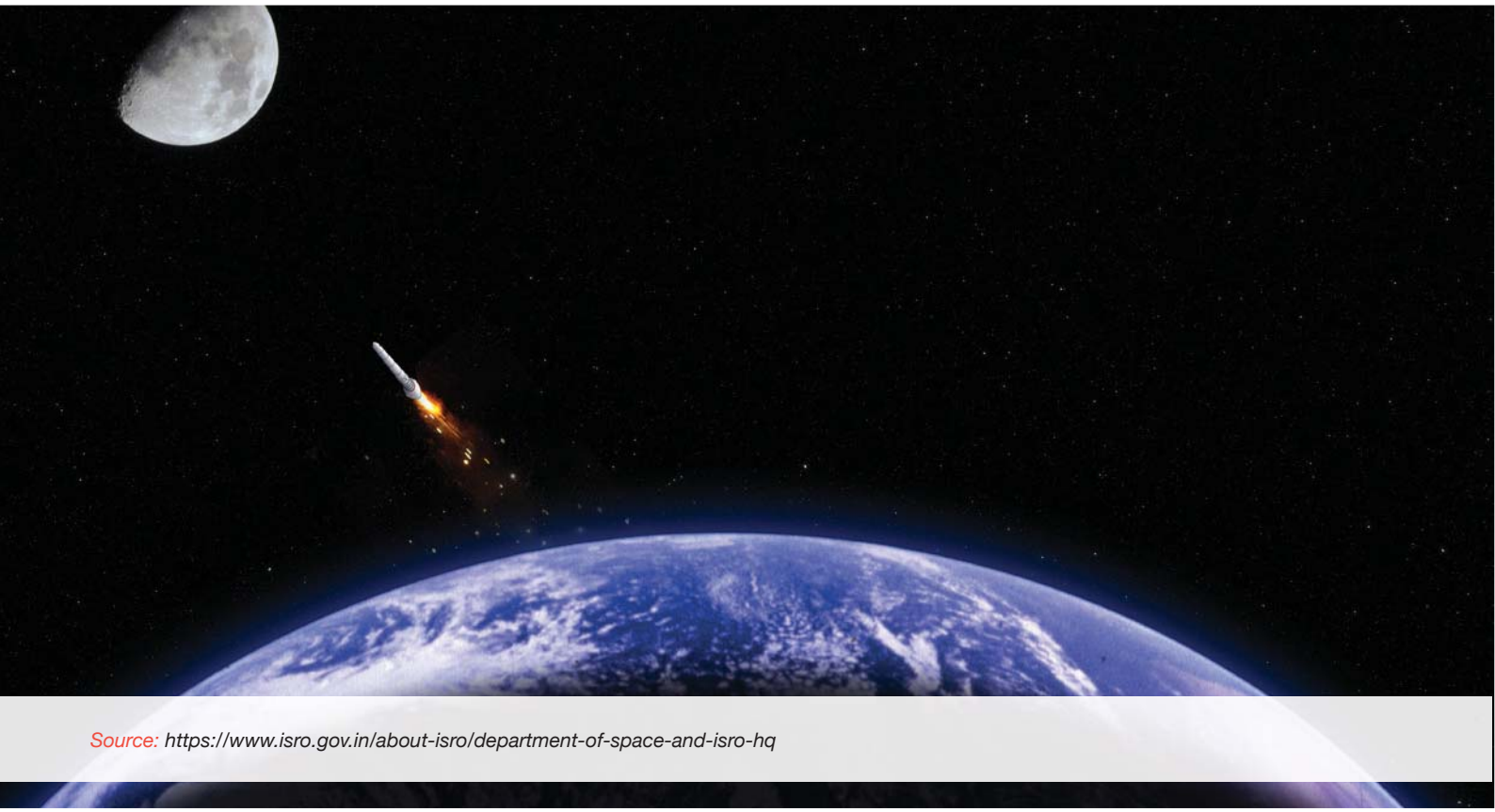
- Master Control Facility
- ISRO Telemetry, Tracking and Command Network

Downstream

Applications

- National Remote Sensing Centre
- National Atmospheric Research Laboratory
- Development and Educational Communication Unit
- North Eastern Space Applications Centre
- Regional Remote Sensing Centres

Figure 2



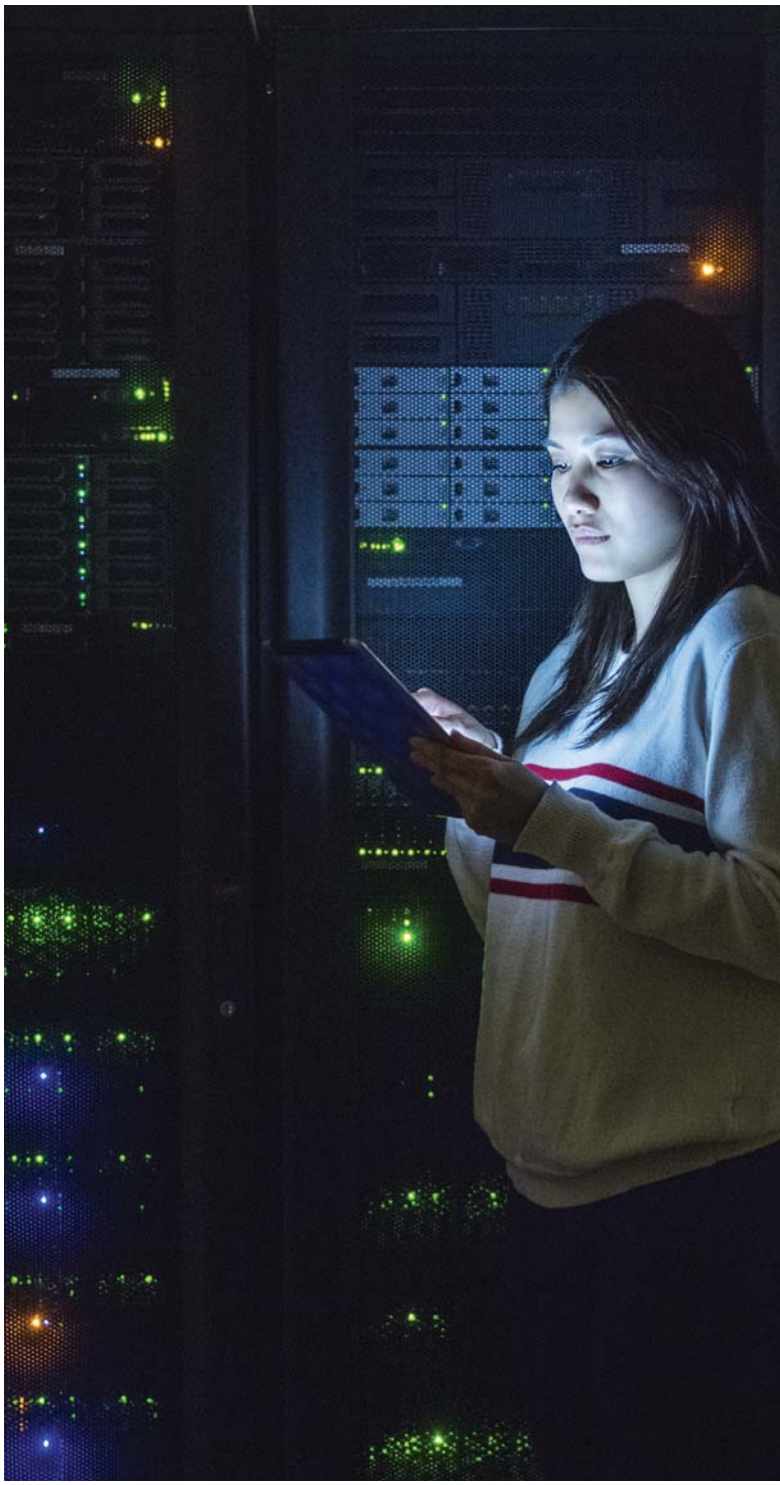
Source: https://www.isro.gov.in/about-isro/department-of-space-and-isro-hq

Private sector in the Indian space domain – current landscape

In India, space activities have traditionally been driven by the government to meet national needs with high focus on self-reliance and security. There has not been much emphasis on enhancing commercial activities in the space sector, and as a result, the participation of the private sector has been minimal in space activities. Commercial activities were driven by ISRO through its commercial arm, Antrix Corporation, and depended on the availability of spare capacity. Also, all commercial space activities were closely regulated and controlled by the Department of Space (DoS). This may be the reason why space commerce has not flourished in India as much as it has in other major space-faring countries. Although India has achieved major feats in space missions and allied activities, Indian space commerce accounts for less than 1% of the global market.

The downstream space segment consists of the application of satellites for communication, scientific research, weather forecasting, geological and oceanographic studies, disaster management, agricultural studies, and all products and services related to these areas. With the right use of data analytics capabilities coupled with artificial intelligence (AI) and machine learning (ML) algorithms, the data generated by remote sensing satellites can be of immense value for decision making. There is huge scope for the commercialisation of the ground operations like mission support, satellite broadband gateways and 5G backhauling.

> The ambition is to build a strong space ecosystem in the country and make India the space manufacturing hub of the world. All the bricks are there, we only need to build.
>
> - Mr. Rakesh Sasibhushan, CMD, Antrix Corporation



Existing value chain mapping of the private space sector in India

India has seen a large base of SMEs involved in supplying parts and components for satellite and launch vehicle manufacturing. These suppliers are tier 2/tier 3 service providers contracted by ISRO for meeting its demands.

In the last few years, there have been initiatives to help private industry build capacity in system-level integration; however, they still lack end-to-end manufacturing capabilities ranging from design to testing and launch.

In the recent times, ISRO has adopted public private partnership (PPP) policies to encourage companies to take up more production activities rather than being part/component manufacturers.

ISRO has also formed a consortium of private industry players for Assembly, Integration and Testing (AIT) of 30–35 satellites. To encourage more private participation, ISRO has built a facility spread over 25 acres in Bengaluru where the amenities have been set up for use by the industry.[5]

Government entities involved in commercial space activities

Antrix Corporation Limited

Antrix Corporation was incorporated in September, 1992 as a company under the administrative control of Department of Space, Government of India. Antrix is the commercial arm of ISRO and it promotes and markets the products and services generated by the Indian space programme.

Antrix recognises the necessity of private sector participation for the Indian space sector to grow and harness a fair share of the global market and strives to develop better models for inclusion in the sector.

The current responsibilities of Antrix include:

A

Provision of communication satellite transponders to users: Antrix enables satellite communications service providers with necessary space segment capacity, predominantly covering the Indian region. Over 190 transponders in the INSAT/GSAT system and close to 100 transponders leased from foreign satellite operators are provisioned to Indian users for various services.[6]

B

Market data from Indian and foreign remote sensing satellites: Antrix offers data from a constellation of Indian Remote Sensing (IRS) satellites to international customers. Currently, Antrix markets IRS data and services from RESOURCESAT, CARTOSAT and OCEANSAT satellites. It has signed five reseller agreements to promote IRS products across the globe and is in the process of identifying more resellers for wider outreach of IRS products. In addition to data dissemination, Antrix is focusing on value-added services and capacity building to global customers.

C

Build and market satellites, satellite sub-systems and user applications: Antrix is supplying NavIC only SPS receiver modules, NavIC + GAGAN/ GPS receiver modules and NavIC only passive antenna to various parties. The company has fabricated the NavIC Messaging Receiver through industry, which will find wide acceptability with the end user community.

D

Establish ground infrastructure for space applications: Turnkey end-to-end solutions in designing, system engineering, procurement, installation, commissioning, operationalisation, hosting and maintenance of state-of-the-art satellite earth stations/telemetry, tracking and command (TTC) stations and associated support systems, safety and security systems, and integrated monitoring and control systems.

E

Provide mission support services for satellites: Antrix serves prestigious customers for Telemetry, Tracking and Command (TTC) and other associated services for satellite operations from across the globe. In agreement with M/s Intelsat, it has supported the Transfer Orbit Support Services (TOSS) for the Amazonas-5 and Viasat-2 satellites using the Earth Stations at Master Control Facility (MCF). It also provided TTC support to the Swedish Space Corporation and KSAT of Norway.

New Space India Limited (NSIL)

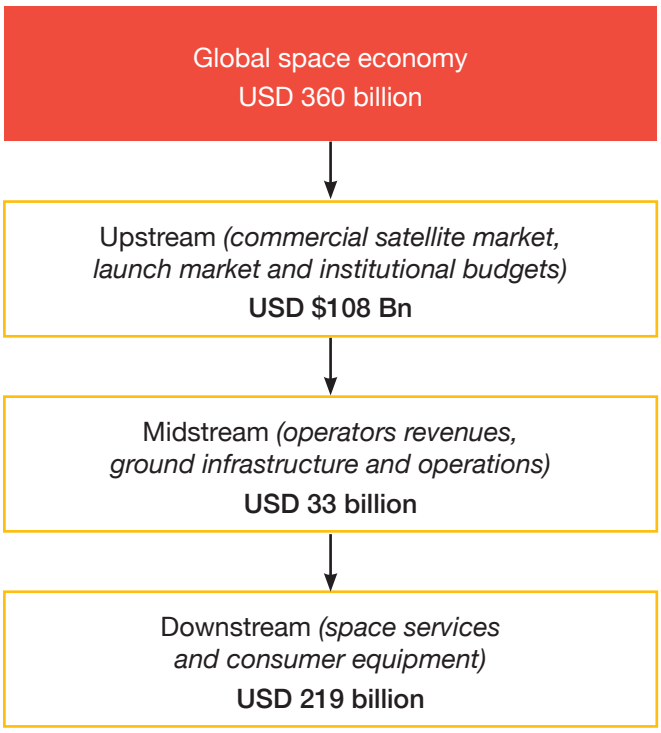
The New Space India Limited (NSIL) was set up by the Department of Space in March 2019 to handle the commercial activities of ISRO. It aims to supply the products and services developed through the Indian space programme to customers across the globe, and to boost the growth of the Indian industry by taking up more technologically advanced space-related work. It plans to empower the industry in India through mechanisms like ToT and to serve the Indian and global market in the areas of Small Satellite Launch Vehicles (SSLVs), satellites for multiple applications, and leveraging space technology by-products for the betterment of mankind.

Major areas of work:

- Obtain licence from DoS/ISRO for SSLV technology and transfer it to the industry through sub-licencing
- Provide launch services for customer satellites
- Manufacture SSLVs in collaboration with the private sector
- Production of Polar Satellite Launch Vehicle (PSLV) through industry
- Production and marketing of space-based services
- T-o-T to the industry through sub-licensing
- Market by-product technologies and products or services.

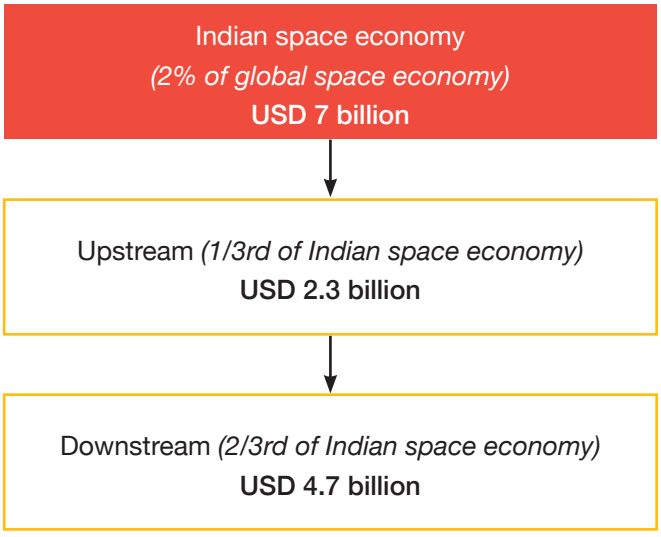
3 Size of India's space economy

The current global space economy is pegged at USD 360 billion[8] and the approximate split between upstream, midstream and downstream activities[9] is as follows:



Source: PwC analysis

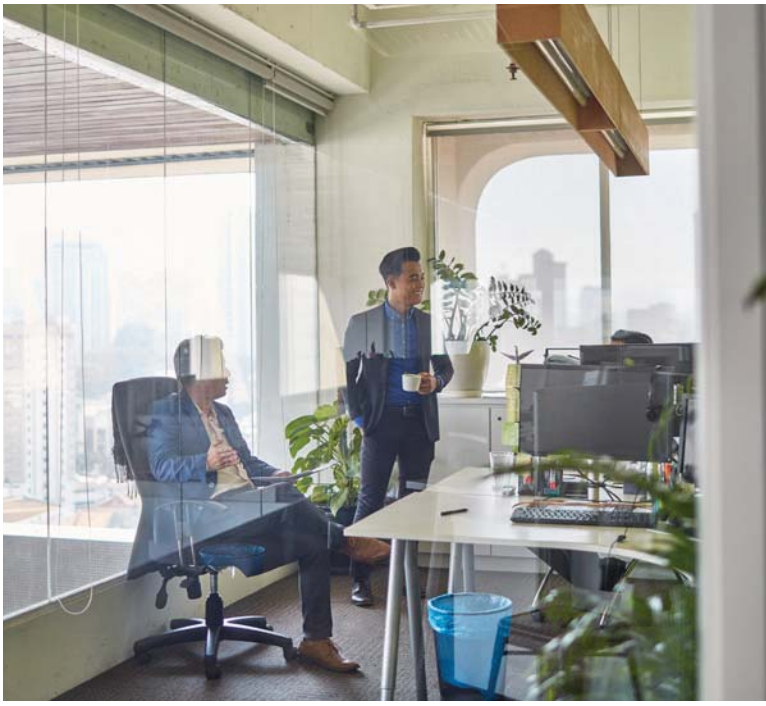
The Indian space economy is valued at USD 7 billion, which is around 2% of the global space economy. Of this, upstream activities contribute USD 2.3 billion and downstream activities contribute USD 4.7 billion.[10]



Source: PwC analysis

With a target to contribute 1% to India's envisaged USD 5 Trillion GDP in 2024, the Indian space sector needs to reach USD 50 billions.

The Indian space sector needs to grow at ~approximately 48% CAGR over the next five years to reach USD 50 billion.



4 Opportunities

With the success of exploratory missions to Moon and the Mars, and the government's impetus on promoting space technology-based tools and applications in governance, along with the growth in commercial applications, newer avenues are opening up to tap the economic and commercial potential of space technology products and services. With significant market advantages like high demand for services, strong domestic manufacturing base, cost advantage, a large human resource pool, and ability to leverage IT skills, the time is ripe for Indian policymakers to encourage a greater role for the private space industry.

Private industry's contribution to Innovation in the space sector and at ISRO has traditionally come through the subcontracting mode, while critical value addition activities have been carried out in-house. However, association with ISRO has helped many industries to recognise the potential of space technology and to acquire many space-related skills. ISRO's reputation for developing high-quality products based on decades of expertise and reliability becomes a leverage point for domestic companies engaged with ISRO missions to compete globally in various space markets. With the right set of policy directives and the increasing influence of India in global affairs, ISRO can exploit its position and launch segment capabilities to provide services to developing and developed countries who do not possess similar capabilities or a cost advantage. As a result, the Indian private space industry, which mainly comprises the SMEs that have expertise in fields like precision machining, precision assembly, fabrication and integration of electronic packages, calibration, testing and evaluation of space systems, will benefit immensely.

> The country wants to support innovation in the space sector and increase its contribution to the national GDP.
>
> - Dr. V.K. Saraswat, Member, NITI Aayog

To boost industry participation, ISRO has recently set up an outreach facility for geospatial application at the National Remote Sensing Centre (NRSC) and announced a plan to set up 12 space technology incubation centres across the country to promote innovation and research. Similarly, the Government of Kerala has also invested in a space technology park to support the development of space technology products and services.

Trends and perspectives on upstream and downstream sectors of the space industry

Upstream

Satellite manufacturing

In the current environment, with the rising space-based needs of security agencies, ISRO will not only have to continue the routine development of remote sensing and telecommunications missions but also need to deliver for national security requirements. A large-scale market opportunity for private enterprises in the Indian space sector can arise if there is a flagship programme to facilitate the development of spacecraft by the industry on a routine basis. This will enable ISRO to focus on the development of the next generation of technologies.

Small satellites are transforming the dynamics and economics of the space industry. **According to a recent market study, it is estimated that more than 10,000 small satellites will be launched in Low Earth Orbit (LEO) by 2026.**[12] There has been a global trend of collaboration between government agencies and private parties for manufacturing small satellites and microsatellites, which has been made possible through the miniaturisation of electronic and other components and increasing effectiveness of global supply chains.

Cost of launching accounts for more than 60% of the budget.[13] Lighter satellites have a cost advantage and if advanced and affordable electronics are leveraged, then lightweight satellites can easily become alternatives to large satellites.

Small satellites require less time to build, thus improving the upgrade frequency. Setting up a large constellation of small satellites to secure wider coverage can also be achieved in a shorter span of time. The faster development cycle ultimately helps in planning and managing the launch schedule with higher predictability.

There has been a spurt in demand for satellite-based applications such as remote sensing and communication, and this has boosted the demand for small satellites, which New Space start-ups are aiming to fulfil. Antrix initiated the ToT of small satellites to boost the New Space ecosystem in India.

Another important trend is an increased demand for servicing satellites required for in-space repair or upgrading satellites in orbit. According to Northern Sky Research (NSR), a major satellite and space market research and consulting services provider, **the total size of the in-orbit servicing market (IOSM) will be USD 4.5 billion by 2028.**[14] Organisations like the Defense Advanced Research Projects Agency (DARPA), Orbital ATK and Effective Space are developing servicing spacecrafts.[15]

Launchers

There has been a rise in demand for nanosats and mega constellations of small satellites, which has in turn made satellite launch services a lucrative business. According to Euroconsult, the launch and manufacture of small satellites together can increase by about 3.5 times in the coming decade – from USD 12.6 billion in 2009–18 to USD 42.8 billion 2019–28.[16]

To tap this huge market, companies across the world are developing small satellite launch vehicles. ISRO has also announced the building of an SSLV that can lift satellites up to 500 kg to in LEO[17] and that can be assembled by a handful of people in three days, compared to the few months required for bigger rockets.

For the production process, ISRO has been successfully practicing a subcontracting model for all its launch vehicles.

However, such a model is not adequate to achieve cost optimisation and production efficiency. These objectives can be achieved by executing an end-to-end production set-up, with optimum numbers planned and transparently communicated to the industry.

> The important thing is to manufacture a quality product in a cost-effective manner. Currently, there are nearly 40 companies globally, including 4 in China, developing small launch vehicles. One has to wait and see who will survive in the long run.
>
> - Mr. Rakesh Sasibhushan, CMD, Antrix Corporation

India's ability to stay at the forefront in an increasingly competitive space market with multiple actors, including commercial players, depends on how it integrates private players into the ecosystem and encourages them to lead from the front. For this purpose, the manufacturing of SSLVs by Indian private players is aimed at building a strong space ecosystem in the private sector and, through this, garnering a fair share of the growing launch market.

There exists a scope to commercialise the development of medium and heavy-lift launchers. This will provide India an opportunity to capture a larger portion of the international launch market.

Increasing private participation for quicker manufacturing can enable the Indian space industry to increase the number of medium and heavy-lift launches and gain volumes in business and further traction in the global market.

Downstream

Earth observation

ISRO possesses critical resources like data archives from Earth observation satellites which can be beneficial to citizens and businesses and can support better decisions and policies. This model has been adopted in Europe for the Copernicus Programme, which has supported numerous start-ups that have developed multiple services by leveraging this data. Innovative and methodical planning for sharing of ISRO assets to build a start-up ecosystem is of utmost importance.

Technologies like hyperspectral imaging and synthetic aperture radar (SAR) can be deployed on small satellites, and this can open up new markets, which hitherto were not using satellite imaging. The companies traditionally involved in the earth imaging business are now moving to data analysis using the huge amount of data generated by the satellites. **The imaging data analytics industry itself will be a massive market, which is poised to grow by nearly 30% over the next decade.**[18]

The role of earth observation in the areas of environmental protection, disaster management and defence is increasing with the improvement in existing technologies and development of newer ones. These technological developments, coupled with advanced big data analytics and improved ML algorithms, are providing better insights into multiple sectors of the economy, which are being leveraged for commercial use.[19]

Scaling up private sector services will allow several SMEs to cater to local business-to-government (B2G) and business-to-business (B2B) requirements, while creating several services such as data analytics based on remote sensing for commercial applications. In order to foster commercial applications based on remote sensing, there is a need to engineer mechanisms that act as a bridge between the data producer (ISRO), the data seller (NRSC/Antrix), the data application builder and the end user.

The Earth observation downstream market is expected to be worth EUR 4 billion by 2022, growing at a projected CAGR of 7% and primarily driven by information products and big data solutions.[20]

Trends in the EO market

Changing market dynamics

- Vertical integration - data providers are becoming analytics providers
- Cost reduction – access to computing power and storage capacity is becoming cheaper thanks to cloud technologies

Move towards open innovation

- A number of open data sources for EO data are becoming available
- Increase in innovation with open source tools

Emerging platform paradigm

- Thanks to digitalisation of geospatial market-places, satellite data providers are moving to a subscription-based business model

Need for actionable intelligence solutions

- End-users of Earth observation data do not have strong technical knowledge or storage capacity in-house, and so require very specific insights

Figure 3

Source: https://www.pwc.fr/fr/assets/files/pdf/2019/06/fr-pwc-main-trends-and-challenges-in-the-space-sector.pdf

Communication

Satellite communication is still the largest services market.

The estimated global market for satcoms (from upstream to downstream) in 2017 was approximately USD 130 billion, 80% of which was generated in downstream work.[21]

There is a major trend of deploying LEO smallsat constellations with thousands of satellites, to achieve high throughput and global coverage. To overcome the constraint of limited availability of radio frequencies, there will be increased interest in optical communication, which is already used in some constellations like the European Data Relay Satellite System (EDRS). An Indian start-up intends to build the entire chain of an optical communication system to provide secure communication links at higher data rates with lower form factor and power compared to RF systems.

The other significant trend driven by commercial satellite operators is the building of in-space edge routing and other networking platforms, like terrestrial applications. The miniaturisation trends would extend to satellites across all orbits and would provide new connectivity methods for areas not covered by fibre or 5G.

Start-ups are also developing ultra-high capacity transponders which operate in the millimetre wave frequency range to provide better spectral efficiency and a large amount of unused bandwidth. These provide much higher uplink/downlink capacity per satellite.

There is considerable demand in India for satellite-based services for communication purposes, and this will see upward movement with the implementation of initiatives like 5G, Internet of Things (IoT) and BharatNet.

Challenges

- The absence of a national space legislation leads to a lack of clarity on conducting space-related business activities in the country, especially those involving ToT, liability provisions, insurance and matters of indemnification. This significantly increases multiple risks to businesses in the Indian space sector. The swift approval of the Space Activities Act will address these issues and risks and pave the way for better business environment in the space sector.
- One key issue to be addressed related to IPR is the licensing and certification norms for space entrepreneurs who are interested in undertaking commercial activities in India.
- There is a lack of awareness about the demands of the global space industry and the technical know-how to develop end-to-end space systems to cater to the global needs.
- Lack of established regulatory framework and guidelines for technology commercialisation and funding in the space sector result in a dearth of private investment in the Indian space sector as private companies and start-ups do not find much incentives for investment.

5 Enablers

Private investment in the sector

According to the research firm Bryce, space start-ups raised USD 3.2 billion in funding last year globally.[22] However, India has only managed to attract a small share of the investment, despite it being one of the few countries with a well-developed space programme.

The complexity of India's space sector has not proved to be a hindrance to India's flourishing start-up ecosystem. Nevertheless, one common problem that start-ups face is that of financial support, and this needs to be immediately addressed to ensure the commercial success of companies and enable them to gain a sizeable share of the global space market.

Several venture capitalists (VCs) are ready to invest in space start-ups; however, they do not have clear visibility into potentially successful business cases. Private investment is not the only channel to build capable space companies. As the New Space ecosystem is still emerging, contracts with a shorter life cycle (e.g. design contracts, study contracts, developmental contracts) would be beneficial for start-ups. The government should explore the possibility of joint space initiatives involving ISRO and these start-ups in equal capacity.

VC investors are of the view that the combination of intellectual property (IP) and commercialisation of products is ideal to get a VC on board. They also attach importance to a start-up's level of readiness to decide on funding. For instance, if a start-up has its hardware ready and functional in the laboratory, then the decision and quantum of funding would be different than in a situation where the concept is at the ideation stage. Venture capitalists in India prefer a start-up with some relationship or engagement with premier research institutes such as the Indian Institute of Technology (IITs), Indian Institute of Science (IISc) or Indian Space Research Organisation, as it helps build trust in the technological foundation of the business.

Institutional and legal framework and capital investment

The regulatory framework is one of the biggest challenges faced by the private sector in the Indian space domain. Hopefully, the new Space Activities Bill, which is expected to be enacted soon, will bring the required clarity to the Indian space scenario.

Service delivery and decision making are critical challenges. ISRO is a party involved in both, thus creating doubt in the mind of investors, if their licence applications will receive fair consideration. However, ISRO has now begun to express interest in partnering with the private sector for operations in order to focus on research and development (R&D) and begin disinvesting from existing governmental space operations. This move will help ISRO retain its position as a leading innovator in space technology while allowing the private sector to assume a larger role in space operations. A business-friendly and encouraging space act will encourage VCs invest more actively in the Indian space sector.

The regulatory structure also needs to be refined as more players join the ecosystem. Today, the Department of Space (DoS) acts as the regulator, but since it is a major service provider through ISRO, there exists scope for a conflict of interest. This model was followed in the telecommunication sector, with the Department of Telecom (DoT) being the regulator and a service provider through the public sector corporations BSNL, MTNL, and VSNL. In 1997, an independent regulator was formed through the introduction of the National Telecommunications Policy.[23] The Indian space regulatory framework is due for such an overhaul. This will help in fuelling the growth of private industries in the Indian space ecosystem.

Today, there is lack of clarity about the procedure for obtaining authorisation to launch, frequency allocation mechanism and the different agencies involved in the procedure. A licensing/spectrum allocation framework that simplifies the procedure is a must for successfully building a start-up ecosystem. The critical requirement for start-ups is a single window system that will eliminate the entry barriers.

Key considerations for enhancing the attractiveness of the space sector for private industry:

- **Duration of licensing procedures**
  - Reducing duration of procedures
  - Holding pre-consultation workshops to shorten application delays
- Reduce inter-agency procedures as much as possible to avoid application delays
- **Insurance:** Introduce a suitable insurance policy that limits the liability of the start-up while fulfilling the obligations of the nation under the Outer Space Treaty

Public-private partnership and transfer of technology

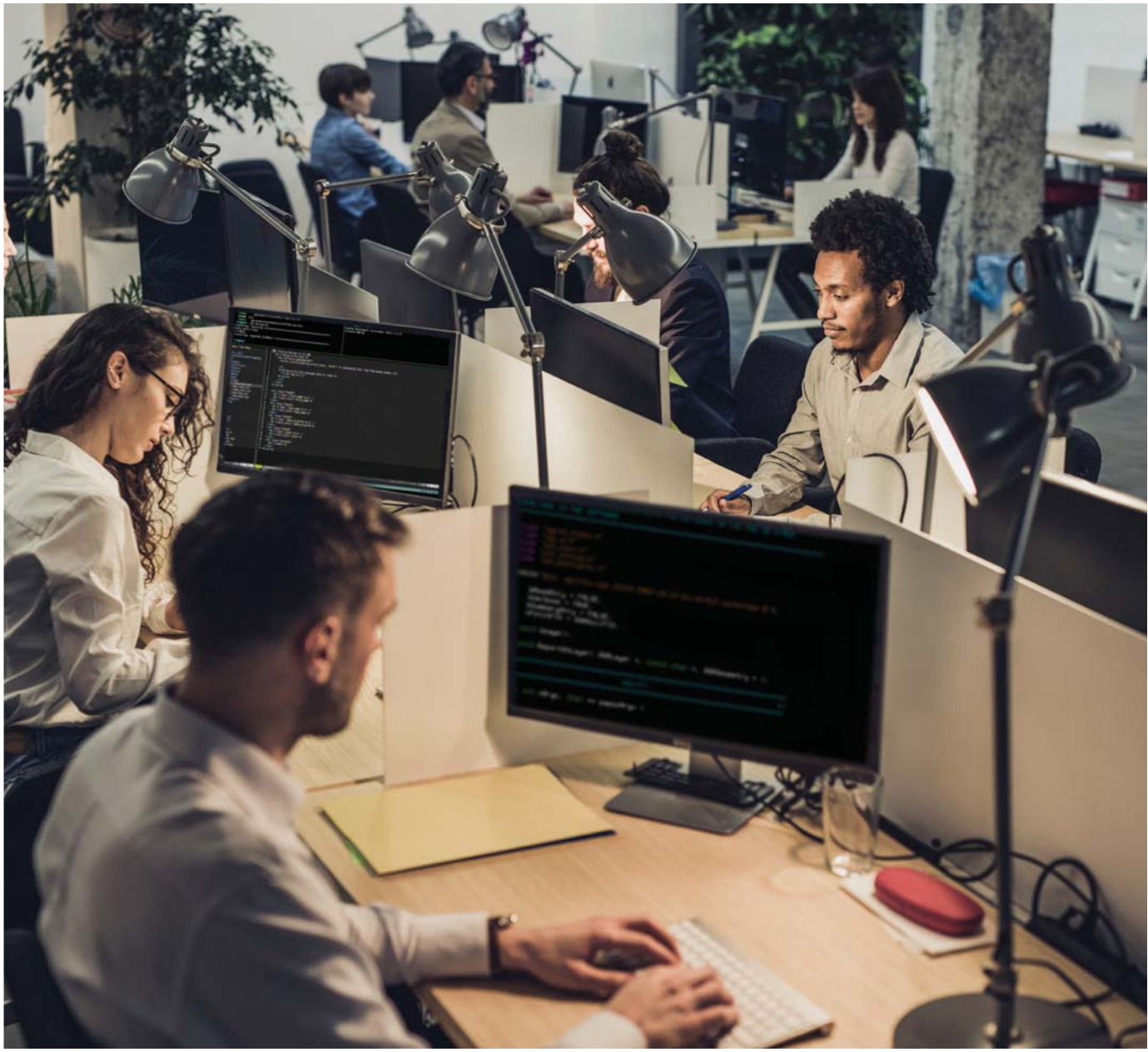
ISRO has been encouraging PPP in the Indian space sector in multiple areas like component manufacturing and satellite AIT. These activities are rightly positioned to help private players mature technologically and adopt the technical and process requirements of space systems.

> The PPP model of engagement should be followed up by ToT. Also, building facilities required for space are too capital intensive and may deter ambitious projects. Therefore, defining guidelines on which facilities can be spared for industries, including the commercial terms, will be of great value to the budding space industries.
>
> - Mr. Rakesh Sasibhushan, CMD, Antrix Corporation

India is a major space-faring country, but only a few industries possess the technology to design, manufacture, qualify and supply space subsystems like various types of sensors, inertial systems, control mechanisms, propellant storage and delivery systems, thrusters, power systems and payloads. This can be addressed by a well-defined ToT policy and identifying technologies and products that are of commercial interest. A ToT policy coupled with a buyback arrangement will ensure that the industry is qualified to compete in the global market. This was the objective behind Antrix Corporation's ToT process for small satellite technology.

In this regard, NITI Aayog is of the view that a layered technology transfer mechanism will be suitable for the Indian scenario. Initially, ISRO will provide the private sector with detailed designs and drawings, and the latter will build components and subsystems as per the designs. As the private industry matures, the 'build to specifications' practice will commence, wherein ISRO will share the technical specifications with the private industry and they will start by creating detailed designs and drawings before development. Finally, when the private industry is highly mature and capable of developing end-to-end systems on its own, ISRO will only share requirements with them, and thus the build to requirements practice will come into play. In the build to requirements stage, private players will be expected to design, develop and commercially produce launch vehicles and spacecraft on their own.

6 Privatisation across global space agencies



Space exploration started with the launch of Sputnik 1, the world's first artificial satellite. It was developed and launched by the erstwhile USSR in October 1957 and was followed up by sending an astronaut on board Vostok 1, in the year 1961. The USA launched its first satellite, Explorer 1, in 1958, which it followed up by sending an astronaut into space in 1962.

The space sector has come a long way since then and today many countries around the world have space missions and dedicated space agencies to realise their ambitions. The following are the major international space agencies:

- National Aeronautics and Space Administration (NASA), USA
- European Space Agency (ESA) and European Global Navigation Satellite Systems Agency (GSA), European Union
- Indian Space Research Organisation (ISRO), India
- Japanese Aerospace Exploration Agency (JAXA), Japan
- The National Centre for Space Studies (CNES)
- China National Space Administration (CNSA), China
- Roscosmos State Corporation for Space Activities, Russia

There have been multiple instances of collaboration between the above space agencies with the goal of advancing space science and realising benefits for mankind. A few countries have also formed regional cooperation programmes in the space sector, the prime example being the Asia-Pacific Space Cooperation Organization (APSCO), a cooperation initiative between eight countries focused on sharing of ground infrastructure and information for monitoring and other applications and knowledge development.[24]

Major space agencies

Case study: Privatisation in the European space industry

An overview of the European space ecosystem

The European space ecosystem comprises a mix of public and private entities acting across the entire space value chain. Within Europe, there are national space agencies like the Centre Nationale d'Etudes Spatiales (CNES) in France and the Agenzia Spaziale Italiana (ASI) in Italy.

The ESA is an intergovernmental organisation dedicated to the peaceful utilisation of space by its 22 member states (ESA's programmes range from launchers, Earth observation, navigation, and science and exploration). In addition, the European Commission (EC) is increasingly starting to play a strong role in developing the European space ecosystem. In collaboration with ESA, the EU member states and the private sector, various research and innovation activities are being carried out to boost the private uptake of the space industry.

Europe has strong competence and capabilities in the aviation and aerospace industries. As such, Europe's space ecosystem is considerably privatised compared to its Indian counterpart. Across the value chain, from launcher production and satellite manufacturing to satellite operation and downstream applications, Europe encourages strong private participation in the space sector.

The next section discusses the instruments and spacecraft in European public space programmes which have largely been developed by private sector entities, despite being owned and operated by public entities in most cases. The section also illustrates the strong private presence across the value chain – from launchers to downstream applications – driven by the industrial and commercial policies of the governing bodies along with the rich technological expertise and focus on research and innovation.

Upstream

A. Space transportation

Space transportation activities at ESA include the Ariane and the Vega programmes which contribute to the launch services at the Centre Spatial Guyanais (CSG) and the Future Launch Preparatory Programme (FLPP). The design, development and manufacturing of the launchers are carried out by the European private sector, for which ArianeGroup acts as the prime contractor. For instance, ArianeGroup has manufactured the small-lift launch vehicle Vega-C by creating collaboration between multiple suppliers. Apart from the Ariane and Vega programmes, Europe is also encouraging the development of private launchers through its FLPP. In addition to ArianeGroup, a number of other private players are pursuing the development of micro launchers which are capable of carrying up to 500 kg to a low Earth orbit.

B. Space exploration and human space flight

Space exploration forms the core of ESA's activities, with upcoming missions including ExoMars, ESA's Mars exploration mission, and the JUpiter ICy moons Explorer (JUICE), ESA's upcoming mission to the Jovian system. The spacecraft and instruments for these missions are manufactured in partnership with the private sector, where the private sector builds and/or designs the components based on ESA's requirements. As a result of the collaboration with NASA, ESA is involved in building the service module for the Orion.

To enable private industry participation in lunar exploration, ESA came up with the concept of a 'Moon Village', where ESA envisions itself in a stewardship role for developing lunar missions. For this, ESA wants to connect entities with complementary capabilities to support the development of the Moon Village. For example, ESA may help a lunar resource exploitation firm to set up lunar resource utilisation infrastructure by connecting the entity with a lunar lander manufacturer and a launch provider.

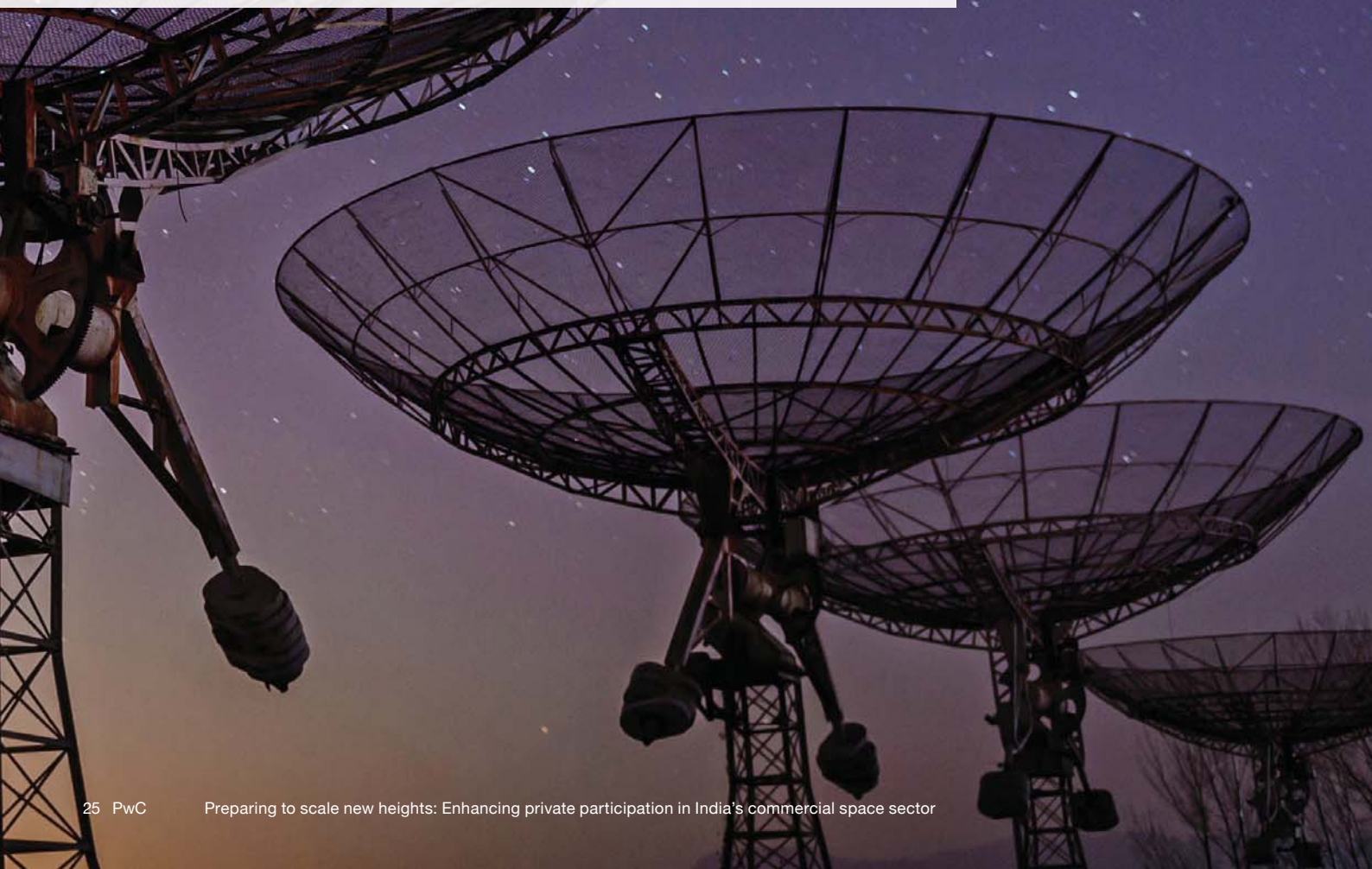
Downstream

A. Navigation, communication, and Earth observation

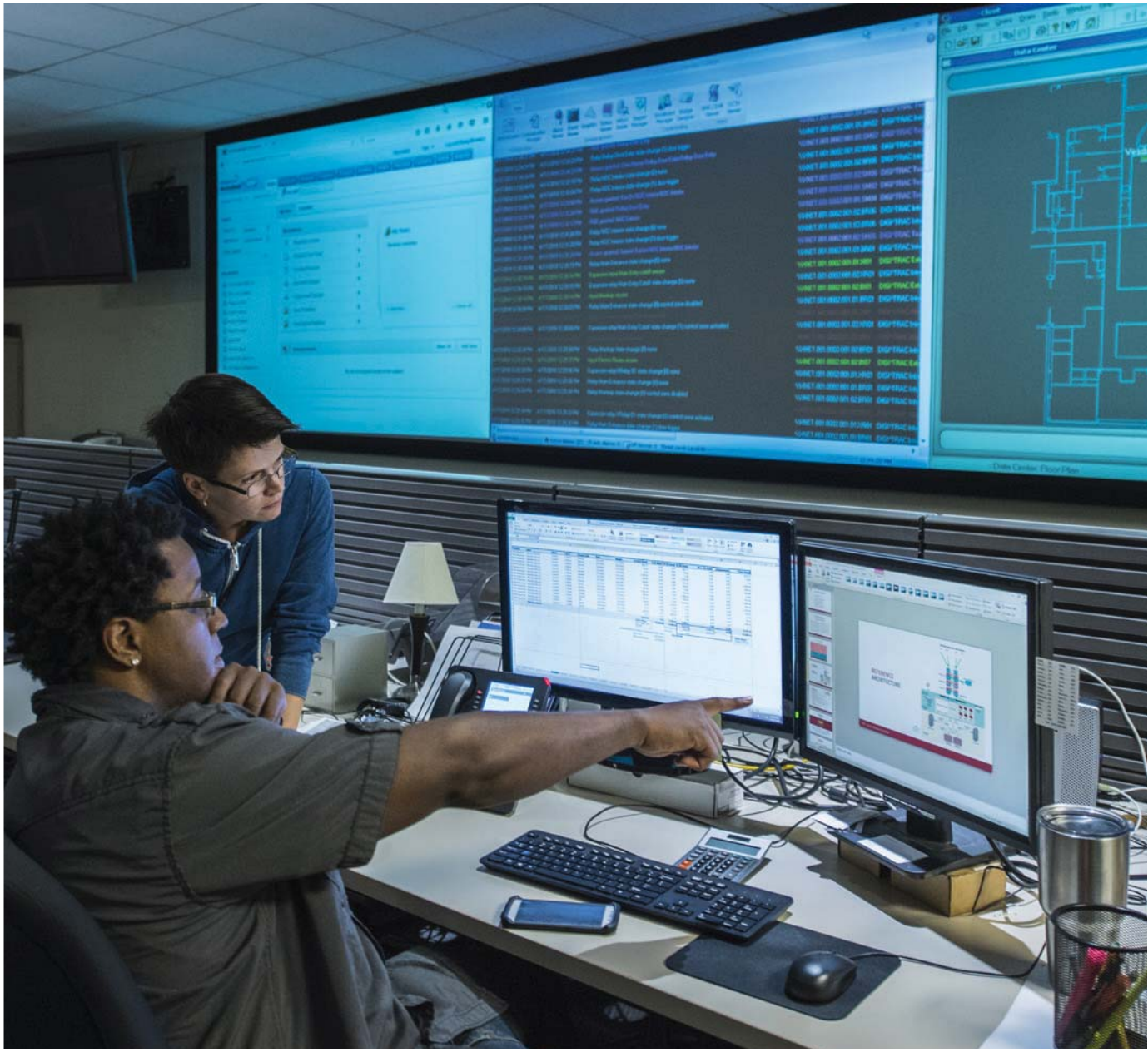
ESA's earth observation strategy is driven by major programs like the Future Earth Observation programme (formerly the Earth Observation Envelope Programme (EOEP) and Copernicus Programme among others. The Copernicus Programme was started in 2014 and is coordinated and managed by the European Commission (EC) in partnership with ESA and national agencies. The programme aims at collating data pertaining to the environment to provide an overview of the planet around six main themes: atmosphere, marine, land, climate, emergency, and security.

Galileo, the European global navigation satellite system (GNSS), is another EC initiative to which ESA and various private entities contribute. The EC manages Galileo through the European GNSS Agency (GSA), the entity that aims to ensure European public interests are represented in European satellite navigation programmes.

Communication, on the other hand, has a strong presence from the private sector. The ESA's activity in the communications sector is primarily research oriented, mainly through the Advanced Research in Telecommunications Systems (ARTES) programme, which aims to support the development of often economically risky technologies in the satellite communication sector. This is done by developing business applications that use satcom technology, supporting next generation satcom products and technologies, and through PPPs to co-fund the investment in new technology.



7 Conclusion



India possesses the critical capabilities to become a major player in the global commercial space market. The areas of application with huge potential are communication (5G, broadband) and earth observation for better governmental and commercial decision making. There is a trend towards service delivery through small satellites and small satellite constellations, which are suited for the growing needs of the sector. The private industry is well placed to take up a leading role in meeting security, R&D, and innovation needs as ISRO shifts its focus towards pursuing research and development and innovation. The emergence of new communication technologies, advanced data analytics capabilities and greater use of Earth observation data are enabling the private players to come up with newer applications and ensure greater participation in the space ecosystem. Privatisation of manufacturing in the space sector will help India capture a larger share of the global market. The absence of a space policy poses a hindrance for commercialisation of the sector in India. Some start-ups have already begun to capitalise on the opportunity, but India needs much higher participation by private organisations to meet domestic needs fully and capture a sizeable portion of the global market. The initiation of New Space in India has given rise to expectations of de-regulation of the space sector by the government.

Private organisations are favourably disposed to invest in the sector, with large corporations having made an entry and MSMEs continuing to play a critical role in ISRO's current value chain. However, lack of clarity regarding space sector regulations, the absence of an assured market and a long incubation period disturbs the risk-return profile and leads private organisations to take a cautious approach in order to ensure maximum returns to their shareholders. Additionally, with a lowest cost selection approach in practice, instead of lower total cost of ownership, the business case for these companies becomes unsustainable. This is where ISRO and the government need to play a crucial role in promoting both the supply as well as demand side by assuring the private sector of a market for its products and services.

To realise the goal of space sector's contribution to the tune of 1% of the USD 5 trillion GDP by 2024, India needs to create a conducive environment through suitable legal provisions, the presence of a strong regulatory framework and agency, ToT arrangements along with IPR management, liability and indemnity clauses, positive tax laws and strong insurance arrangements, etc. Start-ups need unhindered access to capital to scale up capacities and capabilities. The investment ecosystem for the space sector is very nascent in India and so, a congenial regulatory environment will be able to help Indian manufacturers attract seed funding and attention for possible foreign direct investment (FDI), mergers and acquisitions (M&A) and joint ventures (JVs) with international partners that will bring mutual benefit. Government support is also needed in the form of buyback arrangements or schemes to incentivise investors.

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