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TIP

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Volume 9 ǁ Issue 2 ǁ May 2022

SPACE INTELLIGENCE THE FUTURE IS NOW

Azadi Ka Amrit Mahotsav Special Edition

75 Students' Satellites Mission

Azadi Ka Amrit Mahotsav

आज़ादी का अमृत महोत्सव

75 Students' Satellites Mission

ITCA's Engineering Prowess and Ingenuity

INDIAN
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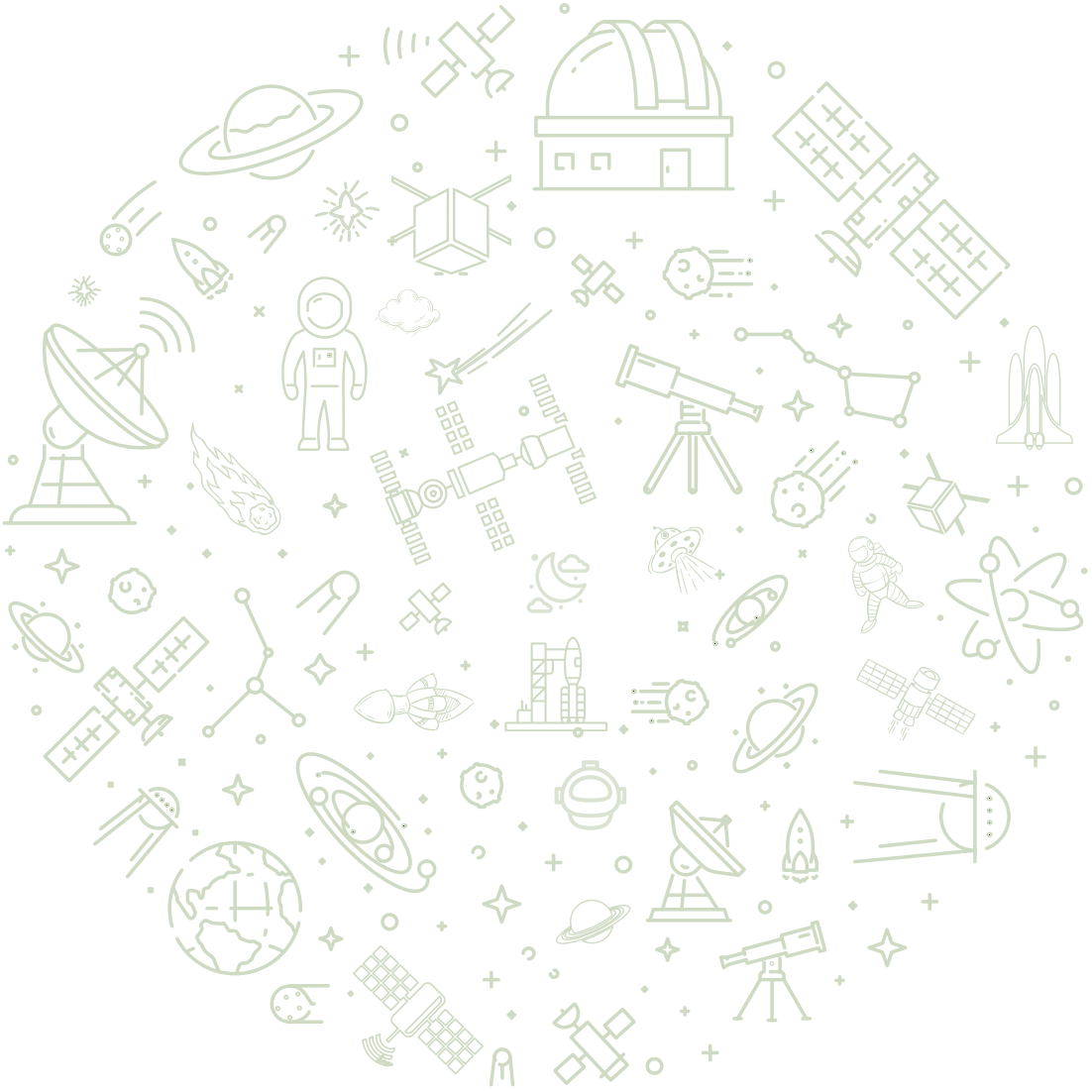

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Azadi Ka Amrit Mahotsav Special Edition

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Mission

Encourage interdisciplinary thinking by disseminating curated scientific and engineering knowledge to stimulate and inspire Indian engineering and technology ecosystem

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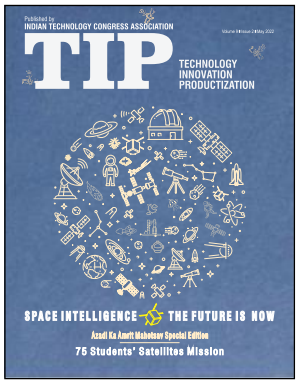
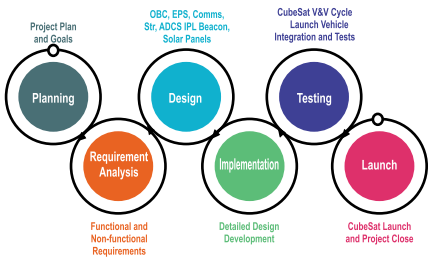
The set of images symbolizes everything that can be observed on the Earth and in Space.

This publication is a collaborative effort between ITCA and the 75 Students' Satellites Mission.

CONTENTS





Unraveling Space Intelligence

Editor-In-Chief

L V Muralikrishna Reddy, PhD
President
Indian Technology Congress Association

On 11 May 2022, India observed National Technology Day to commemorate a significant and landmark event in its long and illustrious path of technological advancements. The celebrations honour the professionalism, contributions, and achievements of Indian engineers, scientists, and technologists who are responsible for the country's development trajectory through epochal technological and scientific breakthroughs. This year also marks the commemoration of Azadi Ka Amrit Mahotsav, an exemplary time in India's rich history of people, culture, and achievements. ITCA is delighted to dedicate this issue of TIP, titled "Space Intelligence: The Future is Now," to this momentous occasion.

When it comes to the transmission and dissemination of cutting-edge and multi-dimensional technology developments for a diverse spectrum of aficionados, ITCA possesses a significant advantage as a result of the consistent support it receives from its audience. Over the last four years, ITCA has established itself as an influential organisation promoting NewSpace advancements and CubeSats. Such expansion has allowed ITCA to create a niche as a frontrunner in its chosen sector. This recognition is a direct result of the ITCA's persistent devotion to the Student-built Satellite Mission, and it is now widely recognised by Indian academics. The 75 Students' Satellites Mission is thriving on the steadfast support received from every space enthusiast.

Billions of people throughout the globe stand to gain significantly from space technology on social, scientific, geopolitical, and economic levels. A bright and sustainable future can only be achieved if we keep finding and developing innovative solutions to a wide variety of human concerns from an ever-changing NewSpace. Humanity has just skimmed the surface of space's immensity, which holds enormous potential for our future needs.

Space has an impact on all of us, connecting global citizens and providing us with countless opportunites. Every individual on our Earth recognises how amazing space is. Whatever has to do with space is exciting, whether its satellites orbiting the Earth, large constellations wandering around LEO, individuals prepping to land on the Moon or Mars, or telescopes staring into the furthest reaches of the universe.

The ongoing Russia-Ukraine conflict has shown both the positive and negative sides of space solicitations. Unfortunately, the war has already created numerous impediments to the array of solutions given by the space domain. The fighting, for example, has intensified pandemic shutdowns and disrupted global supplychains for critical semiconductor components. At the same time, proof of the exponential rise of space-related news can be witnessed on a regular basis across the globe. It is important to all of us that the war issues are resolved, and that peace be restored.

The Department of Space (DOS) fosters the country's space ecosystem via its national agencies by enabling favourable regulations and encouraging the industry's self-reliance through its flagship programme Attmanirbhar Bharat and Make-in-India Missions. For instance, the government's space policies created the way for private enterprises to build partnerships with public institutions in order to achieve business transformations that are on par with the global pace of successes in this sector.

In the Lok Sabha, the Union Minister for Science and Technology, Dr Jitendra Singh, stated that the commercial arm of DOS, The NewSpace India Limited (NSIL), had already launched 45 foreign client satellites onboard ISRO's PSLV during the course of the last three years. In addition, the agency has secured four dedicated launch service contracts for foreign customers' satellites through launch facilitation by ISRO. As a consequence of the increased demand for global broadband access, the minister said that NSIL is planning to launch a number of these foreign satellites using the SSLV, PSLV, and GSLV-Mk III rockets. The GSLV Mk III is India's giant rocket and can lift about 9,000-kilograms payload to LEO.

The formation of IN-SPACe is another encouraging indicator of DOS's restructured space aspirations. It assures that India will have a greater footprint of knowledge in the production of earth observation & communication satellites and sophisticated Small Launch vehicles in the future years to meet the demands of the global markets. It intends to achieve this ambition by enlisting the help of industry and academia besides extensively engaging the private sector.

This is indeed encouraging news for India's space sector, and it promises to bring about a significant rise in prospects in the years to come.

There are many opportunities for all of us in space. As we continue to explore,

we will discover new footings that will perhaps last forever. As a result, even 65 years after the first space voyage, space remains sentient and has only been sporadically explored. Aspirant businesses from all over the globe are pouring billions of dollars into the space industry, believing that these investments will protect humanity's interests on Earth and other Planets.

The space enterprise was founded on the notion of expanding the boundaries of human knowledge via scientific missions and experiments. Exploration of space required the pursuit of ground-breaking discoveries, which were eventually found to bestow new applications in broader social contexts. As a result, every citizen has benefited from myriad technologies inherited from space expeditions. Newer technologies like edge computing, AI & ML, 3DP, quantum computing, IoT, digital twins, and blockchain have revolutionised the socio-economic landscape, including the space business. This transition, which has resulted in increased efficiency and a deep understanding of space applications, is the outcome of what is often referred to as digital transformation. This has enhanced perspective of space operations, reduced expenses, and expanded the capacity to collect and analyse critical data on a larger scale and at a faster speed.

The idea of sending thousands of small satellites into orbit will become a reality in the coming days as the billionaire space race heats up. We can already see the trend and various significant events occurring in the global space domain on a daily basis. As part of Axiom Space's Ax-1 Mission, SpaceX successfully flew the first all-private crew of space tourists to the ISS. Amazon has signed contracts with Arianespace, Blue Origin, and the United Launch Alliance (ULA) to supply heavy lift launch services for Project Kuiper. Project Kuiper's goal is to deliver high-speed, low-latency broadband to every citizen in areas where internet access is inconsistent and limited.

A couple of months ago, ITCA inaugurated the Satellite Technology Centre, which was a cornerstone for the ongoing 75 Sats Mission. With augmented infrastructure, ITCA is emerging as a contemporary, focal, and inclusive institution addressing the needs and aspirations of the space technology congregation, including its partnered, incubated, and mentored institutions. The facility also serves as the Mission's nerve centre for CubeSat development programmes in the country.

The expansion of the space economy, which now has a value of USD 447 Billion and is growing, is a significant factor in the creation of new jobs, acceleration of the pace of innovation, reorganisation of markets, and the enhancement of the quality of life for individuals.

ITCA is making a significant effort to ensure that NewSpace opportunities are leveraged to the fullest by training and developing students who are equipped to make the most of these possibilities. These initiatives are significant because they align with the New Education Policy ideals intended to reshape India's education system at par with global standards.

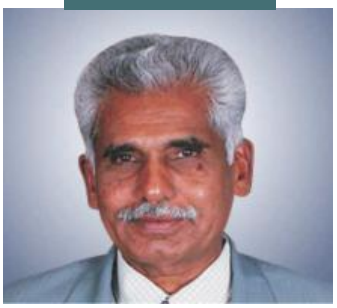
The 75 Sats Mission has made significant progress in recent months thanks to the support extended by a range of government and private organisations. ISRO, NSIL, and IN-SPACe have made considerable contributions to overcoming the numerous challenges and hurdles that this mega constellation CubeSat project is experiencing. In addition, significant strides are being achieved in industry participation toward the fabrication of a wide range of subsystems and the reduction of concerns associated with satellite integration. It's an exciting opportunity for students from all over India to become involved in this unique Mission through various partnering institutions, where they collaborate and exchange multifaceted and transformative ideas.

Despite the numerous challenges posed by the pandemic, global economic downturn, and component scarcity, ITCA has successfully engaged our space fraternity and inspired a broader audience to participate in and contribute to the historic 75 Sats mission. This ensures that engineering and technology remain a formidable force for societal transformations. It is a watershed moment for the burgeoning space industry, which is still in its early phases, and portends many more missions in the years ahead.

The progressive transformation to LEO, SmallSat constellations, and relatively small launch vehicles has resulted in the rise of novel applications, attracting huge investments, establishing new businesses, and, in overall, broadening avenues in a NewSpace economy. Strong space heritage, widening canvas of innovation and technology, and expanding human intellect have all contributed to the formation of profound insights that can be monetized for the greater good of society. This will usher in a completely new way of life for current and future generations. These breakthroughs exemplify the boundless potential of human imagination and Space Intelligence. We've only scratched the surface of the possibilities, and the true potential of space intelligence remains still untapped. The new era of space intelligence has begun and will continue to expand.

Mission Assurance in Development
75 Students' Satellites Mission

Advisor
75 Students' Satellites Mission



Prof R M Vasagam
Vice President
Indian Technology Congress Association

The ambitious 75 Students' Satellites Mission to commemorate 75 years of India's Independence has commenced. Universities, Engineering Colleges, Polytechnics, and High schools are forthcoming to join in this mission. Central and State governments, UGC and AICTE, are extending support for this mission to give impetus to experiential learning a fillip and nurture innovation and entrepreneurship.

From the small beginnings made for the development and launch of CubeSats by California Polytechnic college students mentored by NASA Ames and Stanford university using decommissioned missiles, the number of student-built satellites stands at 3200 plus, and many more are on the anvil in many institutions across the world. A wide range of payloads has been accommodated at a lower cost and turnaround time for the investigators.

The Satellite subsystems have been modularised in the form of a 10 cm cube called 1U for the basis of 1 kg weight. Satellite subsystems like structure, thermal, batteries and solar panels, attitude control, tracking telemetry and command, onboard computer, and data handling systems are accommodated in this modular arrangement. Complex missions with 3, 6, and 12U have already been built and flown. Imaging missions, space science missions, and environmental monitoring missions have dominated the CubeSats deployed. In addition, experiments have been attempted for inter-satellite communications, rendezvous and docking, and deployable de-orbiting systems.

ANUSAT was the first student-built Satellite by Anna University with a PSLV launch, followed by student-built satellites by other institutions. The recent mission of UNITYsat carried three 1/3 U satellites by three institutions to demonstrate inter-satellite links, cloud storage, and a low-cost ground terminal. Based on the experience gained, 1U type CubeSats are being built as part of the proposed 75 Students' Satellites Mission. The mission timelines are critical, and the launch will be on the newly designed SSLV. The mission assurance aspects involve reliability and quality assurance as the key requirements.

It involves reliability apportionment, parts, materials and process plans, launch loads and margins, mechanical, thermal, and electrical test plans, configuration control, and waiver approval for non-conformance. In addition, the assembly, integration, and safety documents are needed for launch clearance. Finally, reviews at various stages from concept, breadboard, electrical, thermal, prototype, and flight models allow going further after clearing shortfall. Extensive documentation is maintained at all stages.

It is the role of reliability and quality assurance to calculate the probability of mission success based on the earlier review results, corrective actions taken, final test results, and clearance for launch. Launch and post-launch operations have similar readiness reviews to ensure a successful mission.

Using commercially available electronic parts (COTS) has become popular as a way to reduce costs, lead times, and mission optimise life. However, designers must derate to minimize heat dissipation and lower clock frequencies. Batteries generally use passive thermal management with no heaters. The onboard processor is the master, responsible for housekeeping, manoeuvres, and payload operation. This will put the satellite in safe mode until the problems are resolved, and it can resume normal operation. Such occurrences can occur anywhere in orbit and Mission operations must handle them. Satellite subsystems will degrade over time, requiring operation teams to modify operations safely.

Most student-built satellites utilise the amateur bands, and there are many stations and operators willing to assist. Cloud-based help must be used wisely. A safe deorbit by natural decay or propulsive measures must also be arranged by the mission crew. In most student-built satellites, electric propulsion is employed.

Satellite thermal and optical properties change over time, necessitating power and thermal design, providing an opportunity for hands-on design experience with modelling and simulation tools. The mission's success requires quality fabrication and assembly. Quality assurance teams will use specialized equipment and highly trained personnel.

Thus, a student-built satellite is a valuable tool for training students and faculty in complex interdisciplinary tasks of realizing a space-worthy object in a time-bound goal-oriented mission mode. This methodology is equally applicable to other engineering projects as well. Let the 75 students'-built satellites succeed in their pioneering role in demonstrating experiential learning!

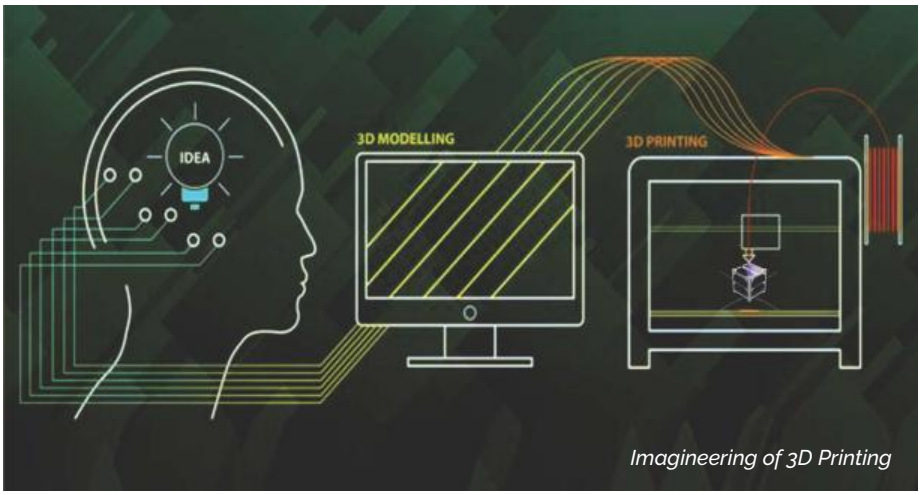
3D Printing Paradigm for NewSpace

Improves agility, lowers cost, and boosts performance

Rapid Prototyping, colloquially known as 3DP, is a pioneering innovation, that has emerged as an integral part of the Industry 4.0 technologies stack. 3DP enables products to be made with accurate functionality while enabling maximum design freedom. The aviation industry is no exception when it comes to sophisticated manufacturing employing Additive Manufacturing (AM), another term for 3DP. In reality, aerospace was one of the first industries to use 3DP technology to build complex components for aircraft and spacecraft, providing significant weight savings and design benefits over conventional parts.

For example, one of the most notable benefits of AM is that it allows the fabrication of complicated shapes and structures that would be difficult to produce using traditional methods. AM makes it an excellent technique for generating spacecrafts, satellites, and other components for the aero industry. In a nutshell, 3DP in NewSpace has the potential to transform the space industry by allowing manufacturers to build small spacecraft and satellites in a timely and cost-effective manner for a variety of applications including Earth observations, communications, and scientific research.

Using Fused Deposition Modelling (FDM), Stereolithography (SLA), and Selective Laser Sintering (SLS) technologies, parts can be manufactured on-site and efficiently, avoiding supplychain issues. Almost every component, such as structural parts, antennas, sensors, and boards, can be made with this advanced technique to build entire spacecraft and satellites, including the launcher, orbiter, and payload.



Imagineering of 3D Printing

SpaceX and Blue Origin, two of the world's wealthiest enterprises, have invested heavily in 3D printing in order to achieve the full potential of this contemporary technology in the NewSpace sector. Blue Origin has developed a three-stage lander that will carry the first woman and man to the Moon's surface using AM methods by 2024.

Contributions to the development of launch vehicles

Rockets have been around for decades, and technology continues to advance with the advent of new applications. However, while the launch vehicle technology has metamorphosed over the last seven decades, one aspect has remained unchanged: the Rockets are expensive to produce. This is now about to change, thanks to 3DP, which uses a layering method to develop complex objects and structures. This enables the development of reusable rockets, engines, and small launch vehicles at a fraction of the cost of the earlier manufacturing methods.

The era of additive manufacturing in space began in 2014 when SpaceX launched its first 3D printed component into orbit. The 3DP component is a primary oxidiser valve for a rocket engine launched into space by Falcon 9, which carried the commercial Thaicom 6 telecommunication satellite.

As space research moves away from massive, expensive single-use rockets, 3DP is becoming an increasingly significant aspect of the manufacturing process. It enables the reuse of components and engines, drastically lowering the cost of space missions.

Presently, only a few nations have built the capability to deliver satellites into orbit using their own launch vehicles, and national space agencies have traditionally backed these. SpaceX, Rocket Lab, a Chinese company, Deep Blue Aerospace and others have reached a significant milestone in the transportation of commercial space launchers employing 3D printing technology, thanks to private investments.

Precisely, 3DP will give space missions a competitive advantage by lowering development costs and improving performance. The emphasis is on high performance at a low cost, making tiny rocketry a winner in space and a differentiator in the launching industry. Smaller rockets propelled by high-performance engines have the potential to double or triple payload capacity.

Another emerging trend in the NewSpace age is the deployment of reusable rockets, courtesy of visionary entrepreneurs. Spares and replacement parts will be in high demand if reusable rockets become the norm for space missions. Complex rocket components may now be manufactured using 3D printing, which will help to prolong the life of launchers while also minimising costs and reducing maintenance intervals. For example, a faster turnaround time for rockets and other vehicles would encourage the development of more turnkey spaceflight systems.

Creating combustion chambers with small, complex-shaped cooling channels is one of the most challenging jobs in developing rocket engines. Mechanically treating such channels, particularly their eventual enclosures or casings, is a tough technical task. Nevertheless, AM has made significant success, and a few relatively tiny combustion chambers are already built using a variety of materials. For example, The Launcher, a 3DP firm based in the United States, helped design the world's largest AM machine capable of processing copper alloys, which is extremely useful in the manufacturing of these components, as well as the most efficient chambers for rockets. Another narrative that had significance in NASA's implementation of metal 3DP technology to modernize rocket propulsion systems to eventually reduce component count and weight.

Metal rapid prototyping has enabled both new generation and legacy space organisations to construct and power future spacecrafts. Propulsion systems that are 3D-printed are less expensive, faster to construct, and lighter than conventional systems. High-performance heat exchangers, motors, structures, and passive microwave devices are now widely produced using 3DP technologies. Because of 3DP's diversity, flexibility, and weight-saving potential, technocrats will be able to experiment with previously unimagined applications and functions in the NewSpace race.

The first company to 3D print entire rockets and created the world's largest metal 3D printers, Relativity Space plans to print virtually every component of its 200 foot tall Terran 1 orbital rockets. It says that their technology will allow them to produce a rocket in less than a month, compared to the usual development schedules of many months to more than a year for traditional rocket production. Conventional rockets have over 100,000 components with varying degrees of operational complexity. Rocket manufacturers place a high value on reducing component counts through the use of 3DP. The centrepiece of these 3D printing efforts is Stargate, a towering 3D printer that Relativity claims is the largest in the world, and it generates parts from amazing metal alloys. For instance, shopfloor robots in conjunction with 3D printers can construct an entire rocket fuselage in a matter of days.

3DP in Satellites

While the CubeSat contains a few hundred components, bigger satellites may have tens of thousands, and flagship projects such as the James Webb Telescope, which was recently launched, have significantly higher numbers. In any mission, especially in the space sector, reducing the number of components is a fundamental consideration. 3DP will assist tremendously in this endeavour.

With advancements in additive manufacturing, the number of 3D printed parts in satellites systems is increasing. Satellite manufacturers are constantly adopting the technology to minimize costs and accelerate development schedules of more capable spacecraft. Recent advances are paving the path for satellites to print parts in space in the future.

One barrier to the space sector's transformation to 3DP would be redesigning and testing space-qualified components in orbit before they could be utilised more widely, such as metal 3D-printed patch antennas for SmallSats. However, the industry has progressed beyond the limitations; for instance, Boeing and Airbus have used additive printing to build bus frames, radio frequency components (RF), and a wide range of space functionalities & components.

Boeing wants to expand the capabilities, particularly for Millennium Space Equipment (MSS), a subsidiary company focusing on the SmallSat industry, where 3DP is proving to be a solid fit for getting systems into orbit faster than ever before. For SmallSats, it showed that next-generation 3D printed buses have a far shorter production cycle time and


Credit: Orbex

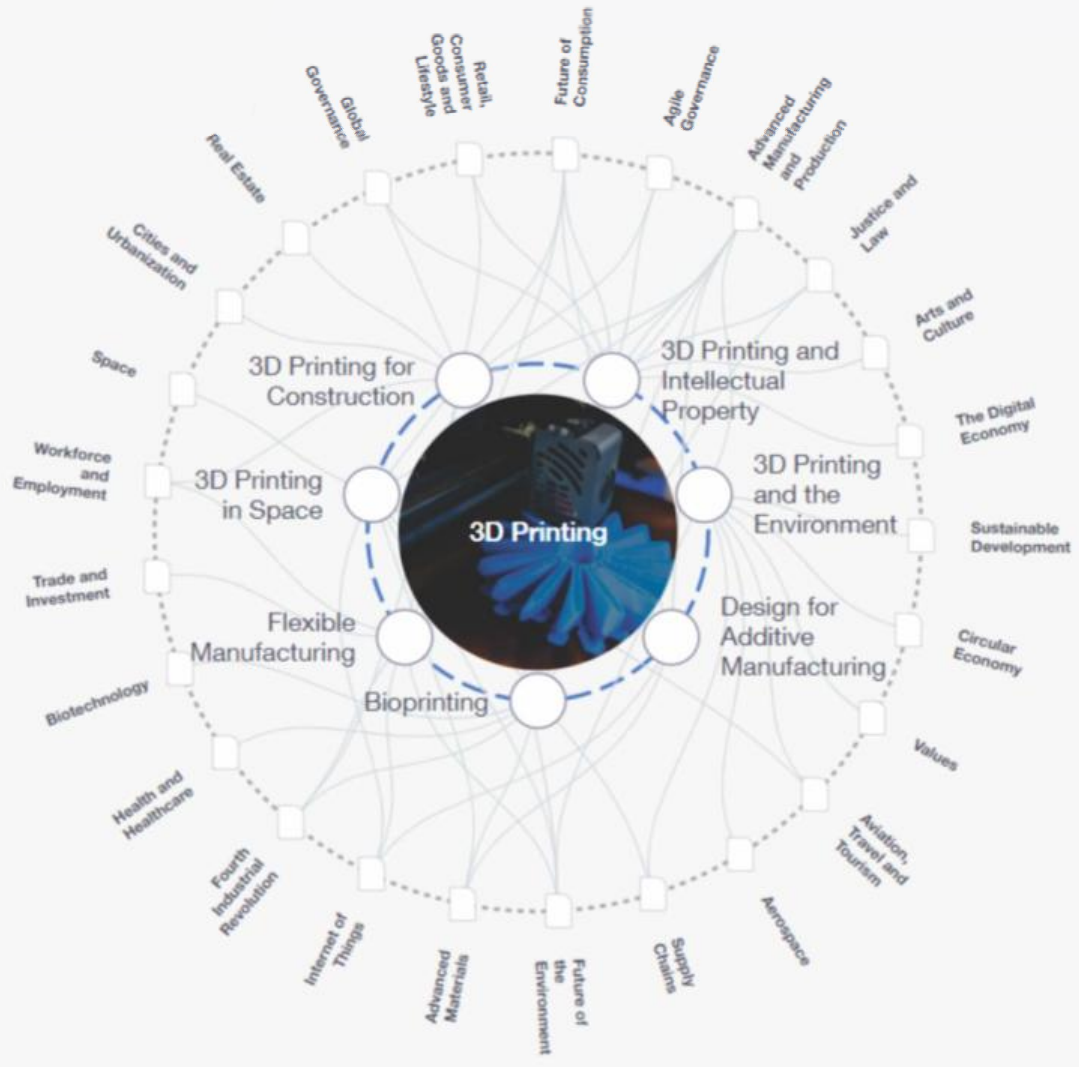
are around 30% less expensive than traditional bus fabrications of assembly.

The National space agency, ISRO, is leveraging 3DP to gain a competitive advantage in manufacturing space company. ISRO sent its first 3D printed satellite part, a radio antenna, into orbit in June 2017 and is presently exploring opportunities to expand the portfolio of 3D printed parts. Components identified for 3D printing include waveguides, thrusters, antenna, brackets, propellant injectors, oxidiser valves, propellant injectors etc are at various stages of prototyping and commercial development.

NewSpace era engineers and entrepreneurs are working to popularise 3D Printing in order to disrupt conventional rocket & satellite technologies' market, and open up new possibilities for space explorations for wider applications with optimised resources.

There is also an upcoming and new trend in 3D Printing for space industry called 'On Orbit Manufacturing' (OOM). OOM brings in a revolution for the development of parts using a microgravity environment, involving manufacturing parts in space rather than launching them from Earth.

3D Printing for space applications has enormous potential for collaboration, innovation, and growth, and it could pave the way for the development of several critical components for future space missions.



This briefing is based on the views of a wide range of experts from the World Economic Forum's Expert Network and is curated in partnership with Roland Logé, Associate Professor, Ecole Polytechnique Fédérale de Lausanne (EPFL)

Image Credit: World Economic Forum

Advancing the Mission...

The 75 Students' Satellites Mission will commemorate India's 75th anniversary of independence, Azadi ka Amrit Mahotsav. The Mission is a collaborative effort between ITCA and a wide range of educational institutions, including schools, engineering colleges, and universities, in which students will design, build, integrate, test, and launch their 1U CubeSats. To make progress toward the ambitious mission, ITCA collaborated with national space agencies ISRO, NSIL, IN-SPACe, and space-related enterprises including MSMEs and Startups. This one-of-a-kind national project would involve the orbital launch of 75 satellites developed and built by students under the close guidance and monitoring of ITCA.

The ITCA believes that the Mission's success would instil in students a national culture of invention and inventiveness. It also assists students to inculcate a scientific mindset and provides them with hands-on experience with cutting-edge space technologies.

ITCA has taken several significant steps towards the advancement of this mission in the last few months, which is noteworthy to know from the perspective of readers and Space adherents.

The Satellite Technology Centre has been established in the ITCA secretariat building to strengthen mission objectives and meet the needs of consortium members in expanding the mission across the nation. The centre's infrastructure, which is outfitted with cutting-edge technology and mission-coordination tools, was officially inaugurated in February 2022. The benefits of this centre are enormous, especially for those who are deeply associated with the mission.

The ITCA's interaction with a wide range of other institutions is now at an all-time high. Many schools, engineering colleges, and universities are in

Dr MGR Educational and Research Institute, Chennai

Karpagam University and their Group of Institutions, Coimbatore

Anurag University, Hyderabad

continuous interaction with ITCA, for their participation and also enquiring how students and institutions will benefit. ITCA teams have been travelling across the country very frequently to spread awareness about the Mission and demonstrate how academic institutions can benefit from participating. Teams have also collaborated with a range of institutions to host and present educational sessions and webinars in virtual mode in order to reach a larger audience.

The All India Council for Technical Education (AICTE) has responded well by organising a nationwide webinar to provide support for this purpose. Prof Anil D Sahasrabudhe, Chairman, AICTE addressed students and faculties from various engineering institutions, expounding on the mission. About 160 engineering institutions have expressed interest in participating, and the ITCA teams are coordinating with these institutions.

Through the collaborations with educational establishments, ITCA has been successful in igniting enthusiasm among students and faculty members for emerging space opportunities and student-built satellite ecosystems. These interventions advanced the cause by taking one step further, which consisted of documenting the institutions' intentions progress their CubeSat development programmes.

To ensure that this mission is carried out successfully, various ministries and departments of the central government of India, in addition to the governments of a few of the country's states, have extended their support. ISRO's Project Monitoring Committee (PMC) is actively involved in the mission's success via a mentorship effort.

ITCA liaises with professionals from space agencies and industry to train, guide, and mentor students and the mission workforce. In addition, the Mission Leadership is working together with a number of prominent Institutions of eminence, such as the Indian Institute of Science, the IITs, the NITs, and other notable universities, in order to broaden the panel of interdisciplinary domain experts who are able to supervise and educate the projects that are being

Karnataka Science and Technology Promotion Society (KSTePS), Dept. of IT, BT&ST, Government of Karnataka

Nettur Technical Training Foundation (NTTF), Bangalore

Jeppiaar Institute of Technology, Chennai

Nagarjuna Group of Institutions, Bangalore

The Indian Public School Group (TIPS), Chennai

AMC College of Engineering, Bangalore

carried out in the various partnering institutions.

Large-scale space industries are working together on this project, and they have been contributing significantly to the manufacturing, testing, and integration of satellites that have been built as part of this mission. Micro, Small, and Medium-sized industries, as well as startups, have presented partnership offers on a range of technology interventions, which are now being considered by the project and leadership teams. The ITCA partnership and alliances team was successful in establishing memoranda of understanding with space organisations, which added profound significance to productivity and quality.

In today's technology-based device development world, the semiconductor chip shortage is the biggest challenge. This mission and the space industry as a whole are affected by supplychain issues. With the help of this mission's renowned group of space experts, many of these problems were resolved. ITCA worked closely with global component suppliers, comprising of solar products, radio frequency (RF) components, telemetry, navigation, and sensing systems, to ensure that they were delivered on time. A network of ISRO-approved space facilities is also helping ITCA meet its goal of producing 75 CubeSats ahead of schedule. The mission has complete control over supplychain issues, thanks to all collaborators.

ITCA teams are currently developing the mission's satellites at a quicker pace in close coordination with registered institutions, with the cooperation of space specialists and agencies. Following on from this implementation strategy, ITCA aims to assist schools, engineering colleges and universities across the country in growing and developing a repertoire of modern space skills among students, as well as cultivating an entrepreneurial spirit among participants in such space-based R&D projects.

This article highlights and reports on ITCA's recent pursuits, including a few illustrious moments. Furthermore, our academic and Industry partners have signed MoUs with the Mission, which can be seen in the gallery.

Hindustan University, Chennai

Xvidia Technologies, USA

Alpha Design Technologies Pvt Ltd, Bangalore

Newtech Aerospace Pvt Ltd, Bangalore

Global Visitors and Partners...

Karnataka Government School Students

SpaceTech Benefits to Society

Innovation and Engineering Breakthroughs

Globally, public funds have made significant investments in space exploration over the last six decades through the development of launch vehicles, satellites, and space stations.

Humanity's exploration of space, including planet expeditions, human-space missions and giant orbiting observatories, has contributed to the development of cutting-edge technologies in the last half-century, that have widespread societal applications. NASA, ESA, ISRO, and other prominent national space organisations have made astounding scientific and technological advances that are intertwined with every facet of the human experience. These technologies have had a significant influence on society, changing aspects of human culture, industry, and entrepreneurial endeavours, which has culminated in a significant shift in the present day society.

Space exploration has aided the advancement of innovation in all geographical regions, resulting in economic prosperity and a competitive advantage for many nations.

Space-based technologies that have made significant contributions to modern society are listed below.

Medical device used to monitor patients awaiting heart transplantation

The MicroMed-DeBakey VAD was invented in the 1980s as a result of a collaboration between NASA scientists and Dr Michael DeBakey, who spent the better part of a decade investigating and testing the device.

The MicroMed-DeBakey VAD, which is based on space shuttle fuel pump technology, is credited for keeping patients alive as they await heart transplants by pumping blood around the body and relieving stress on the heart. It's been implanted in hundreds of patients and is helping save terminally ill cardiovascular patients.

Braces that are Not Visible

A collaboration between an organization and NASA resulted in the development of the translucent ceramic that became a vital component of the first "invisible" dental braces, which went on to become one of the best-selling orthodontic material of all time.

Effective Drugs For Osteoporosis

A new phase in osteoporosis research has emerged thanks to NASA's bone density study. On three separate assembly trips, NASA sent mice into and out of the International Space Station in order to better understand the problem. The researchers discovered that mice given osteoprotegerin had less bone resorption than mice who were not. To combat osteoporosis and increase bone density, the FDA-approved drug Prolia was developed as a result of this ground breaking space experiment.

CT And MRI Scans

During the different Apollo flights, NASA scientists used digital signal processing to create computer-enhanced photographs of the Moon. This invention would later have countless applications, including serving as the foundation for CT Scans and MRI machines that aid clinicians in diagnosing and treating illnesses, advancing their understanding of biology, and preventing premature deaths each year.

Mylar

Mylar was designed in the 1950s to insulate and protect spacecraft from the Sun's heat. Since then, it has been used on every manned space trip and thousands of satellites and even the eponymous Hubble telescope. Apart from its continuous usage as an insulator for spacecraft, Mylar is used to insulate computers and other electrical devices.

Cell Phone Camera

Compact, high-quality cameras were developed and manufactured by a team from the Jet Propulsion Laboratory. In today's world, a large percentage of all cameras, especially those in cell phones, utilise this technology.

Water Purification Techniques

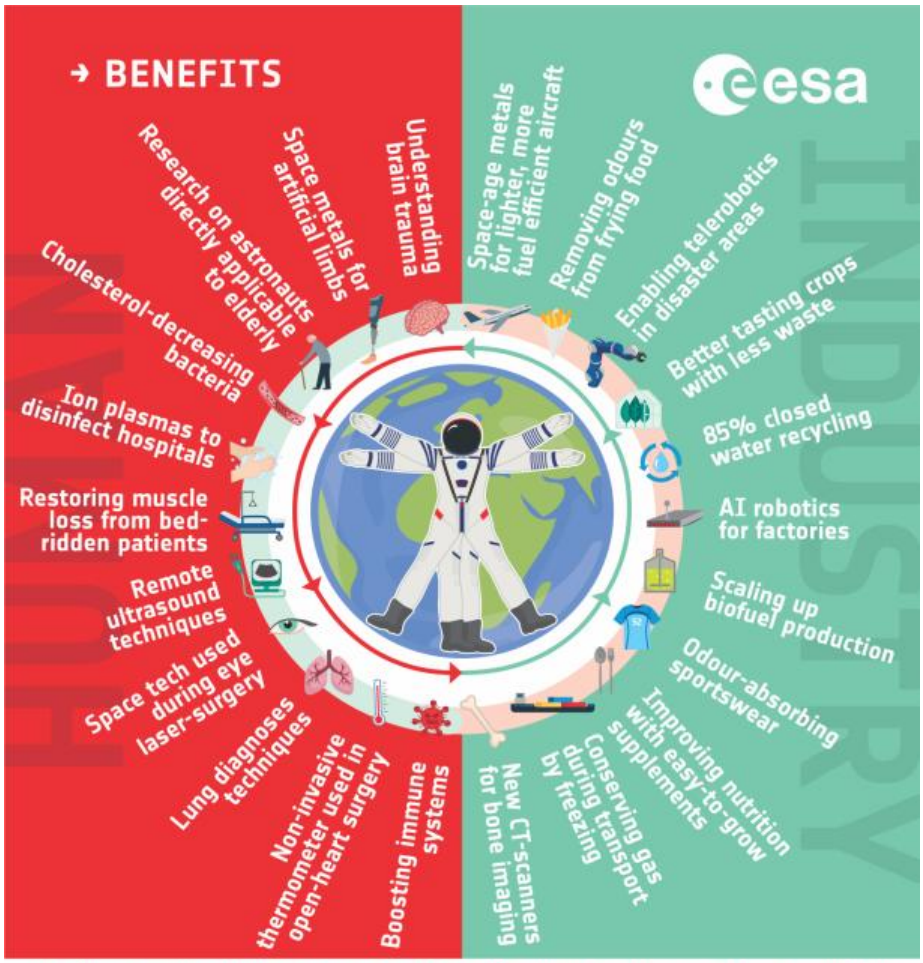
Technology developed for the space station to provide clean water to astronauts by using activated charcoal that contains ions to neutralise pathogens in water. These technologies now used in water-deficit areas around the globe are making a life-saving difference to communities.

Treatment of Corneal Refractive Errors

Microgravity research has aided in developing a novel type of lens that reshapes the cornea while an individual sleeps, resulting in superior eyesight without the use of lenses throughout the day. Additionally, these lenses are oxygen permeable, less vulnerable to germs, and resistant to deposits than conventional contact lenses.

Foam Memory

NASA developed an open-cell polyurethane-silicon material in 1966 as a pad for astronaut seats that would mould to their bodies during the intense stresses associated with take-offs and landings. The material distributes weight and pressure uniformly for shock absorption and, when not in use, returns to its original shape rest state, hence the term "memory foam". This design reduced the requirement for seats to be customized to the body sizes of individual astronauts. NASA made memory foam available to the public in the early 1980s. Today, foam



Human and robotic spaceflight, due to its nature of supporting astronauts in space, contributes to a circular economy by improving energy efficiency, automation, robotics and artificial intelligence as well as habitation, recycling, waste management and additive manufacturing.

manufacturers across the globe are using memory foams in sleeping mattresses to provide a trouble-free and comfortable rest to millions of people.

Photovoltaic Cells

To address the need for powering spacecraft, NASA invented and improved photovoltaic cells. These technologies have been transferred to industries to expedite the product development for civilian and military applications. Aircraft and Sensor Technology Alliance and SunPower Corporation developed high-performance, low-cost power cells as a result of this, enabling weightless powering of remotely piloted aircraft.

Wireless Headsets

NASA developed wireless headsets to facilitate astronauts' communication without the complications of tangled wires. This had a noise-canceling feature and was integrated with the astronaut's helmet. The technology was subsequently commercialised, and new devices for home and office usage, such as Bluetooth headsets, were developed, allowing wireless connections for mobile phones, computers, and tablets.

Automatic Weather Stations

ISRO has created a state-of-the-art Automatic Weather Station (AWS) that is highly compact, modular, resilient, powerful, and affordable. It is housed in a portable, self-contained box. The AWS is composed of a small data transmitter, a data logger, a crossed Yagi antenna, a GPS receiver, a solar panel, and meteorological sensors (e.g. relative humidity, wind speed, air temp, wind direction, atmospheric pressure, solar radiation, rain gauge, etc.). AWS transmits meteorological data from any remote station located within the INSAT Satellite's footprint every hour. The Data Relay Transponder (DRT) onboard the INSAT satellite is capable of supporting over 10,000 such AWS systems located throughout the country. The AWS can provide rapid information about the weather and any deviation from average typical weather.

Ground Penetration Radars

ISRO developed Ground Penetration Radar (GPR), a high-resolution electromagnetic imaging method that uses electromagnetic wave scattering to find hidden objects. It is generally used to explore the Earth's or Planet's subsurface profiles. In addition, GPR is a technique widely used in environmental, engineering, archaeology, and other investigations.

The advancements in space technology have significantly enhanced humanity's quality of life. Innovations gathered via space missions have not only fulfilled their original goal, but have also helped transform society, resulting in a better livelihood for civilization.

ISRO's Vikram Sarabhai Space Centre (VSSC) has developed technology for processing super capacitors (2.5 V) with varying capacitance values such as 5 F, 120 F, 350 F, and 500 F for specific applications. Super capacitors developed with indigenous materials and technology transferred by VSSC have made a name for themselves as an import substitute as a power source for various defence, space, and civil sectors. Super capacitors are increasingly being used in defence equipment such as radar-mounted vehicles, battle tanks, artillery guns, satellites, and launchers, where energy supply is critical.

These are also used for regenerative braking and short-term energy storage in luxury buses, high-end cars, high-speed trains, and elevators in tall skyscrapers.

Road to Success: Process-In-Place
75 Students' Satellites Mission

Member Secretary
PMC

K Gopalakrishnan, PhD
Project Director
75 Students' Satellites Mission
Advisor, Nagarjuna Group of Institutions/
Nagarjuna College of Engineering & Technology

A Project Monitoring Committee (PMC) was constituted by ISRO on 23 December 2021 to review and coordinate the mission activities up to the launch of the student built CubeSats. Seven meetings of the PMC have been organized to date, where the project team has highlighted issues faced during mission execution. PMC has been very supportive and proactive in facilitating coordination amongst various organizations of DOS and enlisting the support of vendor organizations. PMC is playing a mentoring role in helping the ITCA project team to complete the formalities for regulatory compliance of registration of the student-built satellites including frequency allocation, and orbit spectrum coordination.

Shri Prakash Rao PJVKS, Chairman, PMC and his team visited the 75 Satellites Technology Centre on Friday, 13 May 2022 to review the progress, and motivate the project team.

Meeting with Chairman

Shri S Somanath, Secretary, Department of Space (DOS), Government of India and Chairman ISRO has reviewed the progress of 75 Students' Satellites Mission 2022. Padma Shri Prof R M Vasagam presented an overview of 75 Satellites' mission and its background.
Dr L V Muralikrishna Reddy, President, ITCA and Chairman, 75 Students' Satellites Mission has highlighted the major milestones achieved as per the plan and delineated the issues and challenges in procurement of various active/passive components for satellites subsystems post-Covid pandemic due to global chip shortage and other supplychain disruption related issues. Shri Prakash Rao PJVKS, Chairman, PMC explained the efforts of multiple teams at ITCA, TSC, SRC-URSC, VSSC, and other Space Industries to realize the hardware in such a way to facilitate the batchwise launches of 75 Satellites based on their readiness from August 2022 onwards.

Shri GNV Prasad, Head and Mentor, Core Technical Team and Former Dy Director, ISRO Satellite Centre articulated various efforts being made by the project team to address the issues and adhere to the timelines set for the mission. Chairman motivated the technical team to explore new avenues and development pathways that would be of strategic advantage to space-tech start-ups and support ISRO programmes.

Meetings with Indian National Space Promotion and Authorization Center (IN-SPACe)

Dr K Gopalakrishnan, Project Director apprised the IN-SPACe Chairman, Dr Pawan Kumar Goenka on the genesis, objectives, and status of the mission. Chairman, IN-SPACe was apprised

L to R (Sitting): Prof R M Vasagam, Dr S Somanath, Dr L V Muralikrishna Reddy
Standing: Shri Prakash Rao PJVKS, Shri Ashwin Reddy, Shri G N V Prasad, Dr K Gopalakrishnan, Shri Nikhil Riyaz, Shri Jegan R Mani and Shri Denzel George

ITCA Mission Team at ISRO-Hq with Shri S Somanath, Chairman, ISRO

The ITCA Mission team had a fruitful meeting with **Shri S Somanath**, Chairman, ISRO on 4 April 2022. This was the first meeting of the ITCA Mission team with Shri Somanath after he took over as the Secretary, Department of Space, Government of India and Chairman, ISRO.

Chairman motivated the technical team to explore new avenues and development pathways that would be of strategic advantage to space-tech start-ups and support ISRO programmes. Shri Somanath suggested to the ITCA team to progress simultaneously establishing ground stations in participating institutions. Chairman assured the Mission team all support from ISRO and wished the team success.

about ITCA's efforts to align India's academia to the cutting edge of space technological innovations by designing, developing, and launching student-built satellites as part of this unique and ambitious mission. The team articulated the mission's purpose of educating students on the development lifecycle of CubeSats through hands-on paradigm. This science-based approach and experience-based learning would build a culture of innovation in the country in alignment with the new education policy. There are 75+ Ground Stations (GS) to be established at Engineering Educational Institutions (EEIs) across India and will be connected through MobileApp TSC SatNAV to provide 24x7 connectivity to all the interested students to access the GS to monitor their own satellites. The emphasis of this programme to develop NewSpace skills that would be of significant value to the students and also enhance the education and research levels across India, was articulated by the mission team.

Subsequently, IN-SPACe team including Dr P K Jain, Director-Programme Management and Authorization has been extremely proactive in following up on the mission progress and facilitating solutions and clearance of impediments. The team has received very useful inputs for networking with organizations including various work centres of ISRO.

Meetings with NewSpace India Limited (NSIL)

Mission leadership team has had fruitful meetings with Shri Radhakrishnan Durairaj, CMD, NSIL to understand the launch options, and availability of missions during the calendar year 2022 for launching the 75 students' satellites. Launch pricing for non-government private entities was also discussed.

The interactions with the PMC team have contributed to enhancing the learning by the project team to manage large SpaceTech programmes and have helped strengthen our CubeSat development processes. Engaging with distinguished members of the PMC has been a major takeaway for the career development of the project team members

Strengthening Synergy with Industry Partners for the Mission Consortium

To enhance the industry-academia partnership and minimize execution risks for the mission, ITCA has worked on on-boarding leading industries to augment the rigour of verification and validation process, and flight certification at ISRO approved facilities for the 75 satellites. This will enhance the overall focus and drive towards mission success.

The Mission team gratefully acknowledges the stellar support that has been extended by the DOS for this mission. The interactions with the DOS teams have contributed to enhancing the learning by the project team to manage large SpaceTech programmes and have helped strengthen our CubeSat development processes. Engaging with distinguished members has been a major takeaway for the career development of the project team members.

Dr Pawan Goenka, Chairman, IN-SPACe flanked by **Dr Vinod Kumar** (Director, Promotion), **Dr PK Jain** (Director, Project Management & Authorization), and **Mr Rajeev Jyoti** (Director, Technical).

IN-SPACe would be responsible for regulating and handholding private industry to enable private participation in the space sector.

Students' Satellites
Advise for Success

The 75 Students' Satellites Mission had its inspiration at the Indian Technology Congress-2018. From its modest beginnings, the Mission has steadfastly grown and evolved over the intervening years. ITCA had also formed an Advisory Committee of renowned aerospace scientists and engineers to help structure the mission. Recently, two of the committee's esteemed members offered their suggestions for a successful mission and their views are highlighted herewith.

Dr K Gopalakrishnan, Project Director, facilitated the discussion by outlining the Mission's status and accomplishments. He stated that the ITCA was collaborating with larger number of educational institutions in India to advance student-built satellite initiatives. He also confirmed that the partnering institutions will be implementing a structured curriculum that includes nanosatellite courses with 24-30 credits. This course, delivered by by space industry partners and specialists would strengthen the hands-on learning of students. Project teams have been formed in the participating institutions, and they are now finalising multiple engineering models. The fabrication of the flying models will begin after the engineering models have been tested and certified.

Prof Vasagam eminent space scientist and Padma Shri Awardee, Chancellor, Dr M G R Educational and Research Institute suggested that a launch window commencing from 15 August 2022 should be identified, and mission activities should be pursued in line with this schedule. In the context of the academic and examination schedule in various educational institutions, the training program could be structured as a summer school of about 45-60 days' duration. He also suggested that the setting up of Ground Stations in the participating institutions could be progressed as a parallel activity.

Dr Y S Rajan
Padma Shri Awardee, and Chairman PAMC of Technology Interventions for Disabled and Elderly (TIDE) of DST, GoI

He said space initiatives are very demanding and needed detailed System Design and Interface Definitions. Mission definition and payload identification are very critical. He emphasized the need for comprehensive and rigorous testing. He advised that technical clearances should be obtained. He cautioned that waivers are the starting point for unfavourable project outcomes and should be sought only if absolutely unavoidable. He opined that the student-built satellite development activity project schedule should not be rushed but progressed diligently. He concurred with the suggestion that ground stations should be pursued as a parallel activity, as it would help students receive meteorological and space data. Establishing ground stations would facilitate ITCA teams to remain engaged with the project teams.

Dr Rajan also emphasized the need for student training, satellite development work and the design and establishment of ground station activities should be progressed simultaneously. It is essential for the institution stakeholders to see infrastructure being established in the institution premises as a capital asset. His point of view was that institutions and their faculty and students should be encouraged to conceptualize and design their unique secondary payloads, to enhance the learning experience for the students.

Prof B Dattaguru
Padma Shri Awardee, Distinguished Professor, and Miles Endowment Chair, Jain University

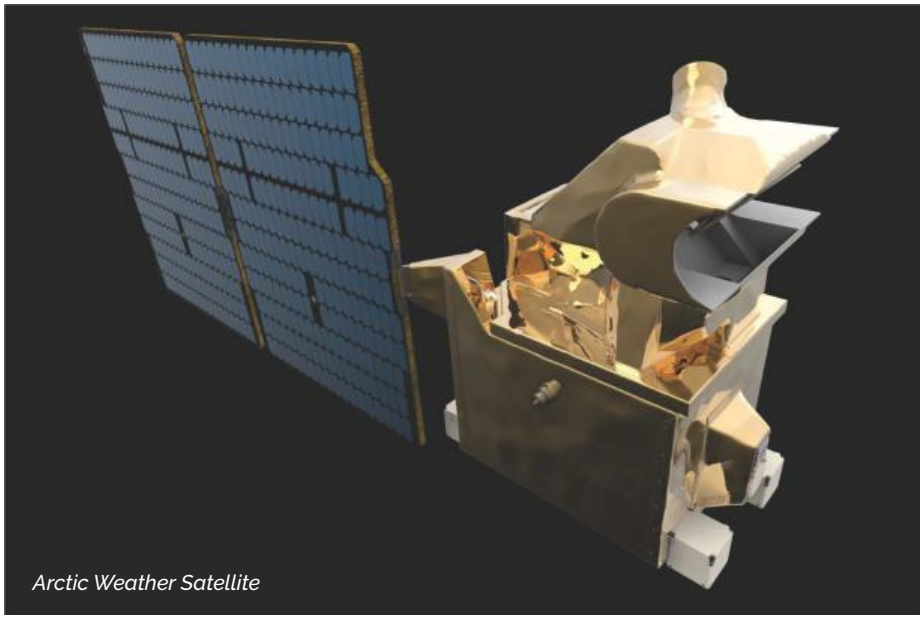
He articulated that student satellite development is a multidisciplinary and complex technology development project that requires high reliability of operation. Therefore, stringent processes are to be followed for testing and qualification to ensure mission success. He opined that a staggered approach to launching the satellites could be considered in the context of continuous onboarding of institutions to the mission. Institutions would prefer to have their unique secondary payloads and suggested that this should be encouraged. He opined that the teams should progress bulk procurement of electronic components to ensure that the project schedules are not impacted by the global semiconductor crises.

Prof Dattaguru also said that the institutions' academic schedules should be considered while drawing up the project milestones. Various alternatives for completing the training schedule for students of institutions onboarding the mission should be evaluated and considered so that maximum number of institutions are able to launch their satellites as per the schedule.

President, ITCA confirmed that a start has been made to establishing ground stations and cited the inauguration of the ground station at Chandigarh University by the Hon'ble Defence Minister, Shri Rajnath Singh earlier this year. The advisory board was apprised of the challenges faced by the procurement team due to the global scarcity of critical electronics components.

Invited Article

Weather Satellites
For Forecasting



Arctic Weather Satellite

Emilie
Head of Communications
ANYWAVES
France

Artic Weather Satellite, here is the name of the next mission onboarding ANYWAVES' antennas by 2024. Part of the ESA's Earth Watch programme, Artic Weather Satellite aims at demonstrating the usefulness of radiometric measurements in improving weather predictions globally and specifically in the Arctic region. OHB Sweden has been appointed as the prime contractor for the development of this program by the European Space Agency and will use ANYWAVES' antennas for its satellite telemetry, telecommand, geolocation and also for the data downlink.

By providing global measurements of atmospheric temperature and humidity with frequent revisit times, the polar-orbiting Arctic Weather Satellite (AWS) mission will complement the European MetOp and its counterpart US NOAA Joint Polar Satellite System.

Its launch is scheduled for 2024 and a constellation may follow this prototype mission aiming to allow very short-range weather forecasting, or 'nowcasting', in the Arctic.

In this context, antennas are the key equipment for the success of the mission. Artic Weather Satellite will onboard three different types of antennas delivered by ANYWAVES before December 2022. Regarding the telemetry and the telecommand, S-Band TT&C antennas will be supplied. Orbiting at a 600 km altitude, AWS' geolocation will be obtained using a L1/E1 band antenna designed using ANYWAVES' technology stack based on additive manufacturing. Last but not least, the payload antenna ensuring real-time data downlink will be an L-Band antenna, the key equipment for the mission's success.

ANYWAVES
S-Band Antenna

ANYWAVES
L1E1-Band Antenna

So far, this first order from the European prime contractor OHB Sweden amounts a deal to tens of thousands of Euros for the French antennas manufacturer. It could reach several hundreds of thousands if the decision is made to continue to build the constellation.

According to Nicolas Capet, ANYWAVES' CEO: 'This order from OHB Sweden is very significative. First, because being once again selected by an historical European satellites manufacturer is a true recognition of our know-how. Then, because Artic Weather Satellite's mission perfectly pictures what space can bring to humanity: a better understanding of Earth as well as a major benefit for citizens thanks to better weather forecasting.'

According to Benoit Mathieu, OHB Sweden's CEO: 'OHB Sweden is happy to collaborate with the well-established antenna manufacturer ANYWAVES as their products fit the full range of antennas needed for this mission.'

When ESA launched the Artic Weather Satellite project, its objective was to embrace a NewSpace approach by proving new concepts in a cost-effective and timely manner. By 2024, OHB Sweden, as prime contractor, as well as ANYWAVES as payload antennas provider, will both try the challenge to demonstrate the usefulness of radiometric measurements in improving weather predictions. Teams are already at work to achieve their mission and to pave the way to a new European satellite constellation.

In India, Valles Marineris International with cooperation of ANYWAVES, France is planning to build the Weather Satellite aiming at demonstrating the usefulness of radiometric measurements in improving weather predictions globally and specifically in the Bay of Bengal region and improve the sea routes traffic management.

About ANYWAVES

ANYWAVES develops revolutionary antennas for the satellite constellations market. Based on a breakthrough technology and an expert team, ANYWAVES designs and manufactures according to space standards a new generation of high quality antennas, on demand or off-the shelf. Unique European «pure player» antenna equipment manufacturer, ANYWAVES has sold more than 90 flight models since its inception in 2017 and reached One Million Euro turn-over in 2020. Based in Toulouse (France), the European Space capital, the company aims to become the leader of miniature antennas for critical systems.

About OHB Sweden

OHB Sweden is a Swedish provider of space systems and develops, builds, tests and operates satellites for different kinds of space missions within communications, earth observation, space research and exploration. From low-orbiting satellites via geostationary ones and all the way up to interplanetary missions.

The Copernicus
ESA Earth Observation Satellites

The Copernicus program run by the European Union (EU) and European Space Agency (ESA) that builds and manages a fleet of Earth-observing satellites called Sentinel. Eight missions have been launched to date, providing data about changes occurring to the oceans, land, and atmosphere of our planet.

The current mission is Sentinel-6, which would eventually comprise of two satellites, the first of which, Sentinel-6A, was launched in 2020 using a SpaceX Falcon 9 rocket from California's Vandenberg Air Force Base. A collaboration with NASA and the U.S. National Oceanic and Atmospheric Administration, Sentinel-6A is also known as the Jason CS satellite and was renamed in honor of oceanographer Michael Freilich, the former head of NASA's Earth Science division.

Each Sentinel project is built around a two-satellite constellation that addresses and revisits the coverage requirements for each mission, resulting in complete datasets. The eight missions that have been launched till date, are carrying a range of contemporary technologies including radar and multi-spectral imaging instruments to provide data about changes occurring in the oceans, land and atmosphere.

Sentinel-6A uses a radar altimeter to monitor global sea-surface height alterations related to climate change with unprecedented accuracy. It is 16.7 ft (5.1 m) long and weighs 2,628 lbs. (1,192 kg). The Sentinel-6B satellite will join its companion in 2025, according to NASA.

The EU is studying six additional high-priority future missions as part of the Copernicus program, which would plug current monitoring gaps and look at vegetation, surface temperatures, polar ice, carbon dioxide levels, and sea-surface salinity, among other parameters.


Credit: ESA

Satellite Technology Center

ITCA's State-of-the-art SpaceTech Facility

The Mission has been on a predetermined path since the launch of the UNITYSat on 28 February 2022. Regular institution onboarding, enhanced industry engagement, and consistent government support have all contributed to strengthening ITCA's consortium. It has continued to expand the aims and objectives while building the necessary infrastructure to exceed the expectations of its collaborators. Towards this ITCA has built a cutting-edge technology centre incorporating the best infrastructure.

Students and faculty can participate in hands-on and immersive CubeSat development activities thanks to this facility's close cooperation with partnering academic institutions. ITCAs advanced technology centre for the Mission was well-received and applauded by all stakeholders.

The Technology Centre is equipped with contemporary workstations and digital engineering platforms that project teams use to complete design iterations and realise engineering models of CubeSats, paving the way for flight models. The Boardroom and Discussion rooms have proven to be an ideal environment for project teams to collaborate, brainstorm, and complete tasks such as programme planning, technical reviews, project management, and compliance.

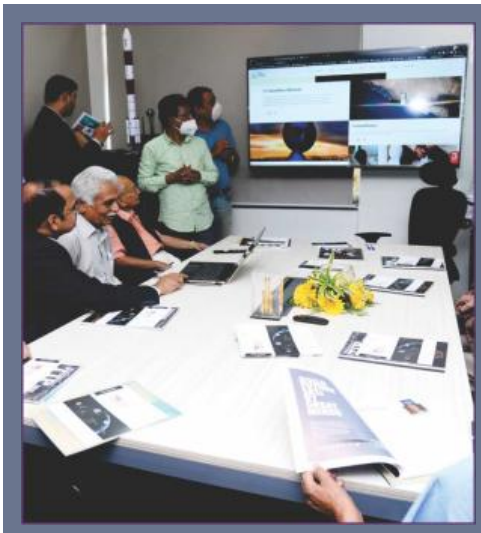
The CubeSat Development facility has been outfitted with a cleanroom and Electrostatic Discharge (ESD) protection. The facilities are equipped with Assembly, Integration, and Testing (AIT) instruments and associated tools. A sterile access area circulating freshly scrubbed air precedes the cleanroom. The cleanroom can be used by two CubeSat project teams simultaneously.

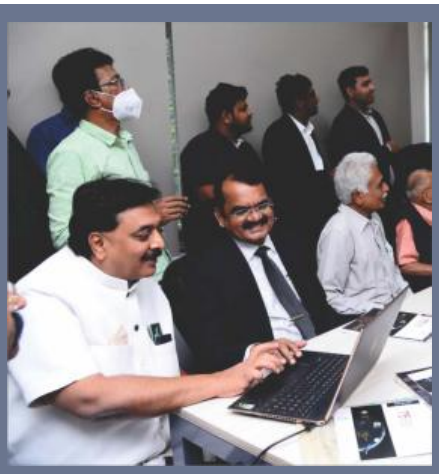
A sophisticated ground station, which will serve as the demo, has been established to track the orbiting satellites, including the UNITYSat. This ground station is capable of tracking other open-source nanosatellites and will enrich the real-time experience.

These facilities are also available to students from participating institutions, allowing them to gain insight into the industry's work environment. Recognizing the shift to virtual meetings, infrastructure for hosting webinars and hybrid meeting mode facilities has been created in multiple places across the technology centre to facilitate simultaneous conversations.

This centre has emerged as a clearinghouse for industry and domain experts to engage with the project teams to realize the mission objectives.

The 75 Satellites Technology Centre precisely conveys what ITCA does to enhance the value of the Mission and promote NewSpace happenings and opportunities.





The ITCA Corporate Office in Bangalore hosted the launch of the Technology Centre on **7 February 2022. Prof R M Vasagam** and **Dr Mylswamy Annadurai,** both Padma Shri Awardees and distinguished Space Scientists, inaugurated the centre and wished the project teams success. Veterans from ISRO and the aerospace laboratories, industry partners, faculty & management of the collaborating institutions, ITCA Board members, Fellows & adherents, entrepreneurs, technology partners, and SpaceTech vendors all attended the inauguration, interacted and wished the project teams.

The following were also inaugurated and released by notable engineers.

Board Room **Dr (Ing) BVA Rao,**
Former Chairman, NDRF

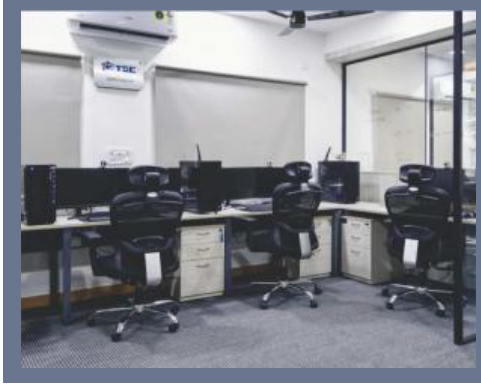
Clean Room **Shri D V Nagabhushan,**
Board Member, ITCA

Newly Designed Websites
Prof R M Vasagam - www.itca.org.in
Dr Mylswamy Annadurai - www.75satellites.org
Nadoja Dr Wooday P Krishna -
Board Member, ITCA

TIP Publications
Dr K Ramachandra, Former Director, GTRE
Shri T K Sundaramurthy,
Former Mission Director, ISRO

Project Collaterals
Shri O P Khanna, Former MD,
Schlafhorst Engineering Ltd

President, ITCA and 75 Students' Satellites Mission Project Director Dr K Gopalakrishnan gave information on the mission's status and milestones to visitors and invited participants. Guests had the opportunity to interact with TSC Technologies, an ITCA-incubated startup.



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THE INDIAN PUBLIC SCHOOL®

TIPS Chairman & Managing Director Mr.Ashok Kumar signed an MoU with ITCA '75 Student Satellite Mission 2022

TIPS Group of schools strives to create pioneers for the future, who break all barriers and succeed in developing skills and ideas to make the world a better place. In alliance with the Globeducate Group, one of the world's leading international K12 educational group, TIPS provides world class education with lessons that are carefully integrated with systemized teaching and learning methods from various international curriculums to provide the finest educational experience.

Mr. Ashok, Chairman of the TIPS Group, takes immense pride in touching several lives by being a catalyst in helping many envision their dreams. His efforts and vision have been recognised and acknowledged for several years in a row with the Best International School Awards to his credit.

In a recent event, TIPS has partnered with ITCA, by giving 75 students a monumental opportunity to take part in the 75 Student Satellite Mission.

The school is truly a forerunner in the educational industry and has been awarded with plentiful honors and accolades, including prestigious Best International School awards.

TIPS has its presence over 9 countries, including 60 schools, creating a global family across the world.

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Navigating Indian Space Programs
Through Sectoral Reforms

Globally, the Indian space industry has been recognized for its capabilities in manufacturing satellites and launch vehicles at competitive price points. It has a successful track record of launching 342 satellites from 34 countries through its 83 launch missions. Missions to Moon and Mars have been of significant interest as they have been progressed in a frugal manner. India currently accounts for 2-3% of the global space economy and is expected to grow to more than 10% by 2030 at a CAGR of 48%.

Department of Space (DOS), Government of India, as an enabler, has formulated several policies to develop the sector and enhance the competitiveness of Indian space economy. These futuristic and strategic policies aim to de-regulate the sector and promote the spread of space technologies across the country in order to advance the entire spectrum of space activities. These reforms have piqued the private sector's interest and provided significant impetus to the industry, entrepreneurs, and startups.

ISRO, NSIL, and IN-SPACe are currently at the forefront of driving these transformations. ISRO has focused its mandate on pursuing science-based research and space missions of national importance. NSIL is a public sector enterprise that works with industry to provide high-tech manufacturing bases for space programmes. Production of launch vehicles, manufacturing of satellites, providing launch and satellite-based services, and promoting Indian space technology are among its functions. IN-SPACe will serve as a facilitator and regulator of space operations in India and will function as a single-window nodal agency for industry, government, and academia.

The private sector has benefitted from these space reforms and has emerged as an early mover to conceptualise and progress opportunities in the space business, including developing launch vehicles, manufacturing and managing satellites, establishing ground stations, and forming new companies. It has been observed that there has been an increase in new business, with entrepreneurs, startups, and investments coming into this sector in recent years.

In a nutshell, several activities related to space projects are currently taking place in India, and there is an effort to move these in a time-bound mission mode. The following are some curated press and media excerpts that will give a comprehensive perspective of Indian space.

SFO Technologies, Thiruvananthapuram and Hical Technologies, Bengaluru, have developed and delivered to ISRO flight grade RF systems and Electromechanical Actuators in February 2022. The private sector is utilizing the Vikram Sarabhai Space Centre (VSSC) facilities in a new engagement model-Government-owned, Company-operated (GOCO) to design and develop some of the most complex systems in launch vehicles including RF Packages and Actuators. RF system realisation involves intricate frequency tuning, complex integration, and rigorous testing. Likewise, the actuation systems encompasses complex mechanical and electrical integration requiring immense skill in both areas. The demand to focus on new technology developments prompted VSSC management to open the doors to private partners by adopting the GOCO model to realise and test RF packages and Actuation systems for launch vehicles.

Chairman ISRO emphasised the importance of a holistic approach to understanding Space and its components in his inaugural address at the National Space Science Symposium- 2022 (NSSS-2022), which was held during 31 January to 4 February 2022. In this pursuit, scientists, engineers and students were encouraged to investigate not only the solar system bodies and astronomical sources as single objects but also the interconnection between them.

Ambassador of Israel to India H E Mr Naor Gilon, in his meeting with the ISRO leadership reviewed the ongoing cooperation between the two space agencies and explored avenues for expanding space relations between India and Israel in view of space reforms contemplated by the Indian Government.

Speaking at the National Science Day celebrations organised by the Indian Institute of Astrophysics (IIA), Bengaluru, Chairman, ISRO said space technology is an important tool that a nation needs for a good command on the scientific front. He recalled that space technology and rocket science have enabled human beings to send instruments into space to carry out observations and helped in gaining a better understanding of the evolution of our universe.

He emphasized that while ISRO is mandated to carry out national-level space missions for efficient communication, satellite networks for defence, weather forecasting, and other applications, the space agency also launches dedicated science-based programmes.

On the agency's future scientific collaborations, Shri Somanath mentioned, "ISRO will offer all the required support and encourage the Indian scientists in realising their goals

for carrying out space observations for astronomy studies, through the payloads hosted by ISRO's missions". He added that the space agency was planning to host more scientific missions periodically and was keen on closer partnerships with other science based institutions in the country.

Union Budget and Indian Space Programme Plans for 2022

Department of Space (DOS) has been allocated a whopping ₹13,700 crores in the annual budget for the FY 2022-23, with ₹7,465 crores being earmarked for capital expenditure.

ISRO expects to generate a revenue of ₹219 crores from the launch services in 2022-23 under its commercial wing NewSpace India Limited (NSIL). It plans to launch ten satellites with its rockets. This year five satellites will be launched using the Polar Satellite Launch Vehicle (PSLV), two satellites with the Geosynchronous Satellite Launch Vehicle (GSLV), one with the GSLV-Mk III rocket, and two satellites with the newly built Small Satellite Launch Vehicle (SSLV).

ISRO looks to transfer mini-satellite bus to the private sector

As part of its effort to commercialize the nation's space scientific know-how, ISRO is pursuing the transfer of small satellite bus technology to the private sector. UR Rao Satellite Centre (URSC) has developed a small satellite platform which would enable low-cost access to space by providing a dedicated platform for payloads including earth imaging, ocean & atmospheric studies, microwave remote sensing, and space science missions with a quick turnaround time.

Successful Ground testing of Solid Booster Stage (SS1) for SSLV

Ground testing of the newly developed solid booster stage (SS1) for the new launch vehicle of ISRO, the SSLV, was successfully carried out at the Satish Dhawan Space Centre, Sriharikota. It was highlighted that all the propulsion parameters during the test were found satisfactory and closely matched with the expectations.

The successful test of the solid booster stage has inspired confidence to proceed with the first developmental flight of SSLV (SSLV-D1) scheduled any time now. The remaining phases of SSLV, the SS2 & SS3 stages, have successfully undergone necessary ground tests and are ready for integration. Manufacturing SSLV through Indian partners will be facilitated by NSIL.

IN-SPACe Structure

Dr Pawan Kumar Goenka is heading IN-SPACe. The centre will assess the aspirations of the private sector companies and educational institutes; and build synergy to address these requirements, in consultation with ISRO. IN-SPACe will have directorates for space, and safety, with specialists from Academia and Industries, legal and strategic experts from other departments, and members from the PMO and MEA of the Government of India.

Dr Vinod Kumar has been appointed as Director, Promotion, with Dr P K Jain taking over as director-project management and authorization. Mr Rajeev Jyoti has assumed charge as director-technical.

The promotion and monitoring directorate will develop programmes to promote the space industry ecosystem, enhance space awareness, and progress capacity-building facilities and infrastructure.

Space legislation and FDI regulations

The government is likely to introduce at least three policies as part of the Space Activity Bill, Lt. General (Retd) Anil Kumar Bhatt, Director General of the Indian Space Association (ISpA), said.

The upcoming space regulatory bill is expected to clearly define the scope of Foreign Direct Investments (FDI) in the country's space sector and the role that the ISRO would play alongside Indian startups.

Three policies including Space Communication, Remote Sensing, and the Transfer of Technology for which discussions have been held between the IN–SPACe, and private companies.

An ITCA's flagship initiative 75 Sat mission, which was conceived to commemorate Azadi Ka Amrit Mahotsav, has received the support and cooperation from all the three space agencies of DOS. Through the Project Monitoring Committee, ISRO is facilitating, monitoring and mentoring the mission, while NSIL is providing guidance on launch services, and IN-SPACe is evaluating the mission's readiness and providing inputs to ensure regulatory and licencing compliances.

Taking into consideration the entire gamut of operations currently underway, the reforms in India's space programme have resulted in excellent response, including expanded private engagement, burgeoning startups, increased strategic partnerships and collaborations, and breakthrough technological advances, all of which have combined to give a big push to the Indian space industry, facilitating India's dream of becoming a USD 5 Billion sector a reality in the not-too-distant future.

Successful launch of PSLV-C52 with EOS-04 Satellite

India's Polar Satellite Launch Vehicle PSLV-C52 injected Earth Observation Satellite EOS-04, into an intended sun synchronous polar orbit of 529 km altitude on 14 February 2022 from Satish Dhawan Space Centre, SHAR, Sriharikota.

PSLV lifted off at 05:59 hours IST from the first launch pad at SHAR. This was the 80th launch vehicle mission from SDSC SHAR, Sriharikota; 54th flight of PSLV; and the 23rd flight of PSLV in XL configuration (6 strap-on motors).

The satellite EOS-04 was realised at U R Rao Satellite Centre, Bengaluru. It is a Radar Imaging Satellite designed to provide high quality images under all weather conditions for applications such as Agriculture, Forestry and Plantations, Soil Moisture & Hydrology and Flood mapping. Weighing about 1710 kg, it generates 2280 W power and has a mission life of 10 years.

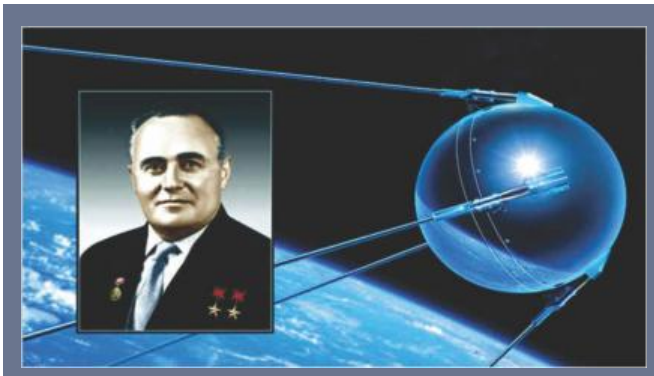
Future Space Technologies and Experiments in Space

XVII Summer Space School, Samara University, Russia

The summer school is organized annually by the Interuniversity Space Research Department of the Samara National Research University, and is supported by the Volga Branch of the Russian Academy of Cosmonautics named after K E Tsiolkovsky, the International Astronautical Federation (IAF) represented by the Administrative Committee for Space Universities (SUAC, IAF), the United Nations Office for Outer Space Affairs (UNOOSA), and the University Space Engineering Consortium (UNISEC). The school is dedicated to the 65th anniversary of the launch of the world's first artificial earth satellite "Sputnik" and the 115th birth anniversary of Sergei Korolev, former lead Soviet rocket engineer and regarded as the father of practical astronautics.

The summer space school is one of Samara University's highly successful international educational programmes, and has the motto "From mission idea to nanosatellite project". The programme of the school comprises a mix of lectures, labs, and workshops on a space theme and is delivered by academicians and researchers from the Department of Inter-University Space Research. In the first week, participants will have lectures on the basics of nanosatellite technologies (design and construction of nanosatellites, features of the dynamics of motion, navigation, control, etc.). Training will be held on the use of MATLAB software for nanosatellite mission analysis and other simulations. In the second week, students will be exposed to several lectures on advanced space technologies. All participants will be divided into four teams, and each team will be offered a nanosatellite mission for analysis and research. The main goals of these missions will be announced, and school participants can also propose their own missions. Each team will perform a mission analysis, prepare a presentation and defend the results of their work in front of the experts.

569 foreign participants from 13 countries have registered to participate in the 17th School. ITCA has encouraged and facilitated students from India to participate in Samara Summer Schools, and 9 students mentored by ITCA spacetech team have been shortlisted for this programme. This year, the summer school is being organized from 29 August to 9 September 2022.



World's First Satellite "Sputnik" was built and launched by Samara University Lab. Also, the World's First Astronaut/Cosmonauts have been sent to Space and brought back them alive by Samara Lab, during the then USSR (Russia).

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UNITED NATIONS Office for Outer Space Affairs

UNISEC SAMARA

Opportunity for Institutions
Build and Launch their own CubeSat

K Mallikharjuna Babu, PhD
Director
AMC Group of Institutions

India's foray into space started in 1962 and, over the last six decades, has conquered many milestones to emerge as the fifth most active nation in the area. With more than 350+ private enterprises actively pursuing business opportunities in space, India accounted for USD 7 Billion or 2% of the global space industry and employed more than 45,000 people.

While these figures give citizens immense pride, the academicians' utmost concern is the methodology to create an environment for the young workforce entrants to pursue research and progress careers in space. Given the availability of high-quality academic programmes, corporate ecosystems, and aggregated domestic and international demand for specialized services, India is perhaps the most appealing place to pursue a 'NewSpace industry career.

ITCA, a professional body of multidisciplinary engineers with a keen interest in engineering and technology, has conceptualized a unique 75 Students' Satellites Mission, where students in progressive and forward-looking institutions could work in tandem with industry partners and global organizations to design, develop and launch their own nanosatellites.

This programme is, in my opinion, well thought out and calibrated to conform to the recent guidelines, including NEP 2020, that place significant emphasis on research, multidisciplinary studies, innovation, and patents. Globally, student-built satellite programmes have been pursued by institutions to differentiate themselves from their peers and position themselves as leaders in research and innovation. Educational Institutions in India that pursue student-built satellite activity and launch their institution satellites will be able to showcase their capabilities in interdisciplinary research and innovation, and achieve the desired outcomes as envisaged in NEP 2020.

The Mission of Students' Satellites

The 75 Students' Satellites Mission is an initiative where students at participating colleges and universities build and deploy the cube satellites to orbital space. This mission helps students to understand systems engineering practices and an overview of satellite and space technologies through a structured 6-month training programme. There is a substantial component of industry-academia interaction, and this would help build actionable linkages with industries participating in the mission. Students and Faculty can also file IPR's and showcase their innovations, which would also enhance the institution's brand equity. As an educational outreach programme, students can leverage ITCA's synergy with University Space Engineering Consortium (UNISEC-India) and World CanSat Rocketry Championship (WCRC) to engage with their global peers and exchange best practices.

Attractive Deliverables and Takeaways for the Institutions

Through this programme, students gain experiential, hands-on learning in Design, Development, Integration, Qualification Testing and Launching a CubeSat including its operations and management on day to day basis.. Institutions will be able to claim 'Heritage Status' by Launching the Satellite to Space/LEO. Faculty can utilize the Classroom Models, which is a replica of the functional CubeSat launched into space, to explain and highlight concepts to subsequent batches of students. The Ground Station, which would be set up on the campus of the participating institutions, would be beneficial for students to track their own CubeSat and other satellites in the amateur radio domain.

Institutions can offer and teach elective subjects/courses across disciplines with hands-on experience to students at their campus. For example, institutions can extend their offering of classes to include MTech in Space Engineering or Satellites.

In conclusion...

Satellite Project is always a feather in the cap of any Institution among its competitors. In India, during the last 74 years of free India, only 12 Institutions alone were able to build and launch their Satellites. Of these, 7 are degree awarding institutions (Universities and IITs). Only 5 engineering colleges alone have launched their satellites. By launching an institution's Satellite, each of the Self-Financing Colleges can aim to be among the Top 25 or 50 or 75 Institutions that have launched their satellites in India.

The SpaceTech lab, cleanroom and the ground station established at the Institute can be utilized as the nucleus for subsequent space tech activities. The project team can be the source to establish startups focused on the space domain, which can then inspire and create other startups. The potential is unlimited, and institutions must seize the opportunity to create a niche for themselves as the space sector opens up to all citizens.

Let's thrive in NewSpace era!

AICTE Webinar

75 Student Satellite Project Mission 2022

The All India Council for Technical Education (AICTE) has organized a webinar on 28 January 2022 to facilitate the stakeholders including promoters of institutions, HoDs/Faculty members and students to gain more information about the 75 Students' Satellites Mission, and assess how this project could be progressed in their institutions. AICTE has shared preliminary information with all the institutions, and the webinar witnessed substantial participation to explore collaboration modalities with ITCA.

The webinar was presided over by Prof Anil D Sahasrabudhe, Chairman, AICTE, and Padma Shree Awardees and doyens of the Indian space industry, Prof R M Vasagam and Dr Mylswamy Annadurai participated as guest speakers.

Students attended the event and evinced significant enthusiasm and interest to participate, and build a career in the exciting Space sector.

Several questions about mission comprehension and implementation were raised during the webinar. The following are some of the pertinent questions and their answers.

What is NewSpace Era and Space 2.0? and how is it relevant to EEIs?

Democratization of space and affordable access to space are the characteristics of the NewSpace era. A few years ago, space activities were in the realm of national space agencies, and investments for space programmes would come largely from the governments. Today, space has become accessible to citizens-students and researchers in academic institutions and universities, entrepreneurs and venture capitalists, government supported/funded organizations, and private sector users for commercial endeavor. The advent of what is being called Space 2.0 offers the valley a fresh opportunity to craft new companies and technologies that help solve some of our biggest challenges and rebuild its sagging reputation.

Global technological advances, including high-quality semiconductors from the extremely price-sensitive mobile phone industry, 3D printing of parts, access to the spare capacity of large rockets through ridesharing, have helped to grow the use of Commercial-of-the-shelf (COTS) high-performance and affordable-cost hardware including miniaturized optics for mobile cameras, Micro-Electro-Mechanical Systems (MEMS) devices-sensors and accelerometers, advanced lightweight materials, high efficiency batteries (Li-Ion) and solar cells (multi-junction GaAs-gallium arsenide semiconductor) have established the standards for enhanced reliability of operational nanosatellites. The usage of COTS subsystems has helped in reducing the complexities associated with traditional satellites, thereby making them easy to assemble and test.

The standardization of SmallSats and CubeSats has facilitated the transformation of the space industry, with missions' development costs dropping to fractions of the price of conventional satellites and development time reduced to about 6-12 months from the time the need is assessed to the time the satellite is placed in orbit. In addition, SmallSats

constellations can ensure continuous renewal of the satellite system, which translates to the delivery of optimum technological services at all times. EEIs can provide the contemporary knowledge required for growing space industries and enlighten their own students/faculty members on emerging global market in space industries!

How to create a campus-based Satellite Team?

Identify the passionate students and faculty members CubeSat projects who are willing to learn space technologies on their own or collectively with the help of mentors and industry partners. Commitment from your top- level management with adequate budget or as a self-supporting project of entire campus or at Group of Institutions etc. Signing MoU with ITCA, the institution will be part of the consortium to launch 75 Satellites as part of the mission during later part of the year.

What is the most important factor in developing and launching our own satellite?

Proactive decision of Top-Level management and taking into account the cost-benefit analysis of the Satellite Project and Facilities that are going to be with the EEI during or after the implementation of Satellite Project at your campus is important.

Each privately funded engineering colleges may pursue their objective of being a top ranked institution with leadership in Space R&D and delivering the best to students by conceptualising their own satellite.

More than 160 institutions evinced interest in this unique mission, and ITCA is engaged with the institutions to facilitate their participation and have their students benefit from this unique programme.

Newtech Aerospace Pvt Ltd.

Newtech Aerospace Pvt Ltd (NAPL) provides the most reliable solution for aerospace electronics hardware realization requirements! It has become one of the figureheads to serve the aerospace industry with low-volume PCB assembly, high-mix facilities, advanced assembly technology and multi layered quick turn prototypes. When it comes to aerospace manufacturing, stringent quality standards are a given. After all, the electronics in aerospace face harsh environmental conditions! Besides with them being thousands of feet in the air repairs aren't possible. It is imperative; therefore, that aerospace PCB assembly works with precision in such mission critical applications. Our process includes manufacturing single, double-sided and complex multilayer PCBs with critical layouts.

NAPL have the necessary value-engineering expertise with dedicated program management and best-in-class quality and IT systems to manage the complex product requirements of aerospace customers. Our manufacturing facilities hold extensive number of certifications and licenses to meet complete turnkey PCB aerospace and military solutions.

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ITCA
Practice Initiative

Digital Engineering Paradigm
for Successful CubeSats Missions

Srinivas Durvasula
Program Manager
Indian Technology
Congress Association

The 75 Students' Satellites Mission envisions CubeSats' conceptualized, designed, and developed by students with support from the industry to be launched into low-Earth orbit (LEO) in conjunction with the national space agencies. This initiative has received the acclaim of global space professionals and has been referenced by the Hon'ble Prime Minister at his address to the world leaders at the United Nations General Assembly in September 2021.

A successful mission requires improved system design, quality assurance, adherence to development schedules, increased capacity for reuse, flexibility to incorporate changes, tracking the impact of changes, and facilitating a higher level of support for integration.

These mission requirements necessitated the incorporation of Systems Engineering practices and deploying a suitable framework that facilitated automation, knowledge management and structured workflow for the development teams.

This article chronicles ITCA's teams' journey in creating a Digital Engineering platform for assuring mission success.

What is Digital Engineering?

In the era of NewSpace, it is important to move contemporary advances in technology swiftly from concept to launch. Digital Engineering (DE) offers a pathway for a seamless transition from prototypes to a viable products.

DE, propounded in a U.S. Department of Defence-sponsored report, "uses authoritative sources of systems' data and models as a continuum across disciplines to support lifecycle activities from concept through disposal". A DE ecosystem is an interconnected infrastructure, environment, and methodology that enables the exchange of digital artefacts providing a single source of truth for stakeholders for all activities throughout the lifecycle. Model-Based Systems Engineering (MBSE) is a subset of DE, defined as the formalised application of modelling to support system requirements, design, analysis, verification, and validation activities commencing in the conceptual design phase and progressing throughout the development lifecycle.

MBSE is the integration of discipline-specific engineering models and simulations using graphical-based modelling tools. Requirements and interfaces are no longer confined to previously isolated engineering artefacts but are now integrated into a single system model. This facilitates a thorough examination of the model, with modifications transmitted and reflected in all the system's views. The purpose is to use the model to design the physical system and to generate documentation from the model.

Importance of DE for Space Systems Engineering

NewSpace organisations are evaluating several techniques to build a digital workflow for developing space systems to realise the DE vision. By speeding up some of the essential development processes, DE has shortened the development period of space assets from years, if not a decade, to months and weeks.

Following their flight into orbit, spacecraft and satellites are beyond the physical reach of crews tasked with maintenance and support. MBSE allows ground-based technicians to generate a virtual counterpart of a spacecraft (also known as a digital twin) to evaluate vulnerabilities, assess and predict performance, and arrange software updates for these orbiting assets.

DE for CubeSats

Since the definition of the CubeSat standard around the year2000, satellite development and launch have become a routine activity in the leading global universities. Over the last two decades, academic CubeSat missions have evolved in sophistication into projects with more advanced research objectives.

CubeSat teams leverage DE using Computer-Aided Design (CAD) tools and packages, shared cloud documentation and productivity packages, version-controlled software repositories, and cloud-based issue tracking and project management software for progressing CubeSat projects and facilitating team collaboration.

MBSE has been used to capture and document the CubeSat domain, which includes the CubeSat, Stakeholders, External Environment, and External Constraints. The Space Environment and the Earth Environment are two examples of external environments. Licenses and regulations would be examples of external constraints. The model also includes the concept, development, production, operations, and retirement phases of the lifecycle. All phases of activities, such as pre-launch integration and testing, launch, early orbit checkout, and complete mission operations, are also documented.

Development Methodology

A student-built CubeSat development project lifecycle has multiple

development milestones. The figure shows the sequential approach for a typical student-built CubeSat project.

It is preferable to use agile methodology for the development of the CubeSat. Each subsystem has been subdivided into multiple levels of functional units that may be tested; these units are then designed and tested before proceeding to the next subsystem. Each unit will then be combined into more complex functions, which will be designed, assembled, and tested. This iterative process is repeated until all subsystems and, ultimately, the entire CubeSat system is realised. Integrated into this process is the development of documentation and the use of standards and conventions throughout the hardware development process, including designing, testing, and reviewing. This agile methodology aims to prevent bottlenecks caused by the breakdown of the individual components and enable a quicker turnaround of prototypes.

Throughout the design phase of the project, the student-satellite project team must make numerous decisions. The team must conduct a comprehensive analysis of the requirements and develop test scenarios. Additionally, the team must review the conditions and ensure that they are sharply articulated.

Integration and Testing

CubeSats have evolved into highly integrated systems with built-in modularity in hardware and software systems. However, these CubeSat projects being undertaken in collaboration with academic institutions, are operating on tight budgets. Therefore, it is essential to fix bugs and issues early in the development cycle through early integration and testing.

Integration processes have been strengthened by using commercial-off-the-shelf (COTS) components to the maximum extent possible and, for the remaining, using advanced, industrial type electronics-based subsystems.

Verification and validation are critical to ensuring that the spacecraft functions as specified (verification) and meets the needs of the stakeholders (validation).Testing is the term used to describe all these activities. Hardware-in-the-loop (HIL) setups have been particularly valuable for verifying functional requirements, and they can also check performance requirements when deployed on target hardware.

Using HIL set-ups during the development lifecycle has facilitated the early discovery of bugs and enabled iterative development of successful CubeSats.

Knowledge Management

The complexity of the CubeSat system necessitates better information accessible to all members of the project team and comprehensive capture of knowledge across all team members and during brainstorming sessions and reviews.

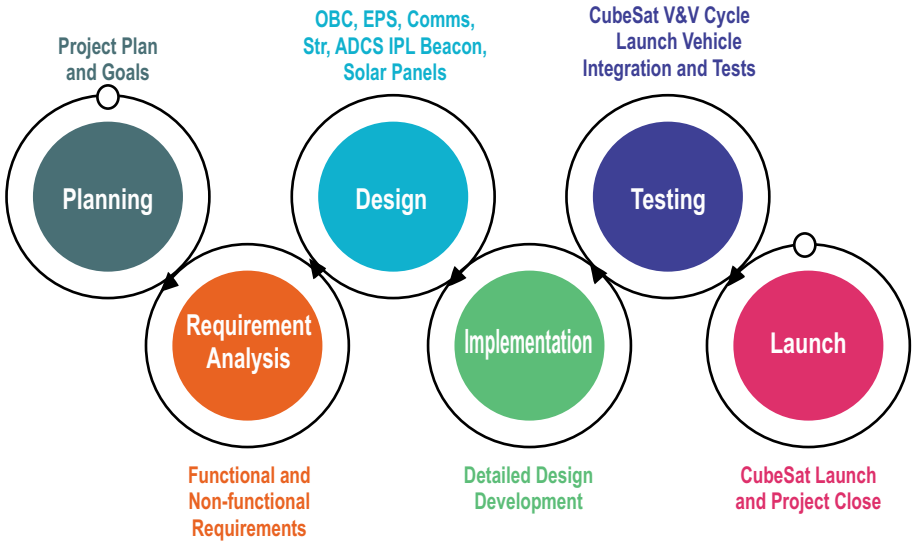
Using the techniques of progressive elaboration and prototyping, enhanced collaboration and instances of non-communication of changes that influenced both hardware and software performance were minimised. In addition, shared repositories enable project teams to see how the team members write code and test, improving consistency across the entire codebase, and functioning as a resource for reuse for other satellites.

Benefits of DE Deployment

Adoption of DE tools, techniques and practices has led to increased information sharing amongst the project teams, access to information in a timely manner, enhanced collaboration and better knowledge capture through comprehensive feedback being obtained during interactive project reviews.

Project teams have reported improved issued tracking, enhanced traceability of design choices, and better troubleshooting and resolution of defects. In addition, ITCA has been successful in enhancing the user experience of the project teams by empowering smaller functional-focused teams to make faster and informed decisions while facilitating continuous improvement.

The use of the DE platform in an interdisciplinary programme like the mission referred to has successfully prepared participating teams for future work ethos across multiple industries. In addition, the DE platform has helped project team members build competencies and larger skill sets for favourable consideration by prospective employers.



Upcoming Global Space Launches

The year 2021 was replete with several trailblazing achievements, including the launch of the James Webb Space Telescope, SpaceX's Inspiration4, NASA's DART (Double Asteroid Redirection Test), and 134 launches that put astronauts and satellites into orbit. The highest number in the entire history of humankind's spaceflight expedition including humans in space. The following six months of 2022 are set to be even more interesting, with numerous space agencies, including NASA, the European Space Agency, the Indian Space Research Organization, and the Korean Aerospace Research Institute, revealing their ambitious plans to explore the unknowns of space. In addition, with the orbital testing of SpaceX's Starship (spaceship), the introduction of United Launch Alliance's (ULA) Vulcan Centaur rocket, and the debut of Blue Origin's New Glenn rocket, commercial spaceflight is entering an exciting moment.

USA's Space Schedule...

SpaceX has rescheduled the maiden orbital launch of its Starship rocket from the company's Brownsville spaceport in Texas, United States of America in the coming days. SpaceX's Starship—the most powerful rocket ever launched—is expected to sail into orbit for the first time in 2022. It is entirely reusable, has more than double the thrust of the Saturn V, and can carry 100 tonnes into orbit. Musk's ambitions to establish a self-sustaining facility on the Moon and, eventually, a city on Mars is centred on the enormous rocket.

NASA also announced a tentative launch windows between July and December this year for the Artemis I mission, which aims to redirect humanity's eyes to the Moon by sending a spacecraft into lunar orbit. The agency has announced that the crucial testing of the mission's SLS rocket, conducted at the Vehicle Assembly Building (VAB), has been completed. Artemis I, which includes the SLS rocket and the Orion spacecraft module, could soon be rolled out to the launchpad.

This year, ULA plans to launch its Vulcan Centaur rocket into space. It is powered by two Blue Origin BE-4 engines instead of the company's Atlas V rockets fueled by Russian-made engines.

Soon Blue Origin will test its New Glenn orbital rocket. Seven BE-4 engines power the reusable rocket's first stage. Two BE-3U re-ignitable engines propel its second stage. New Glenn will generate 18,200 kilonewtons of thrust and be capable of transporting around 45 metric tonnes of payload to LEO.

Boeing has successfully launched the CST-100 Starliner spaceship the spacecraft that will take astronauts to ISS. The capsule was deployed to orbit on 19 May riding to space on a ULA's Atlas V rocket; it approached and docked with the ISS on 20 May. After spending five days at the ISS, the uncrewed test flight OFT2, returned to Earth landing intact with the help of parachutes and airbags in the New Mexico desert.

European Space Agency's Plans...

Launcher integration for the inaugural flight of Vega-C (VV21) began in Kourou, French Guiana, in April 2022. For flight VV21, LARES-2 will be the primary payload, a scientific mission conceptualized by the Italian Space Agency (ASI). Onboard would be six European research CubeSats.

The ESA has certified that the ExoMars rover is technically ready for launch, and a fast-track analysis is underway to determine the mission's possibilities for reaching Mars. The teams will seek to launch as soon as feasible, depending on the speed with which technologies can be integrated to support a European-led mission or in cooperation with other international partners and the availability of compatible launchers & launch sites.

South Korean Plans...

South Korea will make a second attempt to launch it's first domestically designed and developed space rocket, the Korean Satellite Launch Vehicle Two (KSLV-II), nicknamed Nuri, meaning the world in Korean, on 15 June. The June launch will carry a working satellite weighing 168 kg.

Indian Space Programme Schedule...

PSLV-C53 is tentatively scheduled to launch an earth observation satellite, EOS-06, in the second quarter of 2022. Satellite integration with the launch vehicle and testing activities are being progressed.

SSLV-D1, the first developmental flight of a Small Satellite Launch Vehicle, is expected to deploy, in the second quarter of 2022.

Bharti's OneWeb Partners with ISRO to Launch Satellites

OneWeb, a global commercial satellite operator, will collaborate with the ISRO to launch several of its spacecraft & ISRO has become the second launch provider for Bharti Enterprises' OneWeb, after United States' SpaceX, using which the company intends to launch its satellites.

NSIL's first demand-driven communication satellite for Tata Sky

The Ku-Band four-tonne GSAT-24 will be launched by Arianspace on 22 June from the Guiana Space Center will provide high-quality television, telecommunications, and broadcasting services over India

An JAXA and UNOOSA KiboCUBE

KiboCUBE is a joint initiative between JAXA and the United Nations Office for Outer Space Affairs (UNOOSA), started in 2015. The purpose of this program is to offer opportunities to deploy a 1U CubeSat from the Japanese Experiment Module "Kibo" of the International Space Station (ISS) with the objective of contributing to the capacity building of developing countries in space technology and human resources development.

JAXA and UNOOSA ran the sixth round of invitations in 2020 and 2021 and selected the Private Higher School of Engineering and Applied Technology from Tunisia and the Popular Autonomous University of Puebla from Mexico.

The two selected projects aim for image acquisition and communication technology demonstration using the CubeSat facility, which is expected to contribute significantly to the future growth of space development activities of the two countries. Satellite deployment for both is scheduled for 2024.

Source: global.jaxa.jp

ESA Academy's CubeSat Summer School 2022

ESA's Education Office is developing an innovative new multi-week training opportunity: the CubeSat Summer School 2022. In the frame of ESA Academy's Training and Learning Programme, this Summer School is designed for university students with engineering and physics backgrounds who are highly motivated to participate in a CubeSat project or pursue a career in the space sector, but currently lack knowledge or experience within this area.

The Summer School will run for four weeks from 8 August to 2 September 2022 at ESEC-Galaxia, Transinne, Belgium.

Source: esa.int

Eight African countries To Build First Satellites

The All Nations University (ANU) in Koforidua is leading a team of experts from eight African countries to help solve Africa's environmental problems.

Engineers and scientists collaborate to design and build satellites that monitor floods, forest degradation, climate change, and pest invasion. The project will allow each country to build its own satellite.

ANU President Dr Samuel H Donkor said the Space Systems Technology Laboratory on campus had the first digitised industrial tour and virtual reality learning.

Source: graphic.com.gh

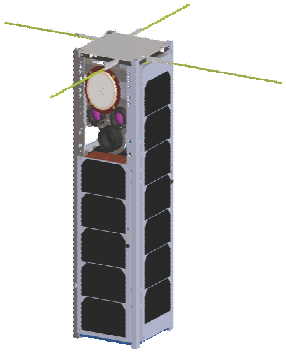
BeaverCube MIT's Mission

BeaverCube is an educational mission led by the Massachusetts Institute of Technology (MIT) to introduce high school students to aerospace science and technology by designing a 3U CubeSat.

Its science payload will measure cloud properties, ocean surface temperatures and ocean colour to study Earth's climate and weather systems. BeaverCube also will demonstrate an application for the use of shape memory alloy technology via on-orbit calibration.

Temperature gradients in the thermohaline circulation affect the rate of sea ice formation near the poles, which in turn affects albedo and thus solar heating at high latitudes. Two Small- and meso-scale ocean features like fronts and eddies can also be tracked using SST properties. BeaverCube will track warm core rings on the Northeastern US coast, one of the world's hottest regions due to climate change.

BeaverCube was delivered to Nanoracks on 30 March 2022, and the space company will be ready for launch on 7 June 2022 (SpaceX CRS-25)



Source: starlab.mit.edu

LEO Economy
The NewSpace Normal

Historically, most of the efforts of government-driven national space agencies have centred on satellite communications, including telecom, television coverage, and global positioning systems (GPS). These applications necessitated the use of satellites in medium-Earth orbit (MEO) or geosynchronous equatorial orbit (GEO).

Over the last decade, there has been a trend where space investments are flowing into activities primarily focused on the low Earth orbit (LEO), including telecommunications and Earth observation applications. Satellites in LEO closer to the Earth than their MEO and GEO counterparts are ideal for enabling high-speed and low-latency communications. They are also typically smaller in size, with affordable development costs, and need to position multiple LEO satellites in constellations to ensure adequate networking and coverage. Beyond SmallSats for related applications. The investors and space organizations are also focused in LEO for space travel and entertainment. It is estimated that about 60 to 70 percent of present-day investments in space are focused around LEO.

Launch costs are significantly lower for LEO as compared to MEO or GEO, and this is very beneficial as it facilitates nations, organizations and even individuals to access space. In the last few years, we have witnessed the rapid transformation of the launch services industry with the introduction of reusable launch vehicles. In December 2021, the sector achieved the landmark milestone of the 100th successful recovery of a commercial reusable launch vehicle, a breakthrough achieved about six years after the first successful retrieval. The Space Shuttle programme took 19 years to complete 100 successful flights to put this in perspective. The NewSpace industry has clearly demonstrated the accelerating pace of technological innovation and a significant expansion in the capabilities of the participating entities to address challenging and complex missions.

Methods to Foster Growth in LEO

It is critical for governments, policymakers, entrepreneurs, investors, and industry to work together to develop a coherent and conducive environment and to build a sustainable ecosystem for an LEO economy. Continued and increased investment in technology and competency development is required to address. In addition, the industry will need a coordinated effort to reduce entry barriers while also promoting the sustainable commercialization of technology & solutions to enable lower-cost and higher-frequency human space operations.

Supply and Demand Analysis

Commercialization of the LEO has seen early successes through the growing launch services activity and deployment of SmallSats as constellations. Currently many new entrants are announcing missions on both the supply and demand side opportunities to bolster the market activity.

New age businesses specializing in commercial space travel are stepping up their efforts to bring citizens closer to exploring and accessing earth orbit. Blue Origin and Virgin Galactic have succeeded in transforming space travel from a concept of science fiction to a commercial reality.

New entrepreneurs and startups are deploying and establishing large-scale additive manufacturing capabilities to influence and drive unmanned and manned mission launch services.

Commercial innovation in the growing private sector is helping space manufacturing rapidly move beyond 3D printing into other manufacturing modes, facilitating the development of new processes that produce high-value materials. Space-based manufacturing takes advantage of the unique microgravity environment, which naturally modifies materials on an atomic level and converts them into superior materials and products compared to their terrestrial analogues.

As technology advances and the Space Station ecosystem becomes more accessible due to decreasing launch costs, it will be more economically viable for space-enabled manufacturing to establish profitable markets in LEO. While the cost of launching materials to the Space Stations and returning them to Earth remains high, research indicates that money generated by producing space-based products substantially outweighs the operational costs of space manufacturing.

This enhanced high-tech manufacturing process solves specific market needs, provides value to the products required for these business, and generates sophisticated items for Earth's customers. It creates new markets by raising demand for Earth-space partnerships and the associated need for space infrastructure, both of which are expected to accelerate LEO commercialization.

The future, as we see it...

The LEO economy can pave the way for improved technologies in space and on Earth, as well as exploration of deep space. LEO allows us to broaden our terrestrial supply networks and sustainably support global economies. It facilitates a synergistic link that has the potential to contribute to humanity's growth and prosperity in the coming century.

LEO Satellite Navigation Services

Precision PNT Services for the Age of Autonomy

Satellite navigation has empowered our society with the availability of a plethora of applications delivering Position, Navigation, and Timing (PNT) services. Industry analysts have estimated that the global satellite PNT technology market valued at USD 962 Million in 2020 is estimated to reach USD 8,817 million by 2031, at a compounded annual growth rate (CAGR) of about 22% during the review period 2021-2031. Satellite PNT technology determines precise geographical location or position, navigates the route, and accurately predicts the time to reach the destination. PNT is obtained from the Global Navigation Satellite Systems (GNSS). These are space-based navigation systems providing navigation signals across the globe. Presently, there are four global navigation solutions in use, GPS from the USA; GLONASS from Russia; Galileo from European Union, and BeiDou from China. There are two regional navigation satellite systems, India's NavIC and Japan's QZSS offering PNT signals for the defined coverage areas.

India's satellite navigation service sector is expected to grow as a result of the government's efforts to promote the efficient development, operation, and maintenance of these systems. The DOS Indian Satellite Navigation (SATNAV) Policy, as a comprehensive and substantive national policy for satellite navigation, will have a significant impact on the global navigation arena.

In addition to its primary function of providing PNT services, the NavIC system can broadcast short text messages. A life-saving alert service is used in areas with little or no communication, such as the oceans.

These navigation signals are offered free-to-air for a variety of air, space, maritime and terrestrial applications ranging from tracking, telematics, location-based services (using mobile devices), automotive, survey, and mapping including Geographical Information Systems (GIS). The number of possible GNSS applications is not limited by technology, but by our ability to imagine and envision new services and applications. And it is expected that the development of satellite navigation technology will not reach a steady state anytime soon.

There is another revolution silently underway that promises disruption of mobility, transportation, and safety. Autonomous systems in the avatar of self-driving cars, aerial platforms including drones, mobile robotics, and others are on the rise, promising improved access to the mobility of citizens, goods, and services. This technology-driven transformation is one whose complexity demands more than what current navigation systems can provide.

When we look at the history and evolution of the navigation industry, we notice an order of magnitude improvement in location accuracy every thirty years. Each incremental step requires investment in enhanced infrastructure to achieve new capabilities. In the mid-1990s, GPS was used to provide metre-level positioning; now, with the advancement of GNSS, prediction levels are closer to decimeter, with improved performance.

Autonomous systems are one of the upcoming functions that are driving this need. Where it is estimated that 10 cm, 95% accuracy in position will be required for self-driving cars. Many technologies are being developed simultaneously to address this challenge. GNSS, LiDAR, computer vision, and radar are all striving to deliver this critical and demanding performance. Though some progress has been achieved in meeting these needs under certain conditions, there is still a long way to traverse for addressing the critical requirements of safety, security and more importantly, reliability. The challenge facing the auto manufacturers is on methods to achieve localization requirements on accuracy, integrity, availability, scalability, and security while optimizing the Cost, Size, Weight, and Power (CSWP) of onboard equipment. These systems will need to interoperate in our cities and rural areas where cellular and internet connectivity is sparse.

Satellite navigation offers a ubiquitous reach with established global datums and is emerging as the logical choice for the delivery of enhanced PNT services. With subscription-based correction services and powerful receiver chipsets, GNSS navigation accuracy is approaching the standards for autonomous driving. However, autonomy has raised the standards for navigation services in terms of interference resilience and cyber security.

Access to space affordably through the use of reusable launchers, along with commoditized satellite buses and components, offers new options for delivering new services. A LEO-based navigation service can serve as the backbone for Intelligent Transportation Systems (ITS) navigation requirements. The NewSpace ecosystem of constellations of SmallSats in LEO, together with the current GNSS infrastructure, provides the solution framework for a sustainable commercial LEO navigation service.

LEO satellites can provide high accuracy due to the rapid convergence of precise locations produced by their fast motion across the sky. Proximity to the Earth also means stronger signals for the end user, which results in better tracking and resistance to radio interference. It is possible that a LEO network of over 300 satellites could provide coverage comparable to GPS today.

Role of Professional Societies
Space Programs

O P Khanna
Chairman
Needy Heart Foundation

From time to time, some professionals have raised pessimistic views regarding the quality of engineering education in the country. That may be true in some engineering colleges where guidance is absent to students or where an adequate number of good teachers are not available. However, that impression is not accurate in respect of engineering colleges in general-particularly those institutions where ample care is being taken to provide necessary guidance to students.

To enhance the quality of engineering students joining the workforce, it is essential to help them to develop a repertoire of skills, not just in their chosen field of specialization, but in related domains like project management, working and managing with teams, written and oral communication, amongst others. The curriculum generally taught in institutions and universities is the minimum content of knowledge that a student would require to work in an organization. Therefore, there is a need for experiential, hands-on training, which can best be obtained through internships in the industry. It is also essential for students to learn the art and techniques of innovation, that is, to introduce new ideas and methods and make changes in the contemporary practices. This becomes possible only when students are provided with an opportunity to engage and work with veterans & experts with knowledge, understanding and professional skills. A professional society is an ideal forum to help students pursue internships and engage with experts to gain exposure to the best practices that would help to build a mindset and culture of innovation. Through conferences, seminars, community meetings etc., professional societies present a pathway for students to constantly upgrade their knowledge and build relationships that would help them advance their careers pursuits.

The Indian Technology Congress Association, a professional body comprising veterans and doyens from the industry and academia, has structured the 75 Students' Satellites Mission. Over the last four years, the team has diligently worked on organizing international conferences and seminars to bring contemporary space-tech expertise and best practices to the student fraternity. International visits, SpaceTech Leadership Exchange Programmes to Israel and the thematic editions of the Indian Technology Congress, including the most recent edition hosted by Chandigarh University on "Space for Everyone and Satellites for Everyone", have been very fruitful in facilitating a cross-pollination of ideas.

Students in participating institutions are building a knowledge base through the 24-credit course in space technologies through the mission. This is supplanted with the experiential, hands-on learning that students are exposed to designing their institution satellites and developing unique secondary payloads. In addition to this, students can progress internships in the organizations mentored and incubated by ITCA.

The management team at ITCA has strived and built a strong working relationship with ISRO leadership, developing synergy with many suppliers of satellite parts & devices. It has also enlisted specialists from ISRO and other aerospace organizations to mentor and motivate students across the institutions. These mentors are also helping students in participating institutions file IPR & patent applications in addition to progressing the CubeSat missions.

In all these initiatives, ITCA has worked steadfastly in encouraging gender diversity and helping the girl students think and dream big. For them, ITCA has helped breaking the glass barrier, even before they join the workforce.

ITCA team is functioning as a nerve centre to help participating institutions' ideas and develop secondary payloads for wide variety of applications. It has established a well-equipped contemporary 75 Satellite Technology Centre, to motivate the project teams and helps them focus on the adhering to programme schedules and deliverables.

This Satellite Mission has been stitched together, keeping in mind the national aspiration of being recognized as a Global Space Hub and the enabling policy initiatives of Atmanirbhar Bharat & the National Education Policy. This initiative strengthens the industry-academia-research interactions, correlates theoretical knowledge with 'real world' practical challenges faced by industry and facilitates the adaptation of research outputs by the industry for commercialization. With this, the mission has emerged as a standardized framework for industry, academia, policy makers and R&D institutions.

From all the reports on the mission's progress, one can say that given the proper guidance and encouragement, students can achieve anything beyond their current imagination. This Project has given much-needed credibility to the standards of Engineering Education in India. This mission's consistent growth and success make me proud as a founding member of ITCA.

We at ITCA seem to be on the right path at the objectives of the mission. May the ITCA leadership continue to inspire students to succeed in the Mission.

Small Satellites
Era of Mass Production

Per the Index of Objects Launched into Outer Space, maintained by the United Nations Office for Outer Space Affairs (UNOOSA), there were 8,261 individual satellites in various orbits around the Earth at the end of January 2022. The year gone by, 2021 saw a record number of 1,807 satellites being launched into orbit, corresponding to an increase of about 12 percent when compared with April 2021 statistics. Industry analysts point out that more than 3,790 satellites are in LEO. Key trends of increasing automation, modular development of SmallSats, exponential deployment of software-defined satellite designs, and adoption of mature and standardised manufacturing processes are driving this unprecedented increase in the number of LEO satellites.

The other trend of satellites being manufactured using lightweight materials including aluminium and titanium; alloys including aluminium-beryllium and nickel-cadmium; and contemporary composites is also an influencing factor. Miniaturization of electronics components and subsystems has resulted in reducing the size and mass of satellites while enhancing the payload capabilities. These simultaneous advances have helped expand the SmallSats development market. These SmallSats enable constellations of satellites to be carried on a single launch vehicle, enhancing the profit margins for the organisations.

The high costs of constructing satellites and their subsystems can be reduced by utilizing additive manufacturing (AM) processes. Rocket engines, satellite buses, and bespoke payloads for satellite launches are increasingly being developed using the AM process. Many startups are deploying 3D printing technologies for mass-producing LEO constellation satellites. This shortens the time required for prototyping and testing satellites and their components, lowering manufacturing lead times & costs.

Another industry tending that is standing out is that all profitable operators are working with external manufacturers to build their satellites. Manufacturers are steering in innovation and designing their products, emphasizing scalability and reliability. Fabricators are leveraging a modular subsystems' design approach to tweak their process and enhance the pace of production while mitigating the risks of unstable global supply chains. By deploying standardized production processes and using modular subsystems, manufacturers are attempting to keep a substantial portion of the design and satellite bus consistent for each mission, thereby achieving gains in scalability. This approach slashes the time required for customising a satellite and helps reduce development costs. Customers can realise CapEx savings through faster integration and deployment of their satellites.

Satellite production is still dominated by direct human efforts, despite the introduction of robots to the assembly lines of automotive and aeroplane companies many years ago. The use of robots and collaborative robots (cobots) in satellite constellation production is expected to become more common in the near future because of this shifting movement. Compared to the millions of cars and thousands of aeroplanes produced each year, satellites are made in much smaller quantities. Northrop Grumman Innovation Systems (NGIS), which was formed by the acquisition of Orbital ATK in 2018, employs robotics to assemble electronic boards with computer chips. Satellite manufacturers are experimenting the automation of repeatable processes, for example cell placement on solar arrays. The amount of touch labour involved is reduced by automating some manual procedures, to avoid risk of human error. Programs are currently underway to bring robotic capabilities to the cleanrooms of satellite manufacturers. Cobots are being evaluated for deployment in spacecraft manufacturing. Cubic Mission Communications and Computing, a provider of amplifiers, space-qualified phased-array antennas, filters, diplexers, and other components, is leveraging robotics to create more reliable products, circumventing human error.

OneWeb and Airbus Defence & Space have successfully mass-produced satellites using a highly automated approach. The joint venture OneWeb Satellites' factory currently produces two satellites per day. As the market leader in OneWeb satellite manufacturing, Airbus is also exploring future manufacturing options for the orbit-proven platform for imminent commercial requirements beyond connectivity.

China is accelerating the expansion of its satellite manufacturing business. It began testing operations of its first intelligent mass production line last year, with a capacity of more than 240 tiny satellites per year. According to an article published online by China Aerospace Science and Industry Corporation, Ltd. (CASIC), machines now perform more than ten fundamental operations, boosting manufacturing efficiency. The production line's equipment could be changed to manufacture components of different sizes and weights. The facility combines cutting-edge intelligent manufacturing technologies,

satellite research and development, core component fabrication, advanced testing and quality control, cloud computing, extensive data analysis, and modular production to assemble, integrate, and test various types of satellites used for communication, navigation and remote sensing. Satellite production can be transitioned from human to data-driven processes enabling mass production. The intelligent manufacturing line improves production efficiency by more than 40%, reduces and speeds up the production cycle by more than 80%.

SmallSats today are limited to one kilowatt of power or less. The power system, which is being created using Made in Space's Archinaut in-space manufacturing and assembly technology, will initially provide up to five kilowatts of solar energy. Solar array systems based on Archinaut use space-manufactured structures and robotically built state-of-the-art solar cell blankets to offer upto 20 square metres of solar array for SmallSats launched from tiny launch vehicles (in the 150-300 kg class). The Archinaut power system has now become possible because of decade-long additive manufacturing and robotics advancements. The power technology will enable numerous major satellite applications on small spacecraft. Archinaut's power system can either be used as a stand-alone system or linked into larger satellite buses.

Boeing has announced the opening of a new high-throughput SmallSat production facility powered by Millennium. The facility will be used to scale manufacture for very large, small-satellite constellations. The SmallSat Factory is in El Segundo, California, within Boeing's million-square-foot satellite production facility. Boeing has created a 30,000-square-foot high-throughput SmallSat manufacturing, integration, and test facility to adapt and respond to its clients' increasing constellation needs. It significantly enhances Boeing's capacity to switch easily between small and big constellations for both government and commercial applications.

Lockheed Martin is also progressing investments at its Waterton Campus in Littleton, Colorado, to support significant expansion in small satellite production over the next few years. A contract to build 52 satellites across the first two phases of the SDA's Transport Layer, which will create an on-orbit mesh network in low Earth orbit to connect space-based sensors with shooters on the ground, has been awarded to the company, and the company expects to win more SmallSat business in the future as demand increases.

Raytheon is another worldwide player looking into the possibility of mass-producing SmallSats. In November of last year, Blue Canyon Technologies, a SmallSat company, was purchased by Raytheon in 2020 and finalised its acquisition of SEAKR Engineering, a space electronics provider.

In addition, the spurting demand for SmallSats has prompted structural revamping at L3Harris, a business entity that has always been known for its space technology research. In recent years, the company has increased its manufacturing capacity, and started last year that it would expand its facility and increase its production output to six satellites per month, from three previously.

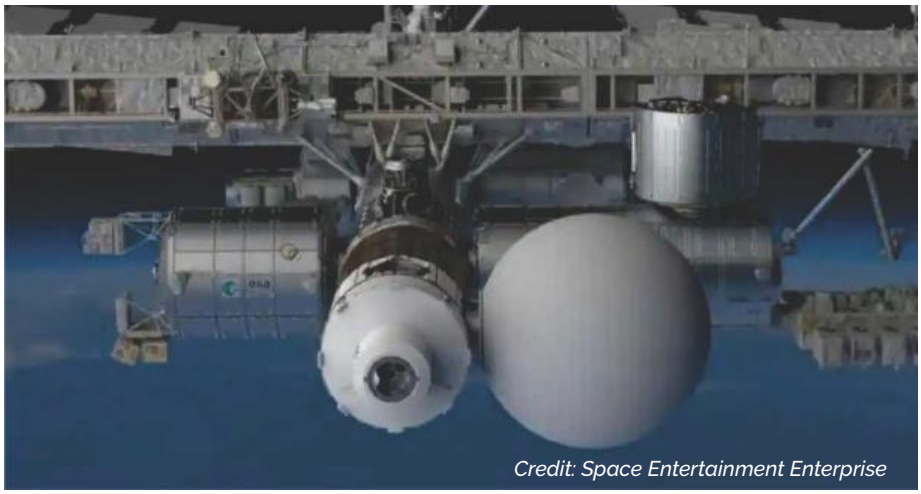
Organisations are working on developing ways to put many satellites in a variety of orbits simultaneously. In addition, organisations are rapidly investing in research and development facilities to create extensive SmallSats production capabilities to manufacture spacecraft at competitive price points, facilitating many satellites to be launched at the same time to maximize efficiency.

Industrial production technology is disrupting the space industry. NewSpace business models require prominent constellations, and there is a need to compress the satellite development time to address market requirements. Contemporary Industry 4.0 technology stack can support mass manufacturing of satellites, and India has the domain expertise and technology integration know-how to make mass manufacturing of satellites a reality.

By adopting the paradigm of mass production of SmallSats, previously unaccomplishable missions are now within easy reach for completion. Manufacturers are able to slash client acquisition time to months from years; and the concept-to-launch cycle time is brought down significantly, thereby making space technology more accessible to customers and citizens. The payload interfaces are compatible with different configurations. All this will enable manufacturers to address the current set of use-cases and generate new applications.

Mass production of SmallSats in Wuhan *Credit: CASICL*

NewSpace-Wealth of Amusement



Credit: Space Entertainment Enterprise

Space already provides a range of entertainment alternatives in the form of television, sporting events, TV shows, and films. The burgeoning NewSpace opens the door to a new world of inspiration by generating new business prospects and serving as an imaginative and easily accessible home for numerous entertainment alternatives in a venue loaded with cutting-edge technology. Imagine a film studio with extraordinary facilities that will be about 400 kilometers above the Earth to produce movies.

The uniqueness about Space movies, similar to terrestrial films, can be of multiple genres, comedy, drama, or horror. Space is merely a setting, a backdrop against which storytellers can create any kind of story they like. Space possibilities are limitless, which may explain why it is possible to base many amazing movies on the theme of space and related futures.

In July of last year (2021), Russia's Progress MS-17 cargo ship transported equipment to the International Space Station (ISS) for the first feature film to be shot in space, titled "The Challenge".

A Russian actor and a film director have returned to Earth following a 12 day stay in October 2021 aboard the ISS, where they shot scenes for The Challenge. Director Klim Shipenko and actor Yulia Peresild travelled in a Soyuz capsule with cosmonaut Oleg Novitsky. The film was about a surgeon operating on a cosmonaut. Shkaplerov, along with the two Russian cosmonauts who were already aboard the ISS, are noted to have had cameo roles in the film.

Space Entertainment Enterprise, a company based in the UK, has secured a deal to establish the first space-based entertainment studio. Elena and Dmitry Lesnevsky, producers of an upcoming Tom Cruise space adventure film, have announced the signing of a deal to create a fully operating film studio. It will be linked to the ISS through a robotic arm. The studio, dubbed Space Entertainment Enterprise-1 (SEE-1), will be 20 feet wide. The module will house films, television, music, and sporting events, as well as artists, producers, and other content creators seeking to create new material in low orbit. The first-ever space-based entertainment studio is all set to launch in 2024.

Axiom, a leading space company, plans to launch a module, a tiny capsule that can be connected to form a larger infrastructure. For the module, SEE will produce its own material & events and make them accessible to other organisations.

In a statement to the press, SEE creators Dmitry and Elena Lesnevsky stated, "SEE-1 represents a wonderful opportunity for humanity to enter a new domain and begin an exciting new chapter in space". It will be a one-of-a-kind and accessible home for limitless entertainment possibilities in a venue brimming with cutting-edge infrastructure that will unleash a new era of creativity.

SEE-1 will be not only the first but also the highest quality space structure facilitating the growth of the global entertainment industry's $2 trillion markets into low-Earth orbit with the help of global leader Axiom Space.

Through technological breakthroughs in NewSpace, we will be able to enjoy new forms of entertainment in the future.

Out-of-the-world Experience - A Hotel in Space

Soon, humanity will have its first hotel in outer space.

The project being overseen by Orbital Assembly Corporation aims to launch two space stations with tourist accommodation: Voyager Station, scheduled to accommodate 400 people and to open in 2027, while the new concept Pioneer Station, housing 28 people, could be operational in just three years.

Ubiquitous Broadband

SmallSats for Healthcare Infrastructure

Sanjay Sinha
Chief Executive Officer
XVIDIA Technologies Inc

As businesses increasingly rely on cloud services, private networks, and high-speed internet, broadband access becomes essential for success. Unfortunately, unconnected rural areas - their banks, hotels, retailers, and utilities, are disadvantaged.

Conventional broadband requires a vast network of underground cables, and satellite communication may be the sole choice in the nation's geographically most dispersed locations. LEO satellites can connect citizens to high-speed internet in areas where traditional terrestrial broadband infrastructure is difficult to access. They are an attractive and viable solution for bridging the rural connectivity gap. Additionally, challenging topography can enhance deployment costs.

SmallSats are replacing large satellites and their related infrastructure with more compact and more competent subsystems. New multi-orbit satellite architecture opens the possibility of improved broadband connections. Satellite service providers use constellations of SmallSats in LEO to provide low-latency coverage globally.

Due to satellite broadband's unique capacity to provide services in remote and unconnected areas, it has the potential to leverage technology to help close the digital divide. It is particularly well-suited to support remote communities by enabling connectivity for medical video conferencing, transfer of medical records and images, digital messaging, prescription generation, and the processing of prescriptions.

Industry analysts believe that current telemedicine and telehealth business models have the capability to handle up to 50 percent of the out-patient consultations in remote areas of the Indian geography. Accelerated deployment of SmallSat networks and telemedicine infrastructure could enable the handling of 60 to 80 percent of out-patient consultations by 2025. Telemedicine initiatives have the potential to benefit patients in remote and rural areas by minimizing their reliance on unqualified local medical practitioners and saving time and money travelling to a nearby city or town to obtain medical advice.

As satellites collect large amounts of data, they present a challenge in handling, analyzing, and managing timely resources. Artificial Intelligence takes care of the more complicated aspects of these challenges. With machine-learning algorithms, satellite data can be analyzed.

With the advancement of Distributed Ledger Technology (DLT), it is possible to create an interconnected node with a consortium blockchain where institutions and healthcare providers can participate in the network securely from different remote regions via satellite internet connectivity, helping various organizations in proper monitoring and management of data from a centralized point.

Primary care remains overlooked in parts of the developed world and vastly ignored in the developing world. However, research into the benefits of primary care using SmallSats has also been studied that 'the availability of primary care services on a 24x7x365 improves patients' self-perceived health status. Furthermore, the longitudinal care afforded by SmallSats-based primary care services available instantly is independently associated with improved patient satisfaction, reduced use of ancillary and laboratory tests, improved patient compliance, shorter length of stay in a hospital, and enhanced recognition of patients' behavioural problems.

"BluConnex is at the cusp of launching such a service that will bridge the time to patient care to increase primary health centres' connectivity, which will lower the burden on secondary and tertiary care by differentiating and treating minor ailments compared to the major ones".

Satellite Enabled Telemedicine Technology for COVID-19 Patients.

Leaf Space, the Italy-based pioneering ground segment as-a-service (GSaaS) solutions provider, is launching the CARES project. The project utilises telemedicine via satellite transmission and allows for the home monitoring of patients recovering from COVID-19. CARES is co-funded by the ESA.

The CARES project consists of a set of medical devices connected to a smartphone collecting patient data and adding them to a database remotely. The database is designed by project partner H&S in a way to provide accessible, comprehensive, and real-time data for doctors with the use of a web browser.

The Health Platform also has an alert system that can contact the patient or dispatch an ambulance if the patient's vitals fall outside of a safe range. Integrating remote monitoring with satellite telecommunication allows patients to receive service anywhere in the world even if they do not have a reliable internet connection. The CARES pilot trial is already underway at Fatebenefratelli Hospital in Erba, Molinette in Torino, and Villa Gioia in Sora.

Space Stations

Avant-garde Space Habitat

The International Space Station (ISS) is the largest single structure humankind has put into space. The space station is approximately the size of a football field and is a 460 ton, permanently crewed platform orbiting about 400 kilometers above the Earth. Built by a consortium of nations, it is an endeavour of pathbreaking scientific and engineering collaboration by the United States of America, Russia, Europe, Canada, and Japan. Its main construction was completed between 1998 and 2011, and it took more than 30 missions to assemble the mammoth structure. The Space Station circles the globe every 90 minutes at a speed of about 28,000 kilometer's per hour.

Two hundred and fifty six individuals from 20 nations have visited the ISS since November 2000. Leading the list of participating nations, the United States (156 people), followed by Russia (54 people). Astronaut time and research time on the space station are allocated to space agencies based on the money or resources (such as modules or robotics) the space agencies contribute. NASA (United States), Roscosmos (Russia) and the European Space Agency are significant contributors to the funding for the ISS; the other contributors include the Japanese Aerospace Exploration Agency (JAXA) and the Canadian Space Agency (CSA). Mission control centres in Houston and Moscow regulate the ISS, and a payload control centre in Huntsville supports the crew. Other international mission control centres in Japan, Europe and Canada assist the space station in executing a variety of activities.

At any given time, there would be an international crew of 7 astronauts and cosmonauts living and working on the ISS. During the changeover of the crew, this number can increase. The record for the most significant number of people in space at one time is when 13 crew members visited the ISS in 2009. Astronauts travel to the space station on a Russian Soyuz capsule, which has long been the only spacecraft that carries people to the ISS, ever since NASA's space shuttle programme ended in 2011. History was created on 15 November 2020 when SpaceX officially began space taxi missions to ISS for NASA carrying four astronauts in a Crew Dragon capsule, including three NASA astronauts, Mike Hopkins, Victor Glover, Shannon Walker and Japanese astronaut Soichi Noguchi. The space station is a platform for long-term research on human health. In addition, it is considered by NASA as an important test platform for humans to explore other solar system destinations, including the moon and Mars.

Contribution of ISS to Advancement of Mankind

Human bodies undergo changes in a microgravity environment, including alterations to the cardiovascular system, musculoskeletal system, and eyes. Scientific investigations are being progressed to assess the severity of the changes and whether these are reversible. Astronauts also participate in product testing of 3D printers or carry out pharmacology, nutritional, and biological experiments. As the only functional microgravity laboratory in space, the ISS has facilitated more than 3,600 researchers to conduct about than 2,500 experiments.

In 2019, NASA executives announced that the space station would open its airlocks to private astronauts and commercial businesses. This facilitates the non-governmental private sector to train astronauts under microgravity and try out new technologies and experiments. There are also plans for the Houston-based organization Axiom Space to build a new commercial module on the ISS to stimulate the growth of an off-Earth economy.

Future of the ISS...

Current plans indicate that the space station will be operated through at least 2024, with the participating nations discussing a possible extension until 2030. However, a recent report by NASA indicates that the lab's operational life is expected to end with a controlled deorbit in January 2031.

In the interim, NASA is working with organizations to implement a plan for transition to commercial space destinations. Towards this goal, NASA has awarded grants totaling USD 415 million to three companies-Blue Origin, Northrop Grumman and Nanoracks, to design and build private space stations in LEO. On a parallel track, NASA is working with Axiom Space to launch multiple modules to ISS in late 2024. These modules are intended to detach eventually from the orbiting station, forming a privately operated "free flyer" in orbit.

As of 2022, ISS and China's Tiangong Space Station (TSS) are the fully operational space stations in LEO. TSS is China's first long-term space station and will be inhabited with the Shenzhou 14 crew in June 2022. China is intending to offer rides to space for tourists as early as 2025 and is developing a 'rocket with wings" for space tourism and point-to-point travel.

Space stations have played a major role in carrying out extensive activities ranging from satellite development to in-space research with the objective of creating a vibrant commercial space economy in LEO.

Expanding Canvas of Private Investments in NewSpace

Kuti Drory
General Manager
Saisanket Technologies Ltd.
Israel

Industry analysts point out that private sector funding in SpaceTech companies crossed USD 15 Billion in 2021, an all-time high despite the Covid pandemic raging across the globe over the last two years. This is nearly double the previous record of USD 7.7 Billion in financing that space startups received in 2020 and represents a figure that is more than half of NASA's entire 2022 budget (USD 24.04 Billion). It is about a tenfold increase in investment over the past decade and has driven a wave of innovation, not just in the space sector but in allied sectors. According to sources, the investment prospects in LEO and those involving lunar and even further-afield orbits around the moon have been the focus of entrepreneurs.

Traditionally, funding is routed through national space agencies, and a significant part of the private investment has been focused on satellite communications, media and entertainment, navigation and positioning systems (GPS). These applications utilized satellites deployed in GEO and MEO.

Over the last five to ten years, since the advent of NewSpace and the participation of private, non-governmental entities, substantial space investments have been flowing in to fund satellite communications and other activities in LEO. Satellites in LEO, which are nearer to the Earth than their MEO and GEO counterparts, are ideal for facilitating high-speed, low-latency telecommunications, including widespread internet connectivity. They are also typically smaller and have lower development and manufacturing costs. Another key differentiator is that organizations consider launching multiple LEO satellites in constellations to ensure adequate coverage. In addition to satellites, investments in LEO have been disbursed to develop infrastructure for space travel and the establishment of space stations. As a ball-park figure, about 60 to 70 percent of space economy funding is deployed for LEO endeavours.

There is also a significant amount of private investment in the launch vehicle business, which helps to increase the number of launches. Both governments and private industry benefit from this trend because it reduces costs and increases the ability to get material into space more reliably and at a frequency driven by market needs.

Record Venture Investments

In 2021, the startup space ecosystem witnessed a significant increase in venture funding. Compared to 2020, venture capital (VC) investment grew by 82%, from USD 5 Billion to USD 9 Billion, while the total number of VC deals grew 54%, from 78 to 120 (Ref.: BryceTech Start-up Space: Update on Investment in Commercial Space Ventures, April 2022). It is also noted that there has been an increase in the average VC investment size, with the average investment growing to USD 75 Million from below USD 25 Million during the period 2018-2021. During the same period, the average number of deals in a year exceeding USD 100 Million has grown from about 5 to 15.

Growing Public Offerings

Space startups raised over USD 4 Billion in public market capital in 2021, representing 28% of total investment over the year. In 2021, 10 space startups went public via a special purpose acquisition company (SPAC), raising about USD 4 Billion (net of shareholder redemptions). Three space startups namely, Satellogic, Terran Orbital, and Tomorrow.io, announced SPAC deals in 2021; of these, Satellogic completed its business combination, Terran Orbital still awaits final shareholder approval (expected to close sometime in 2022), and Tomorrow.io's contemplated deal was terminated (organization quoted "market conditions" as the reason for termination).

Trends for 2022 and beyond...

At MAZ Investments, Israel, we believe that when companies have access to private capital, they will be able to scale faster and bring new innovations to the market, which would fuel further growth. Going forward in 2022 and beyond, we expect to see an increase in the rise of public-private partnerships in all geographies compared to governments and national space agencies doing things by themselves. This would help reduce infrastructure costs for any single mission and would also help build more infrastructure in the long term. In addition, the space economy is bound to create more jobs, which will change the way we do business in space and on Earth.

Looking forward...

Israel has been a significant contributor to the growth of global nanosatellite development activity and has an impeccable track record with respect to the student-built satellites. This has been primarily driven by the close synergies between the Israeli academia (including schools and universities) and industry to leverage frugal innovations being progressed in Israel's aerospace and defence industry with limited budgets. Therefore, we are delighted and fortunate that, in collaboration with several Israeli space and other businesses, MAZ Investments has established working partnerships with the Indian Technology Congress Association to connect space sector investors to advance 75 satellite development missions focusing on academia and commercial sectors.

Invited Article

The United Nations
Space and Sustainable Development

K Sesha Sayanam
Strategic Financial Advisor
Indian Technology Congress Association

Since the late 1950s, the United Nations (UN), through the Committee on the Peaceful Uses of Outer Space (COPUOS), has acted as a forum for debating space projects, national endeavours, international space legislation, and challenges to the way we conduct space activities. UN-Space was formed in the mid-1970s to foster synergies and minimise duplication of efforts linked to the use of space technology and applications in the activities of UN institutions.

Established in 1958, the United Nations Office for Outer Space Affairs (UNOOSA) collaborates with governments and the broader space community on policy, legal, and technical capacity-building issues related to global space activities. UNOOSA plays a critical role in assisting the intergovernmental policymaking process by serving as the worldwide facilitator for such conversations and the COPUOS secretariat. UNOOSA facilitates policy talks on growing space affairs concerns through COPUOS, including resource extraction, space traffic management, and the control of small satellite 'mega constellations'.

The United Nations General Assembly recommended in Resolution 74/82 that more studies be conducted to determine how space research, technology, and applications may contribute to the 2030 Agenda for Sustainable Development. This recommendation was made under the Office of Outer Space Affairs. In addition, UN organisations were asked to assist in UN-Space coordination initiatives on an as-needed basis. Space use benefits a variety of policy areas, including climate and weather monitoring, access to health care & education, water management, transportation & agriculture efficiency, and peacekeeping, security & humanitarian assistance.

With the adoption of three significant international frameworks in 2015, the international community committed to tackle the generation's most urgent concerns: the 2030 Agenda for Sustainable Development, the Sendai Framework for Disaster Risk Reduction 2015–2030, and the Paris Climate Agreement. Space-based technologies are becoming more important in accelerating the fulfilment of such responsibilities. UNOOSA collaborated with the European Global Navigation Satellite System Agency to assess the impact of space technologies on the Sustainable Development Goals (SDGs) in an early 2018 study demonstrating that 65 of the 169 targets underlying the SDGs directly benefit from the use of Earth observation and navigation satellite systems.

The 2030 Agenda is built around seventeen Sustainable Development Goals, which establish the benchmarks that all governments must meet by 2030. These lofty and critical goals can only be achieved via a combined effort by all stakeholders and the judicious application of the appropriate tools. In some circumstances, space instruments can be game-changers for sustainable development.

The World Health Organization (WHO) investigates ways and means to enhance and promote space technology, space systems, and space-derived information and data in the global health sector, subject to adequate financial and human resources. WHO focuses on the following objectives in doing so: (a) strengthening country health systems and medical care service delivery at the national and subnational levels; (b) assisting in forecasting public health epidemics and raising awareness at the national and subnational levels; (c) responding to health emergencies; and (d) providing technical assistance to the Member States in developing a research agenda on the benefits of space science and technology to public health.

Along with offering medical and healthcare solutions, integrating geospatial data and digital technology enables governments to track illness progression and empower citizens with information during pandemics like COVID-19. United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) allows the regional sharing of big georeferenced data, the study of geographical and temporal interconnections, and the identification of risk correlations between pandemics such as COVID-19 and socioeconomic sectors in support of these initiatives (health, finance, connectivity, education, energy, and safety). In addition, the Asia-Pacific Plan of Action on Space Applications for Sustainable Development, which is being developed by ESCAP, provides an opportunity to leverage existing regional cooperation mechanisms to promote the sharing of geospatial data and technical expertise for global health and pandemic mitigation, including through the mapping of risk hotspots and the integration of space technology applications for evidencing.

International migration is frequently a significant driver of demographic change. The United Nations High Commissioner for Refugees (UNHCR) believes that displaced people and the communities that host them have the right and responsibility to be part of a connected society and have access to technology that enables them to create a better future for themselves.

Its Connection for Refugees initiative establishes safe zones for field trials of connectivity solutions and collaborates with UNHCR operations to produce locally relevant, context-specific, and community-driven solutions in the digital era.

The United Nations Office for Disaster Risk Reduction (UNODRR), the United Nations Institute for Training and Research's Operational Satellite Applications Programme (UNOSAT), and the World Meteorological Organization (WMO) are developing integrated urban hydrometeorological, climate, and environmental services to support safe, healthy, resilient, and climate-friendly cities, intending to assist in the achievement of Sustainable Development Goal 11 (Sustainable cities and communities). Combining diverse observation networks, satellite data, high-resolution forecasts, multi-hazard early warning systems, and climate services are all part of envisaged services.

In response to the United Nations General Assembly Resolution approving UNISPACE-82's proposals, the UNOOSA developed a project document recommending the development of Centers for Space Science and Technology Education in developing nations. In 1994, a United Nations delegation evaluated six countries in the Asia-Pacific region. UNOOSA designated India as the host country for the Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP) based on the evaluation mission's findings. The Centre is hosted by the Government of India, with the Department of Space (DOS) as the nodal agency. DOS has provided the infrastructure and domain expertise through renowned space-tech luminaries to the Centre leveraging the talent pool at the Space Applications Centre (SAC), Ahmedabad, Physical Research Laboratory (PRL), Ahmedabad and the Indian Institute of Remote Sensing (IIRS), Dehradun.

Since its foundation in 1995, CSSTEAP has substantially contributed to capacity building in Asia Pacific countries in frontier areas of space science and technology and their applications.

Along with its core regular PG programmes, which UNOOSA well recognises as subjects with the potential for societal benefit, the Centre also offers numerous short courses on various topics in remote sensing and GIS, SmallSat missions, navigation, and satellite positioning systems that are relevant to the commoner and are requested by user departments. Additionally, the Centre supports UN activities, organises alumni gatherings, and participates in meetings on various international platforms.

India was a founding member of UNCOPUOS and has contributed significantly to its operations. Dr Vikram K Sarabhai recognised as the "Father of the Indian Space Program," served as Vice-President and Scientific Chairman of the 1968 United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE-I). Professor Yashpal served as Secretary-General of UNISPACE-II from 1982 to 1997 and as President of UNISPACE-III and Chairman of UNCOPUOS from 1997 to 1999. India was unanimously elected as the new Working Group on the Long-term Sustainability of Outer Space Activities Chair in 2021.

From guidelines to enforcement...

Since 1959, the United Nations Committee on the Peaceful Uses of Outer Space has addressed space activities.

However, the 95 member committee's mandate is to promote international cooperation and investigate legal issues arising from space exploration. It is unable of enforcing the 1967 Outer Space Treaty's principles and guidelines or even compelling parties to negotiate.

The UN resolution from November 2021 mandates that the newly formed working group meet twice annually in 2022 and 2023. Despite the glacial pace of this activity in comparison to the speed of commercial space development, this is an important step in the global space policy. The group must reach consensus on new rules and identify areas requiring further investigation by the end of the given time period. Cassandra Steer, an expert on space law and space security at the Australian National University in Canberra, predicts that drafting norms for the types of activities that escalate tensions or generate debris will be this group's top priority.

While US representatives supported the UK-led proposal, representatives from the other two most influential space powers, Russia and China, voted against it. The opposition of these nations stems from a lengthy debate over whether the United Nations should instead concentrate its efforts on negotiating new treaties among all nations with spacecraft, as treaties carry greater weight and are more clearly enforceable. China and Russia, for instance, have advocated for a resolution preventing an arms race in outer space and a new international treaty prohibiting the deployment of any weapons in space. Currently, only nuclear weapons are banned in space.

The dangers of space debris, which could be caused by an orbital collision or attack, continue to garner attention, particularly in light of the quantity of debris produced by anti-satellite missile tests, such as those conducted by China in 2007 and India in 2019. Even the tiniest pieces of untraceable space debris can be hazardous due to their rapid movement.

It is hoped that the working group will produce highly effective, nonbinding norms with enormous political influence, which in turn will stimulus what states do with their national governing statutes.

Satellite-as-a-Service
The Emerging Space Revolution

Over the last decade, the information technology (IT) sector has transitioned from an upfront customer purchase to a service model, Software-as-a-Service (SaaS). The IT industry has leveraged the evolving technology paradigm of the cloud and a subscription-based service model to scale and realize recurring revenue and enhanced customer renewal. For the customers, the accrued benefits included obtaining the precise (point) solutions they needed and avoiding upfront costs and related risks. Software companies created a platform by putting massive server farms and network infrastructure in place. This platform concept is being extended to other industry sectors, including the space sector denoted as Space-as-a-Service.

Specialization in the NewSpace Sector

As the space sector expands with the entry of new participants, organizations are adopting new business models based on articulating their unique service offerings. These evolving business models include Satellite-as-a-Service, Ground Station-as-a-Service, and Space Data-as-a-Service. These business models promise the participants the benefits of space without being constrained by the requirements of government regulations, launch integration, and the rigours of satellite manufacturing.

Business Paradigm of "as a Service"

As-a-Service (aaS) had its origin in the IT industry, in the context of cloud computing, Software-as-a-Service (SaaS) is an often referred to example of "aaS" model.

Where infrastructure and hardware; middleware, software and applications/user interface are managed by cloud service providers and made available to customers over the Internet, on a "pay-as-you-go" model.

"aaS" offers various benefits to the customers, as it helps them minimize upfront investment while reducing operation, maintenance, and ownership costs. Customers can thus transform their capital expenditure (CAPEX) into operational expenditure (OPEX). Leveraging the benefits detailed above, "aaS" has in the recent months and years, extended beyond the IT realm, and has proliferated into the space sector.

Satellite-as-a-Service Demystified...

NewSpace organizations are increasingly exploring the Satellite-as-a-Service model to slash the time to market and build engagements with clients. Clients intend to test spaceflight software, satellite sensors, or even radiation-tolerant printed circuit boards through this innovative model. Commercial organizations are pioneering these models, including York Space Systems, Spire Global, NanoAvionics, Loft Orbital, and ISISpace, using their satellites to carry multiple instruments or payloads. The advantage is that the customers do not have to spend huge upfront capital expenses (CAPEX) on building and launching a satellite to get the specific data they are interested in; the commercial organizations take care of those expenses through milestone payments before the satellite launch and the subsequent subscription (OPEX).

This approach offers the satellite development organization the flexibility to host multiple missions, sharing the functionality of the platform with several clients who can progress their individual customized operations and payload experiments. Furthermore, clients are only expected to specify the amount of data storage, the processing power of the onboard data-handling and command subsystem, and the power requirements of their payload.

The design of the onboard data-handling and command subsystem will be segregated into individual user segments where the client's unique customized code alone would be executed. The supervisor segment would have multiple safeguards for ground and space segments to minimize the risks of possibly erroneous mission software running on the satellite platform.

Sat-a-a-S had a proof-of-concept case study where NASA utilized the services of Maxar Technologies to integrate and launch NASA's air pollution sensor, Tropospehric Emissions-Monitoring of Pollution (TEMPO), on a commercial communications satellite. Sat-a-a-S was utilized for the hosted payloads. Using a commercial communication satellite to launch a sensor saved money for NASA because there was no need to start ab-initio; it was possible to build on a satellite that already existed.

Benefits of Sat-a-a-S

The advent of Sat-a-a-S has been of significant advantage to clients that leverage satellite development organizations as they do not need to invest large sums of money in acquiring multiple services. All that is required is for them to enlist with a 'satellite network operator' to procure customized, flexible and managed services defined by operators based on the needs articulated by the clients. Sat-a-a-S is a game-changer because it puts the utilization and control of satellite connectivity in the hands of the network operator to deliver the following benefits to their clients:

- Enhanced flexibility to address changing market demands
- Minimal ownership risk

- Availability of a contemporary satellite technology platform with no significant investments
- Access to a customized asset for their connectivity requirements

Mission-as-a-Service or "Software-defined Satellite"

The term "software-defined satellite" has already been in circulation in the space industry for a few years now. A "software-defined-satellite" can be defined as a platform with the capability to conduct numerous missions through software applications, on the same hardware. The advantage of this unique approach is the flexibility to reconfigure a satellite to address multiple users or applications, based on the available payload instruments such as imaging cameras and spectrometers. This philosophy is akin to "software-defined radio" transceivers that can be utilized for a plethora of RF functions. This contrasts with the current scenario where any individual/entity interested in having a satellite in orbital space must progress all the steps of designing and testing a satellite to realize the envisioned concept, completing regulatory compliances including frequency allocation, identifying a launch provider, and establishing or acquiring access to ground stations for tracking and telemetry data. Utilizing the "software-defined approach", software code can be ported onto an existing operational satellite, and re-oriented operations can be commenced within a short span of time.

NewSpace sector is becoming extremely price-sensitive, and it is essential for organizations to offer spacetech services at affordable price points. The increasing proliferation of CubeSats has helped achieve easy and increased access to satellite data, and with multiple satellite missions sharing access to CubeSat's resources, many more individuals/entities would be able to participate directly in the upstream space sector leveraging a "pay-per-use" pricing model.

Removing dependence on specific hardware is a game-changer facilitating software-defining satellite missions to deliver a significant competitive advantage. This enables the design of platform-independent, portable application packages that can be reused on numerous satellite platforms, assuming sufficient model compatibility. Such a development will be analogous to the evolution of terrestrial computers, from unique systems that could only execute software built for their own architecture to modern systems that can run software in native, platform-independent, and virtualized settings.

Ground Station Segment Emerging Models for NewSpace

Ground stations (GS) are essential to operate satellites and ensure mission success for satellite operators (receiving and processing of earth images, telecommunication, and navigation signals, etc.). Located in different parts of the globe, they support the operations of different kinds of satellites, based on the inclination and orbit parameters of satellites.

For satellite providers to build, operate and maintain a ground segment is an expensive proposition that requires expenditure to acquire infrastructure and deploy resources including trained human capital with specialized skills. Building ground stations is particularly costly for satellites in LEO or high-frequency bands requiring expensive antennas. Satellite operators having satellites in LEO usually require a global network of ground stations installed in multiple geographies (nations), to download data as and when it is required, instead of having to wait for the satellite to pass over the desired location.

There is the additional infrastructure that is required to process and manage the data. Ballpark calculations put the cost of the ground segment over the entire satellite lifecycle at about one-third of the total outlay for large programmes and for individual satellites, representing about 12-15% of satellite operators' OPEX. The range of expenses can make investments in a wholly-owned network of ground stations economically unviable for NewSpace satellite operators whose goal for business success is affordability.

In the NewSpace era, satellite operators have very clearly defined objectives including shorter missions, slashed development schedules, and smaller budgets for both satellites and GS.

Dedicated GS providers are entering the market with the objective of offering NewSpace satellite operators an affordable solution to communicate with their satellites-Ground Station as a Service (GSaaS). Building on the cloud-based business models, GS providers are establishing a network of ground stations to enable satellite operators to communicate with their satellites. GSaaS providers are evaluating contemporary technological advances and cutting-edge technologies including Flat Panel Antennas, Optical Communication, and Artificial Intelligence (AI) to drive innovation and expand their service maturity levels to meet client needs.

Intelsat Orders 2 Software-Defined Satellites from Thales Alenia Space

Intelsat has ordered two software-defined satellites from Thales Alenia Space that will contribute to the operator's plans for a 5G unified global network. The two satellites, Intelsat 41 (IS-41) and Intelsat 44 (IS-44) will be based on the Thales Space Inspire product line and are scheduled to be in service in 2025.

Intelsat said the satellite design allows for mission and services reconfiguration, in-orbit adjustment to broadband connectivity demand, and superior video broadcasting performance. The order, announced Wednesday, follows Intelsat's order last year for two Airbus OneSats, and the Airbus' software-defined satellite line.

A network built on open standards allows for the use of the best technology available at any time, says Intelsat CEO Stephen Spengler. "With Intelsat 41 and Intelsat 44, Intelsat will blanket the earth with software-defined satellites, progressing the world's first global 5G software-defined network, designed to unify the global telecom ecosystem".

India-France Bilateral

Secure Access to Outer Space

India and France have agreed to cooperate to tackle "contemporary challenges that have arisen in space," including secure access to outer space.

The pledge was part of a broader set of economic and security agreements reached between Indian Prime Minister Shri Narendra Modi and French President Mr Emmanuel Macron during their 4 May 2022 summit in Paris.

"It will bring together experts from space and defense agencies, administration and specialized ecosystem to discuss security and a economic challenges in outer space, the norms and principles applicable to space as well as unveil new areas of cooperation", the two leaders said in a joint statement.

Under the 2021 agreement, France's space agency CNES is set to train India's flight physicians and mission control teams, support a scientific experiment plan on validation missions, and exchange information on food packaging and spaceflight nutrition.

Source: spacenews.com

Rocket Lab Supporting

NASA's Human Mission's return to the Moon

In 2022, Rocket Lab will launch a CubeSat to the Moon, this historic pathfinding mission supports NASA's Artemis program that will land the first woman and first person of color on the Moon.

Using the company's Electron rocket and new Lunar Photon upper stage, Rocket Lab will inject the Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE) CubeSat into a highly efficient transfer orbit to the Moon.

CAPSTONE's primary objective is to test and verify the calculated orbital stability of a Near Rectilinear Halo Orbit around the Moon, the same orbit planned for Gateway. NASA's Gateway is a small space station that will orbit around the Moon to provide astronauts with access to the lunar surface and feature living quarters for astronauts, a lab for science and research and ports for visiting spacecraft.

CAPSTONE will also test a navigation system developed by advanced space to measure its absolute position in cislunar space using interaction with NASA's Lunar Reconnaissance Orbiter without relying on ground stations for navigation support.

Source: smallsatnews.com

Mission-as-a-Service

A New RF Reconnaissance from Kleos Space

Kleos Space (ASX: KSS, Frankfurt: KS1) has announced that the company is diversifying their business model to include Mission-as-a-Service (MaaS) capability, providing customers with exclusive access to Kleos' dedicated, on-orbit, radiofrequency reconnaissance satellite clusters for fixed periods and capacity.

Each MaaS contract will be tailored to suit the customer requirements and needs, including the percent of satellite capacity needed, level of task ability required, and corresponding data rights.

Kleos' additional product offer caters to growing market demand and complements its existing DaaS business model, which delivers geolocated RF activity over areas of interest to multiple government and commercial subscribers.

Kleos' constellation roadmap includes deploying new clusters in a short timeframe, increasing accuracy, improving latency and supporting a range of intelligence, defence, security, and commercial missions through enhanced situational awareness. Kleos targets as many as 20 satellite clusters for optimal global coverage for its DaaS and MaaS offerings.

Source: newspaceglobal.com

Ground Stations for CubeSats

Tracking and Turnkey Solutions

The ground station assists the space segment (spacecraft and payloads) by relaying mission data to users. To support the spacecraft mission, the ground data system must command, control, and monitor the bus and payload, track the spacecraft's position, and report the satellite's attitude using information from the onboard Attitude Determination & Control System (ADCS) sensor.

The shift to the "affordable cost" paradigm and the accessibility of Commercial-Off-The-Shelf (COTS) components for the space sector has transformed the designer's perspective on-ground data systems and spacecraft architecture. The CubeSat mission is primarily managed from a customised lab room to reduce the costs of a SmallSats ground data system. The ground station is a fixed or mobile COTS antenna connected to a mission control server using standard cabling. Tracking, Telemetry and Command (TT&C) for both the CubeSat and the payload are managed using the monitoring server.

CubeSat missions typically use academic or amateur ground data systems with just one antenna, limiting their ability to communicate with more than one satellite and adhering to stringent power and volume budget constraints. Other drawbacks of using a single isolated antenna include less bandwidth, a lower data rate, and a reduced overall throughput capability.

Traditionally, amateur radio bands have been the primary route for CubeSats to communicate with the ground, as frequency allocations from the International Telecommunication Union (ITU) have been restricted to eliminate frequency conflicts with larger satellites. However, CubeSats are transitioning from low-performance tasks to higher-complexity missions in the recent past. These higher-complexity missions' deals with larger volumes of information necessitate higher communication data rates than what amateur radio bands can provide.

CubeSat programs could use higher frequencies in either the C-band or X- band to reduce the volume & mass of both the transceiver & antenna and to support increased power generation systems for three-axis stability requirements. As this will also increase the bandwidth to support payloads that have a significant data downlink requirement, there is a need for highly precise pointing requirements. However, ground station designers will need to consider the functionality of additional bandwidth with decreased size and mass against increased power requirements to complete the link with the ground station.

Higher working frequencies are becoming possible as CubeSat power generation technologies improve and three-axis stability is attained, allowing for fewer components and increased antenna gain.

The goal for CubeSat networked ground stations is to relay all downlinked data as soon as operations begin and to continue until all intended information is transmitted wirelessly. Theoretically, data is downlinked to the different active ground stations during the satellite's entire pass. However, active ground stations are not always available for every pass, as there could be other satellites transmitting data to them.

Ground station networks for small satellites have vastly improved in the last few years, as many companies are producing and developing new state-of-the-art systems. TinyGS is an open network of ground stations scattered around the world that uses inexpensive and modular modules to receive and operate LoRa satellites, weather probes, and other flying objects. LoRa is a radio signal transmission protocol that uses a chirped, multi-symbol format to encode data. It's a proprietary system developed by chipmaker Semtech and other chipmakers licensing the LoRa IP.

As a part of the Mission, ITCA and its mentored organisations and startups will be establishing ground stations in the partnering institutions. ITCA's ground stations are available as a modular and scalable technology stack for implementation. ITCA's ground station solution adopts innovative technologies that have proven and facilitate interoperability with existing or future subsystems. In addition, its customised ground station offering is available at affordable price points for participating educational institutions.

As the number of CubeSats launches increases in India over the next few years, the ground station segment is expected to show accelerated growth. The proliferation of ground stations and the associated new business models would make access to Space more accessible and act as an enabler for CubeSat operators and manufacturers.

The customers for ground stations would be from multiple entities, including private and Government bodies addressing a multitude of mission applications. We would also be witnessing the seamless induction and adoption of contemporary technologies, including Artificial Intelligence, Flat Panel Antennas and optical communications.

Some general comprehension of the ground station segment;

The Ground Ground Station

A fully custom-built ground station capable of handling both terrestrial and spacecraft traffic like remote sensing observation, satellite communication and other telecommunication services over VHF and UHF.

Distributed Ground Station

A network of ground stations that are interconnected to monitor the spacecraft's performance without waiting for a direct pass over the respective ground stations.

Satellite Command System

Primary configuration includes custom-built hardware and firmware. The ground station software exposes all functionality (status, tracking, signal receiving and processing) over LAN or Wi-Fi for mobility and remote operation.

Client Software

Satellite command centre software includes indigenously built firmware on MATLAB runtime, providing complete satellite telemetry and command processing for operations and test environments for nanosatellite requirements.

Radio Receiver

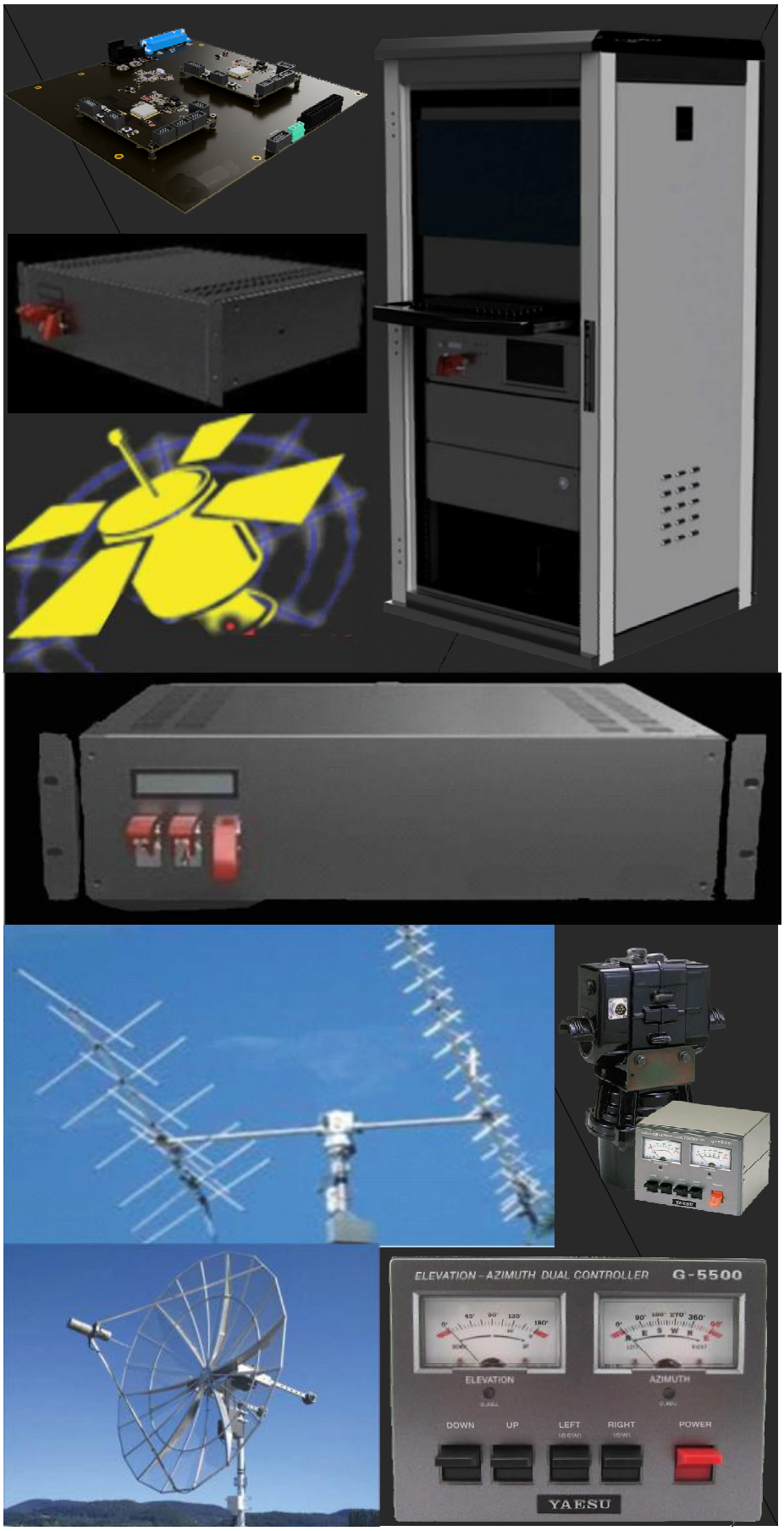
An SDR and custom hardware capable of receiving and processing standard satellite frequencies and modulation schemes of all publicly accessible satellites covering from VHF to S-band.

Antenna System

High performance, lightweight and mechanically steerable antenna booms designed, built and tested in the house as per your mission requirements.

Rotator

An indigenously built rotator provides a smooth azimuth and elevation control capable of software-controlled searching and tracking satellites from horizon to horizon, ensuring accurate satellite pointing to aid in operations.



TSC

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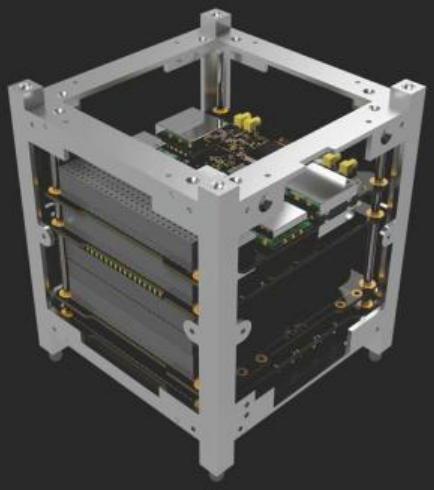

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Cosmonauts aboard ISS

The empowering interactions

Concurrent with the 61st anniversary of the first human spaceflight, an event was organised to showcase the ongoing student satellite development initiatives that are being carried out as part of the distinct national Mission. Valles Marineris International India, in collaboration with the Roscosmos Corporate Academy in Moscow, Russia, and the Russian House in Chennai, India, were the driving forces behind this effort. The programme, titled "Space for Everyone: An Interaction Session with the Cosmonauts on the International Space Station," was presented on 20 April 2022. Participants in this event were adherents of 75 Students' Satellites Mission across the globe.

The event had the participation of Mr Gennadiy Rogalev, Vice-Consul at the Consulate General of the Russian Federation, South India at Chennai, and Director, Russian Centre of Science and Culture, Mr Ivanov Ivan Vladimirovich, Head of the Centre for International Cooperation, ANO "Roscosmos Corporate Academy" Moscow, Russia. Dr Jayakumar Venkatesan, Founder & CEO, Valles Marineris International and Deputy Chairman of the International Academy of Space Law, Russia also helped organise this exciting interaction session. ITCA leadership team, including Padma Shri Awardee Prof R M Vasagam, Dr L V Muralikrishna Reddy and Dr K Gopalakrishnan, contributed to the programme.

M N Visweswaraiah
Consultant-IT
Indian Technology Congress Association

ITCA provided an opportunity through video presentation for international audiences to listen the excerpts from the Hon'ble Prime Minister of India's speech to World Leaders at the United Nations General Assembly, in which he mentioned the unique Mission of 75 satellites built by students at Indian schools and colleges, to be launched in the context of India's 75th year of Independence.

Mr Gennadiy Rogalev presented his perspective on the India-Russia Space collaboration and extended his cooperation for the Satellite mission and Space programmes the organisations can eventually take up.

Dr Jayakumar Venkatesan emphasised India's collaboration with Russian space-tech organisations and the benefits associated with it in his presentation.

Er Nikhil Riyaz, Founder & CEO, TSC Technologies, apprised the global

Hearty congratulations to Indian Technology Congress Association and Valles Marineris International for the ambitious 75 Students' Satellites Mission 2022 to commemorate the 75 years of India's independence (1947-2022) by launching 75 student-built satellites into orbit in conjunction with national and international Space organizations

Cosmonaut Sergey Vladimirovich
Flight Engineer 2, aboard the ISS
talked to the 75 Sat team as he flew over India on Thursday, 14 April 2022, wished the Mission success.

"I wish you all good luck for launching 75 satellites and success". Russian **Cosmonaut Sergey Revin** shared his congratulatory video to the ITCA project team.

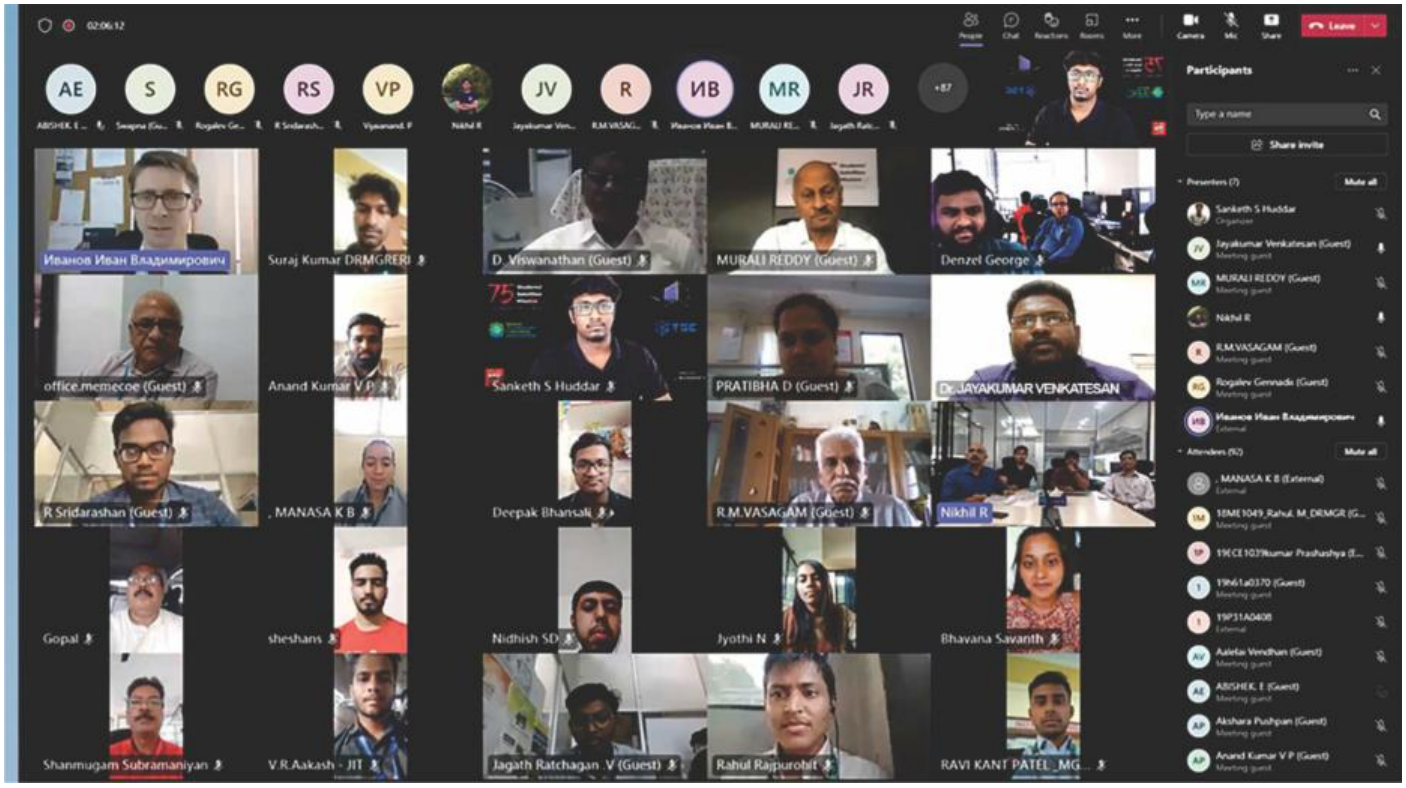
Cosmonaut Sergey Korsakov, Flight Engineer 2, **Cosmonaut Oleg Artemyev,** Commander and **Cosmonaut Denis Matveev,** Flight Engineer 1

audience about ITCA's initiative to have academia comprising Schools, Colleges, and Universities participating in building and deploying 75 satellites into LEO.

Mr Ivanov Ivan Vladimirovich made his presentation on the theme "First in Space-First in the World". He brought attention to the fact that the Roscosmos Academy has taught 287,000 employees across 81 multiple organisations. Academy facilitates building capacity in various skills aligned with management of Science and technology projects and pursuit of space technology programs & applications.

He highlighted that the Academy is the host organisation for the "Centre for Space Science and Technology Education for Eurasian Region", which has been responsible for developing and enhancing the capabilities of COPUOS member states at the regional and international levels in various fields of space science and technology, resulting in their contribution to scientific, economic, and social development. Furthermore, Roscosmos Academy has collaborated with 20 universities worldwide and trained people in short-term space-related courses. He extended an invitation to ITCA to work on various projects, especially those with Roscosmos related to hands-on training and professional advancement.

Padma Shri Prof R M Vasagam was nostalgic. He reminisced his delivering a lecture on Yuri Gagarin on his first flight in the Indo-Soviet Cultural Centre, Trivandrum, for which he was fortunate to receive a medal.



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National Science Day

Honoring Indian Scientific Contributions

Every year on 28th February, India observes the National Science Day. This is an excellent opportunity for the scientific community and students to explore space programmes and honour this historic event. The Karnataka Government had earlier announced the Karnataka Government School Students' Satellite Project (KGS3Sat), which was to be built and launched by government school students. The state government wholly sponsors this project. The project was formally inaugurated at the Government School in Malleswaram, Bangalore, on the auspicious National Science Day.

The student-built satellite design and launch project for government school students has been named after the former Kannada star Puneeth Rajkumar. The Puneeth Rajkumar Student Satellite (PUNEETHSAT) will be launched as part of the 75 Satellite Mission.

The Karnataka Science and Technology Promotion Society (KSTePS) and ITCA have signed an MoU to carry out this initiative. This is one of the 75 satellites that the nation will launch to commemorate the country's 75th anniversary of Independence, Azadi Ka Amrit Mahotsav.

During his inaugural address Shri D V Sadananda Gowda, current MP, former Chief Minister and Railway Minister of India said that scientific research and innovation are key to social empowerment and applauded the initiative of the Government of Karnataka. This function was organised by the Ministry of Science and Technology headed by the Hon'ble Minister Dr C N Ashwath Narayan, who championed this initiative in Karnataka. The first state to initiate such a programme as part of the 75 Satellites at the Government high school levels.

Prof S Ayyappan, Padma Shri Awardee, & Former DG, ICAR-GoI and Chairman of Karnataka Science and Technological Academy said that the nation has a relatively low research spending in Science and Technology compared to developed countries and that such initiatives should be encouraged at the school level to enhance the motivation for students to build a scientific temperament. He also believed there was a need to develop an efficient way to reduce agricultural waste in the nation and opined that this could be effectively achieved using satellites. He commended the this remarkable initiative and congratulated the Mission initiators.

The project's ground station will be located on the campus of the Government Pre-University College, and 200 students from 20 government schools were chosen for the project based on their performance in various competitions and tests.

The project will include preparatory training programmes both online and offline, hands-on learning, and tutorial modes in equally Kannada and English languages.

The project will include activities such as gaining knowledge of the

A Poster was released

Introduction to nanosatellites, CubeSats, payloads and applications, visits to scientific institutions in Bengaluru, & Sriharikota during the satellite's launch, and interaction with space scientists, training at the ground station, publication of space materials, and other such knowledge-sharing & capacity building initiatives.

On this occasion, a handbook on satellite projects was also released. In addition, the distribution of science experiment kits for government schools was also launched. The programme was well-received by participants, who included students and faculty from various schools. The dignitaries, the audience and students had a detailed overview of the scientific models exhibited as part of the event.

Transformations in Space Technology
A Symposium of BIT-Ranchi

Priyank Kumar, PhD
Assistant Professor
Dept. of Space Engg & Rocketry
BIT Mesra, Ranchi

The Department of Space Engineering and Rocketry at Birla Institute of Technology, Mesra conducted a 1-day symposium on "Transformations in Space Technology" on 15 March 2022. The event was attended by various notable and eminent dignitaries from the space sector in India who delivered keynote addresses on the latest advancements in the field of space technologies and its applications. The main focus of the event was on how academia, entrepreneurs and startups can explore many of the emerging trends and contribute to increasing India's share of global space economy.

The symposium was inaugurated by Prof Indranil Manna,honorable Vice Chancellor, Birla Institute of Technology, Dr LV Muralikrishna Reddy, President ITCA and Chief Guest of the symposium, Dr K Gopalakrishnan, Secretary General ITCA, Shri A K Saxena, IE(I), Jharkhand State Center, and Dr Priyank Kumar, Assistant Professor, Dept. of Space Engineering and Rocketry, BIT, Ranchi.

The symposium started with the address of Padma Shree Dr M Annadurai also known as the Moon Man of India for heading the Chandrayaan project, who spoke about how the Indian Space Industry, from having humble beginnings in the 1960s has now evolved as one of the global leaders having end to end facilities for satellites and launch vehicles. He also talked about the various areas of satellite and launch vehicle manufacturing and services where there is enormous opportunity for academia and private players to explore and help fuel the growth of space industry further. Prof Indranil Manna, Vice Chancellor of BIT Mesra addressed the audience by talking about how India from being a follower has now emerged as a leading player in space technology. He also mentioned about how advancements in space technology in India is helping common people on a day-to-day basis.

Padma Shri Prof R M Vasagam, former distinguished scientist of ISRO, addressed the audience by providing an overview of a number of Green Propulsion initiatives such as Ion-Thrusters, Carbon Nano Tubes, Solar Sail Propulsion, Laser Propulsion and Space Tethers, etc., where extensive research is ongoing globally. He also outlined a number of near-term opportunities where the Indian Space Community can be actively involved in areas such as De-orbiting propulsion system, Debris management, Satellite Life Extension, etc. Prof Vasagam also provided a brief about the Indian Government coming up with a NewSpace policy in 2020 which promotes startups to take part in space efforts and has also set up a regulatory body IN-SPACe for permitting Indian startup firms and academia to develop space technology.

Dr LV Muralikrishna Reddy, President, Indian Technology Congress Association (ITCA) highlighted how SmallSats (satellites having less than 600 kg payload, abbreviated to SmallSats) have become disruptors in the space industry globally as more than 90% of all satellites launched within the last couple of years were all SmallSats and because of the ease with which they can be manufactured and launched, a whopping 94% of all those SmallSats were launched by private players. He talked about how some Indian startups started primarily by students were successful in placing satellites in LEO with minimal of investments such as Skyroot, Agnikul and TSC Technologies.

Shri GNV Prasad, Former Deputy Director, URSC, ISRO talked about the various launch vehicles and their utilities for the space programme.

A highly interactive session with the students of the Department of Space Engineering and Rocketry and the satellite team of BIT Mesra was conducted by Dr K Gopalakrishnan, Secretary General of ITCA. He discussed about how democratized space had become and that it is now within easy reach of academia to create their own satellites through the Indian Government's initiative to launch 75 student satellites as part of the celebrations for the 75th Year of India's Independence - "Azaadi ka Amrit Mahotsav".

Department of Space Engineering and Rocketry, Birla Institute of Technology, Ranchi

The Department of Space Engineering and Rocketry, the first of its kind in the country, was established in 1964 to train scientists and engineers in the important areas of Aerospace Engineering and Rocket Technologies. Since 1968, it has been offering a postgraduate degree course leading to M.Tech. in Space Engineering and Rocketry with in-depth specialization in two specific areas namely Aerodynamics and Rocket Propulsion. The Department aims to provide state-of-the-art education and training to its students to enable them to contribute efficiently to the national efforts being made in the fields of Space & Defense related technologies and challenging future missions. The Department has been striving for excellence by pursuing R & D work in emerging areas of Aerospace and Rocket Technologies. It is worthwhile to mention that the Department has successfully completed sponsored R & D Projects from premier Agencies like UGC, AICTE, DST, Ministry of HRD, ISRO, DRDO, AR & DB (Min. of Defence) etc. The Department has also been recognized under Special Assistance Programme (SAP) of UGC and has been working on development of a Cryogenic Propulsion System. The Department has also been supported by DST under FIST (Fund for Improvement of S & T Infrastructure) to augment Propellant Technology and Combustion Facility. The Department has currently around six government funded projects worth more than INR 200 lakhs. The Department has state of art facilities in the areas of Aerodynamics and Rocket Propulsion which includes subsonic and supersonic tunnels, free jet facilities, anechoic chamber for acoustic studies, Static rocket testing facilities for solid, liquid and hybrid rockets. The major research areas of the Department are listed below :

- Development of Hybrid Rocket Propulsion Systems
- Droplet Combustion Studies
- Development of High Regression Rate Hybrid Fuel
- Combustion Study of Hybrid Fuels with Nitrous Oxide Oxidizer
- Study on Premixed Flame
- Commissioning of Solid and Liquid Propulsion Lab
- Development of (solid-liquid) Hybrid Rocket Setup
- Thermal Analysis of High Energy Materials
- Slender Body Aerodynamics at High Angles of Attack at Subsonic Speed
- Studies on Reusable Launch Vehicle and Delta/ Double Delta Wing at Subsonic Speed
- Cavity and Protrusion Flow Field Studies at Supersonic Speeds
- Studies on Spiked Blunt Bodies at Supersonic Mach No.
- Supersonic Air- Intake Studies
- Development of Compressible Navier-Stokes Code

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Leveraging Blockchain
For Space Domain

Pradhyumna Kumar ISSA
Director - Finance
Indian Technology Congress Association

Blockchain is a subset or form of Distributed ledger technology (DLT) that consists of cryptographically connected "blocks" (for example, a list of transactions) and a "chain" in which each block is timestamped and chronologically arranged.

The blockchain is essentially a shared and decentralised ledger that can be integrated with pre-existing software programmes. On blockchains geared toward commercial transactions, members are required to join, and the cryptographic keys they provide are used to validate their identities. It is necessary for all of the parties involved in a financial transaction to reach a unanimous decision in order for its legitimacy to be verified before it can be added to a blockchain.

Every bit of data contained within a block is secured by encryption, and each block is connected to the one that came before it by use of a distinct identifier (a "hash"). Each participant's computer receives an identical copy of the transactions that are recorded on the blockchain. These copies of the transactions, which are updated in an almost instantaneous fashion and distributed across the network of participants' computers, are immutable. Members are notified by the hash if someone tries to modify the data that is contained in a block.

The establishment of participant-to-participant confidence is facilitated by blockchain technology, which also minimises the risk of tampering and possesses huge potential to lower costs, speed up operations, and streamline transactions.

How Blockchain works?

DLT stands for distributed ledger technology, which refers to a type of digital database in which financial transactions and the accompanying details are simultaneously recorded in a number of different locations, without the use of a centralised database or an administrator.

The following basic components provide the core of DLT:

- Distributed database
- Peer-to-peer transmission.
- Trust
- Transparency.
- Immutable records.
- Embedded logic

Why Blockchain for the Space sector?

The benefits of blockchain technology for the space sector include the following:

Transparency

A distributed ledger technology (DLT) can begin with either a public or a private setup. An open ledger makes it possible for any user, regardless of the level of access they have, to investigate the history of transactions in that ledger. On the other hand, closed or permissioned ledgers nevertheless allow for some level of openness and accountability to exist within an organisation or consortium of businesses.

Efficiency

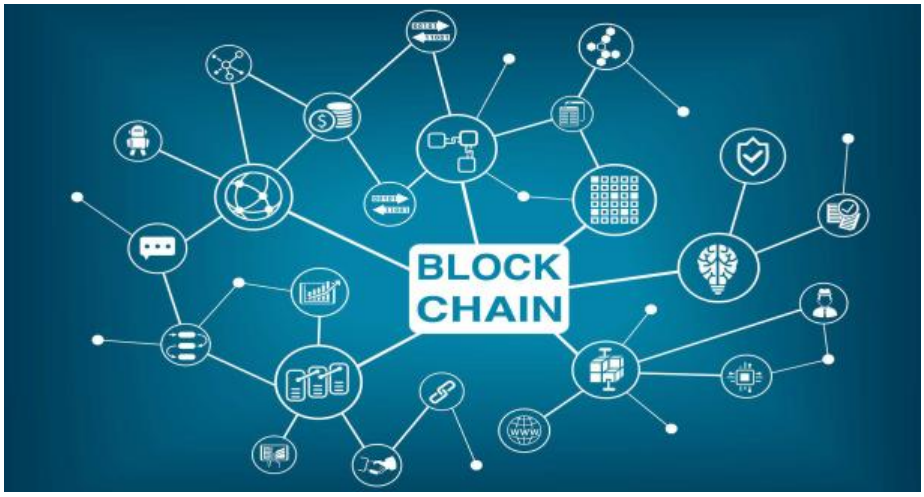
The implementation of the DLT technology has the potential to automate and improve the organisations' business processes, in addition to the efficiency with which they carry out their daily tasks (e.g., self-executing contracts).

Privacy

When cryptography and distributed data storage are used together, it is much simpler to protect the privacy of an individual and ensure that only authorised users have access to their data. This may be accomplished by ensuring that only authorised users have access to cryptographic keys.

Resilience

The implementation of distributed ledger technology (DLT) could make communities and ecosystems more



resistant to the effects of adverse environmental conditions. For instance, embedded peer-to-peer smart contracts do not need to go via a centralised authorization or distribution centre in order to function correctly. This is one of the many advantages of using such contracts. Instead, there are a large number of nodes, and the entire system does not have a single vulnerable spot anywhere in it.

Where Blockchain can be used in the Space sector?

The stages of the space value chain that include idea and design, purchasing, manufacture, assembly, and operations, as well as related user applications, are all places where digital trust solutions give the opportunity for further development. Blockchain technology has the potential to be included in a value chain in its totality if smart contracts and other applications geared toward supply chains are utilised.

Smart Contract

Contracts that are "smart" are basically computer programmes that are stored on a blockchain and are set to run automatically when specific conditions are satisfied. Typically, they are used to automate the execution of an agreement so that all parties can know the result instantly, without the need for an intermediary or any waste of time. This enables the parties to avoid any potential conflicts over the terms of the agreement. In addition to this, they are able to automate a workflow by beginning the subsequent operation only when particular conditions are satisfied.

Supplychain Applications

Integrating distributed ledger technology (DLT) into the network of supplychains for space systems has the potential to confer a number of compelling benefits. These benefits include the audit trail and a single source of truth, amongst others. The supplychain is comprised of a large number of different entities, some of which include customs authorities, freight forwarders, ports and terminals, freight forwarders, and providers of logistical services. Companies in the supply chain can communicate with one another through the use of this supply chain.

Example scenario of adopting Blockchain for satellite development

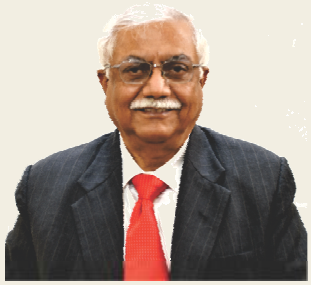
- A commercial network is formed by bringing together entities such as satellite service providers, satellite manufacturers along with their respective suppliers and subsystem contractors, launch service providers, ground control centres, regulatory authorities, insurance companies, and companies that provide access to launch data for third-party research
- Each participant is given a node, which works as a storage site for a copy of the distributed ledger and any smart contracts that may be put into operation in the future.
- The players are able to reach one another through channels of communication that are well-established. In this fictitious scenario, the manufacturer of the satellite has the capability of establishing separate communication channels for each of the several suppliers and subsystem contractors it works with.
- During the process of integration testing, if the subsystem contractor finds an issue, the smart contract will not let the process to advance to the next level until the error has been corrected.
- As the space industry becomes more global and interconnected, a digital platform that is enabled by distributed ledger technology (DLT) can help to associate, trust, and cross-hierarchical mechanization. This platform can extend beyond the tracking or enterprise system of a single company to incorporate all inventory network members, from support to grave, including unrefined substances, parts, parts, and frameworks. For instance, in the event that a fake component is found on a satellite bus several years after it has been launched into orbit, the prime contractor for the satellite might use the DLT record system in order to track the component all the way back to its original source. It is possible for other participants in the DLT supplychain to get notifications and evaluate whether or not they have also used this component.

It is reasonable to assume that the space industry will embrace distributed ledger technology (DLT) in stages, beginning with regional demonstrations and progressing to corporate models later on. This is a legitimate assumption to make.

The first step in this process will most likely consist of demonstrations taking place in a number of different locations. It may someday be possible to establish industry-wide consensus models if certain applications harness distributed ledger technology as the enabling technology. Even if there are factors at play that will move the space sector toward decentralised authorities, it will be some time before there is broad industry cooperation. This is despite the fact that there are dynamics at play.

Reflections

Prime Minister Narendra Modi while addressing the 76th Session of UN Assembly last year had announced that India will launch 75 Satellites to commemorate its 75 years of Independence. These Satellites are to be built by Students in Schools and Colleges with an idea to strengthen Science based approach. In this regard Development of CubeSats by students is a very good idea to enhance their learning. Viewing CubeSat development as a 'system of systems', realizing each of the subsystems and integrating these to develop a functional satellite would help students develop skills to address complex engineering projects efficiently. Developing an implementation plan, progressing tasks in parallel, and assessing and resolving dependencies would be of immense value in honing project management skills. The student-built satellite activity fosters a collaborative approach and helps students to work smartly as team members.



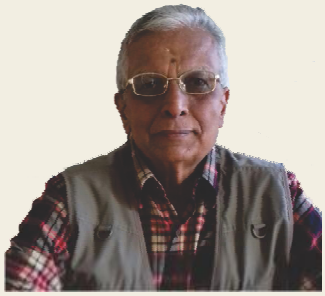
Ashwani K Saxena
Former Director India-RUSSULA Spain
Executive Director-BPSL
Chairman-SEAC Jharkhand

Space has always been an inspiration for school students. The 75 Students' Satellites Mission has brought students closer to space and will help them understand how these satellites can help gather data on critical societal challenges-climate change. This programme also makes the learning of concepts in science more interesting. Visiting the space lab being established in the school would help them understand the importance of a regulated approach to performing and recording science experiments, and this would help them as they move to advanced classes. Working with CanSats, launching them using drones and receiving data would help build a culture of hands-on learning. This mission is a game-changer for schools.

GNV Prasad
Former Deputy Director
ISRO Satellite Centre
URSC/ISRO

Dr K Brahma Raju
Head of Mechanical Department
SRKR Engineering College, Bhimavaram

ITCA's 75 Students' Satellites Mission is of immense value to universities that want to differentiate themselves through significant industry-academia partnerships, and introduction of contemporary courses that can be offered as a specialization. Establishment of contemporary laboratories will help build a nucleus of faculty pursuing research in the multidisciplinary area of space technologies, and this would lead to the overall progress of departments participating in the student satellite activity. Global exposure for students through ITCA's partnerships will definitely be a plus. I wish this mission all success.



Prof Dr M R Pranesh
Former Professor of Ocean Engineering
and Former Registrar,
IIT Madras, Chennai

Student-built satellites is a multidisciplinary project. It helps students to develop a holistic understanding of an integrated system. This approach is extremely useful to students when they enter industry. This will be facilitate them to work and efficiently and realize an optimized solution. The satellite development activity has a component of delivering curriculum in space technologies. I have reviewed the content and found this to be comprehensive for students at the Bachelor's degree level. I am sure students participating in this project will benefit immensely.

Dr R Venkatesan
Former Head, Ocean Observation Systems
and Eminent Scientist,
National Institute of Ocean Technology, Chennai

This is a unique effort by ITCA to take Indian Students' efforts in launching 75 student satellites. Appreciated at the highest level in the United Naitons by all nations after the speech by the Honorable Prime Minister. Scientific data collected from Earth including Oceans would be breakthrough in our understanding on climate Change

INDIAN TECHNOLOGY CONGRESS ASSOCIATION

75 Students' Satellites Mission
ITCA's Engineering Prowess and Ingenuity

K Rajagurunathan
Founder & CEO
Aeolus Aero Tech Pvt Ltd

The 75 Students' Satellites Mission conceptualized by ITCA is a unique mission in that it intends to transform the academic practice through extensive hands-on learning. It has its basis in Systems Engineering and brings in a structured methodology to how students realize solutions to typical engineering projects. Students participating in these projects will be multiple steps ahead of their peers. Institutions will benefit through the setting up of state-of-the-art lab facilities, and faculty will be able to expand their knowledge domain and progress research projects that will have significant value to industry.

Muralidhar G
Director
AisvarA Infrastructure Pvt Ltd

Student-built satellite activity in schools strengthens the science-based approach and experience-based learning paradigm that is so essential for success in today's world. The conceptual learning framework that is part of the 75 Students' Satellites Mission demystifies space technology for students in schools. This programme is in alignment with the new education policy and allows students to remain at the centre of the learning process.

Dr K Manivannan
Director-Industry & Academia Relations
Vinayaka Mission's Research Foundation
Secretary/Treasurer,
Global Engineering Dean's Council (GEDC)
Chennai

Indian engineering curriculum has a significant challenge to address-building synergy with industry needs so that students can work on ongoing projects with minimal training intervention by industry. The 75 Students' Satellites Mission helps enhance the experiential learning by students, and also gives them a pathway to develop some unique solution that can be patented. This mission provides a pathway for motivating and rewarding students, breaking what could be considered the monotony of classroom learning. A good programme for academic institutions that want to make a difference!

Universities need to be at the forefront of bringing in new courses that will meet the requirements of the next decade. The 75 Students' Satellites Mission has been conceptualized keeping in mind the transformation taking place today through the advent of NewSpace, and the opportunity for universities to also participate. This Mission brings in an opportunity for innovation by faculty and students and could be the seed for establishing an innovation park focused on space technologies. The potential for universities to innovate is immense, the university, faculty and students will all benefit through this mission.

Dr A N Parameswaran
Director, NMAMIT &
Coordinator, NITTE Education Trust

Dr V Venugopal Reddy
Professor and Head
Mechanical Engg Dept,
JNTUA College of Engineering

75 Students' Satellites Mission has been an initiative that has been worked on by ITCA's team since 2018. Students have had the benefit of interacting with leading global practitioners and imbibing best practices. Subsequently, when the projects were launched in the academic institutions, faculty and students have received this with considerable enthusiasm. Participating in CanSat design competitions is of great value to students and can validate their design philosophy. Building a functional satellite needs interaction with the industry, and this project provides that opportunity.

ನಿಸರ್ಗದೊಂದಿಗೆ ಸಹಬಾಳ್ವೆಗೆ ಪ್ರೋತ್ಸಾಹಿಸೋಣ

- ನೈಸರ್ಗಿಕ ಸಂಪನ್ಮೂಲಗಳನ್ನು ಮಿತವಾಗಿ ಬಳಸೋಣ
- ಮಳೆನೀರು ಕೊಯ್ಲು, ಅಂತರ್ಜಲ ಮರುಪೂರ್ಣ ಮಾಡೋಣ
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- ಮರಗಿಡಗಳನ್ನು ಬೆಳೆಸಿ ಸಂರಕ್ಷಿಸೋಣ
- ಸೌರಶಕ್ತಿ, ಪವನ ಹಾಗೂ ಇತರೆ ನವೀಕರಿಸಬಹುದಾದ ಸಂಪನ್ಮೂಲಗಳನ್ನು ಪ್ರೋತ್ಸಾಹಿಸೋಣ
- ಕಸವಿಂಗಡಣೆ ಮಾಡೋಣ ಹಾಗೂ ತ್ಯಾಜ್ಯ ಉತ್ಪಾದನೆ ಕಡಿಮೆಗೊಳಿಸಲು ಕ್ರಮವಹಿಸೋಣ
- ಪ್ಲಾಸ್ಟಿಕ್ ಬಳಕೆ ತ್ಯಜಿಸೋಣ
- ನಮ್ಮ ವಾಹನಗಳ ಹೊಗೆ ಪ್ರಮಾಣ ಮಿತಿಯಲ್ಲಿಡಲು ಕ್ರಮವಹಿಸೋಣ
- ಹಬ್ಬಗಳನ್ನು ಪರಿಸರ ಸ್ನೇಹಿಯಾಗಿ ಆಚರಿಸೋಣ
- ಕಾರ್ ಪೂಲಿಂಗ್, ಸಾರ್ವಜನಿಕ ಸಾರಿಗೆ ಹೆಚ್ಚಾಗಿ ಬಳಸುವ ಮೂಲಕ ವಾಯುಮಾಲಿನ್ಯ ನಿಯಂತ್ರಣಕ್ಕೆ ಸಹಕರಿಸೋಣ

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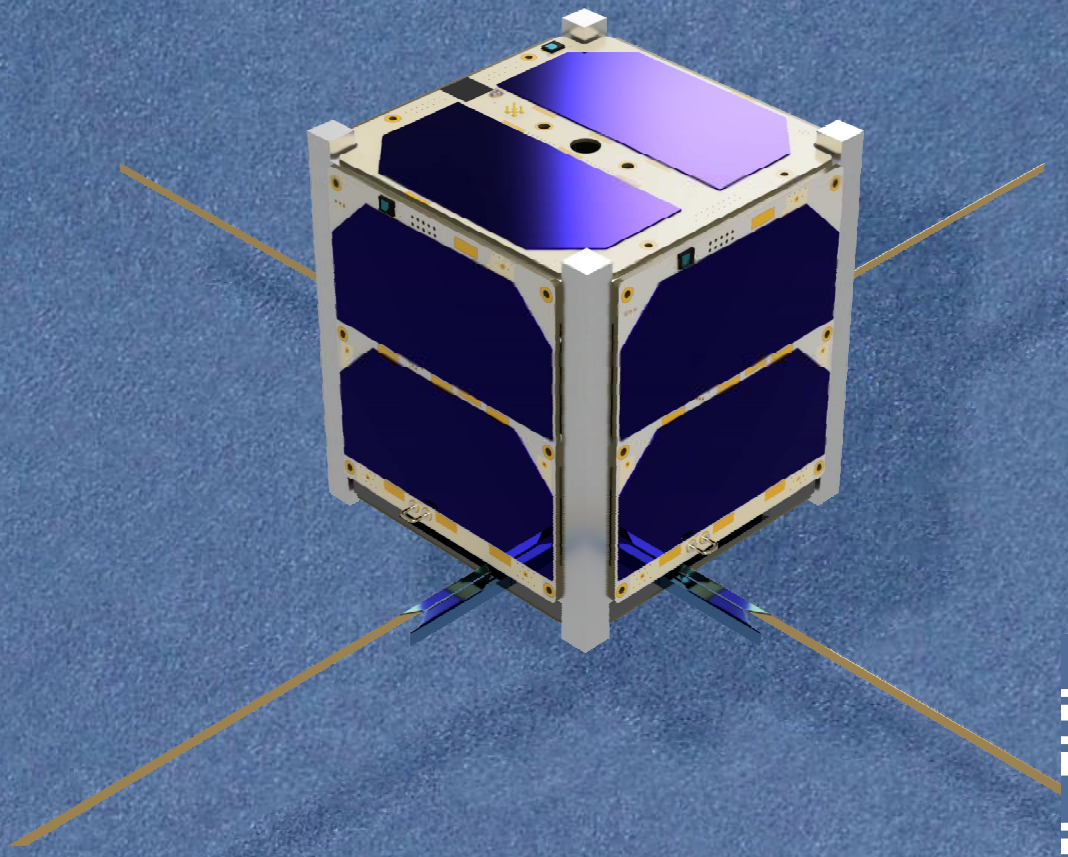

75 Students' Satellites Mission

ITCA's Engineering Prowess and Ingenuity

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