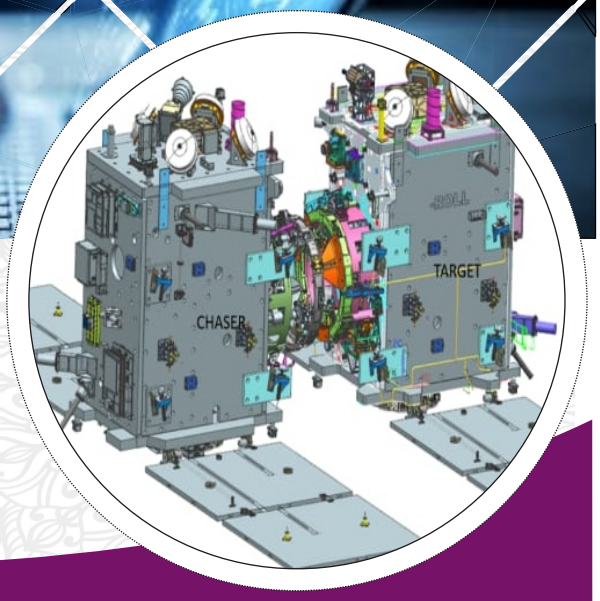
INDIAN SOCIETY OF SYSTEMS FOR SCIENCE & ENGINEERING
BANGALORE CHAPTER

In Association with ISRO Organises

National Conference on System Engineering in Automation

SEA - 2025

On 30th & 31st October 2025 at Hotel Chancery Pavilion, Bengaluru



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Indian Society of Systems for Science & Engineering (ISSE)

Indian Society of Systems for Science and Engineering (ISSE) is a professional body for interdisciplinary collaboration of Systems Science and Engineering. ISSE is unique among the systems-oriented institutions having the objective of bringing together scholars and practitioners from academic, business and R&D organizations for promoting the systems concept.

The society was started in 2010 at Vikram Sarabhai Space Centre (VSSC), ISRO with its Headquarters at Thiruvananthapuram and was formally registered under the Travancore Cochin Literary Scientific and Charitable Societies Registration Act -1995.

ISSE has 13 chapters across the country which are located at Thiruvananthapuram, Kochi, Bangalore, Manipal, Hyderabad, Bhubaneshwar, Ahmedabad, Amaravati, Chandigarh, Shriharikota-Chennai, Trichy, Coimbatore and Kanyakumari.

SEA 2025 : Conference on System Engineering in Automation

Conference on System Engineering in Automation is organized by ISSE – Bangalore Chapter in association with ISRO. This conference seeks to create an interactive forum between the professionals in the field of aerospace and the academia to discuss the automation technologies. The two-day conference comprises keynote address, invited talks by eminent scientist, poster presentation, paper presentation by professionals, research scholars and academia.

Messages.....

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डॉ. व. नारायणन / Dr. V. Narayanan
अध्यक्ष / Chairman

MESSAGE

As President of ISSE, it gives me immense happiness to note that Indian Society of Systems for Science and Engineering (ISSE) – Bangalore Chapter in association with ISRO is organizing a two-day Conference on System Engineering in Automation (SEA-2025) on 30th and 31st October, 2025 in Bengaluru.

Since its inception at VSSC, ISRO in 2010, over the years, ISSE has grown to become a premier forum promoting interdisciplinary collaboration among Researchers, Academia, Entrepreneurs and Professionals working in diverse fields related to Systems Engineering. The SEA–2025 conference carries forward this vision by providing a platform for knowledge exchange, showcasing innovations and fostering partnerships in the evolving landscape of automation.

In today's rapidly advancing technological era and with the growing need to minimize human intervention, automation has become the defining force driving efficiency, reliability and safety across diverse engineering domains. In modern complex systems, automation enables real-time monitoring to detect, isolate and recover from failures while allowing humans to focus on creative and analytical tasks. From precision-driven robotic systems to AI-enabled technologies that analyse data, recognize patterns and make autonomous decisions, automation continues to enhance efficiency and transform productivity. Indeed, system engineering and automation together have been central to many engineering marvels that have made human life smarter and more comfortable.

I am confident that the SEA-2025 will strive to curate a melting pot of brilliant minds and it promises to be an enriching experience, filled with immersive discussions, technical presentations and fruitful networking opportunities, among the participants for the betterment of society, paving the way for more resilient engineering solutions and automations, in line with India's vision for Atmanirbhar Bharat and leadership in advanced technologies.

I look forward to witnessing the impactful outcomes that emerge from this august gathering and extend my best wishes for a grand and rewarding conference – SEA-2025.

October 26, 2025

(डॉ .व. नारायणन / Dr. V. Narayanan)
President, ISSE / Secretary, DoS

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एम. गणेश पिल्लै/M. Ganesh Pillai
वैज्ञानिक सचिव, इसरो / Scientific Secretary, ISRO

MESSAGE

I am delighted to note that Indian Society of Systems for Science and Engineering (ISSE) – Bangalore Chapter in association with ISRO is organizing a two-day Conference on System Engineering in Automation (SEA-2025) on 30th & 31st October, 2025 in Bengaluru. Efforts by Bengaluru Chapter to bring forward the importance of automation in system engineering is impressive and commendable.

Technological automations designed to perform tasks with minimal human effort spans from simple home appliances to intelligent systems that manage scheduling, control and fault recovery. In aerospace and space systems, where precision and reliability are critical, systems engineering ensures that automation functions seamlessly across complex subsystems.

In ISRO, from the autonomous sequencing of launch operations to the onboard fault detection and recovery systems in satellites, automation has enabled us to enhance reliability, reduce response times and manage mission-critical scenarios with precision. The increasing use of AI, Machine Learning and Digital Twins is further transforming how we validate, monitor and control our space assets, ushering in an era of intelligent automation that supports greater mission efficiency and sustainability.

In view of ISRO's forthcoming Gaganyaan, Chandrayaan-4 & 5, Bharatiya Antariksh Station, Venus Orbiter Mission and Moon Landing missions, the role of automation becomes even more crucial in ensuring safety, robustness and adaptability. Conferences such as SEA-2025 provide a valuable platform for the stakeholders of the space eco-system to exchange ideas and strengthen collaborations among the stakeholders.

I thank the ISSE Bangalore Chapter and ISRO team for the initiative in bringing together experts and practitioners under one forum to deliberate on this important theme. I am confident that the discussions and outcomes of SEA–2025 will immensely benefit not only ISRO scientists but also to other professionals and entrepreneurs to advancing automation technologies and systems engineering practices that will continue to shape the future of India's technological and space endeavors.

October 26, 2025

(एम गणेश पिल्लई / M Ganesh Pillai)
Scientific Secretary, ISRO

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एम. शंकरन/*M. Sankaran*
विशिष्ट वैज्ञानिक/*Distinguished Scientist*
निदेशक / *Director*

MESSAGE

In an era where automation drives competitiveness and growth, Systems Engineering provides the discipline required to ensure that technology works cohesively and purposefully. This theme aptly captures the essence of modern innovation, aligning complex subsystems into unified, high-performing systems that elevate productivity, safety and sustainability. It is through this integration that we achieve not just advancement, but excellence.

In today's rapidly evolving technological landscape, systems engineering plays a pivotal role in bridging the gap between design and real-world implementation. From robotics and control systems to AI-driven automation, the integration of multidisciplinary knowledge is essential for developing efficient, reliable and sustainable solutions.

Systems engineering provides the structured framework necessary to integrate complex subsystems, optimize performance and ensure reliability across industries, from manufacturing and transportation to healthcare and smart infrastructure. The synergy between systems thinking and automation technologies such as AI, robotics and IoT is not just transforming how we work, but also how we design and sustain intelligent systems for the future.

National Conference on System Engineering in Automation **(SEA-2025)** provides a valuable opportunity to share advancements, challenges and best practices that will guide the next generation of engineers and innovators. As President of ISSE Bengaluru chapter, I commend the organizing committee for their vision, dedication and professionalism in bringing together experts and enthusiasts from varied domains. I am confident that the insights shared through this initiative will contribute meaningfully to advancing the field of systems engineering in automation.

Let us continue to advance the boundaries of systems engineering by shaping automation that is not only efficient but also sustainable and human-centred.

I extend my warm wishes for the grand success of **SEA-2025** and hope it becomes a milestone in promoting excellence in systems engineering and automation.

[M Sankaran]
President, ISSE Bengaluru Chapter

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Distinguished Scientist & Director

MESSAGE

National Conference on Systems Engineering in Automation (SEA-2025)
Human Space Flight Centre (HSFC), ISRO

At the outset, I would like to extend my appreciation to the *Indian Society of Systems for Science and Engineering (ISSE) – Bangalore Chapter* for jointly organizing the *National Conference on Systems Engineering in Automation (SEA-2025)* in collaboration with ISRO. This event brings together researchers, practitioners, and students to deliberate on emerging trends, challenges, and innovations that are shaping the future of automation and intelligent systems.

For human spaceflight missions, automation is a key enabler in ensuring safety, reliability, and precision. The integration of Artificial Intelligence (AI) and Machine Learning (ML) is revolutionizing autonomous decision-making and fault management. Likewise, Virtual Reality (VR) and Augmented Reality (AR) are transforming astronaut training through immersive and adaptive simulation environments.

Automation also plays a vital role in the realization of the Gaganyaan Mission, supporting mission operations, crew safety, and ground systems integration.

I am confident that *SEA-2025* will provide valuable insights and foster collaboration among scientists, engineers, and academicians towards advancing automation technologies for India's human spaceflight program and beyond.

I wish SEA-2025 national conference a great success.

डी के सिंह

D. K. Singh
Director, Human Space Flight Centre (ISRO)

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म. मोहन / M. Mohan
विशिष्ट वैज्ञानिक एवं निदेशक
Distinguished Scientist & Director

MESSAGE

It gives me great pleasure to note that the Indian Society of Systems of Science and Engineering, Bangalore chapter is organising National conference on System Engineering in Automation (SEA 2025) at Bangalore. The idea behind the Conference is to bring together the professionals in Aerospace, System engineering and Automation enthusing them to the future challenges of most exciting national missions wherein advanced Automation techniques shall play a pivotal role.

The aerospace & Automation industry unlike earlier, has been thrown open to NGEs and start-ups and Automation shall now be mostly taken up by next generation entrepreneurs and our community need to handhold these new players to contribute to the aerospace economy of our country. This conference shall throw light into System engineering models & tools for automation, Human centered automation, Impact of AI & VR in Automation, Flexible automation systems, system integration using automation all of which are most relevant in todays scenario. In space sector itself, we are also going to see the days where development of most complex systems for NGLV, Bharathiya Anthariksh Station, Chandrayaan -4 sample return mission, Gaganyaan continuation, Venus mission etc wherein we need to adopt the best of System engineered Automation technologies for mass production of our systems and subsystems. I am pleased that the conference also looks into ways and means of empowering our youngsters and next generation to take up these challenges.

I am sure this conference shall provide an ideal platform for technical interaction between related professionals and sharing of expertise between Researchers, Academia and Industries. At this juncture, let me once again extend my best wishes for this conference, SEA 2025.

M Mohan

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MESSAGE

October 14, 2025

It is heartening to note that a National conference SEA 2025 is being arranged on theme 'System Engineering in Automation' during the month of October 2025.

India's space program is entering a pivotal phase with a clear roadmap which sets the vision for the nation's advancements in space technology leading up to 2047. Central to this vision is a strong emphasis on Research and Development (R&D), aimed at fostering next-generation technologies to meet emerging challenges and opportunities within the dynamic global space sector. One of the key elements in this multi-disciplinary technology scenario is a robust System Engineering based space ecosystem with strong emphasis on automation.

It is quite apt that to discuss the alignment and evolution of these efforts, ISSE – Bangalore Chapter in association with ISRO is hosting this special Conference. This august gathering of eminent scientists, scholars, doyens from academia and students is significant, as it can provide a much-needed platform for industry leaders to showcase cutting-edge advancements, share their insights, vision and highlight challenges. The feedback and discussions from this conference can guide future policy-making and collaborative efforts, towards meeting the ambitious goals set, incorporating appropriate course corrections.

I extend my best wishes for a highly successful and productive Conference, contributing valuable insights to the highly relevant domain of System Engineering; which in turn would be resulting in due advancement of India's Space Vision.

ए राजराजन
(A Rajarajan)

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Message

The National Conference on 'System Engineering in Automation (SEA-2025) at Bangalore on October 30-31, 2025, organized by Indian Society of System Engineering, Bangalore Chapter, is expected to deliberate on advanced system engineering and technological frontiers. It is heartening to note that the conference is featuring the application of intelligent computational methodologies for process intensification and optimization, to enhance efficiency metrics.

I am sure that the deliberations on high-performance, automation and advancements in system engineering will be very much applicable in the present context of exploring the new frontiers of space exploration, including human space flights.

SEA-2025 is expected to be a pivotal forum for disseminating cutting-edge research findings and fostering inter-disciplinary collaborations, strategically advancing system engineering towards intelligent, advanced and sustainable standards. I sincerely congratulate the organizers for hosting these significant technical presentations with time relevant topics.

Wising very successful and fruitful conference.

(J. ASIR PACKIARAJ)

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पंकज दा. किल्लेदार Pankaj D Killedar
निदेशक Director

MESSAGE

It gives me great pleasure to convey my warm greetings to all delegates and organizers of the *National Conference on Systems Engineering in Automation (SEA-2025)*. This forum provides an excellent platform for professionals, researchers, and students to exchange knowledge and share innovations that advance the state of automation and systems engineering in the country.

MCF operations demand continuous monitoring and control of a fleet of communication, metrological and navigation satellites an area where precision, reliability, and system integrity are paramount. The effectiveness of such mission-critical operations rests on sound systems engineering principles and practices for automation, fault management, and real-time decision making. The integration of big data analytics and AI/ML models offers transformative potential in enhancing operational efficiency for seamless mission control with optimal shared resources across diverse geographical sites.

This conference, therefore, comes at a significant time, when automation is redefining how complex systems are designed, verified, and managed across all the engineering domains. The deliberations and outcomes of this event will surely contribute to strengthening our collective capabilities in building resilient, intelligent, and self-evolving systems. I am confident that the deliberations will inspire innovation and strengthen our collective efforts towards building advanced, safe, and self-reliant systems for India's space endeavors.

I extend my best wishes for the success of SEA 2025 and hope it inspires fruitful collaborations and innovative ideas that will shape the next generation of automated systems in India.

पंकज दा. किल्लेदार

Pankaj D Killedar
Director, Master Control Facility
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Message

I extend my warm greetings to the organizers and participants of the National Conference on System Engineering in Automation (SEA-2025), a collaborative initiative of the Indian Society of Systems for Science and Engineering (ISSE) and the Indian Space Research Organisation (ISRO) aimed at advancing the understanding and practice of systems engineering in automation.

Over the years, the Indian Society of Systems for Science and Engineering (ISSE) has grown into a dynamic professional community that embodies the spirit of collaboration and continuous learning. By bringing together scientists, engineers, professionals and educators from diverse disciplines, ISSE has enabled a shared understanding of systems thinking, transforming it from a theoretical framework into a practical approach that influences design, integration, and operational excellence across sectors. Its role in nurturing young professionals and providing a forum for the exchange of ideas continues to strengthen the nation's systems engineering ecosystem.

In the domain of space exploration, systems engineering provides the essential framework for managing complexity, ensuring reliability, and achieving mission success. From launch vehicle development to deep space operations, every phase demands the orchestration of multiple disciplines, mechanical, electrical, software, and human systems, into a coherent whole. Within ISRO, and particularly in the mission operations supported by ISTRAC, the application of systems engineering principles guides the design and automation of telemetry, tracking, command, and data handling functions across a global network of ground stations, ensuring that mission operations remain efficient, fault-tolerant, and precise in real time.

The theme of this year's conference, *'System Engineering in Automation'*, aptly reflects the growing significance of integrating systems thinking with automation to address emerging challenges in complex environments. As automation becomes central to next-generation systems, it is systems engineering that continues to provide the discipline necessary to integrate intelligence, autonomy, and safety into mission-critical operations.

Through the exchange of ideas and experiences, SEA-2025 will serve as a valuable platform for knowledge exchange, fostering collaboration and advancing the practices of systems engineering and automation. I convey my best wishes for insightful discussions and impactful outcomes.

(Dr. A K Anil Kumar)
Director, ISTRAC

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Message

It gives me immense pleasure to learn that a National Conference is being organized at Bengaluru, jointly by the Indian Society of Systems for Science and Engineering (ISSE) and the Indian Space Research Organisation (ISRO).

ISSE has been consistently at the forefront of promoting the principles and practice of systems engineering across diverse domains of science and technology. Over the years, the Society has established a distinguished record in disseminating knowledge on systems theory and its multifaceted applications. It has provided forums for scholars, researchers, and practitioners to exchange ideas and experiences, publishing significant research outcomes, and recognizing individuals who have made notable contributions to the advancement of systems engineering concepts.

In the contemporary era, the aerospace sector is confronted with the formidable challenge of realizing systems that are simultaneously efficient, reliable, and very cost-effective. Achieving these objectives is inseparable from the growing role of automation. The discipline of systems engineering assumes a pivotal role in the design and realization of automation systems, which integrate numerous components such as sensors, actuators, control systems, software, algorithms, communication networks as well as complex launch support systems. Systems engineering ensure that these elements are coherently integrated and optimized to achieve overall mission objectives.

The National Conference **SEA-2025** aims to deliberate upon the effective application of systems engineering concepts in the development of automation technologies. I am confident that this conference will serve as an excellent platform for the exchange of knowledge and experiences among space centres, academic institutions, and industries across the nation.

On this occasion, I extend my warm felicitations to the organizers and delegates, and convey my best wishes for the successful conduct of the National Conference **SEA-2025.**

(Padmakumar E S)

Place :Sriharikota
Date :17-10-2025

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Dr. K.V Sriram
Distinguished Scientist &
Director

Message

My heartfelt greetings to the organizers and delegates of the National Conference on Systems Engineering in Automation (SEA-2025).

In today's world where system engineering revolves around many complex processes, it is paramount to induct automation which eliminates human errors, thereby yielding more robust and reliable systems.

I am sure the national conference on System Engineering in Automation (SEA-2025) organized by the Bengaluru Chapter of Indian Society of Systems for Science and Engineering (ISSE) will render an excellent platform to showcase technological advancements and share knowledge with domain-specific experts in the country.

It's gratifying to note the inclusion of key topics such as human-centred automation in industries, impact of AI and ML in automation, etc. which are utmost relevant in the current scenario.

I extend my best wishes for the success of SEA-2025.

[Dr. K.V SRIRAM]

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Paper ID: #6-4

Automation of Voltage Drop Analysis in Spacecraft Harness

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Building a Spacecraft is a complex process involving various scientific and engineering aspects such as Power Systems, Control Systems, Communications Systems, Thermal Systems, Structure Engineering, Sensor Systems, Payload Systems, Actuators and more. Integration is the process wherein these respective system packages are interconnected electrically and mechanically to form the satellite. Electrical distribution system (harness), comprising physical wires, serve as interconnections between subsystems.

Power distribution in spacecraft is a critical subsystem, constrained by limited solar generation and on-board battery capacity. Improper harness design can lead to significant voltage drop, impacting electrical performance of the sub-systems. Traditional manual computation of these parameters is cumbersome, error-prone, and impractical for satellites with thousands of interconnections. Voltage drop analysis of power harness is critical to ensure proper subsystem operation and acceptable power dissipation. This study presents the development of an automated software tool with a graphical user interface (GUI) for accurate estimation of voltage drop and power dissipation across spacecraft harness. The objective is to provide harness designers with a reliable, user-friendly solution that enhances accuracy and efficiency during the harness design phase. Validation against integration test data of a spacecraft confirmed the accuracy of this tool. This tool eases overall harness development phase especially for a constellation of similar satellites / standard bus platforms where archived harness data can be reused and the tool can quickly assess the impact of configuration changes.

Paper ID: #12-5

“Custom-counter” selection driven de novo peptide design targeting bacteria: Toward automated therapeutic and diagnostic platforms

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Antimicrobial resistance (AMR) is a critical global challenge that threatens both clinical practice on Earth and astronaut health in long-duration space missions. Conventional antibiotics are increasingly ineffective, and microbial behaviour in microgravity further complicates treatment. Automated, AI-driven peptide discovery pipelines provide an opportunity to generate novel antimicrobials and diagnostics in a scalable, reproducible manner.

This work proposes a custom counter-selection based peptide design pipeline integrated with automation and AI, with the objective of generating pathogen-specific antimicrobial peptides (AMPs) that:

1.Inhibit multidrug-resistant (MDR) bacterial strains
2.Serve as molecular scaffolds for diagnostic probe development
3.Provide a framework adaptable to space microbiology applications

Paper ID: #14-6

Automation in Electrical Integration – Accelerating Spacecraft Realization

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Automation in spacecraft electrical integration has become a critical enabler for accelerating satellite realization. Electrical integration involves harness validation, subsystem functional checks, umbilical interface verification, and operation of Electrical Ground Support Equipment (EGSE) during various phases of Assembly, Integration and Testing (AIT). Traditionally, these activities demand extensive manual effort, making them prone to errors, inconsistencies, and longer realization cycles. By introducing automation, repetitive and time-consuming tasks such as continuity checks, pre-power validation, and interface testing are executed in a standardized, repeatable, and error-free manner. Automated systems also provide autonomous logging and result compilation, ensuring complete traceability and enabling offline analysis. These advancements not only reduce the spacecraft integration timeline but also optimize resources and improve reliability. The paper presents the role of automation in spacecraft electrical integration, discusses its advantages including faster execution, consistency, and data traceability, and highlights its potential as a scalable framework for future spacecraft missions.

Paper ID: #17-8

BinGo: Intelligent Solar-Powered IoT System for Smart Waste Management

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The BinGo system is an integrated smart waste management solution that enhances the efficiency of waste collection using real-time dustbin fill-level data. Utilizing ultrasonic sensors, LoRa communication, and a mobile application, BinGo enables need-based collection scheduling, reducing operational costs, fuel consumption, and environmental impact. Its modular, scalable architecture incorporates a low-power LoRa network for reliable long-range communication. A prototype implemented on a Seeed Studio XIAO ESP32C6 demonstrates reduced bin overflow through optimized collection routes, supporting cleaner urban environments. To improve sustainability, the system integrates photovoltaic modules to power sensing and communication units, reducing grid dependence and extending operational autonomy. It also supports multi-bin configurations, enabling simultaneous monitoring of segregated waste streams to encourage responsible disposal practices. These enhancements make BinGo a robust, energy-efficient, and scalable framework for data-driven waste management.

Paper ID: #18-9

MUC: Multipurpose Universal Chassis for Autonomous Industrial Mobility and Payload Handling

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Factories and warehouses today face rising costs and growing delays because they still rely on a lot of manual work and basic Automated Guided Vehicles. These older vehicles can only move on fixed paths and struggle to adjust to new types of loads or changing layouts. This lack of flexibility slows down operations and makes modern supply chains less efficient.

The Multipurpose Universal Chassis (MUC) was created to solve these problems. MUC is a modular robotic platform designed for moving goods and handling different types of materials in factories and warehouses without needing much help from people. It can map out its surroundings and plan safe paths using advanced sensors like LiDAR and depth cameras, while a robotic arm takes care of loading and unloading items. What makes MUC special is how it combines several important features: it can drive and navigate by itself, handle objects with precision, and safely avoid obstacles. It uses smart controls and built-in safety systems to work well even in busy or changing environments.

Testing of the MUC prototype showed that it can accurately find its way, quickly adapt to blocked paths, and safely handle items. This led to faster deliveries and less need for manual labor compared to traditional systems. The MUC system can make factory and warehouse work safer, faster, and more affordable. By bringing together transport, navigation, and handling in one flexible robot, MUC lays the groundwork for the next wave of smart, automated workplaces

Paper ID: #8-15

Automated Review Management System for Spacecraft Development Programs Powered by AI

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Spacecraft development programs are among the most demanding engineering undertakings, requiring collaboration across multiple disciplines, adherence to strict reliability standards, and execution within compressed schedules. To ensure mission success, projects undergo a series of structured reviews—Baseline Design Review (BDR), Preliminary Design Review (PDR), Critical Design Review (CDR), Test Readiness Review (TRR), Thermo-Vacuum Test Review (TVACR), Non-Conformance Review (NCR), and Pre-Shipment Review (PSR). Each review involves extensive technical discussions and generates a large volume of action items. In missions of national importance such as Chandrayaan-3 and Aditya-L1, the cumulative number of action items has reached several thousand, highlighting the scale of information that must be managed. Conventional documentation practices, which rely on manual note-taking, fragmented spreadsheets, and static reports, have proven inadequate for ensuring traceability, timely closure, and coordination across stakeholders.

To address these limitations, this paper introduces the Automated Review Management System (ARMS), a modular digital platform that integrates speech recognition, speaker diarization, and natural language processing (NLP). ARMS automates the generation of minutes of meeting (MoM), identifies and classifies action items with priorities and categories, and provides dashboards for centralized monitoring and automated reminders. The system ensures secure role-based access, auditability, and compliance with organizational governance standards.

Prototyping and deployment within spacecraft projects demonstrated measurable benefits. Compared to manual processes, ARMS reduced MoM preparation time by more than 60%, lowered transcription and diarization error rates through fine-tuned AI models [2], [6], and significantly improved traceability using unique action identifiers. Stakeholder feedback confirmed enhanced confidence in documentation reliability and accountability. These findings establish ARMS as a scalable, secure, and mission-ready framework capable of transforming review management practices in large-scale aerospace programs.

Paper ID: #20-17

Astro-Autonomy: Computationally Efficient Self-Reconfiguration for Survivable Long-Duration Space Missions

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Interplanetary probes are often subjected to extreme environmental conditions, resulting in radiation exposure, thermal effects, and long delays in communications. Conventional automation performs according to static, pre-programmed responses which precludes effectiveness when responding to unexpected faults and hazards. This effectively limits resilience and reduces the mission life span. To overcome these limitations, this study presents Astro-Autonomy, an adaptive self-reconfigurable automation framework for improving the autonomy and survivability of spacecrafts for long-term missions. The proposed framework utilizes three components: (1) an adaptive method for fault detection through mechanisms influenced by neural plasticity to recognize the onset of anomalies in real time, (2) hardware modules that may be reconfigured through evolvable architectures allowing for redistribution of hardware resources dynamically, and, (3) autonomous decision-making processes that allow subsystems to rewire a function after directing a reconfiguration from its appropriate modules without human intervention. To implement our study, we developed a simulation environment to mimic stressors found in deep-space environments, including radiation faults, thermal effects, and extended periods of communications blackouts. Several metrics were then used to evaluate performance, including rate of recovery, mission continuity, and computational overhead. Results indicate that Astro-Autonomy improves the resilience of automated spacecraft significantly, with recovery rates from a single-point of failure upwards of 85-90% compared to ~40-50% in conventional, static automated systems. Furthermore, during examples of multi-fault conditions, mission continuity was maintained in such cases in ~60% of the examples, as compared with ~20% in baseline conditions. Notably, all conditions of Astro-Autonomy remained at levels of computational overhead below 8% of available power resources.

Paper ID: #26-18

Automation of thruster modelling for characterizing and identifying optimal thrusters for the Space Docking Experiment

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The Indian Space Research Organisation (ISRO) has successfully conducted its first Space Docking Experiment (SPADEX) in recent times. This mission comprises two satellites, viz. chaser and the target. Each of these satellites has an efficient reaction control system comprising accurate relative sensors and actuators. For most of the space docking experiments across the world, the spacecraft actuators play a vital role in achieving the precise docking specifications. Out of all the actuators, modelling the thrusters is a critical task as thruster characteristics cannot be predicted accurately due to the quick reaction time and continuous fuel depletion. Also, in the space docking experiment, there is a requirement for various pulse widths of firing, which emphasises the modelling of thrusters. Apart from modelling the thrusters, identifying and placing the thrusters on the spacecraft decks also requires an accurate prediction of thruster characteristics up to four decimal places. A voluminous thruster data comprising thruster firing patterns needs to be analysed to compute the thruster characteristics precisely.

This thruster firing data is analysed using an automation model that accurately computes the thruster characteristics, viz., rise time, rise delay, fall time and fall delay. These characteristics are eventually used to identify thrusters and their mounting location on the spacecraft. The automation software also computes the incremental velocity acquired by firing a block of selected thrusters, which is useful in designing the threshold limits for the incremental velocity during the mission. The automation software computes the thruster characteristics within fraction of a second and up to 10 decimal places. Hence, the automation software saves both the time and effort involved in manual computation of thruster characteristics, thereby avoiding human errors in the computation. The data provided by the automation software is used in ground testing models to test and qualify the docking algorithm

Paper ID: #31-22

Automatic Calibration Test System for Precision LCR Meters

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Component quality assurance is paramount in achieving successful space missions. Specifically, in human spaceflight applications the quality of measurements is a highly critical aspect. To achieve this goal large number of EEE (Electrical, Electronic and Electromechanical) components are screened, burn-in tested for each of the satellite projects realized in ISRO. Capacitors and inductors are such components screened in large quantities. The quality and reliability of measurements on these capacitors and inductors are ensured by the practice of periodic calibration of measuring instruments. Calibration is the process of comparison of the measurement by a unit under test with another reference unit with one order of magnitude higher accuracy or better which is also traceable to national reference standards.

LCR meters are routinely used for screening tests of large numbers of capacitors and inductors of different types. For example, the Capacitance, Dissipation factor etc. are often measured on capacitors and inductance, Q factor etc. on inductors at various stages of screening tests. To this end LCR meters are used by the user departments.

This work describes the principle of operation and test procedures of an automatic calibration test system for a popular and highly reliable LCR meter (Agilent Model E4980A LCR meter). Equipped with proper jigs and fixtures, this instrument can measure capacitances from 1pF to 100 mF of capacitance and 1nH to 10H of inductance with selectable test frequencies from 120Hz to 1MHz. This instrument is fully controllable through remote commands. A multi-product calibrator which is traceable to national reference standards provides precise, accurate characterized reference impedances for calibration. The multiproduct calibrator can source capacitance with an accuracy of 0.25% consistently. The automatic test system for LCR meter calibration facilitates testing of LCR meters using a programmable multi product calibrator with LAN/GPIB/USB interfaces as the reference impedance source. Figure 1 displays the basic connection schematics of this test system while figure 2 shows a typical screen shot of the program while executing. As part of the calibration tests, Amplitude and Frequency accuracies of the test stimulus, Impedance (Capacitance) and resistance measurement accuracies of the instrument are verified by the test system. This is realized using LabVIEW based program development with a user friendly GUI (Graphical User Interface). By using automated computer controlled testing of the capacitance meter the calibration test time and human errors in logging of test data are reduced compared to manual operations. Thus automation of routine operations of testing can help in enabling mass production of satellites by speeding up testing and evaluation of satellite systems. The uncertainty involved in the calibration is calculated as per ISO/IEC Guide 98-3:2008, GUM (Guide to the expression of Uncertainty in measurement) document by this system and is reported..

Paper ID: #8-23

Real-Time Voice Authentication and Testing Framework for Satellite Commands

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Satellite command testing is one of the most critical steps in ensuring mission safety and reliability. Traditional practices often rely on manual command entry with multiple authentication layers. While secure, such methods are slow, prone to error, and less suited for high-pressure operations where fast and reliable validation is needed.

In this paper, we present a real-time voice authentication and testing framework designed to streamline satellite command validation while maintaining strict security standards. The system works completely offline and combines two key components: Whisper, a state-of-the-art speech recognition model fine-tuned for satellite command phrases, and an ECAPA-TDNN x-vector speaker verification model trained on operator enrolment data. Together, they enable spoken commands to be recognized accurately and authenticated against enrolled users before execution. The framework also includes voice activity detection (VAD), command validation against a secure lexicon, and immutable audit logging for accountability. In testing, the system achieved transcription accuracy above 97%, speaker verification accuracy above 96%, and reduced validation latency by around 45% compared to conventional manual and multi- factor authentication processes. Supporting plots, including cosine similarity, pitch contour, and combined waveform with Mel spectrograms, confirm robustness even in noisy or reverberant environments. This work demonstrates how voice-driven, AI-powered systems can provide faster, more secure, and more natural interaction for satellite command testing, with strong potential for future integration into mission-critical operations.

Paper ID: #32-24

Unified Software Solution in Automation of Spacecraft Integrated Test Operation in NISAR mission

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Satellite system consists of space segment (satellite and its components), ground segment (ground operations and equipment), control segment (ground facilities for management). The control segment manages satellite health and operations. The system health monitoring and control is one of the important parts of any spacecraft mission operations as part on ground & control segment. It has been carried out through telemetry analysis and tele commands uplink. Each of Telemetry sources has been identified with series of parameters through which experts monitor the behaviour of systems to analyse the system performance & their health. Different techniques are available to present the spacecraft health parameters to aid in analysing spacecraft health and control such as tabular displays, graphical displays, pictorial and mimic representations. Similarly, controlling of spacecraft is done through command uplink in appropriate manner and sequences. To carry out efficient in-orbit operations, the evaluation of these aspects is done on ground through spacecraft test operations in multiple phases. All the ground segment elements such as software, procedures, databases, operations sequences, scenarios get qualifies during these tests. The ground segment software brings the major part in spacecraft ground segment elements.

NISAR observatory being joint development project between 2 space pioneer agencies, ISRO and JPL-NASA brought testing individual systems at different setups starting at JPL-NASA to integration testing at ISRO involving different work centres using different methodologies. To carry forward experience across testing levels and phases, a unified approach was required.

The unified software approach in ground software design makes understanding and execution trouble-free for teams working from test environment to mission in-orbit environment. Diversified user teams across different phases, software usage patterns, automating operation sequences, hardware differences, network policies, in spacecraft integration and testing bring challenges to address in unified software approach. In NISAR mission, users (ISRO and NASA) perspective and approach w.r.t. cultural differences also posed a big challenge in bringing authorization and carry forward legacy approaches. The implementation of unified software solution along with automation in NISAR spacecraft integration test phases not only successfully addressed all the challenges but also improved overall spacecraft testing experience right from the beginning of test beds. The amalgamated implementation of standalone and web-based software brought together procedure execution and telemetry analysis involving test procedures conversions/generation, validation, authorization & execution and telemetry analysis, product exchanges. This paper brings out implementation of unified software approach in automation of spacecraft integrated test operations in NISAR mission. The innovative unified software solution addressed multiple critical subjects in NISAR mission, right from setting up mission test beds with simulators for system level testing at JPL-NASA, telemetry database generation & telemetry processing/monitoring for both JPL and ISRO systems, procedure conversions & execution pipeline in system integration tests with FM hardware systems, protocol definition in procedure authorization & telemetry data exchanges towards interfacing of NASA-ISRO software systems. The solution prepared both agencies user segments to carry forward experiences & confidence of critical integration testing phases to mission orbit operations.

Paper ID: #33-25

System Engineering Using Automation for ISR Space Operations: Case Study on AI Enabled Edge Processing and Inter Satellite Links in a TDRS Framework

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Emerging Intelligence, Surveillance, and Reconnaissance (ISR) missions in space demand resilient, autonomous, and bandwidth-optimized communication frameworks. Traditional space-to-ground architectures are constrained by raw data downlink bottlenecks, leading to latency and inefficient spectrum utilization. This work presents a system engineering approach leveraging automation, AI-enabled edge processing, and inter-satellite links (ISLs) within a Tracking and Data Relay Satellite (TDRS)-inspired architecture. Two Low Earth Orbit (LEO) satellites—one equipped with an optical payload and another with a synthetic aperture radar (SAR) payload—relay processed insights to a Geostationary Earth Orbit (GEO) node via dual ISLs: an optical/laser crosslink (>1.5 Gbps) and an E-band RF link (up to 1.5 Gbps). High-performance on-board computing executes AI analytics, including object detection and anomaly recognition, transmitting compressed features rather than raw datasets. Simulation studies demonstrate up to 80% reduction in data volume, near-real-time responsiveness (<200 ms latency), and robust resilience through ISL redundancy. The GEO node forwards optimized intelligence to Ka-band ground stations for mission exploitation. This framework enhances ISR assurance through automation-driven system engineering, enabling interoperability across heterogeneous payloads and ensuring contested-space resilience.

Paper ID: #35-27

Advances in Automated Colony Counting and Antimicrobial Surface Evaluation: Applications in Space Habitats and Beyond

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Microbial monitoring and antimicrobial control are critical for ensuring biosafety in diverse environments, including healthcare, industrial, and closed-loop systems such as space stations. Conventional colony counting and antimicrobial efficacy testing techniques are labour-intensive, time-consuming, and prone to human mistakes. Recent advancements driven by system engineering principles, including increased automation, sophisticated image analysis, machine learning, and artificial intelligence, have revolutionized colony counting, yielding faster, more accurate, and reproducible results. Concurrently, the development of novel antimicrobial surface technologies, including metal-oxide-based coatings and polymer nanomaterial composite thin films, offers a proactive engineering solution to mitigate contamination risks. The current review highlights advance in automated colony counting techniques and the development of advanced antimicrobial surface technology. Crucially, it explores the integration of these automated processes into the standardized evaluation of antimicrobial activity. The review concludes by addressing persistent challenges, identifying research gaps, and outlining a future outlook for integrated, engineered systems to ensure robust biosafety in critical environments.

Paper ID: #36-28

Development of Automated Test System for Launch Vehicle Electrical Umbilical Interface Qualification

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The Electrical Umbilical Interface in a Launch Vehicle Checkout System plays a crucial role in linking ground checkout systems with the vehicle's avionics, pyros, actuators, sensors, and power systems. The reliability of this interface is regularly ensured by Test and Evaluation (T&E) process. Effective T&E is essential to ensure reliable transmission of signals, commands, and DC power across various vehicle stages. Measuring line resistance (Ω), isolation resistance (Ω), insulation resistance (Ω), and performing Surge Protection Device (SPD) functional checks are carried out manually for each channel during T&E which is time-consuming and prone to human error. Moreover, the increasing number of electrical umbilical interface lines in modern launch vehicles has made manual testing inadequate to meet defined timelines and quality requirements.

This paper presents an automated testing framework designed to enhance the efficiency, accuracy, and repeatability of Electrical Umbilical Interface qualification and validation at the launch pad complex. The proposed automation approach ensures readiness of umbilical systems for consecutive launch campaigns, reduces operator dependency, and significantly minimizes testing time while maintaining high reliability and data traceability.

Paper ID: #39-29

Automation of climatic testing of spacecraft sub system

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The increasing obsolescence of hardware-specific control architectures poses a critical challenge in sustaining high-reliability test facilities for aerospace applications. Conventional printed circuit board (PCB)-based controllers used in Thermal Cycling Chambers are particularly prone to failure, difficult to maintain, and offer limited scope for reconfiguration. This work addresses this gap by developing and evaluating a programmable logic controller (PLC) and human–machine interface (HMI) based control and measurement framework as a scalable alternative. The proposed system combines deterministic logic execution, modular input–output abstraction, and hierarchical safety interlocks with a configurable HMI layer to ensure precise thermal regulation, fault tolerance, and operator-centric usability. A systematic design methodology is employed, encompassing requirements analysis, control logic synthesis, hardware–software integration, and validation through operational testing. Experimental results demonstrate significant improvements in accuracy, reliability, and maintainability compared to legacy PCB-based solutions. The contribution of this work lies in advancing an adaptable and research-driven control paradigm for aerospace thermal testing infrastructure, providing a foundation for future investigations into resilient automation frameworks for critical test environments.

Paper ID: #40-30

Automatic Robust Antenna Pointing Algorithm for Continuous Lunar Landing Communications

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Critical mission phases such as lunar landing demand uninterrupted communication between the spacecraft and Earth. High-rate telemetry, including imagery, sensor data, and navigation updates, must be continuously available at the ground segment to support real-time health monitoring and autonomous guidance. For such links, the spacecraft typically employs a high-gain, narrow-beam antenna, while the ground segment relies on large-aperture Deep Space Network (DSN) antennas.

In the case considered here, the spacecraft carries a two-axis rotatable high-gain patch array antenna optimized during in-orbit testing (IOT) to account for structural offsets and calibration biases. The ground segment operates the 32 m IDSN antenna in program mode, meaning it cannot rely on conventional signal strength auto-tracking to maintain pointing. This introduces risk: prediction-based program tracking may drift due to ephemeris uncertainty, attitude jitter, or ground dynamics, leading to potential pointing loss. At X-band, the DSN antenna has a half-power beamwidth (HPBW) of only ~0.08°, which translates to a tolerance of about 1–2 arcminutes for <1 dB pointing loss. Even small misalignments may severely degrade the link, jeopardizing data continuity during descent and landing.

Paper ID: #42-33

Automation of ground station using open source software

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This article presents an automated ground station built entirely with open-source software and lightweight hardware. A Python-based system integrates orbital propagation using the SKYFIELD model, antenna rotator control through real-time azimuth and elevation calculations, and reception/decoding of telemetry and weather images via SatDump. Two-Line Element (TLE) data from public sources are used to compute satellite passes, including Arrival of Signal (AoS), Loss of Signal (LoS), and Time of Closest Approach (TCA), with sub-second accuracy. These predictions directly drive antenna rotors while reception tasks are automated through external tools. To extend usability, the system integrates Internet of Things (IoT) functionality, enabling received data to be uploaded to the cloud for storage and analysis. A mobile-friendly control panel allows users to operate and monitor the ground station remotely, while received satellite data can also be accessed directly on mobile devices. Validated on Raspberry Pi, the system is low-cost, portable, and scalable, providing a practical approach to ground station automation for research, education, and small-scale satellite communication projects.

Paper ID: #41-34

MBSE enabled Automated Multidisciplinary Workflow for STOP Analysis for Space Systems

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Complex engineering systems, such as those deployed in space, are highly sensitive to thermo-structural effects and performance degradation under extreme space conditions. Addressing these multidisciplinary challenges requires more than isolated analyses. Model-Based Systems Engineering (MBSE) has been proven to provide structured framework for design and development of complex systems and conducting multidisciplinary analysis alike Structural Thermal Optical Performance (STOP) Analysis, enabling engineers to design, analyse, optimize, verify and validate complex system designs through integrated, automated, and model-driven workflows. While the discussed use case highlights application of MBSE-led integrated & automated workflow for STOP Analysis, the methodology applies broadly to any kind of system design and multidisciplinary analyses, verification and validation studies across aerospace, defence, and complex systems engineering domains.

This study demonstrates how MBSE supports STOP Analysis as a multidisciplinary evaluation of complex systems, highlighting challenges in predicting coupled physical effects, ensuring requirements verification & compliance, and achieving optimizing designs through iterative, automated workflows. It also illustrates MBSE's role in enhancing accuracy, traceability, and collaboration through integration of diverse toolsets, disciplines and personas into a unified workflow.

Paper ID: #44-36

NISAR Spacecraft Auto Compatibility Test and Challenges

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NISAR (NASA-ISRO Synthetic Aperture Radar) is the joint project by National Aeronautics and Space Administration (NASA) and Indian Space Research Organization (ISRO) on an Earth Science mission, and is successfully launched. It will assess how our planet changes overtime by measuring differences in the Earth's solid surface due to factors like climate change, movement of glaciers, earthquakes, land-slides, deforestation, agriculture and others. This would be the first dual frequency (L- & S-Band) space-based SAR mission to monitor the changes in the earth. In this paper, test carried out to clear the Spacecraft near to TAYF (Test as You Fly) is presented. Auto compatibility is the test which will clear all the Spacecraft subsystems as in orbit configuration. Demonstration of the Dual SAR (L & S band) Payload capability in joint radiation mode along with all spacecraft bus systems as they will be operated in mission was carried out at CATF facility by conducting this Auto compatibility test. The transmit and receive characterization of the both L-SAR and S-SAR as in orbit was carried out to clear the S/C functionality as in orbit in radiation mode at CATF facility and studied the effect of compatibility of all system together.

Paper ID: #45-37

Cable suspended camera system for photogrammetry of very large object

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The paper presents the design, analysis, and validation of a cable-suspended camera system developed for photogrammetry-based measurement of large spacecraft structures, particularly ultra-large antenna (UFA) reflectors. Traditional photogrammetry of large deployable structures is labour-intensive and often infeasible using manual camera positioning. To address this challenge, an automated cable-driven parallel robotic system was conceived, enabling precise and repeatable positioning of a gyro-stabilized camera within a three-dimensional workspace. The system architecture comprises four motorized winches located at the corners of a rectangular workspace, each operating a Kevlar or Dyneema cable attached to a suspended camera dolly. By independently controlling cable lengths through inverse kinematic computations, the camera can traverse any point within the defined volume, allowing comprehensive coverage of large reflectors. The control software integrates camera position inputs, while a remote gimbal head enables full yaw, pitch, and roll motion control. Detailed inverse kinematics modelling, motor selection, and workspace analysis were performed to ensure synchronized motion of all cables and motors. Experimental validation was conducted using a 6-meter UFA model, followed by extrapolation to an 18-meter reflector case. The results confirmed significant improvement in both efficiency and accuracy. The system successfully reduced the measurement duration from four hours to thirty minutes, demonstrating its practicality for large-scale aerospace applications. In conclusion, the developed cable-suspended camera system offers a reliable, automated, and scalable solution for photogrammetric measurements of very large spacecraft appendages. Its modular design and validated performance establish it as a feasible method for precise non-contact dimensional assessment in large aerospace structures.and ensures improved accuracy for large antenna structures.

Paper ID: #47-38

Role of IoT systems in Quality 4.0 applications

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Internet of things (IOT) platform where high speed sensors and data acquisition are connected with internet connectivity. IOT is meant for monitoring, acquisition and control application with high-speed data network by which remote control applications are possible. IOT is the main element of Industry 4.0 platform which facilitates the high-speed industry automation with robotics, cloud computing, block chain systems and data analytics with AI and ML algorithms. Industry 4.0 is used for product manufacturing by integrating various high speed digital systems across world. It connects supplier to customer end through the high-speed internet connectivity by sharing the information of product manufacturing in real time. The IOT systems which is mainly do the controlling, monitoring and data sharing across the other systems which are connected in Industry 4.0 for automated product manufacturing. The product quality is an essential feature of any product and is to be assessed by not compromising any functional requirements of the product. The product will be successful if its quality is assessed in a correct manner and at the speed of industry 4.0 operations in real time. Quality 4.0 is the quality concept where the product quality is assessed and assured with digital technologies in real time. Earlier, the product quality is measured by manual and semi-automatic manner and are time consuming as they are carried out in offline mode. IOT systems are playing a major role to assess the digital quality of the product by utilising the efficient functional digital elements by which it is configured. In this paper, the role of IOT systems to measure and assess the product quality at the speed of manufacturing is explained. A framework is proposed to implement digital quality in real time is proposed by which product quality is assured automatically and without any offline interventions. The framework comprises the IOT systems where the sensors, acquisition systems and controlling interfaces can support the implementation of digital quality and sharing information across the functional blocks of product life cycle. SPC (Statistical Process Control), 3-Sigma, AI driven quality tools are explained to assess and report the digital quality of the product/s towards the successful implementation of Quality 4.0. The proposed framework can be adopted for any product and service sectors where Industry 4.0 is implemented.

Paper ID: #46-39

Automated Modelling of a Large Deployable Antenna Structure (LDAS) for Space Applications

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Large Deployable Antenna Structures (LDAS) are essentially deployable structures in modern space systems, offering high packaging efficiency and significantly large deployed sizes. However, the modelling of such systems poses considerable challenges due to their inherent structural complexity, which involves numerous links, joints, and intricate deployment mechanisms. Traditional modelling approaches require rebuilding models from scratch whenever changes in configuration or design parameters occur, making the process time-consuming and susceptible to errors. To address these limitations, the present work introduces an automated modelling methodology implemented in MSC ADAMS through the use of macros. MSC ADAMS is a multi-body dynamics software used to simulate the realistic motion behaviour of mechanical systems. The proposed macro is designed to automatically generate complete kinematic models of LDAS based on user-defined parameters, including the number of bays, stowed dimensions, and dimensions of structural elements such as horizontal members, radial members, hinge brackets, and folding brackets. By incorporating parameters into the macro, the modelling process is generalised, enabling rapid creation of multiple configurations without repetitive manual effort.

Paper ID: #48-40

Case Studies on Automation Engineering Implementation in High Altitude test facility for testing monopropellant Thrusters

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Ground testing is a critical phase in the qualification of monopropellant thrusters employed for attitude control and orbit-raising maneuvers in Earth Observation Spacecraft (EOS). These thrusters are evaluated within vacuum chambers that replicate space-like conditions, achieving pressures down to 10^{-3} mbar via a dual-stage pumping system comprising rotary and roots pumps.
The proposed framework integrates Programmable Logic Controllers (PLCs) for pump sequencing, Supervisory Control and Data Acquisition (SCADA) systems for real-time monitoring, and Internet of Things (IoT)-based sensors for continuous health diagnostics. Safety interlocks and automated test cycles are incorporated to improve operational reliability and consistency.
During automation implementation multiple challenges were faced such as interfacing of sensors to PLC and acquiring their data for proper functioning, tackling interlock failures due to failure of sensors, devising of interlocks to implement personnel safety during thruster testing, ensuring seamless switching of control from local HMI to a remote SCADA system, etc. All These challenges were mitigated by rigorous testing and smooth functioning of the automated system was established.
This paper presents the design and implementation of an automated control framework for vacuum chamber operations, addressing challenges associated with maintaining operational vacuum levels during thruster firing and expulsion of combustion by-products. Automation replaces manual procedures to reduce human error, enhance test repeatability, and enable real-time decision-making. A modular software architecture is adopted to ensure system scalability and adaptability.

Paper ID: #52-42

GEO / IGSO Spacecrafts Power Subsystem Mission Operations Automation using Model based Health analysis and Operations Management Tools

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Spacecraft power subsystem health analysis and operations planning has been a challenging task in GEO/IGSO mission operations. Over the years, there has been improvements in power subsystem design. Improved solar cells, batteries are being used for high-power GEO satellites. Efficient and accurate planning of power subsystem operations ensures, safe battery operations, during Solar/Lunar eclipse, NSSK/EWSK manoeuvre. Solar array generations and degradation estimations ensures bus–latch-up free operations by proper power margin maintenance. The Power subsystem being a critical element for the spacecraft need timely detection of non-nominal component or subsystem behaviour. Battery cell degradation due to ageing or random cell failure or solar array non-nominal degradations are possibilities. Analysis tools can ensure timely detections and estimations more accurately in an automated manner and finding can help mitigations to prevent further degradations. Tools helps auto Database generations and management which facilitate long term, short term, seasonal and across season comparative statistical analysis.
This paper presents Analysis tools, techniques and methodology of GSO/IGSO spacecraft power subsystem health analysis and operations planning for various mode of operations. Over the years, conventional statistical tools have been used for the purposes. Tools have evolved which make use of machine learning and models based approach along with the conventional statistical algorithms. These tools make predictions and estimation in automated manner and gives output in tabulated report formats along with the relevant findings and charts. These tools have improved accuracies of predictions and made operations planning works more accurate, efficient and timesaving.

Paper ID: #51-44

The Design and On-orbit Experimental Verification of an Electronic Dosimeter System for LEO Missions

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Ionizing radiation can cause significant issues for space assets, potentially leading to performance degradation, loss of functionality, or mission failure. Therefore, accurate measurements of Total Ionizing Dose (TID) and the risk of Single Event Effects (SEE) are essential inputs for designing reliable spacecraft and payloads. Considerable research has already been carried out by universities and research organizations to characterize the radiation environment in low Earth orbit (LEO). However, such experiments are expensive due to the high cost of dosimeters and the substantial launch expenses. A low-cost electronic dosimeter package is highly valuable for in-situ measurement of TID in radiation-prone zones. The most expensive component of a dosimeter is the sensor section, and its cost can be substantially reduced by using a third-party semiconductor-based radiation measurement chip. The overall dosimeter system cost is reduced by using third-party semiconductor-based radiation sensing chips. It enables wider deployment and more frequent radiation monitoring missions without compromising measurement fidelity.

Paper ID: #53-45

Automated System Configuration for Streamlined Spacecraft Design

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Spacecraft preliminary system design presents significant challenges in efficiently configuring complex, multidisciplinary subsystems to meet diverse mission objectives. The process demands careful selection and integration of numerous subsystems from multidisciplinary teams. Existing analytical and Product Lifecycle Management (PLM) tools typically lack an adaptable, integrated framework for early-phase configuration decisions, resulting in manual, time-intensive workflows prone to interface inconsistencies and costly iterations. The CDU is structured as a Knowledge-Based System (KBS), built around a comprehensive Component Specification and Constraint Repository within a PLM environment. The methodology centres on a Rule Engine that executes expert-derived logic to enforce cross-disciplinary interface compatibility and automate design synthesis.

This paper introduces the Configuration Definition Utility (CDU)—a novel knowledge-based automation tool aimed at streamlining preliminary design configurations through codification of expert knowledge. The primary objective is to streamline the configuration workflow, enabling engineers to make informed, seamless, and cost-effective decisions when integrating new subsystems or optimizing existing designs.

Paper ID: #54-46

Automation of Operations for a Spacecraft in Geo Transfer Orbit

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Operating a spacecraft in an elliptical geo transfer orbit throughout the mission life presents multiple constraints and unique operational challenges. The long-term operation at lower perigee altitudes in the presence of atmospheric drag compounds momentum build-up and necessitates optimized momentum desaturation cycles. When perigee height is not maintained, atmospheric drag affects the apogee height. Reaction wheel speeds vary drastically with each perigee passage and due to external disturbances, requiring periodic thruster operations to maintain wheel speeds within limits and ensure stable attitude. To address these complexities, operational strategies have evolved from initial manual ground commands to automation with effective utilization of on-board features, notably leveraging the On-Board Timer (OBT) system for all key tasks such as solar array positioning at perigee, eclipse operations, auto momentum dumping during non-visibility periods, perigee raising maneuvers and payload operations. Attitude control switches efficiently between inertial (sun-safe) and payload (earth-oriented) modes to achieve operational requirements amidst time-varying visibility windows and frequent eclipses. Comprehensive automation was progressively implemented to manage constraints like overhead pass, varying signal and power levels, and limited station visibility without using external station support, ultimately allowing the spacecraft to maintain service and optimize payload usage in an elliptical orbit. This progression streamlined ground resource usage and provided valuable lessons for future satellite missions operating under non-ideal conditions and prolonged orbit raising, such as electric propulsion system-based orbit raising.

Paper ID: #56-47

Design Architecture of an Automated Programmable Power Protection Unit for Spacecraft Power Simulators

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Spacecraft during integrated tests gets interfaced to power simulators. Battery simulators and solar array simulators as electrical sources simulate the terminal electrical characteristics of the on-board battery and solar arrays. It is imperative to provide protection to the spacecraft from power outages witnessed due to either failure in power simulators or in the on-board circuit. The article brings out a design for developing automated and programmable power protection unit that safeguards the spacecraft from power outages. The programmability is achieved in setting the level at which the protection acts as well as in programming the time taken for isolating the power simulators.

Paper ID: #49-48

Automating Spacecraft System Compliance for Environment Test Level Specification

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The increasing complexity of spacecraft architectures and the demand for accelerated development timelines, amplify the limitations of manual compliance methods. Compliance with environmental test level specifications (ETLS) is a cornerstone of spacecraft qualification, ensuring structural robustness and functional reliability under launch and operational environments. Ensuring compliance with ETLS is critical for spacecraft reliability and mission success. Traditionally, this verification relies on manual interpretation of specifications, correlation with subsystem data, and iterative documentation. Such processes are labour-intensive, prone to error, and inconsistent across projects, creating bottlenecks in spacecraft development cycles. Although digital engineering and model-based practices are gaining prominence, a comprehensive and automated framework for ETLS verification is yet to be established.

This work proposes a systematic methodology for automating ETLS compliance assessment. The proposed framework digitizes specifications, applies rule-based and weighted verification algorithms, and integrates visualization through compliance dashboards. By reducing subjectivity and enhancing traceability, the methodology delivers measurable improvements in accuracy, efficiency, and scalability, advancing the state of practice in spacecraft system engineering.

Paper ID: #57-51

On-Orbit Self-Calibration, Diagnostics, and Auto-Recovery of Optical Encoders for Automation in Spacecraft Payloads

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High-precision payload pointing in spacecraft relies on optical encoders as rotary angle feedback sensors, requiring arc-second-level accuracy over long mission lifetimes. Traditional encoder designs, while precise in controlled laboratory environments, are susceptible to calibration drift, thermal variations, mechanical eccentricity, and radiation-induced anomalies in orbit. Their dependence on manual recalibration or hardware redundancy increases mission cost and limits autonomy This work introduces a self-calibrating, self-diagnosing, and self-recovering encoder architecture, designed to sustain accuracy and functionality under on-orbit disturbances. The design has been verified on a flight-model sensor developed, qualified, and inducted for flight use on the Oceansat-3A Scatterometer Scan Mechanism Payload. Verification was carried out through fully automated ground-based test cycles simulating orbital conditions, and the architecture is scalable to on-orbit calibration and verification.

Paper ID: #61-52

Mission Analysis Framework Development Towards System Engineering Process Automation: A Case Study for a Medical Evacuation Aerial Platform

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This paper presents the development of a mission analysis framework aimed at advancing systems engineering process automation, demonstrated through a case study on a medical evacuation aerial platform. Leveraging the HyperKube Framework, the study integrates stakeholder-driven mission analysis with structured artefact modelling, digital thread connectivity, and requirements automation.

Nine core artefacts ranging from mission scenarios to risks and mitigations are systematically linked to ISO 15288 lifecycle processes, enabling traceability, regulatory compliance, and lifecycle rigor. The case study highlights how automated requirement derivation, risk management, and information mapping can improve responsiveness to stakeholder needs, enhance safety assurance, and reduce manual workload.

Early results underscore the potential of mission health dashboards, structured information capture, and digital export functions in driving future model-based systems engineering (MBSE) practices. While the medical evacuation case reveals gaps in stakeholder coverage and requirement completeness, it establishes a foundation for scalable automation approaches in complex aerospace programs.

Paper ID: #60-95

Regex-Driven Automation of Test Log Generation for Star Sensors

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Star sensors are critical elements in spacecraft for determining orientation in space. Due to their importance, extensive testing is carried out before integration. The test logs generated from these experiments must be compiled into standardized documentation. At present, this process is manual, time-consuming, and prone to errors such as typos and inconsistencies. These issues reduce efficiency, delay workflows, and may compromise traceability of test data. Automation offers a reliable solution to address these challenges making log analytics, retrieval and general access of data from logs more efficient.

Test Log Automation tool is a GUI-based application designed to extract data from selected base files. Using placeholders and regular expressions (regex), the application identifies and retrieves specific values from these files. The extracted data is then stored into user-defined template files for further use. This tool is implemented in Python and utilizes JSON files for efficient data manipulation and storage.

Paper ID: #60-96

Automated Unit Testing Framework for Ada Software Using Python

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In space based safety critical processor based systems, Ada language is used for its safety set, modularity and strong typing features. Unit Level Testing(ULT) is the first phase of testing to ensure software correctness and reliability, but analyzing the code and preparing test cases manually is time-consuming and error-prone. Existing commercial ULT tools provide powerful automation, but are locked with higher tier licenses, complex licensing structure where documentation, code coverage, integration with target simulator are all separate licenses. Additionally, there would be no community support for development but rather limited support from vendor which most likely causes delay. To address these disadvantages, the paper presents an indigenous tool development of Unit level test environment for Ada using Python framework. The framework automatically extracts for the user, all details of the Ada body file including procedure arguments, inputs, outputs, constants, variables, and their data types, etc. This aids directly in planning test cases for the user. An Ada code parser is at the heart of tool development. The detailed sections discuss the implementation of the parser and an extension to it where a detailed design document template is generated automatically. The tool overall offers a lightweight, extensible solution for Ada unit-testing automation and documentation.

Paper ID: #60-97

Automation of Common Database Generation for Satellite Telemetry

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An essential aspect of any satellite mission is telemetry, which provides critical insight into spacecraft health and performance. It is required to accurately decode raw telemetry data into user understandable Process Identifiers (PID) for monitoring various subsystems. Manual preparation of PID decoding Common Databases (CDB) is time-consuming and error-prone, especially for missions with thousands of parameters. This paper presents an automated tool that generates standardized CDBs for both existing and new systems. The approach primarily involves reusing existing mappings for heritage subsystems with updated telemetry indexing, while for new systems, it parses telemetry source code to extract PID definitions. Verifications of auto generated CDBs confirmed accuracy and revealed errors in heritage CDBs also. This tool has been applied to Star Sensor and Rendezvous Processing Unit (RPU) subsystems, to generate thousands of PIDs within seconds, significantly reducing manual effort and improving data integrity.

Paper ID: #60-98

Automation of Batching and Packing of Burn Rate Modifier in Solid Propellant

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This paper details about the automation of batching and packing of Activated Copper Chromite (ACR). ACR is a critical ingredient in the formulation of solid propellant. It acts as a burn-rate modifier and determines the thrust profile for the solid motor. The thrust profile of a solid motor plays a key role in designing the flight control systems. Hence, the batching accuracy of ACR plays a critical role in the properties of solid propellant. The batching and packing process of ACR is automated by using a hot-standby PLC (Programmable Logic Controller) and HMI with ring architecture for increased system availability. An algorithm is developed for accurate batching of ACR using of bin vibrator and speed controlled vibro-feeder. The complete process can be operated in discrete and auto modes via HMI. The controller program uses a state-based logic for handling the devices in a pre-defined sequence with various process and safety interlocks. The proposed algorithm for batching results in an accuracy of 0.00143% (100 mg) for varied batching quantities.

The Organizing Committee extends heartfelt thanks to all those who contributed to SEA 2025.

We express our sincere appreciation to our distinguished speakers, sponsors, participants, and reviewers for their valuable support and involvement. Special thanks to the faculty members, students, and volunteers whose dedication and teamwork made this event possible.

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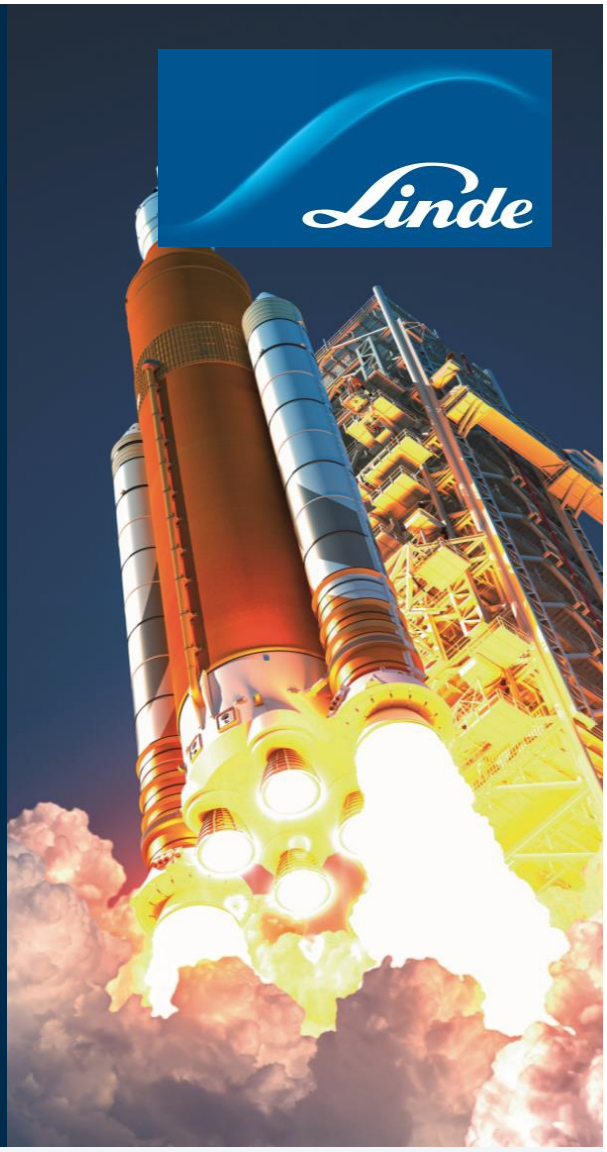

We are a leading global industrial gases and engineering company delivering high-quality solutions, technologies and services.

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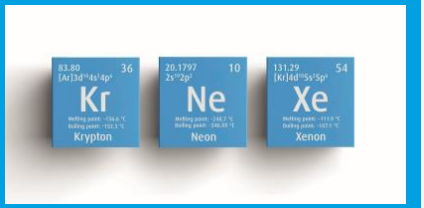

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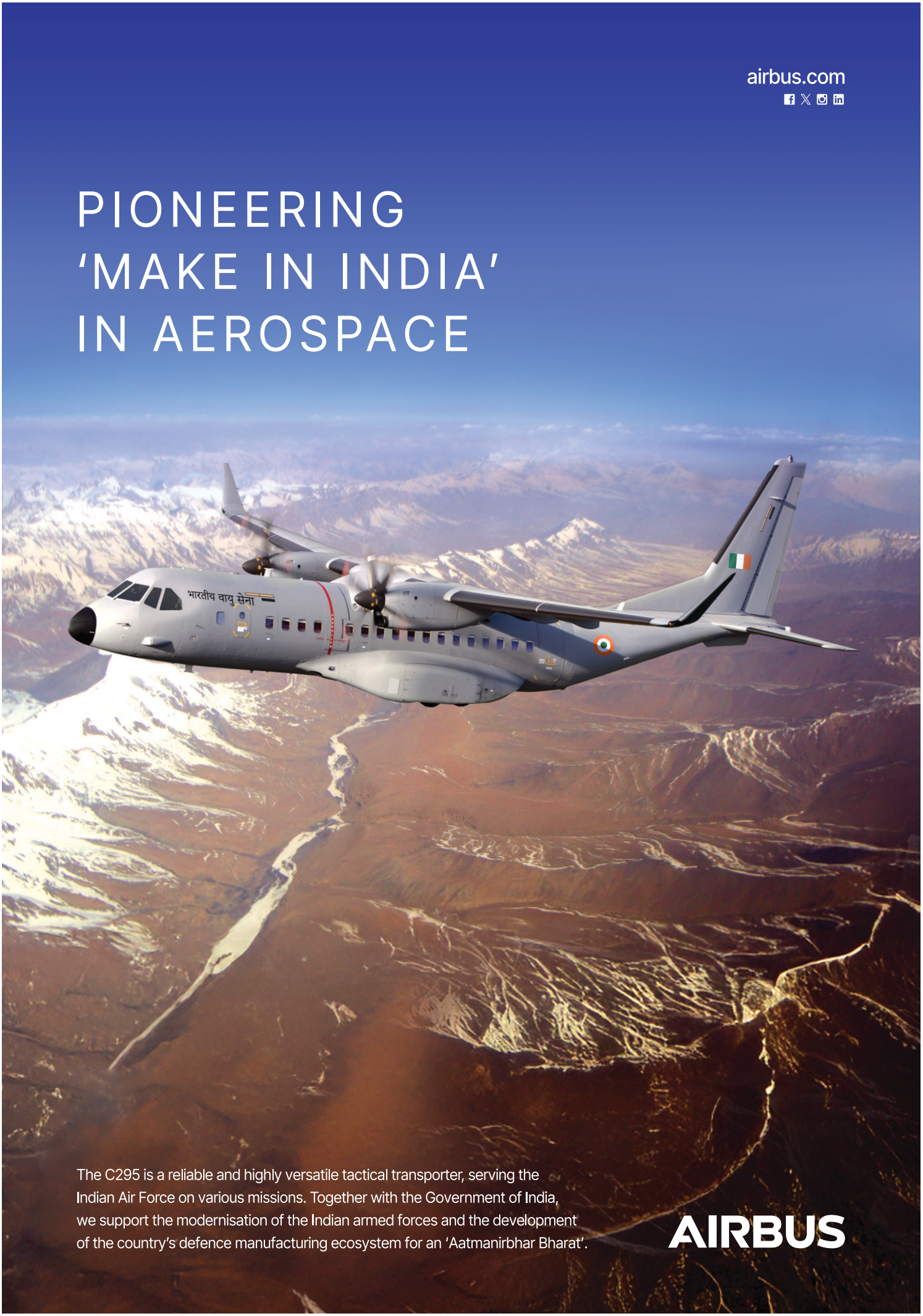
PIONEERING ‘MAKE IN INDIA’ IN AEROSPACE



The C295 is a reliable and highly versatile tactical transporter, serving the Indian Air Force on various missions. Together with the Government of India, we support the modernisation of the Indian armed forces and the development of the country’s defence manufacturing ecosystem for an ‘Aatmanirbhar Bharat’.

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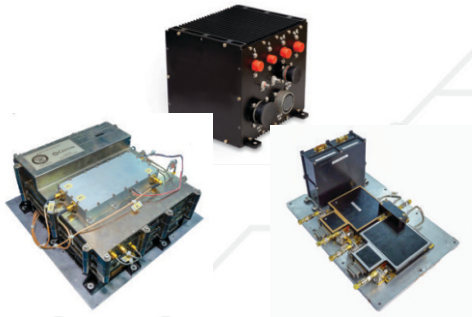
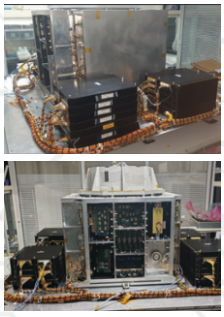
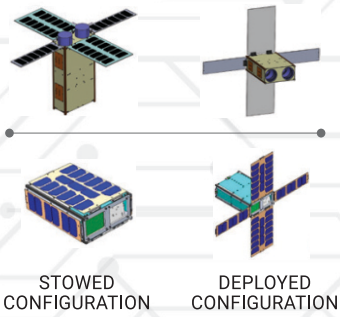
Spaceborne Payloads
(EW, Radar Imaging, Earth Observation)



Integration Capabilities



Small Satellites Designs Capabilities



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Kepler Aerospace is a vertically integrated space based intelligence, surveillance and reconnaissance solution provider powered by swarming satellites and global ground station networks. Kepler's avionics is deployed across space, airborne and terrestrial platforms in several programs including Gaganyaan and Tejas aircraft.

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Launch Vehicle Stage Integration

End-to-End Launch vehicle productionization

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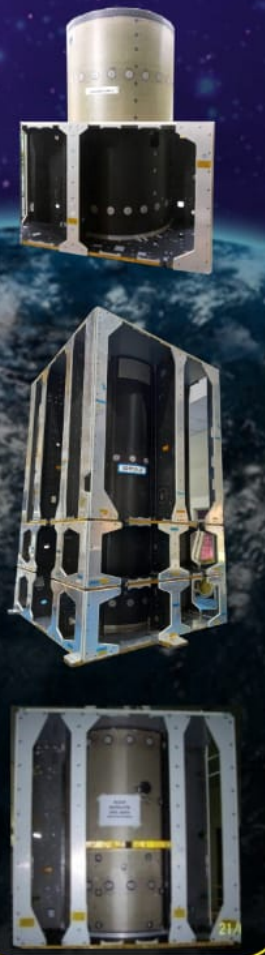
Rocket Engines

Satellite Structures



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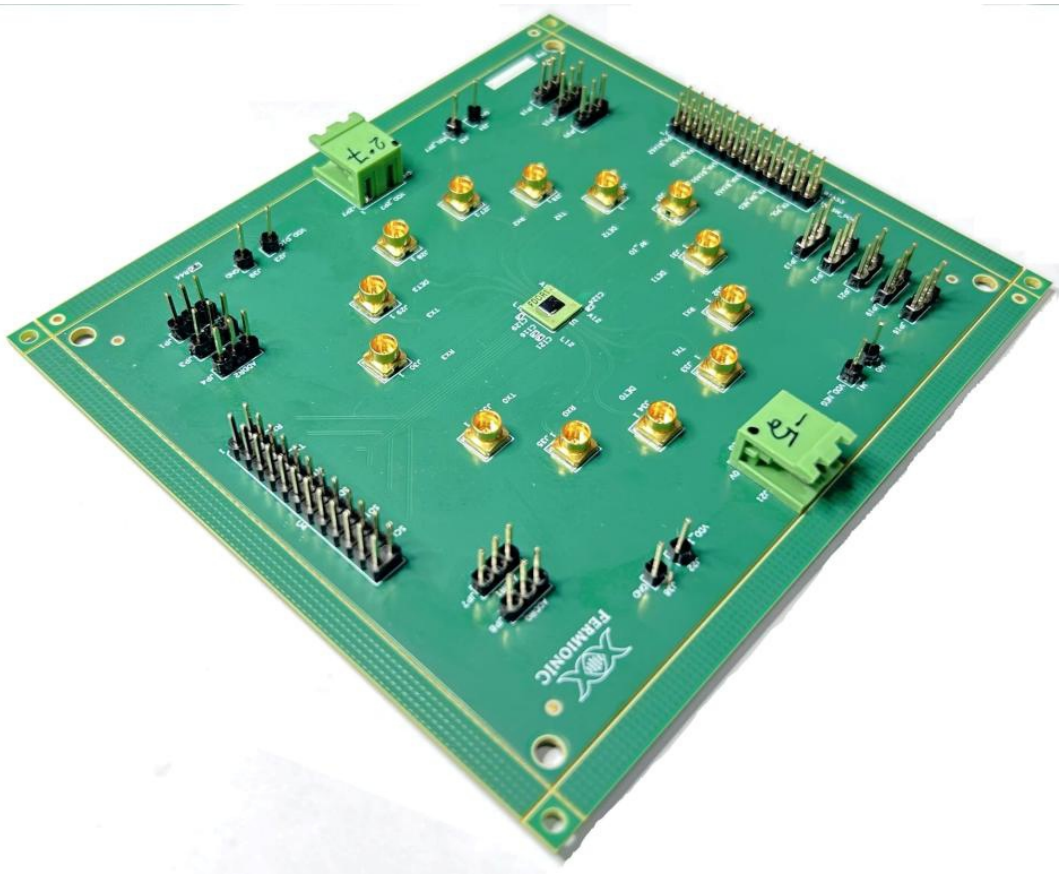

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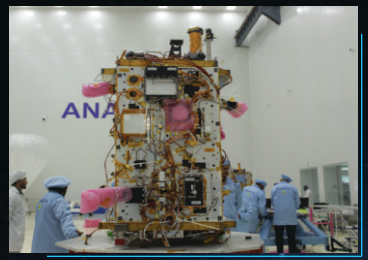

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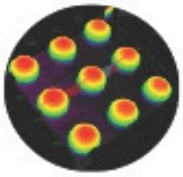
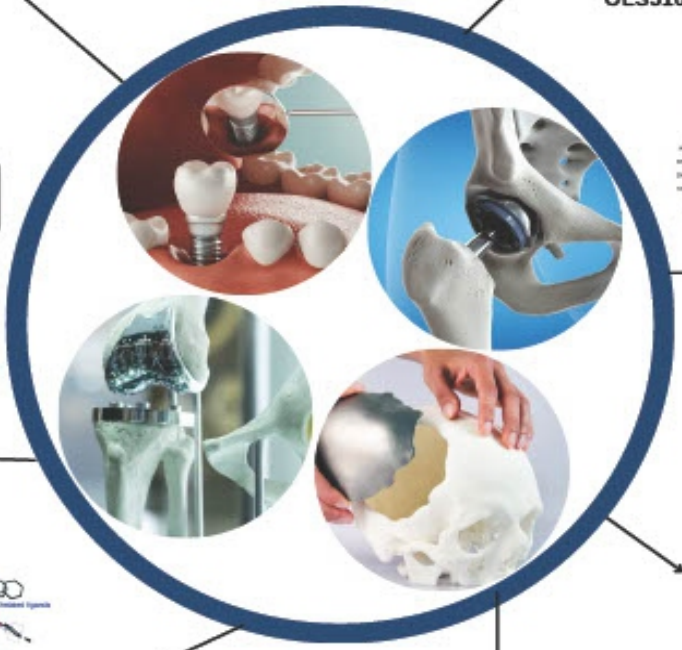
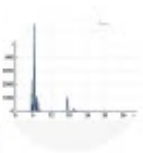


DSX1000 3D Digital Microscope


OLS5100 3D Laser Scanning Microscope

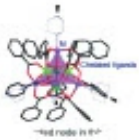
Hot Stage For Microscope






Handheld XRF Analyzer

Scanning Electron Microscope

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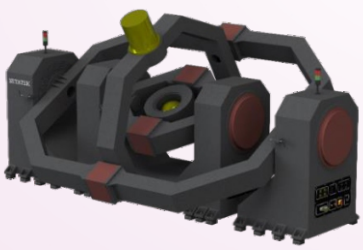
Rate Tables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▪ Transit cases	▪ SLEDs	▪ Precision Optics

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Azista BST Aerospace
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Azista - Electronics & Defence
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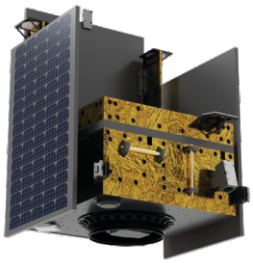

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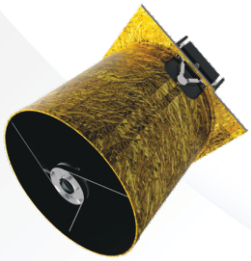

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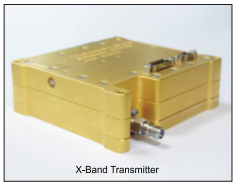
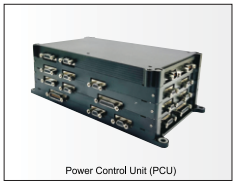
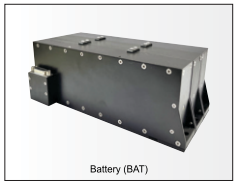


X-Band Transmitter

Reaction Wheel Assembly (RWA)



Power Control Unit (PCU)



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