SUMATI IAS

Article

Axiom-4 Mission

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The Ax-4 mission "realized the return" to human spaceflight for India, Poland, and Hungary, with each nation's first government-sponsored flight in more than 40 years. While Ax-4 marks these countries' second human spaceflight mission in history, it became the first time all three nations executed a mission on board the International Space Station. This historic mission underscores how Axiom Space is redefining the pathway to low-Earth orbit and elevating national space programs globally.

About Axiom 4 Mission

- **Location of Launch:** NASA's Kennedy Space Centre in Florida
- Shubhanshu Shukla from the Indian Air Force is set to make history as the first Indian astronaut to journey to the International Space Station aboard the Axiom 4 Mission.
- Axiom Mission 4 (Ax-4) is a private spaceflight to the International Space Station (ISS) organized by Axiom Space, a US-based company specializing in space infrastructure.
- The mission uses SpaceX's reusable Crew Dragon spacecraft, designed to transport astronauts to and from the ISS.
- This marks the fourth mission in partnership with NASA, following Axiom Missions 1, 2, and 3.
- Ax-4 is a part of Axiom Space's broader vision to build a commercial space station and to democratize space exploration by offering private individuals, researchers, and astronauts the chance to travel to space.
- Axiom Space has partnered with NASA, SpaceX, and other space agencies to provide these opportunities, signaling the increasing trend of commercial players taking a central role in human space exploration.

Mission Objectives

The primary objective of Ax-4 was to provide a crew of private astronauts with the opportunity to stay aboard the ISS for a period of time. During their stay, the astronauts were expected to conduct scientific experiments, contribute to ongoing ISS research, and participate in a series of outreach activities to promote space exploration.

Some of the notable objectives of Ax-4 included:

- **Scientific Research**: The astronauts carried out various experiments in fields like health, materials science, and space technology. These experiments were intended to enhance

human understanding of space environments and contribute to future long-term missions to the Moon, Mars, and beyond.

- **Space Tourism**: The mission marked another step in the growing industry of space tourism, where private individuals pay to travel to space. Ax-4 helped further solidify space tourism as a viable sector in the commercial space industry.
- **Outreach and Education**: The crew of Ax-4 engaged in educational and public outreach programs. They participated in live communications with students and space enthusiasts, aiming to inspire the next generation of scientists, engineers, and space explorers.

Mission Details

- **Launch Vehicle**: The Axiom-4 mission utilized **SpaceX's Falcon 9 rocket** to launch the **Crew Dragon spacecraft**. Falcon 9 is known for its reliability and cost-effectiveness, and it is frequently used in NASA's Commercial Crew Program, as well as by private companies for satellite launches and crewed missions.
- **Crew Members**: The crew for Ax-4 consisted of four private astronauts. These astronauts were not professional astronauts but civilians who had undergone extensive training to prepare for their space journey. The crew members included individuals from various backgrounds, including business, research, and engineering.
- **Duration of the Mission**: The crew spent approximately 10 days in space, most of which were spent aboard the ISS. The mission allowed the crew to experience the microgravity environment of space while conducting scientific experiments and supporting research activities on the station.
- **Landing**: After completing their mission aboard the ISS, the crew returned to Earth aboard the Crew Dragon spacecraft, which safely re-entered Earth's atmosphere and splashed down in the ocean.

SpaceX Falcon 9 Rocket

- **Context**: In a rare event, SpaceX's Falcon 9 Rocket recently suffered a **failure in its upper stage engine** that left 20 Starlink internet satellites in a low, non-survivable orbit. The rocket's second stage experienced a **liquid oxygen leak**, and failed to complete a second, short engine burn needed to place the satellites in the correct/intended orbit.
- Falcon 9 Rocket has been the workhorse of SpaceX, and till date has launched successfully **364 times**, carrying astronauts, payloads for SpaceX's commercial clients and thousands of Starlink satellites to orbit.
- The last time a Falcon 9 experienced a serious incident was when the rocket blew up on the launchpad in **September 2016.**

About SpaceX Falcon 9 Rocket

- The SpaceX Falcon 9 is a **partially reusable two-stage rocket** that can propel **both satellites and astronauts** into a variety of orbits.

- It can lift up to:
  - **22,800 kg** to Low Earth Orbit (an altitude of 2000 km or less).
  - **8,300 kg** to Geostationary Transfer Orbit (GTO).
  - **Designed and manufactured by:** SpaceX

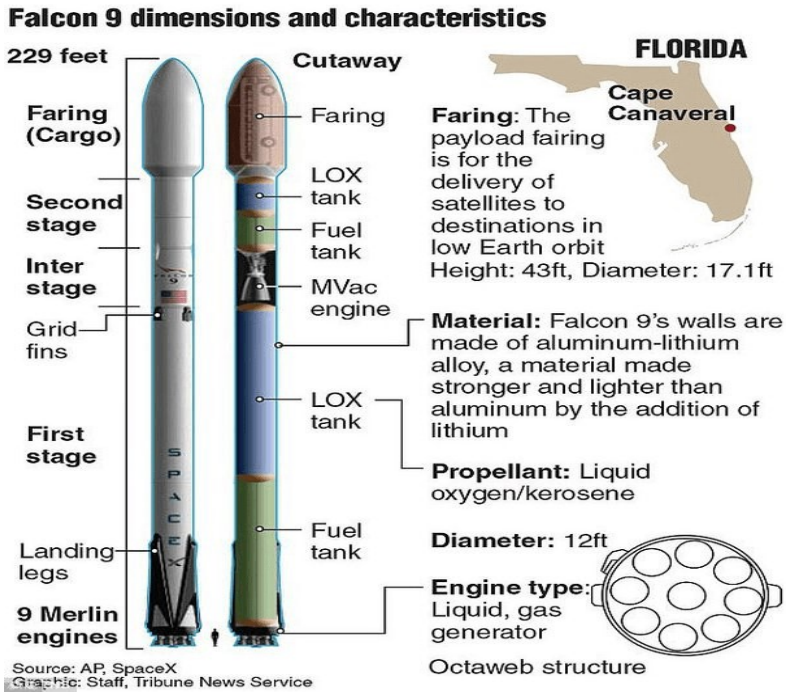
Key Features

The rocket hastwo stages.

- The **first stage or booster stage** comprises nine Merlin engines (a family of rocket engines developed by SpaceX) which use **RP-1** (**rocket-grade kerosene)** and **liquid oxygen** (LOX) as propellants.

The **second stage** consists of a single Merlin engine.

- **Reusability:** The **first stage** of the rocket is reusable. It is capable of re-entering the Earth's atmosphere and landing vertically on Earth after separating from the second stage. This significantly **reduces the cost of access to space.**



Notable Missions of Falcon 9

- **Starlink:** Falcon 9 is the workhorse for deploying SpaceX's Starlink satellites, aimed at providing global internet coverage.
- **CRS Missions:** Falcon 9 has been used extensively for NASA's Commercial Resupply Services (CRS) missions to the International Space Station (ISS).
- **Crew Dragon:** It launched the **first commercial spacecraft (Cew Dragon/ Dragon 2)** capable of carrying astronauts to the ISS and LEO. The **Polaris Dawn mission** is the planned private human spaceflight mission scheduled to be launched in July 2024, using the Falcon 9 rocket.
- **Crew Dragon** is a spacecraft developed and manufactured by SpaceX as part of NASA's Commercial Crew Program.
- It can **carry up to seven astronauts.** For NASA missions, it typically carries four astronauts and some cargo.

What is the International Space Station (ISS)?

- The ISS is a large, permanently crewed laboratory that orbits Earth 400 kilometers above its surface. It is **home to astronauts and cosmonauts** and serves as a unique science laboratory.
- Its research is expected to lead to advancements in many areas, including medicine, technology, science, and understanding of the Earth and universe.
- It's a collaboration between **15 countries and five space agencies,** namely **NASA (United States), Roscosmos (Russia), ESA (European Space Agency), JAXA (Japan Aerospace Exploration Agency), and CSA (Canadian Space Agency).**
- An international crew of **seven people lives and works** while the space station travels at a speed of 7.66 km/sec, orbiting Earth about every 90 minutes. In **24 hours, the space station makes 16 orbits of Earth,** traveling through 16 sunrises and sunsets.
- **Peggy Whitson** set the US record for spending the most total time living and working in space for 665 days.
- The first parts of the ISS were sent and assembled in orbit in 1998. Since the year 2000, the ISS has had crews living continuously on board.

AX-4 Crew

The Ax-4 crew includes members from India, Poland, and Hungary, marking each nation's first mission to the space station in history and second government-sponsored human spaceflight mission in over 40 years.

- Shubhanshu Shukla became India's second national astronaut to go to space since 1984.
- Sławosz Uznański-Wiśniewski, European Space Agency (ESA) project astronaut, is the second Polish astronaut since 1978.
- Tibor Kapu is the second national Hungarian astronaut since 1980.
- Peggy Whitson is commanding her second commercial human spaceflight mission, adding to her standing record for the longest cumulative time in space by an American astronaut.
- Ax-4 is the second commercial spaceflight mission made up of government and ESA-sponsored national astronauts.
- The Ax-4 mission stands as a beacon of opportunity for India, Poland, and Hungary, each poised to leverage this mission to advance their national space programs.

About Shubhanshu Shukla

- Group Captain Shukla, born in 1985, is an experienced Indian Air Force pilot with over 2,000 flight hours.
- Selected by ISRO in 2019, he trained in Russia for India's first human space mission, Gaganyaan.
- In 2024, PM Modi announced him as the pilot for the Axiom Mission 4 to the International Space Station in 2025.

Source:**IE**

Ax-4 research

The Ax-4 research complement includes around 60 scientific studies and activities representing 31 countries, including the U.S., India, Poland, Hungary, Saudi Arabia, Brazil, Nigeria, UAE, and nations across Europe. This will be the most research and science-related activities conducted on an Axiom Space mission aboard the International Space Station to date, underscoring the mission's global significance and collaborative nature to advance microgravity research in low-Earth orbit (LEO). The mission emphasizes scientific portfolios led by the U.S., India, Poland (in partnership with ESA), and Hungary. It aims to boost participation in these countries by involving diverse stakeholders, showcasing the value of microgravity research, and fostering international collaboration.

The studies will enhance global knowledge in human research, Earth observation, and life, biological, and material sciences, demonstrating the space research capabilities of the crew's home nations.

AXIOM Space/Partners

- **ISS HAM Radio**

ISS Ham Radio conducted by crew members on Axiom Space private astronaut missions (PAMs), connect youth, educators, and members of the public with a crew member on the International Space Station via amateur radio. Participating students learn about space, the space station, Earth observation, wireless technology, and radio science. The first-hand exposure to life in space helps inspire the next generation of explorers.

- **Limitless Space Institute Student Experiments**

Axiom Space is proud to partner with the Limitless Space Institute to perform experiments designed by students in Brazil and Nigeria on the Ax-4 mission. The projects are winners of a competition across schools in both countries to design experiments that could be performed in space. Students in Brazil will investigate what happens when two balls of differing mass collide in space. Students in Nigeria will examine how pendulum properties differ on Earth versus in space. This is the first time that students from Nigeria have had access to the microgravity environment to perform science and research.

- **Suite Ride**

This experiment aims to demonstrate that astronauts with insulin-dependent diabetes can be supported for short duration stays in microgravity. This will be achieved by demonstrating accurate blood glucose testing, data transmission, and insulin viability on International Space Station. This research will help enable people with diabetes to participate in future space missions, thus expanding the eligibility of crew and expanding access to space to more people. This project is a partnership with Burjeel Holdings PLC, a UAE-based healthcare services provider.

- **ISS Edge Computing for Crew Readiness Demonstration**

This technology demonstration aims to develop and test the digital infrastructure required to process and analyze data from a wearable device collected during the Ax-4 mission via edge computing. In future, these infrastructure frameworks may enable prediction of human performance based on biometric data, to optimize the completion of tasks and activities during

spaceflight. The technology could be useful for multiple industries on Earth that rely on skilled human performance.

- **Ultrasound assessment of joint health after spaceflight**

The changes to joint loading that occurs when humans enter microgravity can cause damage to their structure and function. This project will investigate the effects of short duration spaceflight on cartilage/tendon/ligament thickness, joint fluids, and blood flow via ultrasound evaluation of lower extremity joints before and after flight. The project aims to develop this method as a non-invasive assessment of cartilage and joint health that could optimize exercise protocols for future spaceflight crew and reduce injury upon returning to Earth."

- **SSA Microgravity Challenge**

The Saudi Space Agency's (SSA) Microgravity Challenge features the winning hardware, science experiments, and artwork from the Madak competition, which received over 80,000 submissions from students aged 6-18 across the Arab region. Ten winners were selected across three categories: arts, agriculture, and engineering. The competition aims to foster innovation in space science, stimulating creative thinking and interest in space-related fields. By encouraging young talents, it seeks to inspire the next generation of space professionals, contributing to the growth of the space sector in the Arab world and the global space economy.

- **TRISH Essential Measures**

Following on from research on previous Axiom missions, the Translational Research Institute for Space Health (TRISH) will gather human physiological and cognitive data on how humans adapt to space, collected from commercial spaceflight participants. Understanding how humans adapt to microgravity helps us develop countermeasures or optimize training regimes for new users of microgravity.

- **Cancer in low-Earth Orbit**

In partnership with Axiom Space, the Cancer in LEO project from the Sanford Stem Cell Institute will study tumor organoids in microgravity with the goal to identify early warning signs of cancer for prediction and prevention of the disease. This project is part of the expanded ISSCOR collaboration between the Sanford Stem Cell Institute, JM Foundation, and Axiom Space, which aims to use microgravity to further understand stem cells, cancer, and aging-related effects in space to develop better prediction of disease and therapeutics for patients on Earth.

The Cancer in LEO-3 investigation builds on research from previous Axiom Space missions that studied cancer growth in space. It aims to validate earlier findings on tumor organoids and explore how a new model of triple negative breast cancer responds to drug challenges in low Earth orbit (LEO). This research is crucial for space missions as it examines the impact of microgravity and radiation in LEO on cancer cell growth compared with growth in a terrestrial environment. The findings could lead to better cancer treatments on Earth by revealing how cancer cells behave in microgravity and identifying new therapeutic targets for metastatic cancers. This project is part of the Integrated Space Stem Cell Orbital Research (ISSCOR) collaboration between the Sanford Stem Cell Institute, JM Foundation, and Axiom Space, which aims to use microgravity to further understand stem cells, cancer, and aging-related effects in space in order to develop better prediction of disease and therapeutics for patients on Earth.

- **TRISH Space Omics**

This project will help establish new pharmacogenomic and personalized medicine capabilities for spaceflight.

- **TRISH Commercial Astronaut Data Repository (CADRE)**

The goal of this protocol is to preserve the very important research data collected from astronauts on a commercial spaceflight mission for future scientific advancement.

- **Human Spaceflight Neuroimaging Initiative**

This neuroimaging study, performed pre- and post-flight, will study the impact of microgravity during space travel on the human brain and aim to identify potential cognitive and performance risks in astronauts. The study will use high field magentic resonance imaging (7T MRI) of the brain to investigate the impact of microgravity on the representation of the body, changes in neural vascular physiology, and aspects of the blood-brain barrier. Results may lead to better understanding of the impact on spaceflight on the brain.

ISRO

- **Crop Seeds on ISS**

This ISRO experiment will investigate the impacts of spaceflight on six varieties of crop seeds. After the mission, seeds will be grown for multiple generations and plants showing preferred traits selected for genetic analyses. This project aims to help understand how crops may be grown in space for future exploration missions.

- **Cyanobacteria on ISS**

Cyanobacteria are aquatic bacteria that can photosynthesize, and are of interest for integration into spacecraft environmental control systems. This ISRO experiment will compare two strains of cyanobacteria to investigate growth rates, cellular responses, and biochemical activity in microgravity. The results could help with the development of future spacecraft life support systems.

- **Myogenesis**

This project aims to identify the pathways responsible for skeletal muscle dysfunction in microgravity and explore therapeutic targeting strategies. By studying how muscle loss occurs in space, the project seeks to pinpoint specific molecular mechanisms and potential interventions. Understanding these pathways is crucial for developing treatments to prevent muscle atrophy in astronauts during long space missions. On Earth, the findings could also impact the understanding of and treatments for muscle-related diseases and conditions related to aging or prolonged immobility.

- **STEMonstrations**

These will consist of four different STEAM outreach activities for Indian students.

- **Sprouts**

This ISRO experiment will investigate the impacts of spaceflight on germination and growth of crop seeds. After the mission, seeds will be grown for multiple generations and the effects on genetics, microbial load, and nutritional profile investifated. This project aims to help understand how crops may be grown in space for future exploration missions.

- **Space Microalgae**

Microalgae are potentially useful organisms for future spaceflight that could be used as foods, fuel, or even used in life support systems. In this experiment, three strains of microalgae will be grown and the impact of microgravity on the growth, metabolism, and genetic activity will be investigated versus algae grown on the ground.

- **Voyager Displays**

This experiment will investigate how the physical and cognitive impact of utilizing computer screens in microgravity. The research will study how pointing tasks, gaze fixation, and rapid eye movements are affected my being performed in space, and how this may interact with subjective experiences of stress wellbeing. The results could inform future spacecraft computer design and interaction.

- **Voyager Tardigrades**

This ISRO project will investigate the revival, survival, and reproduction of tardigrades sent to the ISS. The project will examine the revival of dormant tardigrades, count the number of eggs laid and hatched during a mission, and compare the gene expression patterns of spaceflown vs. ground control populations. The research seeks to identify molecular mechanisms of resilience which has implications for understanding the limits of life in extreme environments. This knowledge could inform future space exploration and help develop biotechnology applications on Earth.

ESA/Poland

- **Bone on ISS**

The ongoing Bone on ISS experiment studies the effects of microgravity on bone health, focusing on bone loss and recovery post-spaceflight. By examining bone markers, inflammation, and growth factors, the study aims to develop a digital twin model to predict bone behavior during recovery. This research is crucial for space missions, as it helps predict individual skeletal risks and enables better astronaut screening. The findings will benefit Earth by advancing the understanding of bone disorders and improving treatments for conditions like osteoporosis, helping populations prone to bone fragility and immobility.

- **EEG Neurofeedback**

This experiment aims to evaluate the effectiveness of neurofeedback sessions in reducing stress and enhancing performance in astronauts. By conducting pre- and post-flight tests (including psychological assessments, muscle activity measurements, blood analyses for stress markers, and brain activity), researchers aim to understand how pre-flight neurofeedback training may impact psychological, physiological, and motor functions. This experiment can help train crews for future spaceflight and develop technologies to help mitigate stress and improve performance on Earth.

- **Leopard ISS**

In partnership with the ICE Cubes Service and developed by KP Labs, the Leopard Data Processing Unit (DPU) will be installed on the International Space Station, which will be part of the digital system enabling clients to remotely test and verify computational algorithms in real space conditions without needing to physically acquire hardware. Testing in space is a vital step for algorithms before they are used in satellites. Other exporation-enabling software will also be tested, such as 3D mapping for spacecraft maneuvers and robotic exploration. This project aims to advance onboard data processing for space applications but also aims towards faster, more efficient satellite operations, potentially transforming data handling in space and on Earth.

- **Scalable Radiation Monitor (RadMon on ISS)**

This project from POLSA/ESA will use a radiation monitor inside the ISS's Columbus module to measure space radiation levels. A larger version of this device has already been deployed inside the tunnels of CERN's Large Hadron Collider (LHC) particle accelerator to monitor for possible radiation damage to electronics. This experiment aims to refine radiation models for space environments and support the planning for future deep-space missions, where space radiation can cause damage to human bodies and electronics. On Earth, this technology could enhance radiation monitoring in various healthcare and industrial settings.

- **Wireless Acoustics**

The Wireless Acoustics project will test a commercially-available acoustic monitor for user experience, comfort, and effectiveness of capturing the acoustic levels within the ISS. The device will be worn while engaging in activities and compared to a nearby stationary sound level meter. This study will evaluate any improvement in this system compared to legacy systems, and could help inform the future design of spacecraft.

- **Muscle Stimulation**

This ongoing ESA study is exploring neuromuscular electrical stimulation (NMES) as a possible countermeasure to protect crew from the deleterious effects of microgravity on muscle mass. Crew will conduct NMES sessions and draw blood to monitor physiological changes. The findings could also provide useful insights into muscle and bone health for Earth-based medical conditions, such as osteoporosis and muscle atrophy.

- **AstroMentalHealth**

The AstroMentalHealth project is studying astronauts' mental and behavioral health during space missions and focuses on observing changes that may occur in the functioning of astronauts working on the International Space Station (ISS). Crew complete questionnaires, give interviews, and make video diaries before, during and after spaceflight so that researchers can develop personalized support programs for future crew. This research can benefit others on Earth by developing remote technologies for diagnosing and treating mental disorders, particularly for individuals in isolated or challenging environments where access to mental health care is limited.

- **Human Gut Microbiota**

This study will investigate the effects of short-term stays in low Earth orbit on astronaut health by examining changes in the human gut microbiome. Stool samples will be collected at regular intervals before, during, and after flight and the microbiome composition analyzed. Changes in microbiome composition could impact the health of future crews, so this research can help inform dietary or medical treatments for crew in future. The research also offers insight into gut health, which could lead to improved management of gut-related conditions on Earth and development of personalized nutritrion programs.

- **Immune Multiomics**

The Immune Multiomics project aim to examines the molecular adaptation by human immune cells to microgravity and other space-related stresses. Blood samples will be collected before, during, and after the mission, with analyses exploring how changes persist after returning to Earth. Insights from this research could help understand crew health during long-duration space missions. On Earth, the findings could inform understanding of immune disorders and the immune response to stress.

- **Mollis Textus**

This project from the Polish Space Agency (POLSA) and ESA is to monitor and assess the health and adaptation of astronauts' soft tissues during space missions. Before and after flight, crew will undergo soft tissue assessments to measure changes in muscle mass, tendon properties, and flexibility. The study will examine the impact of microgravity on structural and metabolic changes in soft tissues and could help with the development of crew health measure on long duration missions, or lead to improved soft tissue disorder treatments on Earth.

- **PhotonGrav**

This project from ESA/POLSA aims to assess whether the collection of neural activity data via near-infrared spectroscopy (fNIRS) can be used to establish a human-computer interface in microgravity. The study will collect neural activity and questionnaire data before, during, and after flight. The outcomes from this project could contribute to thedevelopment of advanced technologies on future exploration missions and also provide insights for Earth-based biomedical applications of human-computer interfaces, such as neurotechnology for rehabilitation and assistive devices.

- **Stability of Drugs**

This POLSA/ESA project aims to test methods for extending the shelf-life of pharmaceuticals during long-duration space flights by studying the effects of cosmic radiation on drug stability. The experiment will launch sample packages to the ISS to be stored under different conditions for 1, 2, and 3 years. After return, samples will be analyzed and compared to ground control samples. The findings could improve drug preservation and storage on Earth, especially in challenging environments.

- **Space Volcanic Algae**

Developed by Extremo Technologies and implemented onboard the International Space Station in partnership with the ICE Cubes Service, the Space Volcanic Algae project from POLSA/ESA investigates the potential of red microalgae for use during for long-duration space exploration missions. These algae are hardy and thrive in extreme environments, and could be used for oxygen production, waste management, and toxic compound decomposition in space. The study will analyze the genes that control oxygen production and metabolism in space-grown algae, comparing them with ground controls. Data from these experiments will enhance our understanding of extremophiles - organisms that thrive in extreme environmental conditions - and identify adaptations essential for oxygen production and other biochemical processes. The insights could also lead to improved industrial applications on Earth.

- **Yeast Tardigrade Gene**

Tardigrades are known for their resilience and abvility to survive extreme environments. This project will investigate whether a tardigrade gene, integrated into a yeast gemone, can protect the yeast from the negative effects of microgravity. After genetic editing is done, yeast will be launched to and grown on the ISS, then returned to Earth for post-flight analyses. The implications of this research could be used when considering the design of sustainable ecosystems in space, on the Moon, and on Mars.

- **MXene in LEO**

Non-intrusive yet effective health monitoring is needed for future space exploration missions as well as for management of chronic diseases on Earth. This project from POLSA and ESA aims to develop wearable biomonitors using MXene nanomaterials (2D nanomaterials made of inorganic compounds). The project will assess six different devices flown on the mission, investigating the function and environmental stability of the materials.

HUNOR

- **Acquired Equivalence Test**

This project aims to study the cognitive process of associative learning in space and investigate how spaceflight affects the processing of simple and complex visual stimuli, especially in tasks impacted by up-down orientation, comparing it to data collected pre- and post-flight. The research could inform future long-duration mission planning and add to the broader understanding of learning and cognitive processing.

- **Cerebral Hemodynamics**

This project will consist of ultrasound-based studies to investigate cerebral blood circulation in space. Hemodynamic responses to microgravity, increased carbon dioxide levels, and specific visual patterns are of particular interest. The results will help researchers understand more about cardiovascular adaptation to spaceflight and could be useful for assessing cardiovascular conditions on Earth.

- **Comparison of 3D Prints**

This materials science investigation will explore the effect of spaceflight on 3D printed materials after launch and return from the International Space Station. The study will characterize the properties and compositions of 3D printed polymers after space radiation exposure and g-forces in order to compare them to the properties of polymers stored on Earth. This could inform the design and composition of materials that may be used in 3D printing in space in future.

- **DNA Repair**

This study will investigate radiation-induced DNA damage to adult fruit flies and fruit fly larvae after exposure to the space environment. The project aims to assess if temporary over production of certain DNA-repairing enzymes may act as biochemical protection against space radiation-induced damage. The results from this experiment could help develop countermeasures against damage to human DNA on future deep space and long-duration spaceflights.

- **END-SANS**

The END-SANS project from HUNOR tests a novel, solid nanostructured drug formula that can be used inophthalmic inserts to treat Spaceflight-Associated Neuro-ocular Syndrome (SANS). The project has two aims. Firstly, it plans to study the impact of microgravity on eye insert materials containing Active Pharmaceutical Ingredients (API). Inserts with API will launch passively and return for further stability analyses. Secondly, one crew member will use the eye inserts without the API once daily for at least five days and complete a questionnaire about their experience using the insert. Pre- and post-clinical testing will also be carried out to assess ocular health and monitor biological effects. Results will show whether nanofibrous drug carriers may offer a promising and innovative approach for stable and precise treatments in ophthalmic applications, which are also relevant to terrestrial applications such as macular edema.

- **Environmental Perception**

The Environmental Perception Characteristicsof Astronauts in Microgravity (ENPERCHAR) experiment studies how microgravity affects human perception and connection with the environment. Crew performance on scientific activities will be analyzed with reference to environmental psychology to investigate how microgravity may distort spatial awareness and perception. Analyses of verbal commentary while conducting experiments may reveal insights into the psychological effect of working in extreme environments. Understanding these effects are important for ensuring crewmembers can accurately perform tasks and ensure mission safety. Insights from this research could enhance general understanding of human perception.

- **Hungarian STEM DEMO**

The SPHC project is a series of educational experiments that students will perform simultaneously with crew, demonstrating different manifestations of the laws of physics in space versus on Earth. The experiments will cover topics such as friction, surface tension, buoyancy, conservation of angular momentum, the Bernoulli effect, geometry, and how to

measure mass in weightlessness. In addition to promoting space exploration and education, the project will develop recorded material for future use in Hungarian schools.

- **Hungary in Space Awareness**

The SUMISPACE project is a public outreach campaign aimed at increasing awareness of the HUNOR program and Hungarian space activities, particularly among children and young adults. Participants can submit their names and photos online to receive a "boarding pass" for names and pictures to be launched and returned on an SD card.

- **IMU DRS**

Dead reckoning, or the ability to determine current position and navigate based on previous position, may require different methods to calculate in space compared to on Earth, with the promise of greater accuracy. In this project, the accuracy and 'drift' of inbuilt sensors in a cell phone (accelerometer, gyroscope, magnetometer, proximity sensor) will be tested via motion and movement-based gestures and compared to those taken on Earth to prove that a wide range of paths can be reconstructed in weightlessness. The results from this study could help inform future spacecraft navigation systems design.

- **Kid Forum Connection**

This HUNOR project aims to promote space research and communications technologies in schools, with active involvement and participation of the Hungarian astronaut on the ISS via ham radio. The crewmember will conduct activities involving a smartphone’s acceleration sensor, gamma radiation measurement, and a water experiment, to help students gain an understanding of space science.

- **Microbiome Profiling**

The Mapping Astronaut Meta-GenOmics: a Microbial Profiling Research (MAGOR) project will monitor the changes in astronauts' gut, urine, and oral microbiomes before, during, and after spaceflight. By identifying changes in the body’s bacterial, fungal, and viral cultures from saliva, urine, and fecal samples, this project will provide insight into how space conditions impact human microbiomes. Insights from the research could inform strategies to maintain astronaut health and could shed light into research to manage microbiome-related conditions on Earth.

- **Microfluidics Design**

The Microfluidic Drug DosageDetection Development (M4D) experiment aims to understand better how liquids behave in "lab on a chip" microfluidics devices in space. The overall goal is to eventually design and manufacture microfluidic devices that can analyze drug stability and quality on long-duration and deep space missions. The experiment will inject liquidi nto the microfluidic device and analyze fluid flow characteristics. Additionally, the study will examine the impact of spaceflight and radiation exposure on a commonly used drug (Tylenol).

- **NeuroMotion VR**

In this experiment, a virtual reality (VR) headset system will be used to investigate the effect of microgravity on cognitive function and motor skills. Tasks to assess attention will be performed while a crewmember wears a cap that monitors neural activity (via functional near-infrared spectroscopy, fNIRS). Saliva and tear samples will be collected to investigate stress hormone and biological responses to spaceflight and demanding experimental cognitive tasks. This research adds to data exploring how space travel impacts human cognition and motor planning and execution.

- **ORBGEO**

The ORBGEO project aims to demonstrate the feasibility of geolocation using images captured in orbit. Images of Earth will be taken with onboard cameras and assessed for the accuracy of geolocation possible from the images. Factors like cloud cover, angle from which the image was taken, and other aerial effects will be examined. This research could help improve current Earth observation techniques and improve applications for Earth observation including environmental monitoring and disaster response.

- **Rad Nano Dosimeter**

The HUNOR RANDAM (RAdNano Dosimeter Astronaut Module) project aims to monitor crew radiation exposure and environmental conditions during the Ax-4 mission. The miniaturized devices designed for everyday personal wear will track radiation levels, temperature, humidity, air pressure, carbon dioxide levels, light intensity, and magnetic fields. Measurement of radiation levels are important for crew health and safety. Insights gained could improve radiation protection strategies for future spaceflight and advance Earth-based technologies for radiation monitoring and environmental sensing.

- **Shear Instabilities**

DiRoS-B experiment investigates fluid dynamics in conditions that only microgravity can provide. Namely, where multiple physical characteristics (flow velocity differences, inertial forces and spherical geometry) interact simultaneously as main actors on the fluid flow. By precisely adjusting fluidics parameters and tracking microparticles in a spinning tennis-ball-sized water drop, the results will provide analogous insights into large-scale atmospheric phenomena on gas giant planets, such as Saturn's North Polar Hexagon. The theories tested on orbit will benefit planetary science and improve our knowledge of atmospheric behavior in space, with potential applications for both space mining and Earth-focused climate research into atmospheric and fluid dynamics.

- **Space Basics Outreach**

The CORVUS Project aims to engage all ages of the public by presenting a Hungarian astronaut conducting various educational experiments and sharing insights on daily life in space from onboard the ISS. It aims to inspire a deeper understanding of how space research impacts Earth and showcasing the importance of space exploration for humanity.

- **Space Buzz Hungary Astronaut**

This is an educational activity to provide Hungarian children an opportunity to ask crew questions and inspire interest in space exploration, STEM subjects, and environmental awareness.

- **Step in Space**

The aim of this HUNOR project is to create an interactive 3D video tour of the ISS, with a special focus on the everyday activities of the HUNOR crewmember and mission. The tour, available in VR and compatible with VR headsets, will provide a personal perspective on life in space, including tasks like eating, working, and moving in microgravity.

- **Suit Fabric Study**

This project aims to validate a system that simulates how clothing affects heat transfer in different gravity environments, including microgravity, where heat convection is altered. The research will involve monitoring physiological and cloth responses to exercise on orbit and could inform suit development for future space applications. This technology could be used on

Earth to enhance clothing technology for extreme environments, and imrpove body thermal management in industries such as healthcare and sports.

- **Telemetric Health AI**

The Telemetry system for SpaceHealth (TESH) project from HUNOR aims to study the complex changes in astronauts' cardiovascular and balance systems during space travel. By integrating the data from various medical devices with mission-specific data and applying emerging data science techniques to analyze the information, this project could advance real-time health monitoring and predictive healthcare technologies on Earth.

- **VITAPRIC**

The VITAPRIC investigation will study plant germination, microgreen production, and leaf development in space. The project will investigate the impact of low selenium concentrations on the production of vitamins, proteins, minerals, and other nutrients by the plants, and aims to improve food production options for long-duration space missions. The results could also impact agricultural practices on Earth, particularly in resource-poor or urban farming environments.

- **Voice in Space**

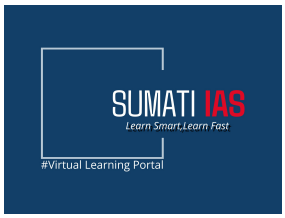
This experiment seeks to determine whether influenced voice pattern and listening capabilities of the participant might be able to be detected by an Artificial Intelligence (AI) algorithm. Vocal characteristics of an International Space Station crewmember can change in a zero-gravity environment, and after undergoing cognitive function changes. Electroglottograph measurements of vocal fold vibration provide a quantitative indication of vocal fold function. Scripted voice audio recordings (reading, singing, vowel enunciation, audio pitch matching) allow for tonal analysis. These data allow the investigator to test and analyze vocal performance and voice pattern changes in space and then evaluate how space journey influences the human voice.

- **UHU**

The UHU experiment aims to study Transient Luminous Events (TLEs) - electrical phenomena associated with thunderstorms which produce bursts of light reaching altitudes of up to 100 km. By recording various TLEs from orbit, coordinating ground and space-based observations, and measuring electrical parameters, the research can understand more about the nature and causes of TLEs. This could improve our knowledge of thunderstorms and atmospheric processes, which could enhance weather forecasting, improve safety in storm-prone areas, and advance our understanding of atmospheric electricity.

- **ISS HAM Radio**

ISS Ham Radio conducted by crew members on Axiom Space private astronaut missions (PAMs), connect youth, educators, and members of the public with a crew member on the International Space Station via amateur radio. Participating students learn about space, the space station, Earth observation, wireless technology, and radio science. The first-hand exposure to life in space helps inspire the next generation of explorers.



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