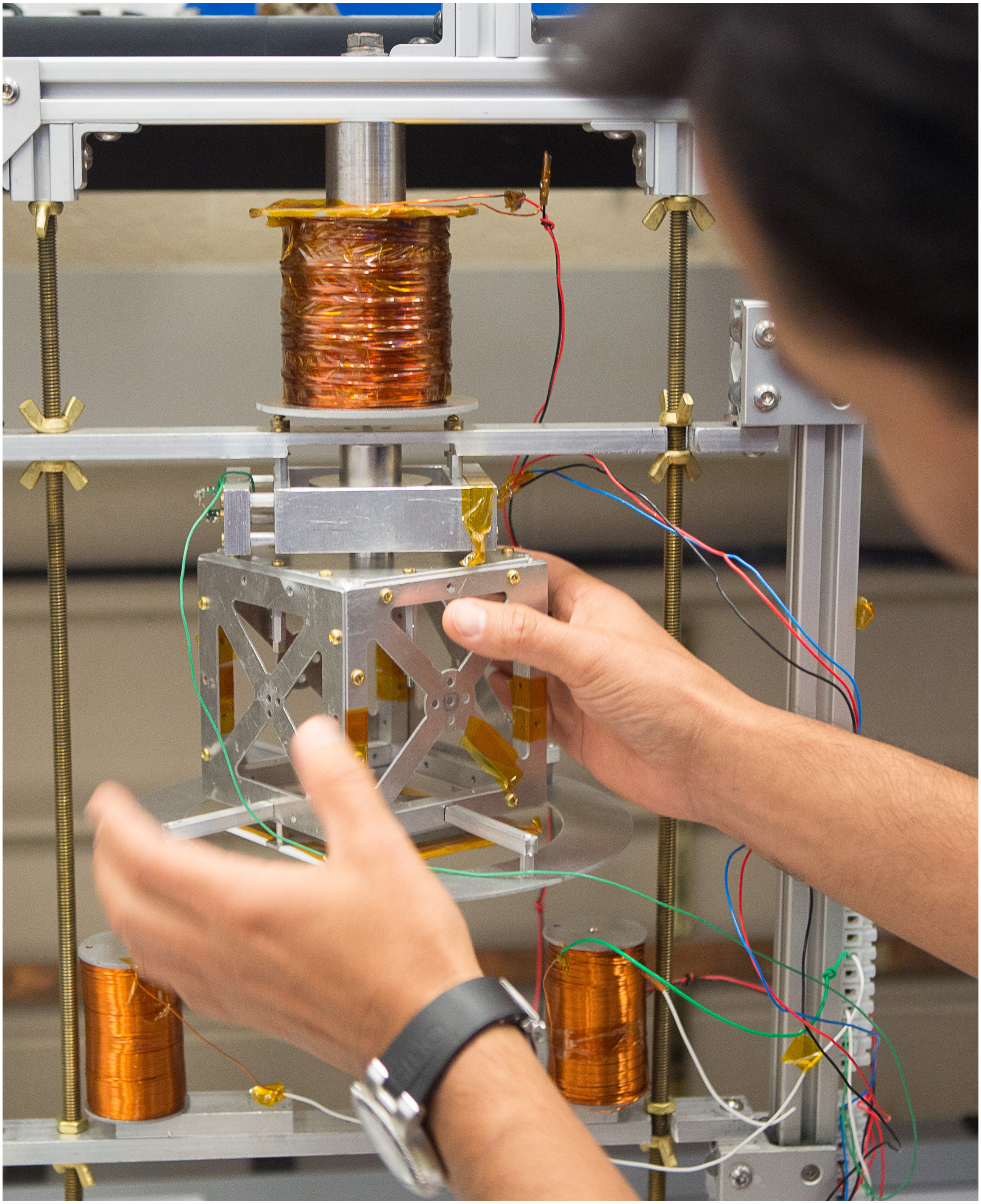
Massachusetts Institute of Technology

Small Satellite Collaborative Facility

A Concept-to-Orbit Environment for Space Missions



Paulo Lozano, the Miguel Alemán Velasco Professor of Aeronautics and Astronautics, examines a prototype of a magnetically levitated thrust balance developed in his lab to measure the minute forces produced by electric thrusters for small satellites. A key tool in his research on miniaturized propulsion, the system suspends a satellite structure in a vacuum to recreate spaceflight conditions and advance the next generation of small spacecraft technologies.
Credit: Bryce Vickmark

Small Satellite Collaborative Facility

A New Era of Space Systems

We are entering a new era in space. Small satellites are transforming how we observe our planet, communicate across the globe, and respond to natural disasters. Today, they represent the vast majority of spacecraft launched, enabled by advances in miniaturized technology and the rise of large commercial constellations.

Small satellites are rapidly becoming critical infrastructure, helping nations protect vital systems, secure space-based assets, and accelerate scientific discovery.

Yet these advances take shape on the ground, where engineers test ideas against real constraints before the technology reaches orbit. Constellation-scale systems demand tight integration across software, autonomy, communications, and flight operations. This work requires sustained engineering before launch.

For MIT, this moment presents an opportunity – and a responsibility – to lead. What this era demands is enduring capability: infrastructure that supports the full lifecycle of space systems, from concept through on-orbit operations.

The Department of Aeronautics and Astronautics (AeroAstro), with philanthropic support, will create the Small Satellite Collaborative facility, a dedicated home at MIT where spacecraft move from design and integration through testing and mission operations in one place.

MIT in Space: Missions That Matter

MIT has played a defining role in modern space systems, from early satellite programs to today's constellation-scale missions. For decades, AeroAstro has designed, built, and operated pioneering spacecraft while educating generations of engineers who now lead major space programs across government, industry, and academia.

Roger Hou, SM ’24, a PhD candidate in aeronautics and astronautics and two-time MathWorks Fellow, services the metal 3D printer used in research led by Zachary Cordero, the Esther and Harold E. Edgerton Associate Professor. Hou’s research integrates computational modeling with additive manufacturing to understand how advanced alloys evolve during fabrication, informing the design of high-performance space hardware. Credit: Jake Belcher

That legacy is evident in pioneering missions led by MIT and MIT Lincoln Laboratory, including TROPICS, a constellation providing real-time storm monitoring; TBIRD, which demonstrated record-breaking optical communications from orbit; and ASTERIA, the first CubeSat to detect an exoplanet.

Each mission expanded what small spacecraft can do. Yet continued progress requires infrastructure where successive missions build on one another – where expertise compounds over time.

The Infrastructure Constraint

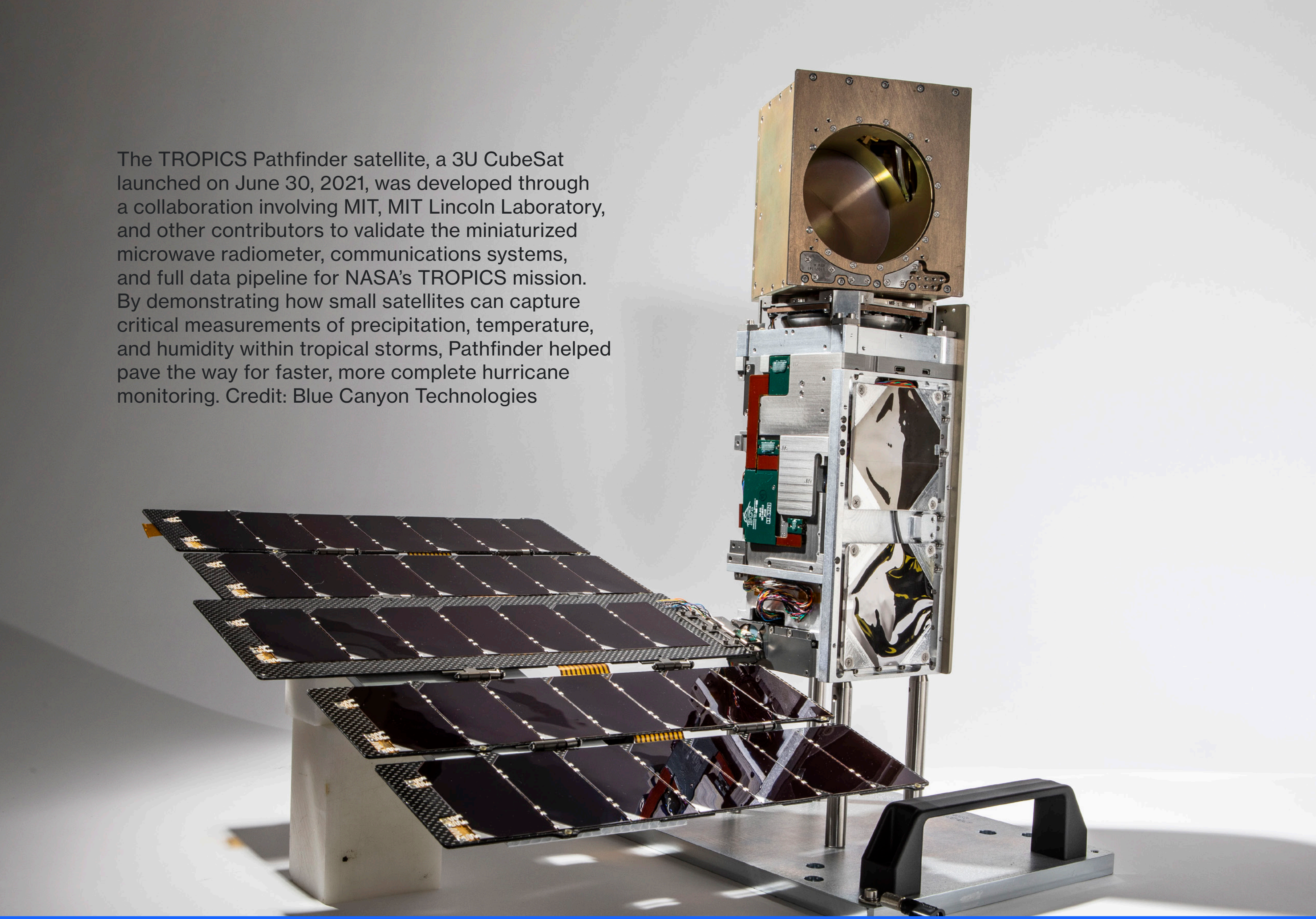
Today, spacecraft development at MIT is fragmented. Research, engineering, and flight operations are scattered across campus in laboratories built for an earlier era of space systems, leaving ambitious ideas – from sensing and communications to autonomy and new mission concepts – distributed across disconnected facilities.

This fragmentation has consequences. When a mission concludes, the team disperses. Knowledge hard-won through months of problem-solving dissipates. The next mission starts fresh, rebuilding what the previous team already learned.

This is the constraint we face.

What small satellites demand is continuity. When design, integration, and flight operations happen together, trade-offs surface early. Problems become visible sooner. Solutions emerge before the next mission launches. Each mission strengthens the one that follows, allowing systems to mature faster.

This requires an engineering environment where insights accumulate across missions. For MIT, now is the moment to build it.



The TROPICS Pathfinder satellite, a 3U CubeSat launched on June 30, 2021, was developed through a collaboration involving MIT, MIT Lincoln Laboratory, and other contributors to validate the miniaturized microwave radiometer, communications systems, and full data pipeline for NASA's TROPICS mission. By demonstrating how small satellites can capture critical measurements of precipitation, temperature, and humidity within tropical storms, Pathfinder helped pave the way for faster, more complete hurricane monitoring. Credit: Blue Canyon Technologies

"Small satellite constellations are transforming how we sense, communicate, and operate in space. The institutions that advance these systems will define the next era of space capability."

Eric Evans

Director Emeritus and Fellow, MIT Lincoln Laboratory 2006–2024; MIT Professor of the Practice

The Small Satellite Collaborative Facility at MIT

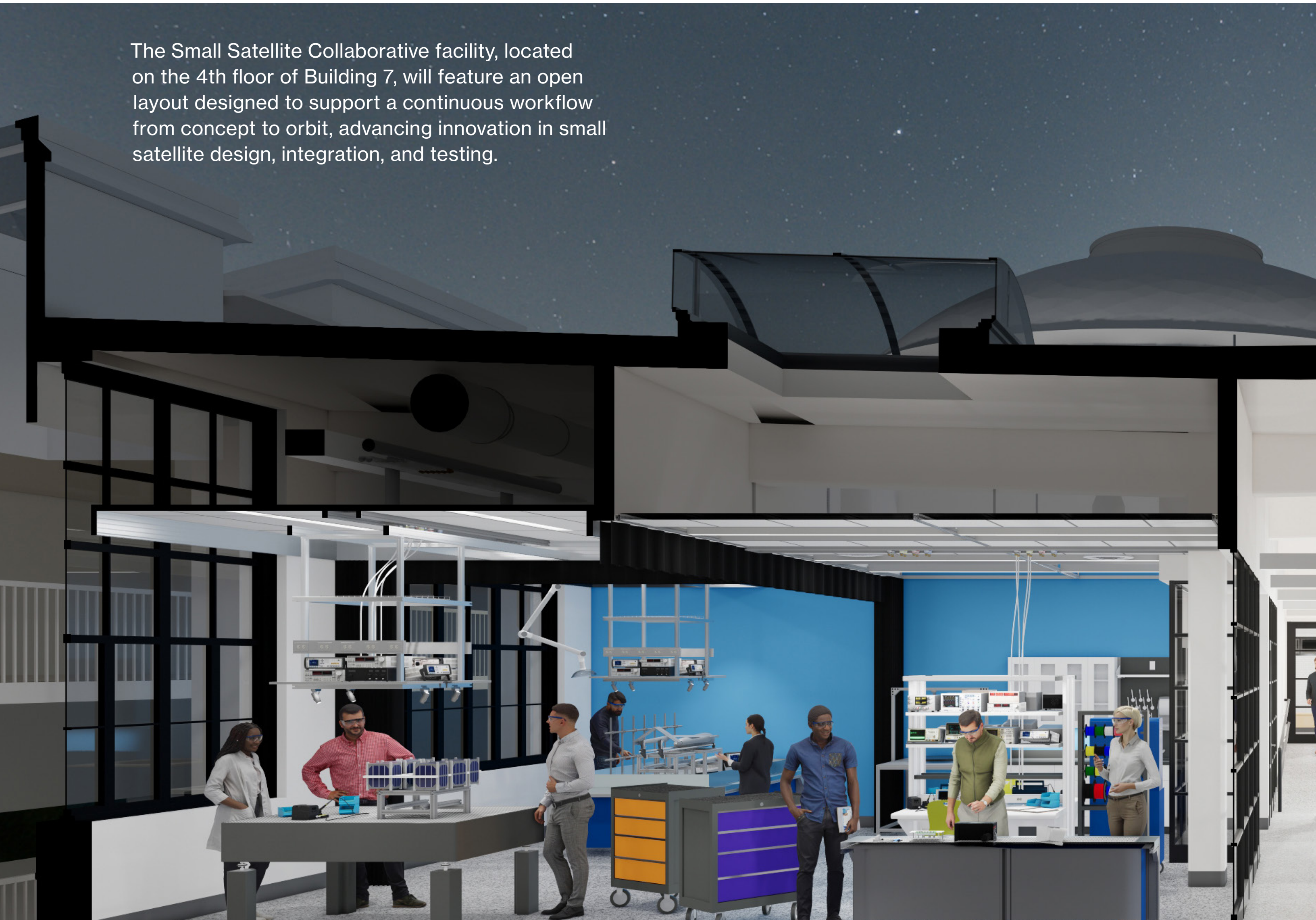
The Small Satellite Collaborative facility will bring spacecraft development and mission operations together in a single integrated setting. This is where MIT's next advances in space systems will emerge — and where each mission will strengthen the next.

Here, faculty, students, and researchers will work across the full mission cycle, moving seamlessly from design to deployment within a continuous engineering process.

This is how spacecraft mature. Teams will test design decisions against the realities of integration and flight. Problems will surface while they can still be solved. What one mission teaches will guide the next, turning promising concepts into reliable systems.

It is also how MIT teaches at its best: by building things, testing them under real constraints, and refining them through experience. Over time, those cycles will do more than improve individual missions. They will build enduring strength in spacecraft engineering, and in aerospace engineers.

MIT has long advanced science and engineering by creating shared environments where knowledge accumulates, expertise compounds, and progress becomes more



The Small Satellite Collaborative facility, located on the 4th floor of Building 7, will feature an open layout designed to support a continuous workflow from concept to orbit, advancing innovation in small satellite design, integration, and testing.

than a series of isolated achievements. The Small Satellite Collaborative facility extends that tradition into the next era of space systems.

Inside the Facility

The facility will support the full spacecraft development cycle in one environment – from design and assembly through environmental testing and mission operations.

- **Design and Fabrication:** Spaces to develop and integrate spacecraft architectures, hardware, and software systems.
- **Systems Integration and Clean Room:** Clean room space for spacecraft assembly, integration, and preflight preparation.
- **Environmental and Thermal-Vacuum Testing:** Facilities that reproduce the vacuum and thermal extremes that spacecraft will encounter in orbit.
- **Mission Operations Center:** Connected to rooftop antennas for real-time command, control, and on-orbit operations.

The FlatSat Area will provide dedicated space to integrate and validate small spacecraft components prior to clean-room assembly, with FlatSat integration tables, signal-generation equipment for subsystem testing, optical tables for laser system integration, and an air table for evaluating guidance, control, and maneuvering systems.

The Components Testing Area will house a thermal vacuum chamber (TVAC) for flight-readiness testing, a bakeout oven for thermal outgassing and material characterization, a solar simulator to replicate the sun's radiation and light spectrum, and a Helmholtz coil to generate uniform magnetic fields for testing sensors and attitude control systems.

What This Facility Will Enable

The Small Satellite Collaborative facility will accelerate breakthroughs in space systems by empowering the next generation of MIT engineers to lead innovation.

Advancing the Frontiers of Space Systems

With this facility, MIT can extend its work from exceptional individual missions to sustained advances in the technologies shaping the next era of space systems, enabling major progress in the domains that will define space capability in the decades ahead:

- Space situational awareness and orbital traffic monitoring
- Earth observation for climate science, weather forecasting, and environmental monitoring
- Resilient communications, navigation, and positioning networks
- Autonomous spacecraft operations and distributed mission control
- Edge computing and radiation-tolerant onboard computing systems
- Rapid spacecraft integration and next-generation satellite manufacturing
- Planetary science and heliophysics missions

Taken together, these domains point to a new way to operate in space: coordinated systems that sense continuously, communicate resiliently, compute in orbit, and operate with increasing autonomy. This facility will provide MIT with the environment to pursue that frontier not as isolated efforts, but as a sustained program of technical progress.

SMALL SATELLITE COLLABORATIVE

Launched in 2019, the Small Satellite Collaborative connects MIT's growing community of faculty, students, and researchers working on small satellites and payloads. It brings together teams in AeroAstro with collaborators at MIT Lincoln Laboratory, MIT Haystack Observatory, and the MIT Kavli Institute, as well as collaborators across government and industry.

By linking independent research groups through shared facilities, mission expertise, and technical resources, the Collaborative supports increasingly ambitious work in spacecraft technologies, multi-spacecraft operations, and missions in challenging environments from low-Earth orbit to cislunar and deep space.

The Small Satellite Collaborative facility will give this growing enterprise a permanent home.

Developing the Next Generation of Systems Leaders

World-class aerospace engineers are not produced in classrooms alone. They are shaped by building complex systems, making tradeoffs under real constraints, and carrying missions from early design through operations.

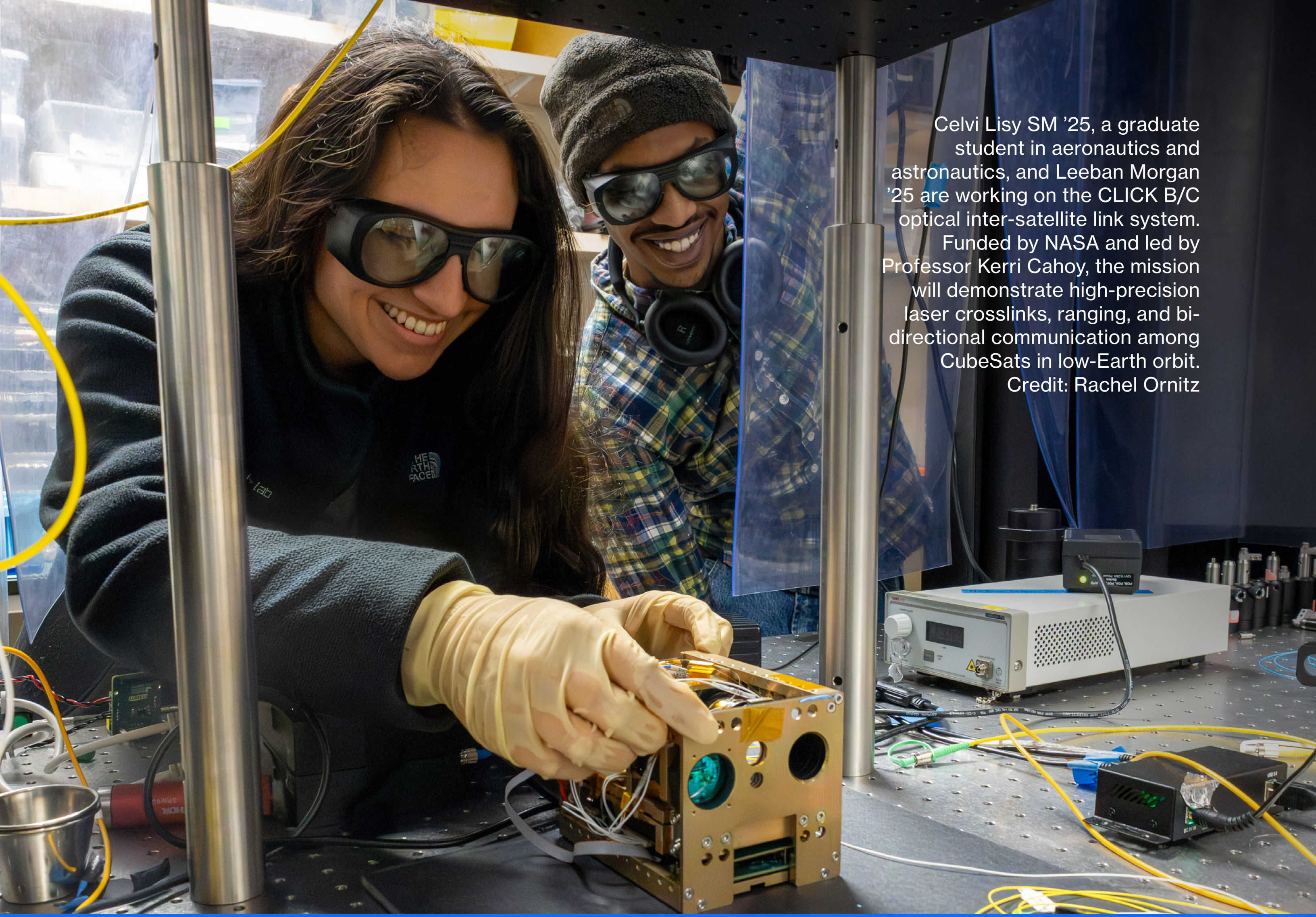
For students, this facility will be transformative. They will take part in spacecraft development across the full mission cycle – from design and integration through testing, flight operations, and anomaly response.

Through this work, they will develop the systems judgment and operational fluency that traditional classrooms cannot teach. They will see how design decisions reverberate through integration, operations, and on-orbit performance. This hands-on experience is what MIT students increasingly seek – and what the space sector urgently needs.

Across successive missions, faculty and students will build knowledge while pursuing increasingly ambitious work. Government and industry collaborators will also take part in these missions, bringing real-world challenges into the lab and giving emerging talent direct exposure to mission-driven work.

> "Success in space is a remote-operations challenge, where you can't get the spacecraft back to fix it. It takes expertise from across several engineering disciplines to design systems, test them, and visualize how they will perform in orbit. The Small Satellite Collaborative facility will give the next generation of engineers the opportunity to develop those skills."

Kerri Cahoy
Sheila Evans Widnall (1960) Professor



Celvi Lisy SM ’25, a graduate student in aeronautics and astronautics, and Leeban Morgan ’25 are working on the CLICK B/C optical inter-satellite link system. Funded by NASA and led by Professor Kerri Cahoy, the mission will demonstrate high-precision laser crosslinks, ranging, and bi-directional communication among CubeSats in low-Earth orbit. Credit: Rachel Ornitz

“The Small Satellite Collaborative facility reflects how MIT builds for the future: by creating the conditions for talent to flourish and innovation to take hold. In a world increasingly shaped by space, this facility will help define what comes next.”

Paula T. Hammond

Dean of Engineering and Institute Professor
Massachusetts Institute of Technology

Launched on March 4, 2024, the AEROS-MH1 CubeSat was developed through the MIT Portugal Program by MIT faculty and students working with Portuguese universities and industry collaborators. The satellite orbited Earth every 90 minutes and was designed to collect hyperspectral data to monitor ocean health and biodiversity along Portugal's Atlantic coastline. Credit: CEiiA.

An Enduring Institutional Capability

Space will be one of the defining technological domains of the 21st century. Constellations of autonomous spacecraft will operate at unprecedented scale, reshaping how humanity observes Earth, communicates, and explores the solar system.

That future requires institutions that can bring spacecraft engineering, autonomy, communications, and mission operations into a single, sustained enterprise. MIT has the people, experience, and institutional depth to do exactly that.

MIT's combination of operational experience, integrated research, and generations of students trained by doing provides a powerful foundation. The Small Satellite Collaborative facility will turn that foundation into an enduring institutional capability – a 5,700-square-foot environment designed to accelerate the maturation of space systems from design through deployment.

More than $11 million is already committed, including support from MIT Lincoln Laboratory. An additional $8 million is needed to begin construction – planned for 2027 – and to equip the facility with specialized capabilities, including a thermal-vacuum chamber, a solar simulator, a Helmholtz coil, and advanced optics and electronics laboratories.

Breakthroughs depend on the fundamentals: the spaces, tools, and continuity that allow expertise to grow, systems to mature, and talented people to do their best work.

Support for the Small Satellite Collaborative facility will help establish the foundation for the next generation of space innovation.

Facility Features

1,200+ sq. ft.
FlatSat integration and testing area for high-fidelity instrumentation

1 sky hatch
Direct-to-sky access for lidar and optical validation

600 sq. ft.
ISO-rated clean room suite with capacity to support two projects simultaneously

800+ sq. ft.
Component testing area

Antenna array
Advanced RF systems for small satellite constellations

For more information, please visit our website or contact:

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Cover: Paula do Vale Pereira SM ’19, PhD ’22 with BeaverCube atop MIT’s Building 9, with star trails and the MIT Mini Dome in the background. This composite image, created from more than 1,000 frames, captures both visible and infrared wavelengths from 400 to 830 nanometers. Credit: Evan Kramer. Page 5 credit: Niki Fandel. Page 9 credit: M. Scott Brauer. Page 10 credit: Christopher Michel.