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Dream Big: A Novel, Flexible and Robust ½U ThinSat Constellation Solution

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ABSTRACT

The Dream Big project is a joint initiative between NearSpace Launch (NSL) and NearSpace Education (NSE), combining commercial satellite development with hands-on educational outreach. Focused on advanced manufacturing and space entrepreneurship, the program engages university teams in designing, building, and integrating custom payloads into a novel ½U ThinSat bus. Over the past year, six Midwestern universities completed Phase 1, culminating in the development of six student-built payloads integrated into the NSL bus scheduled for launch in late 2025 or early 2026.

In addition to satellite development, teams conducted high-altitude balloon flights to validate hardware and promote STEM engagement in their communities. This presentation will showcase the system's innovative flight and ground support technologies, highlight contributions to workforce development, and share key progress updates, challenges faced, and lessons learned from across the program.

INTRODUCTION

The Dream Big project is a collaborative effort between NearSpace Launch (NSL), a commercial satellite developer, and NearSpace Education (NSE), a nonprofit focused on educational outreach. This initiative merges hands-on space systems education with cutting-edge flight hardware, emphasizing emerging technologies in advanced manufacturing and space entrepreneurship. Over the past year, student teams from six Midwestern universities—University of Notre Dame, Purdue University Fort Wayne, Valparaiso University, Taylor University, Western Michigan University, and the University of Toledo—participated in Phase 1. Each team designed, built, tested, and integrated custom payloads into a next generation ½U ThinSat bus design. These payloads include advanced magnetorquers, specialized communications systems, orbital assembly computer demonstrations, and other innovative technologies.

THINSAT DESIGN

The new ½U Dream Big satellites represent the next evolution of the 90 ThinSats previously developed, (4) tested, and launched by NearSpace Launch Since then over two million dollars have been invested into the development of the ThinSat technology through various government contracts. This upgraded platform features a standardized bus equipped with global 24/7 telemetry and control (TT&C) via the Iridium network, (3) along with integrated low-cost in-house ADACS, GPS functionality, particle detectors, diagnostic tools, magnetic field sensors, and sun sensors. A modular interface also enables seamless integration of customized student payloads, supporting both innovation and hands-on learning.

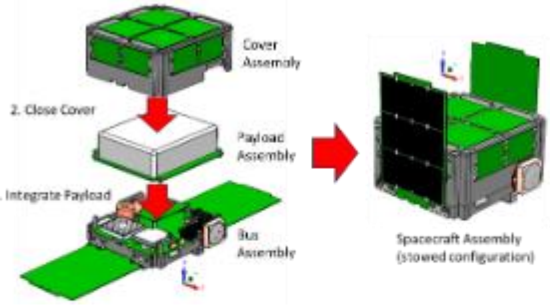

Figure 1: Assembly of the Payload-Buss Stack [2]

Each ½U ThinSat is equipped with two innovative 1U radiation-hardened deployable solar arrays and features an overall radiation-tolerant design. This configuration enables greater power generation, extended mission lifespan, and increased surface area to support controlled deorbit and space debris mitigation. The modular satellite design is compatible with standard 1U, 3U, and 6U deployers, allowing for flexible constellation configurations.

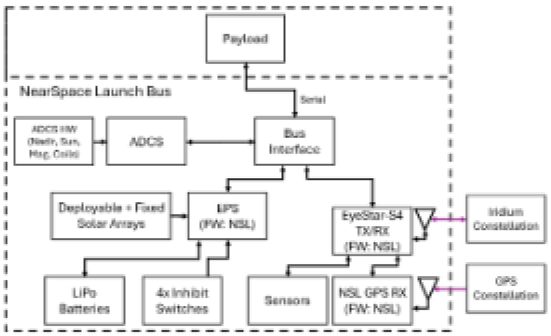

Figure 2: Block Diagram for the 0.5U ThinSat. [2]

This design allows for easy integration by building the bottom of the bus and frame together. Integration of the payload involves plugging in the board-to-board connector and simply securing with four 2-56 screws. Accessibility for this sequence of operations is unparalleled due to the entire "top hat" of the satellite being removed with only mechanical hardware to secure once the payload is integrated.

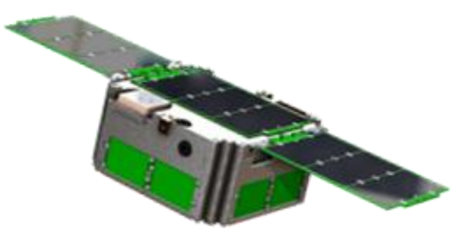

Figure 3 Assembled and deployed 0.5U Thinsat [2]

Once the individual satellite is assembled it is paired with another to where the solar panels overlap with the other satellite which is rotated 90° relative to the other satellite. This forms a 1U cube for the purpose of deployment.

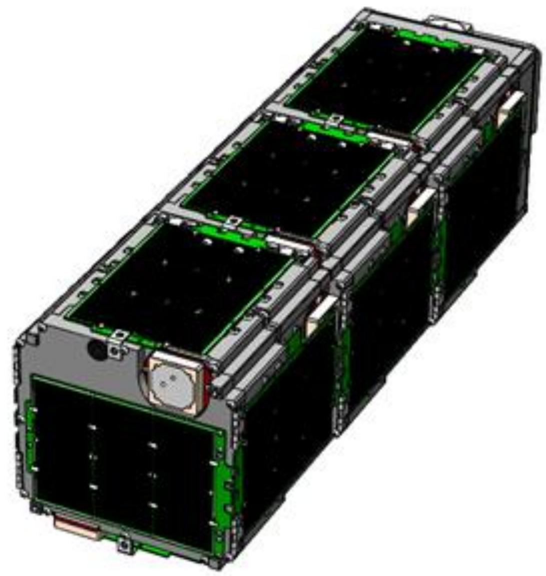

Figure 4: Assembled 3U Orientation [2].

Those six 0.5U satellites are then stacked together to form the required size, in this case a 3U.

Assembly and testing of the initial six satellites have been completed, and the team is currently coordinating with launch providers to deploy the first constellation by late 2025 or early 2026.

INTERFACE

The Dream Big satellite bus features a novel interface inspired by the PC104 format, utilizing four standard mechanical mounting points and a 20-pin electrical connector, while maintaining the use of commercial off-the-shelf (COTS) components. The 20-pin interface functions as a board-to-board connector, available in both surface-mount and through-hole options for the payload. It supplies four switched power rails from the bus, including 3.3V, 5V, and a 6–9V battery voltage. Communication is managed via a single TTL UART serial interface, and four analog input channels are also provided.

The payload volume is designed for maximum flexibility, allowing surface-mount components to be placed on the underside of the main PCB, with the majority of the payload volume above. The frame includes eight configurable side ports with optional PCB panels, along with a large aperture on the +Z face. These access points support sensor exposure to Earth, deep space, or the Sun, as directed by ADACS commands.

All satellite operations are integrated through the NSL web portal and API, which enables real-time data packet retrieval and uplink command transmission.

Conveniently, this is the same platform used by students during high-altitude balloon launches, providing them with prior experience and familiarity navigating the interface .(2)

PHASE I PAYLOAD SUMMARIES

The Dream Big pilot program features six unique university-designed payloads, each contributing to the advancement of small satellite technologies while providing students with direct, hands-on experience in space systems engineering. These payloads served as testbeds for prototyping and validating mission-relevant technologies in a low-Earth orbit environment:

1. Atmospheric Aerosol Spectrometer

A miniaturized spectrometer designed to analyze atmospheric aerosols by capturing spectral data for particulate composition. The payload supports future environmental and climate-monitoring satellite missions.

Figure 5: Dale Miljkovic, from Purdue Fort Wayne's Precision Flight Works team, observes the preparation of the vibration table for their payload by NSL.

2. Automated Detumble and ADSC Testing

This experiment tested an onboard system for autonomous detumbling and attitude determination, using sensor data and control algorithms to stabilize post-deployment satellite motion.

Figure 6: Isaac Brej from the University of Notre Dame explains to Dillon Embry of NSL how their payload has been tested to adhere to the ICD 2)

3. Triplicated Processor Reliability Demonstration

A fault-tolerant processor array based on radiation-hardened architectures was evaluated for error correction, watchdog performance, and resilience under power cycles, targeting LEO and deep space applications.

4. Langmuir Probe and Onboard Processor Testbed

A plasma sensing experiment using a Langmuir probe and onboard processor to collect and analyze ionospheric data—part of early development for a future propulsion diagnostics system.

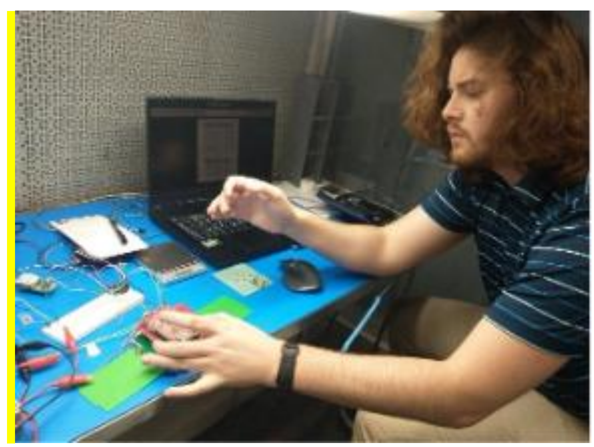

Figure 7: Tom Scott from Western Michigan's WALE satellite program

5. STELLA Sensor Suite Integration

The STELLA payload measured in-situ environmental parameters (temperature, pressure, and acceleration), emphasizing modularity and adaptability for future orbital and suborbital missions.

6. SATNOGS Communications Payload with ADCS Crossover

Combining SATNOGS-compatible communications hardware with an ADCS testbed, this payload validated open-source ground station integration and telemetry downlink performance. This team also expanded on the provided emulator and ICD to build a streamlined test setup and offered the kit at cost to the participating universities.

These student-led projects not only led to the development of critical spaceflight technologies but also served as valuable educational platforms for learning the constraints and complexities of space mission design, environmental testing, and integration processes. Their work underscores the importance of accessible, iterative programs like Dream Big in developing the next generation of aerospace engineers and researchers.

PROGRAM MANAGEMENT

This program builds upon the knowledge gained from previous partnerships and ThinSat missions, (1) which included the successful launch of 90 total 1/7th U ThinSats (4). During Phase I, a single Program Manager served as the primary point of contact (POC) for all program-wide meetings. Initially, bi-weekly meetings were held with participating teams, with additional meetings scheduled or canceled as needed to support effective communication and timely problem-solving. While this centralized structure fostered strong coordination, it also demanded significant time and effort as the program scaled.

Throughout Phase I, numerous technical advisors provided subject matter expertise, either through direct communication with teams or by supporting the POC. Communication primarily took place via email, Microsoft Teams, virtual meetings, and shared folders. However, the shared folders proved to be a challenge and will not be utilized in future phases.

To address this, NSE has developed a dedicated module within the Moodle Learning Management System (LMS) for Phase II. This platform will serve as the central hub for documentation distribution, submission tracking, and knowledge sharing. It includes a comprehensive FAQ section, and a cohort discussion forum designed to promote cross-team collaboration and streamline program operations.

LEARNING OUTCOMES

This pilot ThinSat program generated valuable technical and educational insights relevant to both future space missions and aerospace training initiatives. One key engineering takeaway was the critical importance of disciplined design scope. Teams that prioritized simplicity and limited system complexity in their initial satellite builds achieved greater integration success and experienced fewer technical hurdles. Across institutions, rigorous systems engineering practices, particularly early and repeated hardware-in-the-loop testing using emulators for communications validation, were identified as critical to mission assurance. Project timelines consistently exceeded initial estimates due to a combination of underestimated development complexity and supply chain challenges, including variability in component quality, incomplete vendor documentation, and extended procurement lead times. Firmware development and embedded systems integration proved to be steep learning curves for many student teams, underscoring the need for earlier engagement with software architecture and interface definitions.

Programmatically, the integration and environmental testing phases, especially vibration and thermal vacuum testing—served as the inflection point for mission readiness, revealing the extent to which subsystems had been verified and validated under simulated launch and space-like conditions. Teams that invested in detailed interface control documentation and adhered to payload mass and envelope constraints during preliminary design reviews fared better during final integration. Educationally, the program reinforced the value of experiential learning through authentic aerospace workflows, highlighting that exposure to real-world engineering constraints such as risk mitigation, system interdependencies, and fault tolerance provides unmatched training for aspiring engineers. These findings will inform the next phase of the Dream Big initiative, driving improvements in curriculum alignment, subsystem standardization, and resource sharing to better support scalable and sustainable university ThinSat programs.

OUTREACH

While the Dream Big satellite program was initially designed for college-level students, a central goal was to extend its reach to younger audiences and inspire early interest in STEM. To build a stronger pipeline of future engineers, scientists, and innovators, the program was intentionally structured to include a significant outreach component aimed at K–12 students. This approach empowered college teams to serve not only as satellite developers, but also as mentors and role models for younger learners.

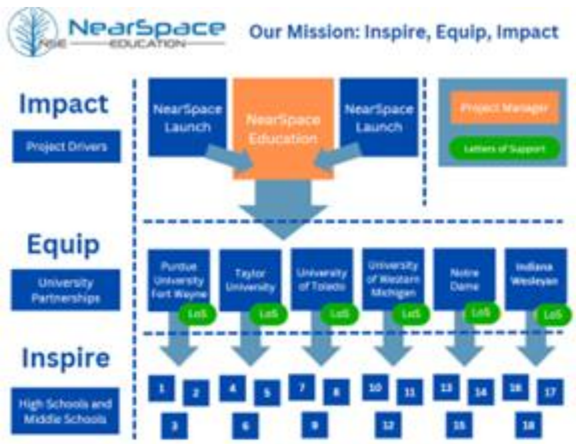

Figure 8: Flowchart of the organization break down of the NSE mission statement

Each participating university partnered with at least three K–12 schools, engaging them through classroom visits, campus tours, and hands-on STEM activities. As part of the program, every school participated in a high-altitude balloon launch, giving students a direct connection to the science and technology behind space exploration. These experiences included building small payloads ranging from experiments to symbolic items that were flown to near-space altitudes. The balloon launches provided an accessible, exciting platform to demonstrate core STEM principles in action.

Figure 9: Balloon Outreach launch for Valparaiso Schools done by Valparaiso University

College students also had the opportunity to share their satellite projects and explain how their systems were being tested on these balloon flights. These interactions not only helped younger students grasp the real-world applications of what they were learning but also showed them tangible pathways into higher education and STEM careers.

To celebrate the achievements and foster further collaboration, the program culminated in the Dream Big Banquet, which brought together students, educators, industry partners, and community leaders. During the event, college teams presented posters showcasing their satellite designs, testing methods, and outreach efforts, giving attendees an in-depth look at the progress made throughout the year. It was also a valuable opportunity for networking and reflection, reinforcing the collective momentum behind advancing STEM education in Indiana and beyond.

In total, over 2,000 K–12 students participated in the Dream Big program's outreach activities. It will be exciting to watch how this early exposure to space-related science influences their future educational choices and career paths. By combining ambitious university-level projects with accessible, hands-on outreach, the Dream Big program is helping shape a new generation of STEM learners.

Figure 10: Team photo of the University of Notre Dame

Figure 11: Balloon Outreach launch for Berne Middle School done by Purdue Fort Wayne

WORKFORCE DEVELOPMENT

The Dream Big program directly contributes to workforce development by providing undergraduate and early-career students with end-to-end exposure to the complexities of satellite mission design, testing, and integration. Participants engage in authentic engineering workflows involving requirements definition, subsystem development, environmental qualification (vibration, thermal vacuum, and bakeout), and interface verification within the constraints of a spaceflight payload lifecycle. These hands-on experiences cultivate competencies in systems engineering, embedded firmware development, RF communications, data acquisition, and advanced manufacturing practices such as precision machining and PCB design. Additionally, by incorporating outreach and mission-specific objectives, students gain project management, stakeholder communication, and iterative problem-solving skills key attributes for careers in both government and commercial aerospace sectors. The program also fosters space-focused entrepreneurial thinking, enabling students to prototype and validate novel sensor platforms and bus technologies that have crossover potential into small satellite and new space markets. Through this iterative, mission-driven approach, Dream Big serves as a scalable model for building a technically proficient, innovative aerospace workforce.

FUTURE PLANS

Future iterations of the *Dream Big* program aim to expand both its technical scope and educational reach, focusing on scalable, lower-cost, and higher-reliability solutions for small satellite constellations. A key development is the creation of a standardized base payload platform designed to reduce complexity and cost, enabling entry-level schools to participate without requiring extensive prior experience in space systems engineering. This modular approach will facilitate wider adoption across varying educational levels and institutional capabilities. Phase II of the initiative will transition to a regional implementation, building a cohesive regional network of satellite programs that share resources and testing infrastructure. Phase III targets a national rollout, creating a distributed, student-built constellation. Long-term objectives include the exploration of international partnerships, extending the program's impact to underrepresented geographic and socioeconomic regions globally. This roadmap supports a more inclusive talent pipeline while advancing practical small satellite innovation through accessible, curriculum-integrated space missions.

CONCLUSION

The Dream Big program, led by NearSpace Education (NSE), exemplifies how ambitious, student-driven initiatives can both educate and inspire the next generation of aerospace professionals. With hands-on experience in satellite development, environmental testing, and mission integration, students gained practical engineering knowledge while solving real-world problems. Beyond technical development, the program achieved substantial outreach, impacting over 2,000 students across elementary schools, high schools, after-school programs, and universities, sparking interest in aerospace and STEM fields at all education levels. This initiative demonstrates how accessible spaceflight opportunities can bridge the gap between classroom learning and career readiness. NSE dreams big, and through programs like this, students are empowered to do the same.

ACKNOWLEDGMENTS

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We also extend our appreciation to the students whose creativity, perseverance, and commitment brought each payload to life. We are especially grateful to our sponsors, The Don Wood Foundation, and The AVIS Foundation whose generous contributions made this program and its educational opportunities possible. Finally, we recognize the broader STEM community for fostering an environment of innovation, education, and exploration.

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