
Image Credit: NASA

Aerospace Experimental Association

1 August 2020

THE STATE OF AXA - 1

Official Student Branch of

SHAPING THE FUTURE OF AEROSPACE

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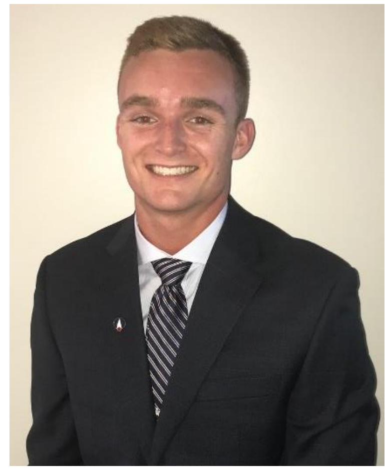
LETTER FROM PROJECT MANAGER

1 August 2020

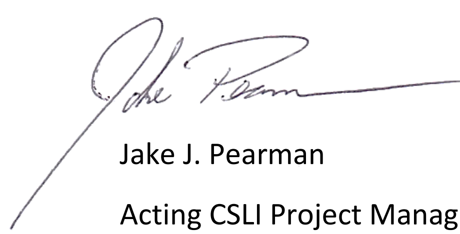


I am pleased to present AXA's first 'State of AXA-1' Newsletter detailing AXA's first CubeSat project milestones achieved over the summer 2020 as well as the next steps for the Fall semester. With the steadfast hard work, interest, and excitement of everyone at AXA, we are forging a path for future CubeSat development at FAU. It is your commitment and dedication that enables us to push the boundaries of our academic understanding, satellite capability, and develop our leadership capabilities for future aerospace careers here on Earth and beyond it.

Throughout the summer I have been continually impressed by the devotion and perseverance of the teams who continue to research and develop the AXA-1 satellite amidst the coronavirus pandemic. Every team member and leader has demonstrated their ability to adapt to the unforeseen situation and continue moving forward to meet our project deadlines. While our team members quarantined, they spent time attending team meetings two or even three times per week, presenting their research and discussing the next steps in the project. In the time span of just under three months, our team have operated at warp speed transitioning this satellite from a distant idea in orbit around Earth into a solid executable plan for development.

The time from now into the Fall semester are poised to be the most rigorous and challenging time our teams will face as mission-critical deadlines are quickly approaching. The strategic plan for Fall 2020 emphasizes the key phase of the satellite's development timeline where teams will conduct rigorous software and hardware component testing and data analysis. The quality of the testing will ultimately equate to a high probability of mission success; therefore, adequate planning of resources and funds are a primary focus in the upcoming weeks.

Beginning in August, AXA will be hosting numerous recruiting events in the Breezeway, fundraising events with local businesses, receiving official 501(c)(3) tax-exempt status, and launching a business sponsorship program. I am confident that everyone can maintain the speed and quality performance achieved over the summer and we will stay on track to meet or exceed our goals.



Jake J. Pearman

Acting CSLI Project Manager

OUR VISION AND MISSION

The Aerospace Experimental Association (AXA) is a fully student-run (501(c)(3) pending) club at Florida Atlantic University that provides students the platform to employ what they are learning at FAU in a real-world aerospace environment. At AXA, students become project managers and team leaders for STEM-related projects, whether it be designing, building, and flying their own R/C aircraft, modelling an experimental Mars rover, or developing a satellite with NASA. The increasing speed of technological development across the world demands that incoming college graduates understand the process of project management, product design lifecycles, technology readiness levels, and model-based design timelines.

AXA provides students with experience by placing them in leadership positions at the tactical, operational, and strategic levels where they learn how to manage people and a complex, STEM-heavy project that takes the lessons taught directly from the classroom into a real-world scenario that requires problem solving, teamwork, and communication. This commitment to develop STEM students for the real world of engineering is the overarching approach and the core mission of the Aerospace Experimental Association.

AXA is an official student branch of the American Institute of Aeronautics and Astronautics (AIAA). AIAA is the world's largest aerospace technical society. With nearly 30,000 individual members from 85 countries and 95 corporate members, AIAA brings together industry, academia, and government to advance engineering and science in aviation, space, and defense. Becoming a student branch only amplifies the opportunities for University club members.

The State of AXA – 1 – NASA's Cube Satellite Launch Initiative

NASA's CubeSat Launch Initiative provides opportunities for small satellite payloads built by universities, high schools and non-profit organizations to fly on upcoming launches. Through innovative technology partnerships, NASA provides these CubeSat developers a low-cost pathway to conduct scientific investigations and technology demonstrations in space, thus enabling students, teachers, and faculty to obtain hands-on flight hardware development experience.

AXA has appropriately named the very first satellite to be launched by Florida Atlantic University students the AXA-1, with the number at the end being a vision for AXA to continually develop CubeSats to be launched into space as new students enter the club. Continual analysis, debriefings and documentation are key components for streamlining the process for future development of AXA CubeSats.

AXA – 1 Chain of Command and Subsystem Elements

AXA's CubeSat chain of command is structured as follows:

- **Project Manager (FD)** and **Deputy Project Manager (DFD)** (Strategic): Oversees entire satellite project, supports team leaders by securing funding, providing resources for mission success, and mentors entire chain of command on leadership strategies and tactics.
- **Standards and Evaluations Officers (STAN EVAL)** (Operational): Oversees team leaders and ensures each subsystem element is meeting deliverable deadlines, appropriately advancing through the MBD and TRL Timelines, respectively, and meeting the standards listed by NASA for each subsystem element.
- **Team Leaders** (Tactical): Leads team within a single subsystem element through the MBD and TRL Timelines, ensuring that their team is on target and on time while providing the necessary resources for their team to conduct research and testing within a collaborative and academic learning environment.

AXA's CubeSat Subsystem Elements are listed as follows:

- The **Ground Station Team (GC)** develops a ground system infrastructure and ground communications necessary to monitor satellite orientation, health, status, power consumption, as well as executing the primary mission of the satellite.

- The **Payload Team** defines the satellite's mission, as well as provides the operating standards (secondary to NASA) required from other subsystems for mission execution and success. The Payload Team is also responsible for writing an after-action report to NASA on the results of the satellite experiment.

- The **Experimental Testing Team** conducts orbital and thermal simulations, vibrations, vacuum, and analysis testing, as well as validating and optimizing the desired vs experimental test results of individual software and hardware components.

- The **Structures Team** utilizes SolidWorks to design and construct the CubeSat chassis, side panels, and internal mounting points, as well as developing a flight packaging plan for the other subsystem elements.

- The **Microcontroller Team** develops the operating code for satellite main and auxiliary control, monitoring, and provisioning, while also decoding transmissions from the Ground Station, executing those instructions, and sending transmissions back to the GC.

- The **Power Supply Team** identifies each subsystem element's power requirements to then engineer an appropriate power supply and distribution software/hardware nexus for the satellite.

- The **Attitude Determination and Control (ADCS) Team** determines the satellite orientation and location by taking the specific requirements from the Payload Team and conducting analyses on various hardware component setups to determine the appropriate system for mission success.

- The **Environmental Factors Team (ODAR)** simulates satellite de-orbit and reentry scenarios to calculate the risk of orbital debris and failure to burn upon entrance into Earth's atmosphere. Also, the Environmental Factors Team analyzes each subsystem equipment to determine the hazardous risk to the Earth environment.

Subsystem Element Priority Goals

Subsystem element priority goals are performance goals set by strategic leadership to ensure that each subsystem is reaching critical pre-flight milestones including research, design, implementation, integration, and testing. Below is the status report summary for the 11 May 2020 to 1 August 2020 summer reporting cycle.

2020 Summer Cycle Subsystem Element Priority Goals

Subsystem Element Priority Goals and Statements	Subsystem Element	Final Rating
Provide a complete parts list, including cost and setup location. Receive RF Experimental Licensing, achieve total understanding of SATNOGS software. Contact other CSLI developers and command their satellites for experience.	GC Team	RED RF Licensing, understanding of SATNOGS, and other CubeSat commanding not achieved.
Provide a complete parts list, including cost. Conduct proof-of-concept experiment at University. Solidify partnerships with businesses who will supply mission-specific optics and hardware.	Payload Team	YELLOW Proof-of-concept at University not achieved. Hamamatsu or FormLabs partnership. Parts list acquired.
Demonstrate the capability to test hardware components in-house to receive appropriate data and determine probability of success. Determine process for Day in the Life Testing, as well as tertiary space environment testing equipment acquisition.	Experimental Team	YELLOW Hardware in the Loop testing and Day in the Life Testing not achieved.
Present a fully developed and compliance-checked structure. Acquire partnership with company to supply materials needed and design specifications required. Demonstrate method for flight packaging calculations.	Structures Team	GREEN Achieved. ProtoLabs partnership acquired. Team is working on further refining model for mission-specifics.
Complete entire wiring diagram including Remove Before Flight pins and other inhibitors, other subsystem integrations and connections, and computing capability and potential limitations with appropriate contingency plans.	Microcontroller Team	GREEN Achieved. Microcontroller nexus with other subsystems diagrammed and thought-out. Team is further specifying diagram as per NASA standards
Solidify a power supply system and method of recharge, as well as necessary integration with Experiment Team to determine solar panel efficiency in various inclinations of LEO orbit.	Power Supply Team	YELLOW Early model circuitry diagram, and subsystem integration method not achieved.
Present a complete parts list, including cost. Present relevant data and graphs to demonstrate probability of success of the in-house built ADCS system. Provide a spec sheet and compare sheet with off-the-shelf products.	ADCS Team	GREEN Achieved. Parts list and costs estimated. Team is refining relevant data and preparing for simulation testing.
Demonstrate all possible risks associated with orbital debris and reentry debris, as well as a plan for de-orbit procedures and materials for high probability of full burn upon reentry.	ODAR Team	YELLOW General concepts covered, missing specifics for our satellite.

NEXT STEPS: PRE-FALL 2020 DELIVERABLES

The pre-fall deliverables focus on strategically planning the fall semester to determine all necessary licensing documentation and testing, hardware testing locations, and any other mission-specific time-consuming deliverables that will want to be avoided during the academic semester. Below is a list of time-sensitive deliverables assigned to each subsystem element to be completed within the shortest time possible.

GC Team

Deliverable 1 – Receive RF Experimental License Under FCC Part 5.

NASA and the FCC require that CubeSat teams receive and Experimental Radio Frequency License under a Special Temporary Authority (STA) Form or Form 422. Form 422 also requires a copy of AXA-1's Orbital Debris Mitigation Compliance Document, IARU Coordination Letter, ITU Cost Recovery Letter, NOAA Remote Sensing License, and SpaceCap Notice. The FCC requires a minimum of 90 days from initial receipt of application to license issuance. SEE: **AFOSHSTD 48-9**

Deliverable 2 – Understand SATNOGS Software.

The SATNOGS software will be utilized to receive data from our CubeSat to our Ground Station and others across the world. Understanding this data is critical for mission success. Contacting other CubeSat developers to request temporary operation of their CubeSats is the most effective way to demonstrate complete understanding of SATNOGS software. SEE: **CubeSat 101 pages 72-3**

Payload Team

Deliverable 1 – Confirm Partnership Company to Supply Experiment Components.

Acquiring the hardware necessary to conduct physical testing and proof-of-concept experiments with appropriate data is required to occur prior to Proposal submittal. Confirming partnership company and associated costs is a high-priority item. SEE: **Optical Vortices with Starlight pg. 1161**

Experimental Team

Deliverable 1 – Determine Plan for Hardware in the Loop Testing.

Once the other subsystem elements purchase and integrate their hardware with their software, experiments will need to be conducted to compare the desired vs actual results of a given scenario. Providing this data is key to smoothing out code issues and design flaws early in the process before DITL Testing. SEE: **GSFC-STD-7000 A**

Deliverable 2 – Determine Plan for Day in The Life (DITL) Testing.

DITL testing recreates what happens to your CubeSat when it is released from the dispenser. To do this, you will start by removing the RBF pin with the separation switch(es) depressed, just as if it were inside the dispenser. Then, to simulate the CubeSat being ejected, you will release the separation switch(es) and time how long it takes for the CubeSat to start transmitting and release its deployables. Developing a plan for this is mission critical. SEE: **GSFC—STD-7000 A**

Structures Team

Deliverable 1 – Complete SolidWorks Model and Integrate into Systems Tool Kit (STK) for Testing.

STK allows for .mdl files to be directly imported into the software so that teams can analyze specific components on the satellite based on scenarios created. All teams need the availability to access the .mdl file to conduct the testing, so the soonest possible completion of the structure is important.

Deliverable 2 – Understand the Science Behind Flight Packaging and Easy Ways to Conduct Testing and Diagnose Broken Components.

No matter how well you plan and design your CubeSat, it is almost certain that something will break. Usually this happens during environmental testing (i.e., vibration/ shock testing). This is normal for a new design, but there are things you can do to make the repair work simpler and quicker. Most of the time, if you need to fix something on the inside of your structure (i.e., remove panels and take things apart), you will be required to perform certain testing again. However, if you design your CubeSat so that important components are near the exterior and easy to access, then the rework may be simple, and retest might not be necessary.

Microcontroller Team

Deliverable 1 – Continue to Develop Microcontroller Nexus in Accordance with NASA's Electrical Report.

Specific information typically required for the electrical report are identifying electrical inhibits, real-time clock circuitry, Remove Before Flight (RBF) Pin location, separation switch location(s), and an explanation of circuit inhibits and how they function. SEE: **CubeSat 101 pg. 58**

Deliverable 2 – Gather Parts List Required to Execute DITL Testing.

The DITL report will show that the CubeSat's timers and inhibit design function correctly, adhering to the appropriate mission ICD requirements. This test must be run with the final flight software and in most cases will be required to be completed prior to environmental testing. This will allow the CubeSat to demonstrate when the deployables will be released without invalidating the vibration testing. After you have completed the DITL testing, you are not allowed to change any piece of code in the software for any reason. Doing so will invalidate your test, and the mission integrator will require you to perform a retest and submit a new test report.

Deliverable 3 – Develop a Command and Data Handling System.

The Command and Data Handling (C&DH) system handles all data sent and received by the spacecraft, including science data and spacecraft or payload operations. The system is connected to the RF transmitter and receiver units provide a communication channel between the spacecraft and the ground operators. The basic data flow over a space link is made of Telemetry (TM) and Telecommand (TC) data.

Power Supply Team

Deliverable 1 – Conglomerate Parts List and Develop Power Distribution Strategy

SEE: **EWR 127-1 Appendix 3A**, **CubeSat 101 pg. 58**

ADCS Team

Deliverable 1 – Understand Sensor Data for Command and Data Handling.

Understanding how the satellite data will be transmitted to the ground station and how to read that data is everyone's responsibility. The sensor feedback required for the ADCS system depends on understanding the data. Partner with the Microcontroller Team to develop the ADCS spec sheet.

Deliverable 2 – Learn STK Software and Required Testing for Feasibility Review.

Developing and testing ADCS components in a university environment is a challenging task. Testing hardware in the loop ADCS systems in a laboratory is difficult because ADCS subsystems often rely on the micro-gravity, reduced friction environment of space to perform as designed. Taking the time to understand what is required for hardware testing now will make the feasibility review run smooth in the middle of the semester. SEE: https://dspace.mit.edu/handle/1721.1/67177

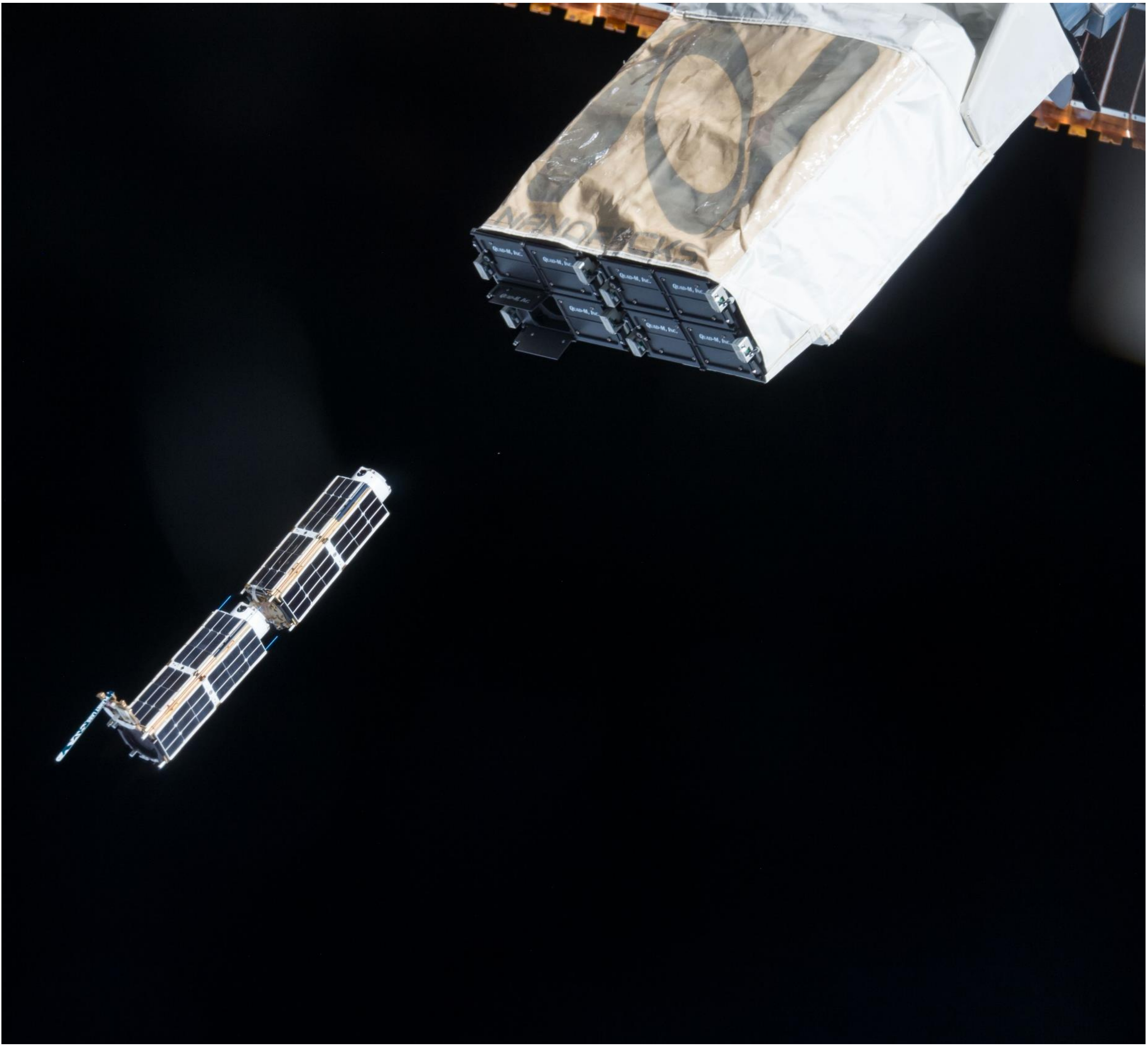
ODAR Team

Deliverable 1 – Understand Range Safety Requirements and Documentation Required for Launch.

SEE: **AFSPCMAN 91-710, EWR 127-1 Appendix 3A, NASA-STD-8719.14A, NPR 8715.6A, GSFC-STD-7000 A, Dove-2 ODAR**

APPENDIX A: ACRONYM LIST

ADCS	Attitude determination and control system
AFSPCMAN	Air Force Space Command Manual
AFOSHSTD	Air Force Occupational Safety and health Standard
AO	Announcement of Opportunity
APIC	Auxiliary Payload Integration Contractor
CAC	CubeSat Acceptance Checklist
Cal Poly	California Polytechnic State University
CDS	CubeSat Design Specification
CFR	Code of Federal Regulations
CG	Center of gravity
CIR	CubeSat Interface Review
CONOPS	Concept of Operations
CRADA	Cooperative Research and Development Agreement
CRSRA	Commercial Remote Sensing Regulatory Affairs
CSLI	CubeSat Launch Initiative
CVCM	Collected volatile condensable materials
DAS	Debris Assessment Software
DITL	Day in The Life
DOD	Department of Defense
ELaNa	Educational Launch of Nanosatellites
ELV	Expendable Launch Vehicle
EMI/EMC	Electromagnetic interference/electromagnetic compatibility
ETU	Engineering test unit
EWR	Eastern and Western Range
FCC	Federal Communications Commission
GSE	Ground Support Equipment
IARU	International Amateur Radio Union
ICD	Interface Control Document
IRC	Internet Relay Chat
ISS	International Space Station
ITU	International Telecommunication Union
JSpOC	Joint Space Operations Center
LSP	Launch Services Program
LV	Launch vehicle
MOI	Moment of inertia
MRR	Mission Readiness Review
MSPSP	Missile System Prelaunch Safety Package
NASA	National Aeronautics and Space Administration
NEI	Non-Earth Imaging
NOAA	National Oceanic and Atmospheric Administration
NRO	National Reconnaissance Office
NTIA	National Telecommunications and Information Administration
ODAR	Orbital Debris Assessment Report
ORS	Operationally Responsive Space
OSL	Office of Space Launch
PCB	Printed circuit board
P-POD	Poly-Picosatellite Orbital Deployer
RBF	Remove Before Flight
RF	Radio frequency
RFP	Request for Proposal
SSDL	Space Systems Development Laboratory
TLE	Two Line Element
TML	Total mass loss
TNC	Terminal node controller
TVAC	Thermal vacuum



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