CubeSat Launch Initiative

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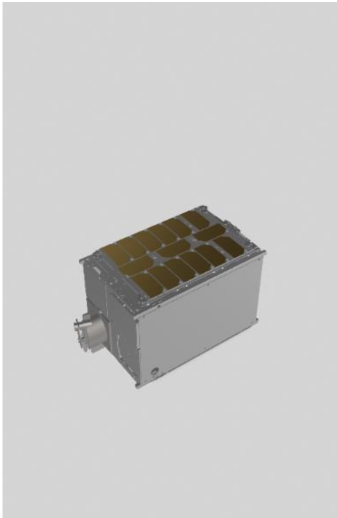
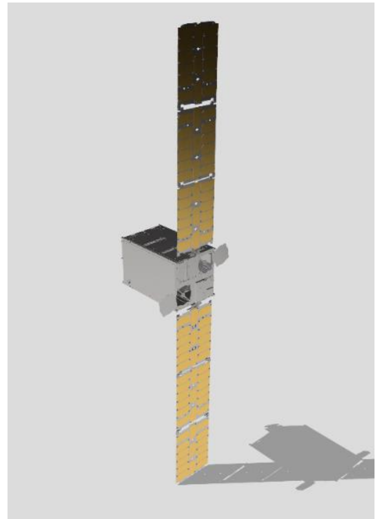

LunOSTAR LimeSAT Mission Proposal

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LunOSTAR Mission Parameters						
Mission Name	**Mass**	**Cube Size**	**Desired Orbit**		**Readiness Date**	**Desired Mission Life**
LunOSTAR	12 kg	12U	Location	L4	Late 2026	1 year minimum, planned EOL 2 years
			Jacobi Constant	2.972518		

LimeSAT Project Details						
Focus Area	**Student Involvement?**	**NASA Funding**		**Sponsoring Organization**	**Collaborating Organization (s)**	
		Yes or No	**Organization**		List	International
Documenting the Sun's corona through high-resolution imagery during lunar eclipses	Yes	No	RASA	RASA	N/A	N/A

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Abstract

The LimeSAT mission "LunOSTAR" aims to study the Sun's Corona – its outer most layer – designed to conduct multiple occultations of the Sun, focusing on the geometric relationships between the Earth, Moon, Sun, and CubeSat's orbit around the L4 Lagrange point. This innovative mission spans two years, during which the CubeSat will achieve a short period orbit (SPO) at L4 by hitching a ride on NASA's Gateway. After traveling from a near-rectilinear halo orbit (NRHO) around the moon leaving for the L4 Lagrange point, the CubeSat will deploy solar panels for power production and charge the electric propulsion system to maintain a SPO for over two years. During its deployment at L4, LimeSAT will have its solar shades activated to minimize damage to light sensors. As a lunar occultation approaches, onboard systems will capture light from the Sun's Corona, focusing on critical features such as coronal loops, prominences, and solar flares. Once the occultation is over the data will be sent to a constellation of satellites around the moon, to be sent back to earth for detailed analysis on the ground. Understanding the Sun's corona is crucial for several reasons. The corona is the source of solar wind, a stream of charged particles that can affect space weather which has significant impact on Earth's technology and communication systems. This mission also demonstrates feasibility of non-low-earth-orbit (LEO) exploration for CubeSats.

Proposal Details

Research Focus

The primary focus of this mission is to observe the Sun's corona during occultations of the Sun by the Moon. Through observation of the Sun's corona, valuable research on the Sun's atmosphere can be conducted including studies on solar wind and coronal mass ejections. Observation of the Sun-Moon system will occur from an orbit around LaGrange Point L4 in the Earth-Moon system. This orbit provides two necessary conditions for observation: stability, and occultation instances. Using the Moon for eclipses not only allows sole focus on the Sun's corona but has the added benefit of zero atmospheric interference as would be present on earth. The dual observatory payload of this mission satisfies the NASA Research Focus Area RFA-086: "Stereo Imaging From Space", as well as the first key priority laid out by the NASA Strategic Plan 2022: "Strengthen STEM education through inspirational missions and collaboration with the academic community". [5]

Use of a small CubeSat provides the opportunity for a high angular resolution observatory with low cost. Secondary to the observation mission is a proof of concept for low-cost, high scientific value missions launched from lunar gateway. The presence of a space station in cis-lunar space provides an invaluable opportunity for low-cost science in previously cost-restrictive areas. The successful launch and collection of data from a CubeSat costing less than 1 million USD could open the door for future science missions and low-cost research solutions in the further reaches of space. In addition to this, LimeSAT is equipped with a novel communication package which will allow it to communicate with a constellation of Lunar satellites. This is directly pursuant of NASA Research Focus RFA-079: "Small Spacecraft Lunar Communications and Navigation Networks".

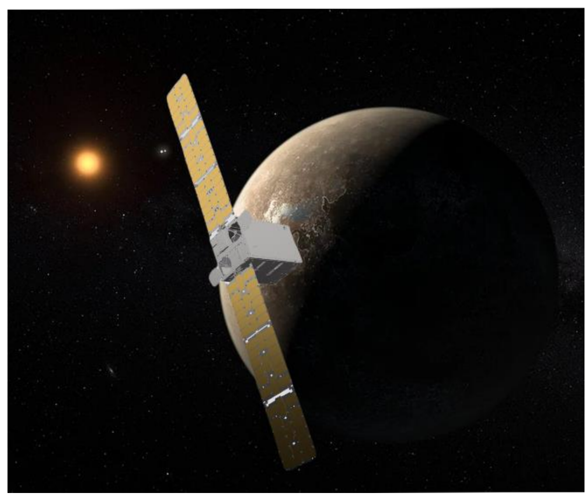
Requirement Compliance

This mission is fully compliant with all necessary requirements, including LSP-REQ-17.01. Embry-Riddle Aeronautical University, an accredited U.S. educational organization oversees the project. The CubeSat, designed as a 12U unit, conforms to the specified mass and volume constraints. It is equipped with a propulsion system that facilitates the maneuver from Earth-Moon Lagrange Point L2 to L4, ensuring precise mission trajectory and station-keeping capabilities. The CubeSat incorporates a sophisticated BUS system that manages the operational and data communication functionalities, effectively supporting the spacecraft's stability and control. The CubeSat is constructed using high-quality materials that comply with durability and safety standards necessary for space missions. The payload is comprised of advanced scientific instruments for conducting extensive observations in lunar and solar environments. These instruments are integrated to optimize data acquisition and operational performance. The design and operational strategy of CubeSat ensures compliance with NASA's guidelines and standards, facilitating a safe and effective mission without environmental risks. This means the satellite will comply with the NASA debris mitigation guidelines specified in NASA-STD-8719.14A even in the event of uncontrolled re-entry which one of the reviewers pointed out was important.

Relevance to NASA's Strategic Goals

This research directly coincides with NASA's goals as outlined in their 2022 Fiscal Year Strategic Plan. Specifically, Strategic Objective 1.2: "Understand the Sun, solar system, and universe." [1] When it comes to Helio physics research, NASA has the specific objective to "...discover the fundamental physics governing how the universe works and helps protect our technology and people from the impacts of space weather." (NASA, 2022) This goal is specifically relevant to heliophysics studies due to the potential danger of coronal ejections and solar wind to both spacecraft and ground-based technologies. The LimeSAT initiative is aligned with NASA in its objective to research the Sun's corona. LimeSAT and its associated research will create a broader base of knowledge on the Sun's effect on space weather and therefore, human activity. Additionally, LimeSAT will also align with NASA's strategy towards "...inventing and using new space-based observing and sampling capabilities..." (NASA, 2022). Although the observational suite of LimeSAT is not revolutionary in its capabilities, the use of a relatively low-cost vehicle to achieve this observation can be considered a new capability and serves as a demonstrator for low-cost science collection satellites. Finally, under NASA's Program Activities for Strategic Objectives, both "Heliophysics technology" and "Heliophysics Research" (NASA, 2022) fall within their desired program activities, aligning with the basis of the LimeSAT mission.

Mission Objectives



Our mission starts out by designing, testing, and launching a 12U CubeSat satellite into space where it will travel to the Lunar Gateway. Once the CubeSat is delivered to the crew of the station, they will perform final checks, remove any prelaunch pins, and turn on the CubeSat. Once loaded and launched out of the NanoRacks deployer we officially begin our mission objectives. The primary objectives are to travel to the Lagrange point L4 from Gateway and establish a short-period orbit (SPO) that will give us the longest observation time of the sun's solar corona. The observation must have a low angular velocity with respect to the moon for the best possible Lunar Occultation (LO) studies. Once this SPO is established, we will observe, record, and transmit to our Parsec Lunar Network orbiting the moon which will then transmit the solar corona data in the NUV wavelengths to our ground stations on earth, pursuant of RFA-079 as mentioned under Research Focus.

Payload Design

Two identical Cassegrain reflector telescope suites are the primary payload of LimeSAT. The observatories consist of fixed position mirrors, at a predetermined focal plane distance ideal for near-infinity focus needed for solar observation. The imaging chip used is a *Gpixel GSense400BSI* CMOS chip with a high quantum efficiency in the near ultraviolet regime of 400nm. This frequency band is ideal for observing the sun's corona during an eclipse. The identical telescopes are arranged in a stereoscopic configuration to allow for some parallax between the imaging planes. While this parallax is low given the spacecraft's modest size, it is a useful proof of concept for future missions and has the added benefit of providing LimeSAT with complete payload redundancy. This also directly corresponds to RFA-086, as mentioned under Research Focus. The Cassegrain reflectors themselves consist of two bespoke stone-ground parabolic mirrors, and two similar hyperbolic mirrors, providing an effective focal length of 42.6 centimeters, an angular resolution of 1.16 arcseconds, and image magnification of 2.5x. Images are captured, stored, and transmitted in RAW format. Payload characteristics meet and exceed requirements set by the LunoSTAR mission objectives.

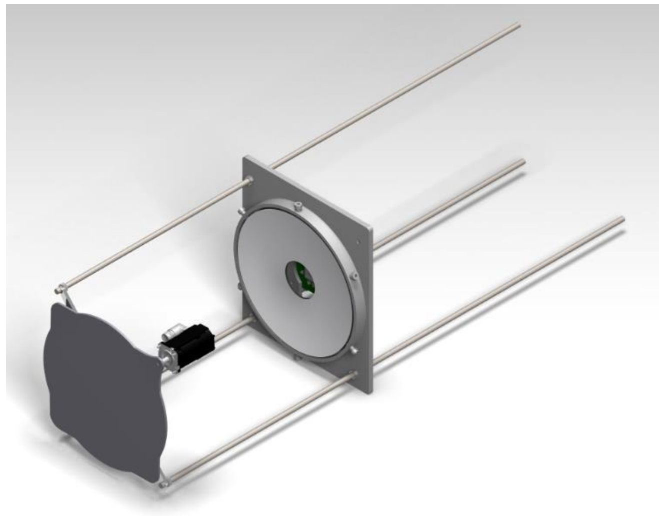


Figure 1: Cassegrain Mirror Assembly

Bus Design

The bus is designed around the two Cassegrain observatory suites. To protect these observation suites, a solar shade connected to a motor is installed on each mirror assembly to protect the sensors from the Sun while an eclipse is not occurring. Due to the over two year intended lifespan of this mission, redundancy is the focus in accommodating the payload. In terms of the avionics stack up, a *ClydeSpace* X-Band Transceiver, *Endurosat* EPS system, and an *Endurosat* On-Board Computer are to be expected. In addition to these necessities, two *ClydeSpace* Optimus-80 batteries are incorporated to allow a high battery capacity of 160 Wh. This high battery capacity will accommodate the heavy demands needed for the station keeping thruster. Keeping with the theme of redundancy and to accommodate the high-power draw of the station keeping thruster, two *NanoPower Tracking Solar Panels* will be used providing 90 watts of power in combination. These solar panels provide a power margin of 26 watts at maximum power consumption allowing continuous operation of systems.

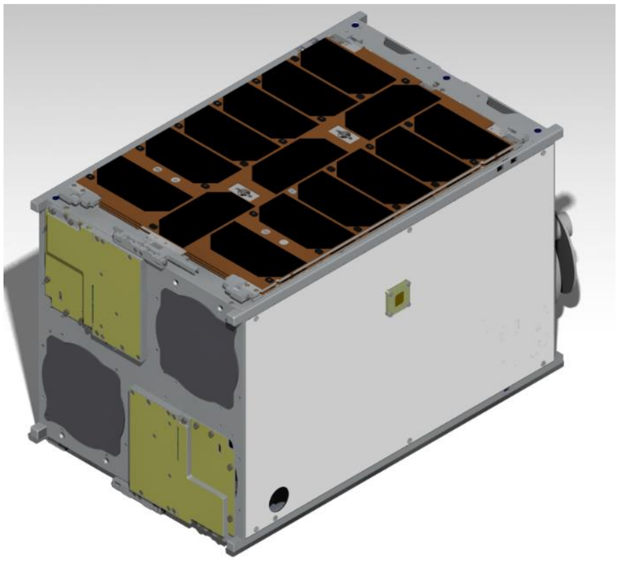


Figure 2: LimeSAT Bus

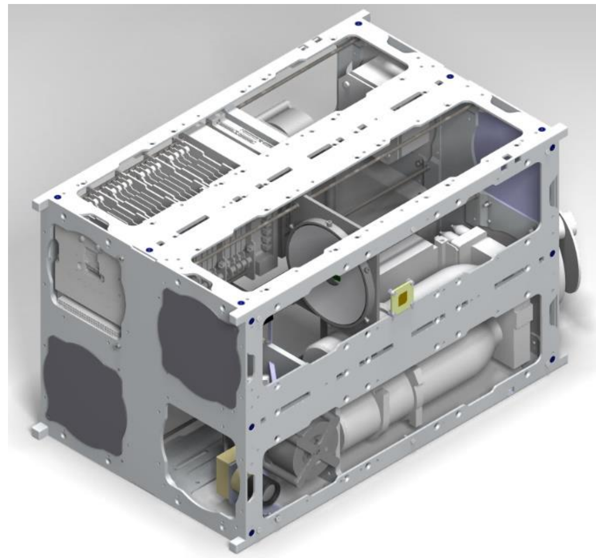


Figure 3: LimeSAT Bus with Interior

Two thrusters are used for LimeSAT. The first, a *VACCO Industries MEPSI* propulsion system providing the delta-V of .53km/s required for the initial transfer burn from the gateway orbit around L2 to the transfer orbit to a stable orbit around L4. The second thruster, a *Spaceware Nano L Thruster* providing up to 5km/s delta-v of station keeping capabilities for the observation phase of the mission. Both thrusters have integrated electronics and propellant management systems, reducing complexity of the vehicle and assembly time.

In terms of attitude control, both attitude determination and attitude control measures are taken to control the CubeSat in space without the presence of strong magnetic fields. For attitude determination, two *CubeSpace CubeStar Gen 2* trackers are used. These star trackers determine the attitude of the spacecraft in space using star maps. To physically control the attitude of the spacecraft, four *RocketLab 30mNms* reaction wheels are used. Using four reaction wheels aligned with different axes, the spacecraft can turn itself about each of its major axes with another wheel in reserve in case of failure which may be likely during a two-year mission. Using reaction wheels over such a long-time span, precautions are taken to avoid saturating the reaction wheels. Specifically, an *Aurora ARM-A Resistojet* attitude control system is used. This ACS system not only provides reaction wheel desaturation capabilities but also lends redundancy in controlling attitude and higher capability during the detumble phase of the mission.

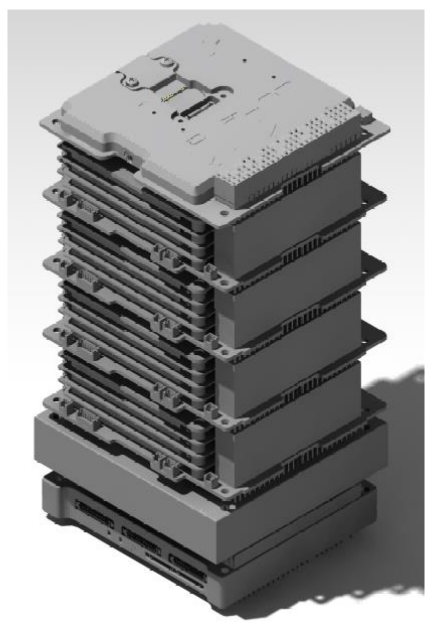


Figure 4: Avionics Stack Up

To accommodate communication in the far reaches of the L4 orbit, X-band communication was chosen as the optimal solution. Along with the transceiver to send and receive data and telemetry, two *Endurosat X-Band Patch Antennae* are used. These two antennae provide both redundancy and allow communication without disruptive pointing of the spacecraft during station keeping maneuvers or observation. To house the instruments and hardware an *Endurosat 12u XL* structure is used. This 12U structure provides ample space for propellant tanks and space for the long focal distance needed for the Cassegrain mirrors. Additionally, the structure provides hard points and threaded rod slots for easy mounting and assembly. The full assembly weighs a total of 12 kg falling well below NanoRacks requirement of 18 kg (NanoRacks, 2017).

Software

The software for both flight and telemetry operations are built on a Linux-based real-time operating system (RTOS), utilizing RTLinux to deliver the necessary real-time capabilities required for critical space mission operations. These RTOS platforms provide low latency and predictable execution times essential to managing the harsh conditions of space. Telemetry integration leverages Dewesoft for advanced data acquisition and processing capabilities. Custom developed APIs ensure seamless integration between the CubeSat's sensors and Dewesoft, facilitating effective real-time data processing and analytics. The output from Dewesoft is fully integrated into the mission's ground software systems, extending capabilities for real-time monitoring and comprehensive analysis. This integration provides mission operators with essential insights and data for ongoing mission management and success.

Transfer Design and Orbit Control

The Lunar Gateway at the time of writing is planned to inhabit a Near-Rectilinear-Halo-Orbit around the Moon, from there LimeSAT will be deployed at the perigee of the station's orbit. After startup checks are complete, LimeSAT will maneuver itself to fire its *MEPSI* Booster towards the cislunar L1 LaGrange point, where it will take advantage of a gravity well, allowing it to coast the majority of the remainder of the transfer journey. After LimeSAT has reached an acceptable proximity to L4, the station keeping controller will assume command of the Hall Effect thruster and begin inserting LimeSAT into the desired initial SPO. Over time, LimeSAT may be allowed to "fan out" its orbit path to conserve fuel. This is admissible, as perturbances are low enough to perform periodic station keeping adjustment burns and maintain a satisfactory orbit for the duration of the mission.

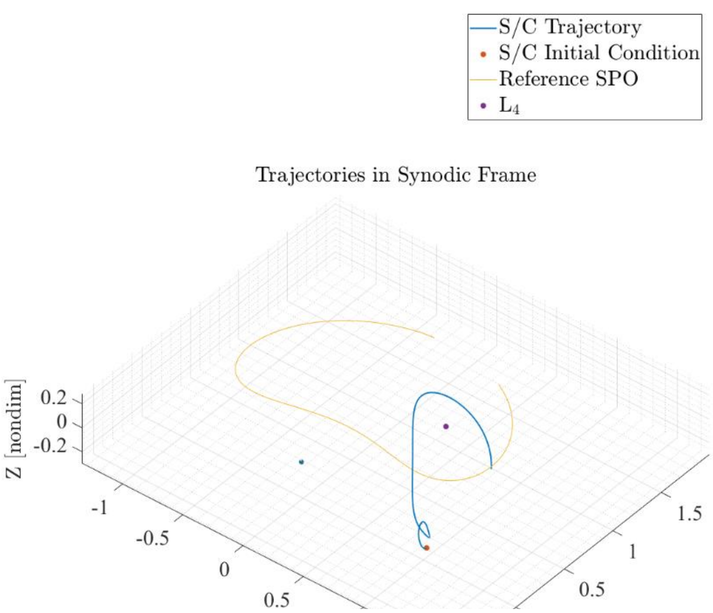


Figure 5 - Transfer Orbit Path

Concept of Operations

The primary mission of LimeSAT is to observe the Corona of the Sun. Riding on NASA's Gateway the satellite will deploy from a near-rectilinear orbit to head towards L4 Lagrange point. Upon deployment the CubeSat will detumble using its four reaction wheels. Once stable the solar panels will deploy and will orientate themselves to begin its journey to L4 using its liquid propulsion system. Once inserted into a short period orbit around L4 the hall-effect thruster maintains station keeping, and the primary mission begins. In preparation for each occultation the satellite contacts the lunar constellation, fulfilling the secondary mission, to confirm contact for data transmission. Star trackers onboard will guide the satellite to orientate towards the Sun, the camera on board will then take a dark photo, and a bias photo to be used for data analyzation. After those photos are completed, the sunshades will move to reveal the camera to the Sun's corona, gathering images during this time period. The onboard computer will compress the photos and save them until the satellite sends them to the moon to be relayed back to earth. Once the pictures are received on the ground the photos will go through a series of analysis such as noise interference patterns, anti-aliasing, and denoised. For end of life (EOL) any data onboard will be sent back to earth before systems check and disposal planning start. Once the plan of disposal is confirmed, any agencies that needed to be contacted will be sent the plan for confirmation again. After acceptance, the satellite will be sent into a graveyard orbit where it will be monitored and eventually activate passivation.

Development Schedule

The following tasks and durations are envisioned, assuming a start date of August 2023 and readiness for flight after 36 months.

- Previous work: Find all necessary parts and contact sellers for purchase. Perform a System Requirements Review (SRR), Preliminary Design Review (PDR), and a Critical Design Review (CDR).
- Months 1 thru 5: Manufacture any parts that are needed. Complete a dry assembly of the CubeSat minus the solar panels and side panels. Test initial communication and onboard computer software (OBC).
- Months 6 thru 12: Final CubeSat wet assembly with solar panels, side panels, and proper wiring complete. Operable communications and onboard computer software.
- Month 12 thru 23: Qualification/acceptance testing as well as thermal and vibration testing in a clean room environment. Verify mission trajectory and station keeping calculations and code.
- Month 24 thru 36: Develop and present System Acceptance Review (SAR). Deliver CubeSat to launch provider.

Project Details and Parameters

<table>
<tr><th colspan="7">LunOSTAR Mission Parameters</th></tr>
<tr><th>Mission Name</th><th>Mass</th><th>Cube Size</th><th colspan="2">Desired Orbit</th><th>Readiness Date</th><th>Desired Mission Life</th></tr>
<tr><td rowspan="2">LunOSTAR</td><td rowspan="2">12 kg</td><td rowspan="2">12U</td><td>Location</td><td>L4</td><td rowspan="2">Late 2020</td><td rowspan="2">1 year minimum,
planned EOL 2 years</td></tr>
<tr><td>Jacobi Constant</td><td>2.972518</td></tr>
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<tr><th colspan="8">LimeSAT Project Details</th></tr>
<tr><th rowspan="2">Focus Area</th><th rowspan="2">Student Involvement?</th><th colspan="2">NASA Funding</th><th rowspan="2">Sponsoring Organization</th><th colspan="2">Collaborating Organization (s)</th></tr>
<tr><th>Yes or No</th><th>Organization</th><th>List</th><th>International</th></tr>
<tr><td>Documenting the Sun's corona through high-resolution imagery during lunar eclipses</td><td>Yes</td><td>No</td><td>RASA</td><td>RASA</td><td>N/A</td><td>N/A</td></tr>
</table>

Funding Commitment

The LunOSTAR mission project is funded by the Riddle Aeronautics and Space Administration (RASA), as part of Embry-Riddle Aeronautical University. The team, comprised entirely of undergraduate students at Embry-Riddle, is receiving funding through the university to purchase CubeSat components and support team members. Each student on the project is actively involved in designing, building, and testing the satellite, ensuring a hands-on learning experience aligned with the practical applications of aerospace engineering and space research.

Budget

The budget for this project is set as $1 million. The total allocated budget for this project thus far is $713,100, this price includes all satellite components along with budget for assembly and payment of staff. Therefore, the unallocated budget for this project totals $288,900. This unallocated budget is advantageous for the future of the project as it allows for a large cushion in case of delays in assembly due to part procurement. Additionally, this unallocated budget can be reallocated for future staff to monitor and interpret data from the satellite.

Appendices

References

[1] “NASA Strategic Plan 2022.” *Fy-22-Strategic-Plan-1.Pdf*, National Aeronautics and Space Administration, www.nasa.gov/wp-content/uploads/2023/09/fy-22-strategic-plan-1.pdf. Accessed 22 Apr. 2024.

[2] “Lunar Occultation Spectroscopic Telescope Array (LunOSTAR) Program Level Requirements” *Science Mission Directorate.pdf* Riddle Aeronautics and Space Administration, Accessed 22 Apr. 2024

[3] NASA EPSCoR Research Focus Areas, National Aeronautics and Space Administration, https://www.nasa.gov/learning-resources/established-program-to-stimulate-competitive-research/nasa-epscor-research-focus-areas/. Accessed 22 Apr. 2024

[4] NanoRacks DoubleWide Deployer (NRDD) System Interface Definition Document (IDD), NanoRacks https://nanoracks.com/wp-content/uploads/Nanoracks-DoubleWide-Deployer-NRCSD-IDD.pdf. Accessed 22 Apr. 2024

[5] NASA Strategic Plan 2022 https://www.nasa.gov/wp-content/uploads/2023/09/fy-22-strategic-plan-1.pdf Accessed 22 Apr. 2024

A) Table of Selected CubeSat Hardware

Table 1. Cost, size, power use, and mass for CubeSat components

Component	Options	Mass (g)	Avg power use (W)	Size (mm^3)	Cost (USD)
EPS	Endurosat	330	0.8	156,200	5,800
Battery	ClydeSpace Optimus-80	670	0	492,326	10,000
Radio	ClydeSpace Pulsar-XTX	130	11.0	101,088	32,300
Comm. Antenna	ClydeSpace Pulsar-XANT	29	4.0	15,810	8,700
limeSAT deployer	Nanoracks				
limeSAT reaction wheels	Rocket Lab 30 mNm s	740	1.0	400,000	80,000
limeSAT OBC	Endurosat	130	0.8	113,500	12,500
Solar Panels	NanoPower TSP	600	0	399,929	142,000
Structure	Endurosat 12U Structure	2440	0	18,743,478.5	11,717.20
Navigation	CubeStar Star Tracker	94	0.33	82,320.0	17,599
Transfer Propulsion	VACCO MEPSI Propulsion System	460	4	165,802	88,000
Station-keeping Propulsion	spaceware Nano-L	3400	60	1,336,000	150,000
Primary Mirror	Custom	250	0	33,110	10,000
Observation Chip	Alvium USB90	30	1	7,458	5,000
Shade Motors	RobotDigg	200	10	10,890	4,000
Totals		10,360	63.77	22,057,901	711,100

B) Graphical Depictions of ConOps

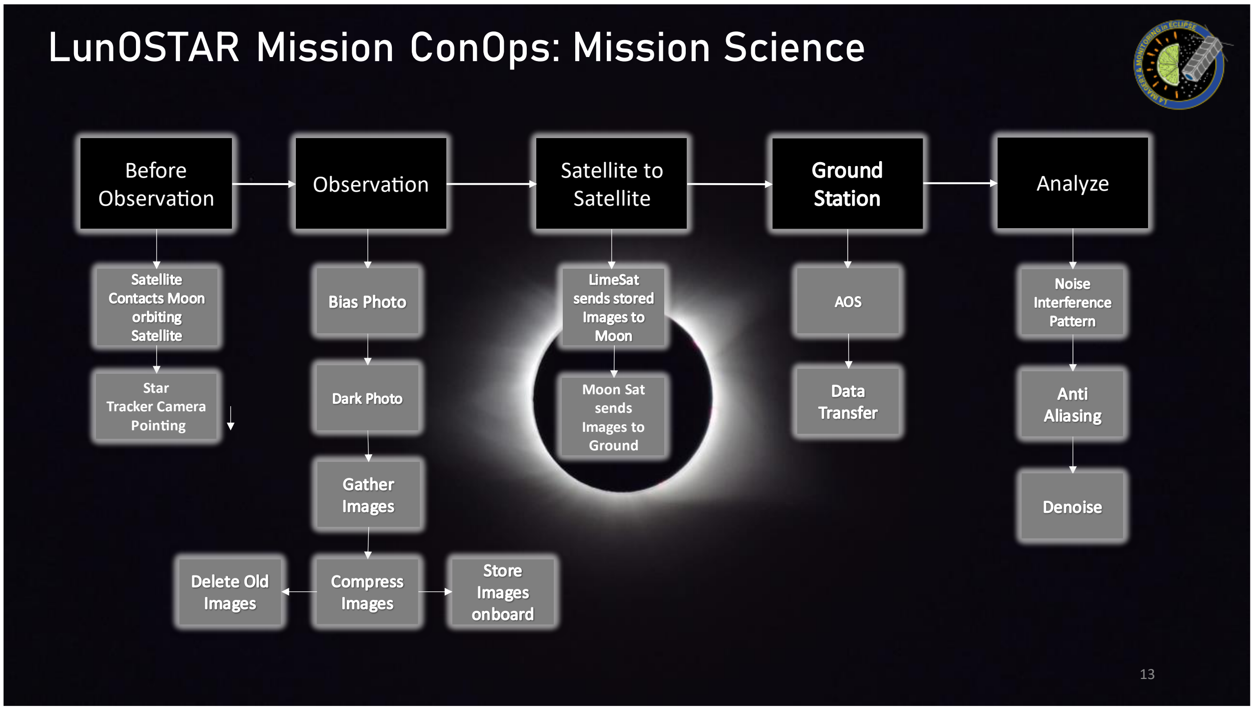


Figure 1: ConOps Mission Science

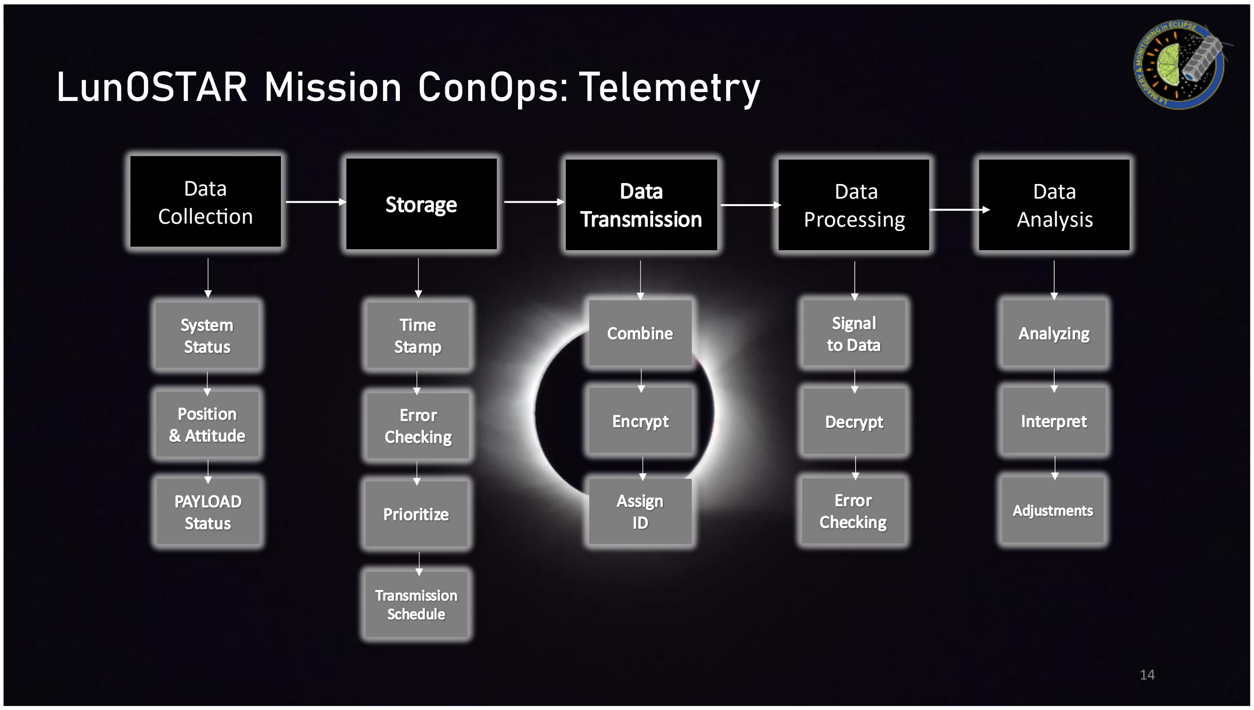


Figure 2: ConOps Telemetry

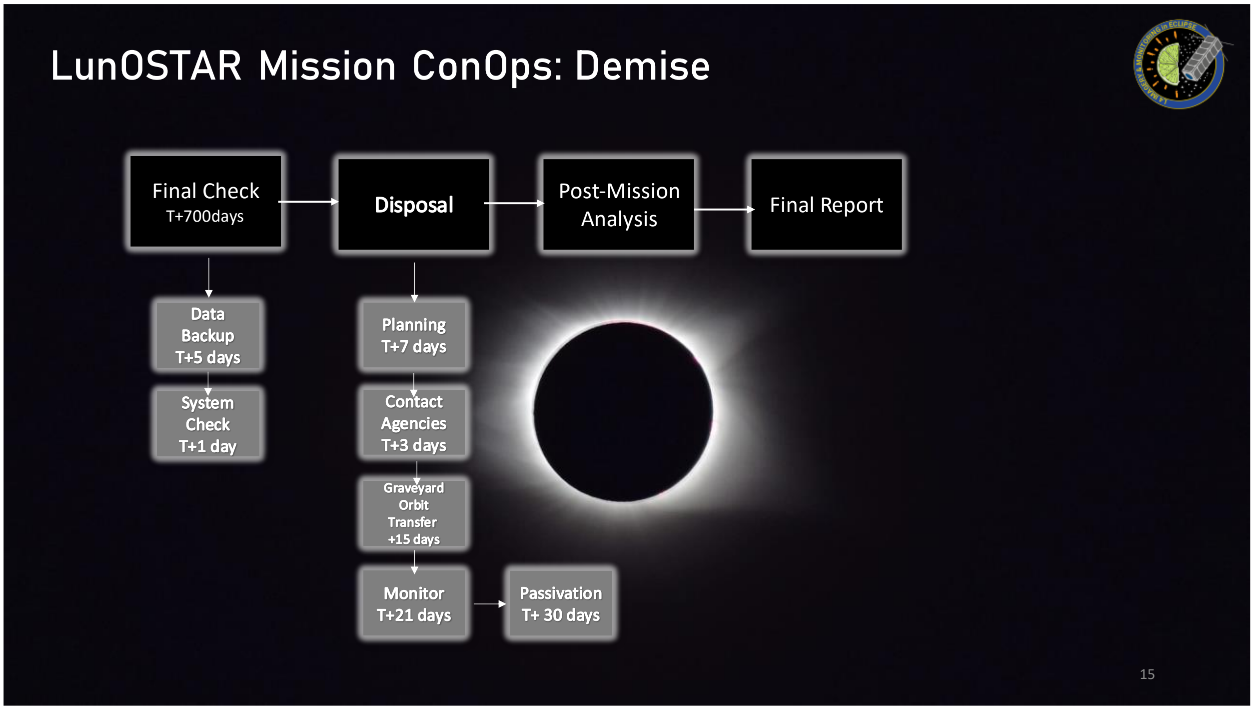


Figure 3: ConOps Demise

C) Mission Success Criteria

Mission Success Criteria	
Orbit Insertion and Maintenance (30%)	Successful deployment of LimeSAT from NASA's Gateway (5%)
	Accurate insertion into the short period orbit (SPO) at L4 Lagrange Point (15%)
	Maintain orbital stability in SPO at L4 for the mission duration of 26 months (about 2 years) (10%)
Instrument Operation and Data Acquisition (40%)	Full deployment and operational functionality of solar panels and other critical subsystems (10%)
	Successful activation and continuous operation of all scientific instruments throughout the mission (15%)
	Collection of high-quality data during solar occultations, specifically targeting the Sun's coronal loops, prominences, and solar flares (15%)
Data Transmission and Analysis (30%)	Reliable data transmission to the satellite constellation orbiting the Moon and subsequent data relay back to Earth (10%)
	Receipt and processing of the transmitted data on Earth without significant losses or corruption (10%)
	Production of high-quality scientific analyses and findings from the data (10%)

Table 2.6 Mission Success Criteria.

D) System Requirements

Requirement Level	Requirement Number	Requirement	Verification Model					Verification Methods	Status
			A	O	D	T	R		
		Administration							
0	1.0	There shall be a budget of one million dollars for design, development, and mission operations.			X			Verify prices of parts with design parameters and determine, if necessary, that parts are within budget.	
		Space System							
0	2.0	There shall be a 12U Satellite (20x20x34.05cm) which contains all necessary equipment and materials to conduct the scientific objectives and support mission operations.		X	X			Compare completed plan with physical measurements to ensure validity.	
1	2.1	There shall be a Bus.			X			The bus will be designed considering structural loads during launch, and any other necessary maneuvers	
2	2.1.1	There shall be an Electrical Power System (EPS) able to provide stable power, ensuring the fulfillment of energy requirements for both spacecraft systems and observatory mission equipment.			X		X	Calculate power requirements of each system and design or choose a preexisting system that meets those power needs	
3	2.1.1.1	The EPS shall include a rechargeable battery capable of storing enough energy to power the operational needs of the spacecraft during periods when solar power generation is not possible.		X		X	X	Test battery capability with reference to batteries datasheet and verify battery capacity and output.	
3	2.1.1.2	The EPS shall include solar panels that can generate sufficient power to meet the operational needs of the spacecraft.			X		X	Verify with solar panel datasheet that sufficient power can be created to keep batteries charged.	
4	2.1.1.2.1	Deployable solar panels shall have independent restraint mechanisms.			X	X		Verify that procured solar panel restraints can restrain solar panel design and test the restraint mechanism.	
3	2.1.1.3	The EPS shall distribute power to all systems compatible with their voltage and current requirements.		X	X	X	X	Test that electrical power system can verify where power is needed and distribute power accordingly and compare to datasheet.	
3	2.1.1.4	The EPS shall regulate power to stable levels that meet the requirements of all systems of the spacecraft.		X		X	X	Test that power supplied to components is steady and the amount of noise is minimal with reference to the datasheet.	
3	2.1.1.5	The EPS shall have a lifespan that exceeds 25-month mission duration, accounting for environmental factors.					X	Compare usage of power system to expected mission duration.	
3	2.1.1.6	The EPS shall have three independent electrical inhibitor deployment switches.			X		X	Procure switches and validate capability of switches with design and reference sheet,	
4	2.1.1.6.1	Rail deployment switches shall have a minimum actuation travel of 1 mm.				X	X	Validate switches travel with reference sheet and physical testing.	
4	2.1.1.6.2	Deployment switches shall reset the payload to pre-launch if cycled within 30 minutes of switches closing.			X	X		Design EPS with disable condition, validate design through testing.	
4	2.1.1.6.3	Deployment switches shall be captive.			X			Design switches to be retained in the CubeSat after launch.	
4	2.1.1.6.4	Force of deployment switches shall not exceed 18N.				X	X	Test switch applied force and validate with reference sheet.	
4	2.1.1.6.5	Deployment switches shall have a contact width of at least 75%.			X		X	Design and choose switches, validate with reference sheet.	
3	2.1.1.7	EPS shall not be energized for a minimum of 30 minutes where hazards existed.			X		X	Design electrical system and validate with EPS reference sheet.	

Requirement Level	Requirement Number	Requirement	Verification Model					Verification Methods	Status
			A	O	D	T	R		
2	2.1.2	There shall be an Environmental System designed to ensure that the satellite systems and payload can withstand the various conditions they will encounter from launch to the end of the mission.	X		X			Structural design will ensure no failure from G loads, protective material around payload will protect from vibrational loads/resonance.	
3	2.1.2.1	Materials and controls will be put into place to manage thermal pressures from the environment.	X		X		X	Thermal simulation will be done and compared to sage temperature allowances for materials used.	
3	2.1.2.2	Cosmic Radiation should be managed to mitigate damage to payload, instruments, and electronics.					X	Compare expected radiation levels to references for sensitive electronics and instruments.	
3	2.1.2.3	Solar Radiation should be managed to mitigate damage to structures, payload, instruments, and electronics.	X		X	X	X	Simulate sunlight exposure time and heating/cooling cycles, Test materials for UV resistance, payload shielded from direct sun exposure.	
3	2.1.2.4	Components of satellite will be able to operate in vacuum conditions without convective cooling.			X	X	X	Design and test cooling system that can mitigate temperatures on electronic and instruments to appropriate levels dependent on their reference sheet.	
3	2.1.2.5	The satellite shall be resistant to electro-magnetic interference.			X	X		Design satellite with protection from EMI in the form of insulation and frequency hopping techniques.	
2	2.1.3	There shall be a Communication system able to provide reliable and secure two-way communication between the spacecraft and Earth-based ground stations.			X	X	X	Choose a communication system capable of transmitting and receiving from cislunar space and test communication system for functionality.	
3	2.1.3.1	The communication system shall provide the essential uplink and downlink data rates for payload data and command/control instructions.			X	X	X	Test uplink and downlink data rates and compare to reference sheet.	
3	2.1.3.2	The communication system shall have adequate antenna coverage to establish a stable signal link between the spacecraft and the ground station.			X		X	Review manufacturer documentation, datasheets, and design documents.	

Requirement Level	Requirement Number	Requirement	Verification Model					Verification Methods	Status
			A	O	D	T	R		
3	2.1.3.3	The communication system shall be operated within X-Band 8-12 GHz in compliance with international regulations.				X	X	Test the system under controlled environment to check both transmit and receive data within the specified X bands.	
3	2.1.3.4	The communication system shall have error detection and correction techniques to ensure the integrity of transmitted and received data.	X			X		Simulate transmission scenarios with injected errors to observe the system's ability to detect and correct them.	
2	2.1.4	There shall be a Computing system able to manage and process data, execute commands, and control spacecraft operations.	X	X	X	X		The computing system will be designed/chosen based off necessary possessing power for spacecraft systems	
3	2.1.4.1	The computing system shall have sufficient processing power to process all spacecraft operations.	X			X		Overload the system with tasks and data to evaluate how it performs under maximum stress.	
3	2.1.4.2	The computing system shall manage all data by collecting, storing, and transmitting it.	X		X	X		Simulate the entire process of data collection, storage, and transmission to ensure seamless integration of all steps.	
3	2.1.4.3	The computing system shall be able to receive and implement software updates transmitted from the ground station.			X	X		Simulate a software update and ability to rollback if update fails or causes issues.	
3	2.1.4.4	The computing system shall incorporate security measures to protect the system against unauthorized access.	X		X		X	Perform vulnerability assessment and security architecture analysis and simulate various threat scenarios to determine how system would respond.	
3	2.1.4.5	The computing system shall uphold precise timekeeping, in synchronization with a universal time standard, for all mission operations and data logging.	X			X		Test synchronization with a universal time standard source.	
3	2.1.4.6	The computing system shall promptly and accurately carry out commands received from the ground station.	X			X		Simulate by transmitting a series of commands from a ground station and observe the system's response and accuracy.	

Requirement Level	Requirement Number	Requirement	Verification Model					Verification Methods	Status
			A	O	D	T	R		
2	2.1.5	There shall be an Attitude Control System.			X	X	X	MATLAB/Simulink	
3	2.1.5.1	The attitude of the spacecraft should be controlled within ± 10 arcseconds during each occultation opportunity.	X					The control system simulation shall be conducted in MATLAB/Simulink	
3	2.1.5.2	The ACS shall provide stable control of the spacecraft.	X		X			MATLAB/Simulink	
2	2.1.6	There shall be a Propulsion system.			X	X	X	Nozzle and system will be designed considering thrust requirements and physics of space propulsion	
3	2.1.6.1	The Propulsion system shall have adequate fuel for the duration of the prescribed mission length, and an additional 5% ΔV for unplanned/recovery maneuvers.	X		X			Maneuvers and attitude control system desaturation shall be simulated using STK/MATLAB/Simulink	
3	2.1.6.2	The Propulsion system shall enable controlled disposal at the end of the mission life.	X		X			The design should account for enough fuel for disposal.	
2	2.1.7	There shall be a Navigation system.		X	X	X	X	Star Tracker/Sun Sensor	
3	2.1.7.1	The Navigation system should consist of an adequate selection of Star Tracker, Horizon Sensor, Gyroscope, Sun Sensor, or others, to accurately determine the spacecraft's orientation and position.			X			Validate each sensor's functionality and integration in simulated conditions.	
2	2.1.8	There shall be a Telemetry and Tracking system able to monitor and determine the spacecraft's location, orientation, and velocity to enable precise orbital and attitude adjustments.			X		X	Star Tracker for location, Sun Sensor for Orientation, velocity with respect to the lunar surface	
3	2.1.8.1	The T&T system shall consistently gather telemetry data from all subsystems and payloads to monitor health and operational status.	X				X	Simulate a scenario where the system collects data from all subsystem and payload as intended.	
3	2.1.8.2	The T&T system shall provide accurate tracking data of the spacecraft's position, and velocity measurements.	X					Simulate software algorithms and methods for tracking to ensure accuracy.	
3	2.1.8.3	The T&T system shall have all telemetry data be time-tagged.	X			X		Simulate by injecting series of events or data into the system and verify that each data point has an associated time stamp.	

Requirement Level	Requirement Number	Requirement	Verification Model					Verification Methods	Status
			A	O	D	T	R		
2	2.1.9	There shall be a Structural system able to provide housing and protection for all subsystems and payloads.			X			Hand calculations will be used to test the structural design.	Completed
3	2.1.9.1	The material of the spacecraft will be an Aluminum alloy			X		X	Material will be inspected to confirm it follows NASA-STD-6016A standards	Completed
4	2.1.9.1.1	The aluminum alloy should be resistant to general corrosion, pitting, intergranular corrosion, and stress corrosion cracking			X	X	X	Material will be inspected to confirm it follows NASA-STD-6016A standards	
3	2.1.9.2	The structural system of the spacecraft will adhere to NASA guidelines and refrain from using any hazardous materials such as Beryllium, cadmium, mercury, silver, or any other such materials.					X	Material will be inspected to confirm it follows NASA-STD-6016A standards	
3	2.1.9.3	Any non-metallic materials used will have a Total Mass Loss (TML) and Collected Volatile Condensable Material (CVCM) equal to or lower than a maximum1.0 percent TML and a maximum 0.10 percent CVCM.					X	Material will be inspected to confirm it follows NASA guidelines based on current outgassing data	
3	2.1.9.4	Geometry and Dimensions shall comply with the standard CubeSat unit system and will comply with the 12U specification.		X	X			20 cm x 20 cm x 34.05 cm, rectangular prism shape	Completed
3	2.1.9.5	The payload should be able to withstand stresses as outlined on the NRDD IDD reference section 4.3.4.					X	The payload will be vibration tested to ensure it can survive shock from ignition	Completed
3	2.1.10	The structural system shall be compatible with NanoRacks requirements.			X		X	Structure will be designed to meet Nanoracks requirements and will be validated with individual part reference sheets.	
4	2.1.10.1	There shall be four rails along the z-axis to interface with slots dimensioned in *Figure 4.1.2-1* in the NRSC IDD.			X		X	Rails will be designed and validated with existing dimensioned diagrams from Nanoracks.	
5	2.1.10.1.1	Edge of rails shall have a radius of .5mm (+/-0.1mm)			X		X	Purchased rails should have dimensions validated through their provided reference sheets.	
5	2.1.10.1.2	Interface rails shall have a length of 366mm (+0.0/ -65.0).			X		X	Purchased rails should have dimensions validated through their provided reference sheets.	
5	2.1.10.1.3	Interface rails shall be contiguous and have no interruption across their length.		X			X	Rails should be purchased containing no interruptions and should be validated by observing the purchased part.	
5	2.1.10.1.4	Interface rails shall be the only mechanical interface between the NRDD and the CubeSat in the lateral axes.			X		X	Design shall be made with reference to Nanoracks deployer reference sheet,	
5	2.1.10.1.5	Interface rails shall extend beyond the +/- z faces of the payload with the exception of load points.			X			Rails should be designed to extend past Z faces.	

Requirement Level	Requirement Number	Requirement	Verification Model					Verification Methods	Status
			A	O	D	T	R		
5	2.1.10.1.6	Interface rails shall have a hardness equal to or greater than hard-anodized aluminum (Rockwell C65-70).				X	X	Rail hardness should be chosen for hardness with respect to their reference sheet and validated for hardness through testing.	
5	2.1.10.1.7	Interface rails shall have a surface roughness of less than or equal to 1.6 μm.					X	Rail surface roughness shall be validated through the rail reference sheet.	
4	2.1.10.2	The structural system shall be dimensioned to comply with *Figure 4.1.2-2* in the NRSC IDD.					X	Ensure compliance with NRSC IDD reference sheet.	
4	2.1.10.3	There shall be load points on the +/- z-faces.			X			Load point existence shall be validated through design of satellite.	
5	2.1.10.3.1	Load points shall be coplanar with end of tabs.			X			Load point location shall be validated through the design of satellite.	
5	2.1.10.3.2	Load points shall envelop areas designated in *Figure 4.1.2-1* of NRDD IDD.			X		X	Load point design shall be validated with NRDD IDD reference sheet.	
5	2.1.10.3.3	Load points shall have a hardness equal to or greater than hard-anodized aluminum (Rockwell C65-70).				X	X	Load point hardness should be chosen with respect to their reference sheet and validated for hardness through testing.	
5	2.1.10.3.4	Load points shall have a surface roughness of less than or equal to 1.6 μm.					X	Load point roughness shall be validated through the load point reference sheet.	
2	2.1.11	The CubeSat shall have mass requirements complying with the NRDD IDD document.			X	X	X	Satellite will be designed and validated through testing and compliance with the NRDD IDD reference sheet.	
3	2.1.11.1	The center of mass shall be located within the geometric center within tolerances: X: (+/- 5cm) Y: (+/- 3cm) Z: (+/- 8cm).			X	X	X	Satellite will be designed to be within center of mass requirements and validated through testing and compliance with Nanoracks reference sheet.	
3	2.1.11.2	The maximum mass of the satellite shall be 12 kg.			X	X	X	Satellite will be designed to be below weight limit and validated through testing and compliance with the NRDD IDD reference sheet.	
1	2.2	There shall be an Observatory Payload.			X			Observatory will use Near UV imaging techniques	
2	2.2.1	There shall be a Telescopic Array of 2 co-aligned telescopes to view the solar corona, consisting of Optics Assemblies and Focal Plane Modules (FPM).			X			The design will include two observational telescopes.	
3	2.2.1.1	The Optics Assembly shall consist of focusing lenses which transfer optical information to the FPM.			X		X	Verify type of data transfer is possible with telescope being used through reference sheet.	

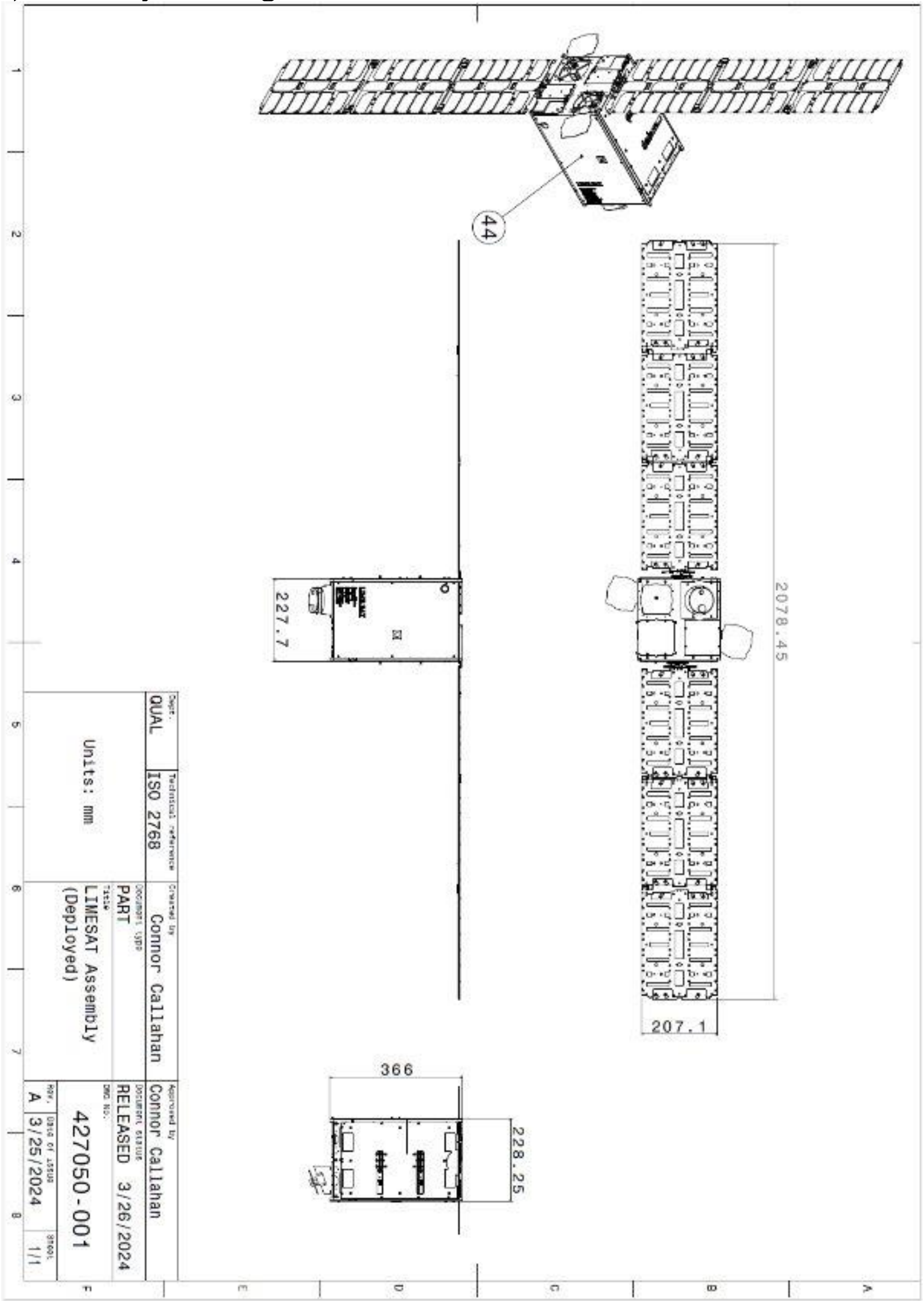
Requirement Level	Requirement Number	Requirement	Verification Model					Verification Methods	Status
			A	O	D	T	R		
3	2.2.1.2	The Focal Plane Module shall consist of a Near Ultra-Violet (NUV) sensitive CCD capable of interfacing with the data transmission hardware.			X	X	X	Verify data can be collected in NUV using reference sheet compared to test and that data can be transferred with chosen hardware.	
2	2.2.2	There may be a deployable mast to accommodate additional focal length/parallax.			X			Mast will be designed with proper curvature for accurate imaging, design and testing at a ground facility will verify results	
2	2.2.3	The observatory payload shall have the capability to measure over the NUV range of 300-400 nm.			X	X	X	Choose telescope with given capabilities with reference to a datasheet and test for accuracy.	
2	2.2.4	The observatory shall have an angular resolution with half power diameter <3 arcseconds.			X	X	X	Choose telescope with given capabilities with reference to a datasheet and test for accuracy.	
	3.0	Ground System							
0	3.0	Pre-Flight Handling			X			A storage unit meeting the humidity, temperature, and sterilization requirements will protect the payload. Design will also consider launch loads	
1	3.1	The Satellite and components shall not be subjected to humidity greater than 70% or less than 30% during construction, storage, or transportation.		X	X			Preexisting facilities with humidity and temperature requirements will be used, or one will be constructed if necessary	
1	3.2	The Satellite and components shall be able to withstand temperatures as outline by the ranges seen in the NRDD IDD reference, Table 4.3.6-1.		X	X			Preexisting facilities with humidity and temperature requirements will be used, or one will be constructed if necessary	
1	3.3	The Satellite shall be sterilized at determined intervals during construction and maintained in an ISO Class 8 clean room during all phases of the mission prior to launcher integration.		X	X			Regularly inspect and test post-sterilization to confirm the absence of contaminants.	

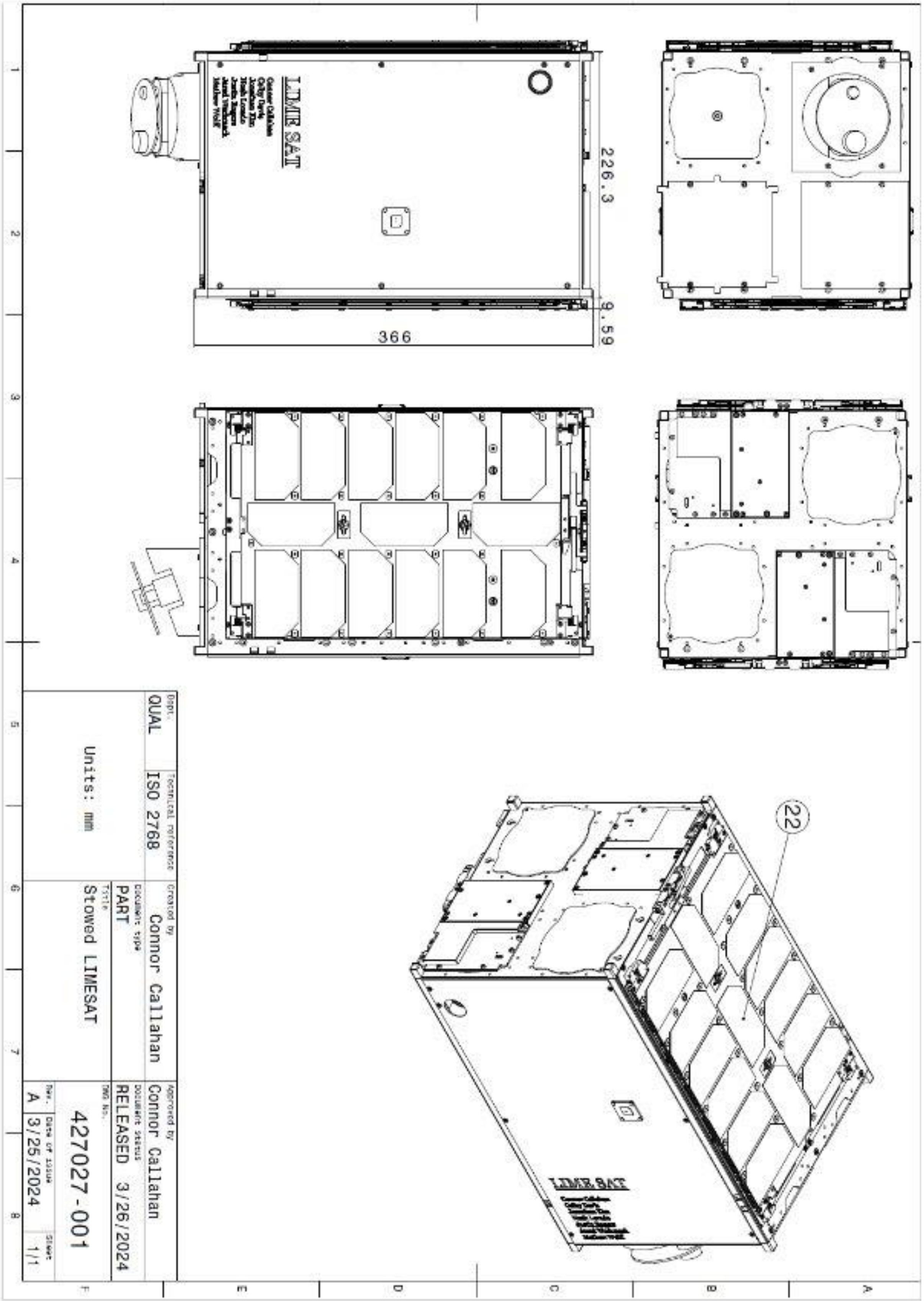
Requirement Level	Requirement Number	Requirement	Verification Model					Verification Methods	Status
			A	O	D	T	R		
1	3.4	Data Acquisition systems shall maintain compatibility with all relevant Communication Systems Requirements in 2.1.1.3	X		X	X		Simulate scenarios by injecting data into the system.	
		Validation and Testing							
0	4.0	All components of satellite shall be compared to physical plans for validation and tested for functionality.		X	X	X		Components will be measured to verify design is correct	
1	4.1	Measurement of satellite components' dimensions shall be compared to planned dimensions.		X	X		X	Use CAD model with reference to datasheets on various components.	
1	4.2	Satellite shall be tested for functionality of the electrical power system.		X		X	X	Tests will be done by running all systems simultaneously to ensure the power source can withstand the load placed on it as designed.	
2	4.2.1	Solar cells will be tested before launch to ensure adequate generation of power for satellite functions.	X				X	STK	
2	4.2.2	The EPS shall be tested to ensure distribution of power to appropriate instruments and verify the correct amount of power is being sent to specific satellite components.		X		X		Required power for every instrument/ component will be demanded and then feedback will be recorded.	
1	4.3	Optical instruments shall be tested for functionality before launching the satellite.		X		X		Telescopes and other instruments will be placed in an environment simulating mission conditions	
2	4.3.1	Main observing optical instrument shall be tested to verify an angular resolution with half-power diameter <3 arcseconds can be achieved.		X	X	X	X	Validation of physical test of optical instrument chosen with datasheet for optical instrument to ensure proper functionality.	
2	4.3.2	Main observing optical instrument shall be tested to verify solar radiation measurements can be made in Near UV range of 300-400nm.			X		X	Measurements will be conducted and analyzed in a test to confirm near UV capabilities	

Requirement Level	Requirement Number	Requirement	Verification Model		Verification Methods				Status
			A	O	D	T	R		
1	4.4	All elements of satellite will be tested to comply with environmental standards.	X	X		X		Satellite will be tested to withstand thermal stresses, radiation, attitude control, tracking, and observation of solar corona	
2	4.4.1	The satellite's thermal protection and all components of exterior faces shall be able to withstand a temperature range of −250 to 250 degrees Fahrenheit.	X		X		X	Using thermal simulation, a prepared CAD model of the satellite, and datasheets of components.	
2	4.4.2	The satellite shall be able to withstand material stresses due to thermal shock between lit and shaded regions.	X		X		X	Using thermal simulation, a prepared CAD model of the satellite, and datasheets of components.	
1	4.5	The propulsion system shall be tested to ensure accuracy of commanded thrust and impulse.	X		X	X	X	MATLAB Simulink along with reference to propulsion system datasheet through tests shall be used.	
1	4.6	The attitude system shall be tested for functionality and accuracy of controls within ± 10 arcseconds.	X		X		X	MATLAB Simulink along with reference to propulsion system datasheet shall be used.	
		Operations							
0	5.0	There shall be procedures and timelines for every section of the operation			X				
1	5.1	There shall be pre-flight procedures and timelines.							
2	5.1.1	The Satellite shall undergo a charging cycle to optimize capacity upon deployment and lifetime cyclability before delivery.		X		X	X	Battery cycle testing shall be conducted, and data sheet referenced.	
2	5.1.2	The Satellite shall be stored in an ISO Class 8 clean room before delivery.					X	ISO Class 8 clean room will ensure sterilization, observation of components will check for unwanted contamination	
2	5.1.3	The Satellite shall be made 'safe' and flight-ready by means of "Remove Before Flight" safety features before delivery.		X	X		X	Inspectors shall verify that RBF implements are in place.	

Requirement Level	Requirement Number	Requirement	Verification Model					Verification Methods	Status
			A	O	D	T	R		
2	5.1.4	The Satellite shall undergo a final flight readiness inspection to be signed by the Project Manager(s), Principal Investigator(s), and Technical Authority.		X			X	Inspectors shall validate dimensions, the engagement of any single use deployment mechanisms, power systems, state of charge, etc.	
1	5.2	Deployment			X				
2	5.2.1	The satellite shall be deployed from Gateway orbital science station at the cislunar L2 LaGrange point.			X			The design shall comply with the Nanoracks dimension specifications and launch requirements.	
3	5.2.1.1	The deployment readiness date shall be NLT 31 December 2026			X		X	Frequent progress checks and effective planning will ensure the deadline is made	
3	5.2.1.2	The Mission Elapsed Time (MET) shall begin when the spacecraft is deployed from Gateway.			X			The release of a depression switch shall initiate the MET Timer	
3	5.2.1.3	The Satellite shall enable primary power to the Bus NET T+ 00:30:00 from the MET.				X		The Boot-On command shall be sent 30 minutes after the MET begins	
1	5.3	Station Keeping	X		X			Regularly scheduled maintenance checks will be conducted to ensure station is performing as planned	
2	5.3.1	The Satellite's orbital period around L4 shall be near the orbital period of the Moon around the Earth, within a tolerance TBD.	X		X			The orbit shall be validated with STK simulation/MATLAB/Simulink	
1	5.4	End-of-Life			X			Deorbiting the satellite into a graveyard orbit will ensure safe End-of-Life is responsible	
2	5.4.1	The Satellite should be decommissioned in a responsible and timely manner at the mission conclusion.	X		X			TBR in accordance with NASA NID 8715.129	

E) Assembly Drafting





LIMR SAT
226.3
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Dept.
QUAL
Technical reference
ISO 2768
Created by
Connor Callahan
Approved by
Connor Callahan
Document type
PART
Document status
RELEASED 3/26/2024
Title
Stowed LIMESAT
DWG No.
427027-001
Units: mm
Rev.
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Date of issue
3/25/2024
Sheet
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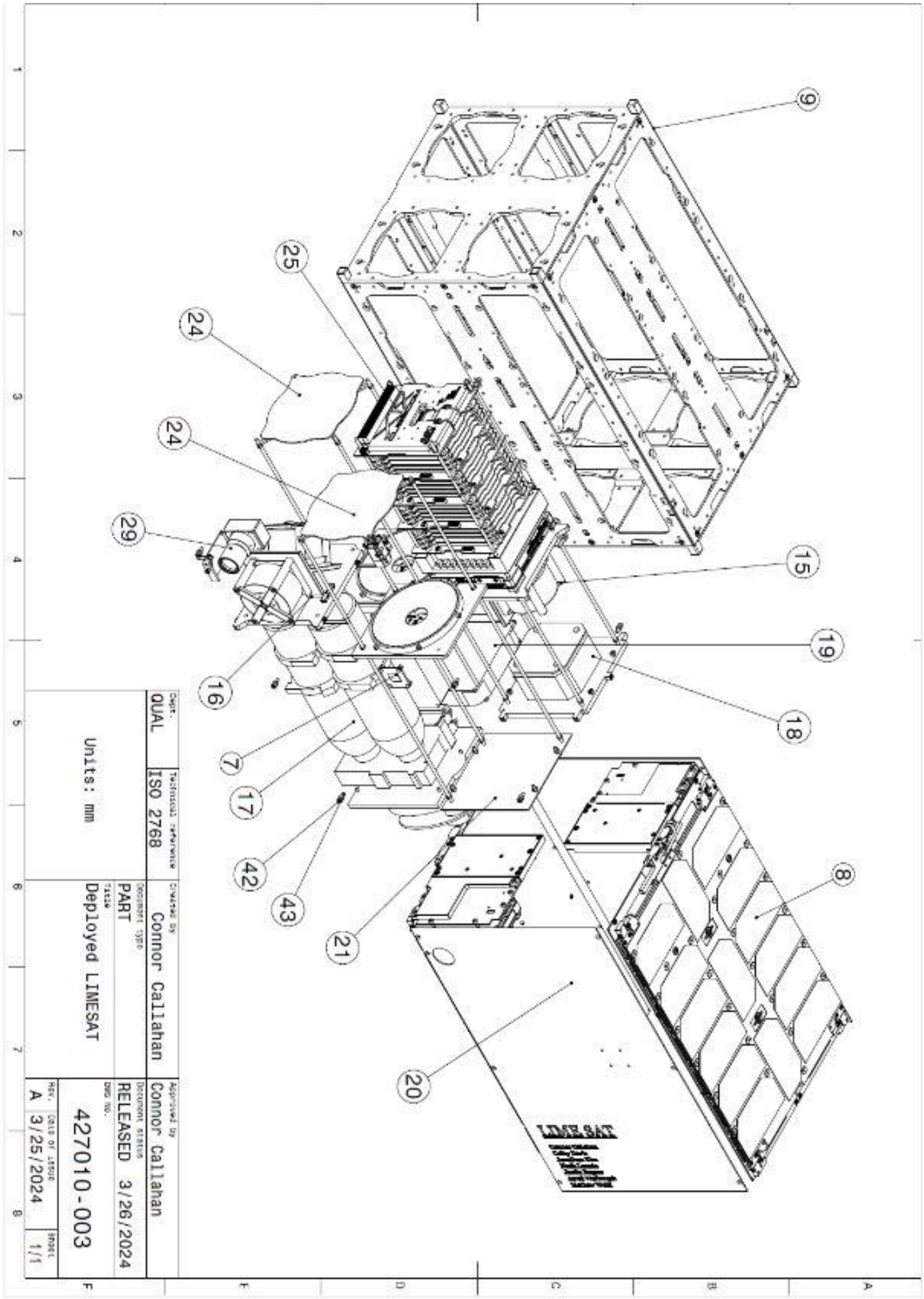
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427010-003
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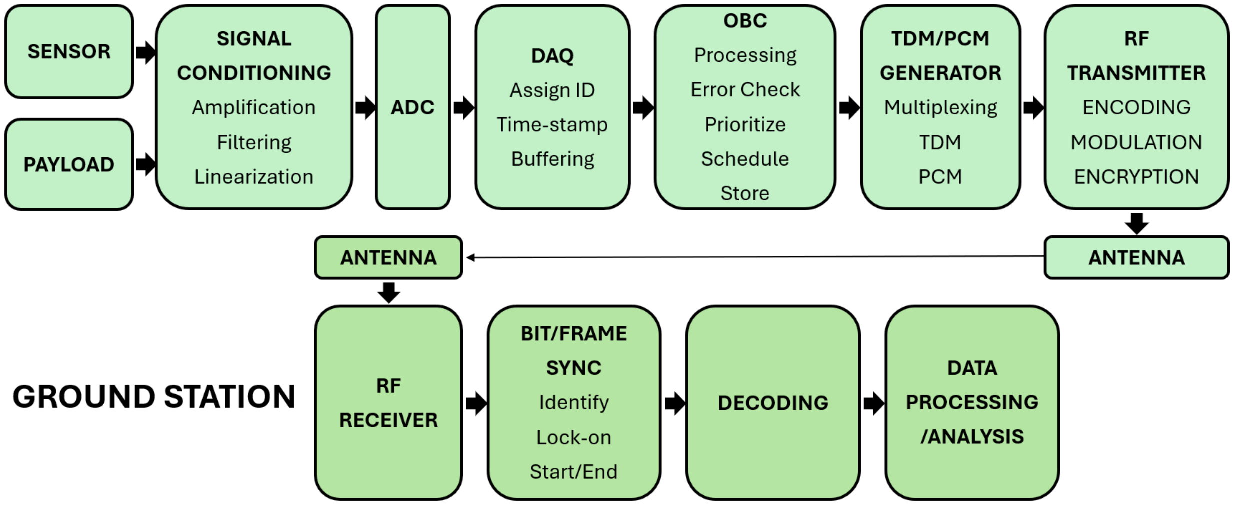
Item No.	Part No.	Description	Quantity	Material	Source
1	427001-001	Reaction Wheel -30 mNm s	4	Pre-Fab	Rocket Lab
2	427003-001	Primary Mirror	2	Glass	Syntec
3	427003-002	Secondary Mirror	2	Glass	Syntec
4	427005-001	OBC	1	Pre-Fab	Endurosat
5	427006-001	EPS	1	Pre-Fab	Endurosat
6	427007-001	CubeStar Star Tracker	2	Pre-Fab	CubeSpace
7	427008-001	X-Band Antenna Patch	2	Pre-Fab	ClydeSpace
8	427009-001	NanoPower TSP Solar Array	2	Pre-Fab	GOM Space
9	427011-001	Endurosat 12U Structure	1	Pre-Fab	Endurosat
10	427012-001	Optimus-80 Battery	2	Pre-Fab	Clyde Space
11	427013-001	X-band Transmitter	1	Pre-Fab	Clyde Space
12	427016-001	Ball Screw Motor	2	Pre-Fab	Assembly
13	427017-001	Solar Shade Assembly	2	Al 6082	In- House
14	427018-001	Star Tracker Bracket	2	Al 6082	In- House
15	427019-001	RCW Assembly X-Y	1	Al 6082	Assembly
16	427019-002	RCW Assembly Z-XZ	1	Al 6082	Assembly
17	427022-001	Spaceware Nano L Thruster	1	Pre-Fab	Spaceware
18	427023-001	ARMA ACS Module	1	Pre-Fab	Aurora
19	427024-001	MEPSI Booster Jet	1	Pre-Fab	VACCO
20	427025-001	Shielding (sides)	2	Al 6082	In-House
21	427026-001	Shielding (back)	1	Al 6082	In-House
22	427027-001	LimeSAT Assembly (stowed)	1	Pre-Fab	Assembly
23	427028-001	Thruster Assembly	1	Pre-Fab	Assembly
24	427029-001	Mirror Assembly	1	Pre-Fab	Assembly
25	427030-001	Avionics Bus	1	Pre-Fab	Assembly
26	427031-001	Bolt M3 x 7.5mm	5	Pre-Fab	McMaster-Carr
27	427032-001	Bolt M2 x10mm	5	Pre-Fab	McMaster-Carr
28	427033-001	Alvium USB90	2	Pre-Fab	Allied Vision
29	427034-001	Star Tracker Assembly	2	Pre-Fab	Assembly
30	427035-001	Nano-L Thruster Head	1	Pre-Fab	Spaceware
31	427036-001	Nano-L Propellat Tank Adaptor	1	Pre-Fab	Spaceware
32	427037-001	Nano-L Propellant Tank	1	Pre-Fab	Spaceware
33	427038-001	Nano-L Propellant Management System	1	Pre-Fab	Spaceware
34	427039-001	Nano-L Thruster Control Unit	1	Pre-Fab	Spaceware
35	427050-001	Nano-L Propellant Tank Bracket	1	Pre-Fab	Spaceware
36	427029-005	Secondary Mirror Housing	2	Pre-Fab	Assembly
37	427029-006	CMOS Body	2	Pre-Fab	Allied Vision
38	427029-006	Threaded Rod M3x343	10	Pre-Fab	McMaster-Carr
39	427029-007	Primary Mirror Housing	2	Pre-Fab	Assembly
40	427051-001	M2 Nut	8	Pre-Fab	McMaster-Carr
41	427052-001	M2x5 Screw	8	Pre-Fab	McMaster-Carr
42	427053-001	M2.5x16 Screw	30	Pre-Fab	McMaster-Carr
43	427054-001	M2.5 Nut	30	Pre-Fab	McMaster-Carr
44	427050-001	LimeSAT Assembly (deployed)	1	Composite	Assembly
45	427010-003	LimeSAT Assembly (stowed, expanded)	1	Composite	Assembly

F) Data Handling



NUV Image Data Size: 4MB per Image			
	# of Images	**File Size (MB)**	**File Size (GB)**
Low Estimate	180	720	0.72
High Estimate	360	1,440	1.44

G) Resumes

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Port Orange, FL 32128
(213) 268-0173
Kim6fe@my.erau.edu

Jonathan Kim

As a dedicated Aerospace Engineering graduate, I possess a solid foundation in the principles of aerospace systems and technologies, complemented by hands-on experience in spacecraft design and simulation. My academic and project work has equipped me with the skills necessary to contribute effectively to CubeSat development projects, from conceptual design through to launch and operation phases.

Through participation in this team, I aim to deepen my expertise in small satellite systems, contribute to groundbreaking missions, and advance the frontiers of space exploration.

- MATLAB
- Python
- Catia
- AutoCAD
- FEMAP NASTRAN
- STK
- ANSYS

- Electronics
- Materials
- Controller Design
- Statistics
- Accounting
- QuickBooks
- Peachtree

2020 – 2024, Education

Embry-Riddle Aeronautical University
B.S. Aerospace Engineering, Astronautics

GPA: Fundamental 3.885, Engineering 3.339

During my college years pursuing a Bachelor of Science in Aerospace Engineering, I consistently achieved high academic standards, earning a place on the Dean's List for all semesters. Additionally, I was recognized with two Honor Roll distinctions, underscoring my commitment to excellence and dedication to my studies. These accolades reflect my ability to excel in a rigorous academic environment and my persistence in maintaining superior performance throughout my university career.

2021 – Present, Work Experience

Accounting Associate
2.7 August Apparel Inc.

During my academic years, I gained valuable professional experience working as a part-time Accounting Associate. In this role, I effectively managed responsibilities remotely by connecting to the company server from home.
My primary duties included meticulous bookkeeping and running payroll processes. This position not only enhanced my organizational and numerical skills but also demonstrated my ability to manage critical financial operations efficiently, ensuring accuracy and compliance in a dynamic work environment.

Jared Warmack

1479 Shady Place Apt 3311| Daytona Beach, FL 32114
jared.warmack@gmail.com | 229-200-7094

EDUCATION

Embry-Riddle Aeronautical University – Daytona Beach, FL — Spring 2024
Bachelor of Science, Astronomical Aerospace Engineering (ABET); Minor in Space Studies

Valdosta State University - Valdosta, GA — Spring 2022
Associates of Arts, Astronomy and Astrophysics

WORK EXPERIENCE

TotalEnergies (SAFT America) — Production Application Engineer — 2018-2021

- Bespoke battery design in the telecom and standby power markets for such customers as Verizon, AT&T, etc.
- Performed material analysis for the U.S. Dept. of the Air Force.
- Conducted battery testing (destructive and non-destructive).
- Determined failure modes and performed root cause analyses and extensive performance testing on affected products. Results saved SAFT hundreds of thousands of dollars in erroneous recalls.
- Implemented parametric design changes for aircraft battery systems for such customers as Bombardier, Boeing, Cessna, Bell, etc.
- AS9100, ISO9001 certified, ITAR work environment

ADAMUS (ASPROS Lab) – Embry-Riddle — Propulsion Engineer — 2022 – 2023

- Designed and implemented an electronically controlled pneumatic propulsion system for two spacecraft research simulators: Luna and Celeste.
- Propulsion system included air-bearings, solenoid actuated thrusters, radio communication and computer vision systems for a 3 DOF controllable system.

EMBRY-RIDDLE CAPSTONE

LunOSTAR – Embry-Riddle — GNC and Integration Engineer and Safety Officer — 2023 – present

- Developed a 12U CubeSat intended for long-duration missions in a short-period orbit near cislunar space.
- GNC - calculated orbit insertion solutions to maximize fuel efficiency and minimize high-thrust maneuvers, while maximizing mission-critical time on station.
- Integration - ensured the CubeSat was compliant with NanoRacks and NASA CubeSat guidelines necessary for deployment.
- Safety - Maintained compliance to regulatory safety standards from NASA and the FAA, as well as commercial partners. Informed design decisions based on relevant safety data.

SKILLS AND PERSONAL PROJECTS

Hi-Fi Audio Refurbishment

- Rebuild and restore cassette decks, Walkmans and amplifiers, including transformer circuitry and tape carrier assemblies; used oscilloscopes and wave generators to set biasing and verify frequency response, etc. Built home stereo audio amplifiers for personal and professional use.

- MATLAB
- FEMAP NASTRAN
- STK
- ANSYS
- Inventor
- SolidWorks
- Creo Parametric
- Catia
- AutoCAD
- Composites Layup
- Controller Design
- Engineering Integration
- Drafting
- RCA Investigation
- MS365
- Electronics
- Mechanics
- Carpentry
- Product Design
- Documentation
- Audio

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OBJECTIVE

Motivated aerospace engineering senior seeking an entry-level position to apply academic knowledge, hands-on experience, and a passion for innovation to contribute to the development of cutting-edge aerospace technologies and solutions.

EDUCATION

Embry-Riddle Aeronautical University — Daytona Beach, FL
Aerospace Engineering — Expected Graduation May 2024
Area of Concentration: Astronautics

Cumulative GPA: 2.9	Year 1: 3.16	Year 2/3: 2.0 (Health Complications)
	Year 4: 3.16	Year 5: 3.18

PROJECT EXPERIENCE

LunOSTAR CubeSat Design: Member of a 6-person team task with designing a 12U CubeSat that will be launched from the space station Gateway at LaGrange point L2 and travel to L4 behind the moon where it will observe a sliver of the sun called the corona. The CubeSat is modeled in CAD using real parts. The structural stress, thermal analysis, and vibration analysis simulated in ANSIS, and the orbit simulated in STK.

Projectile Laucher: Member of a 6-person team task with designing and constructing a device that can launch a tennis ball in a straight line over a certain distance. Created engineering drawings of the launcher, researched parts under a certain budget and then construed and tested the launcher.

Nastran I, II, & III: Completed finite element analysis (FEA), modeling two beams, and an aircraft wing box utilizing FEMAP and found the strain and stress along all three axes of the models.

EMPLOYMENT HISTORY

- Galaxy Hill Farm — Aug 2019 – Aug 2022
  Pomfret, Vermont
- Five Guys Burgers — June 2017 – May 2019
  Lebanon, NH 03784

SKILLS

Engineering Software:	MATLAB, Catia, Shapr3D, FEMAP, Polycam, ANSIS
Office Software:	Microsoft Word, Excel, PowerPoint, Teams, Project
Technical:	3D Printing, Soldering, Lathing, Wood Working
Personal Skills:	Teamwork, Responsible, Flexible, Positive Attitude

AWARDS ACHIEVEMENTS & MEMBERSHIPS

- Eagle Scout — October 2017
- Member of the National Honor Society — 2017 – 2019
- Lebanon High School Student of the Month — April 2019
- Honor or High Honor Roll at Lebanon High School — 2015 – 2019
- Football Sportsmanship Award (2017) and Most Improved Player — 2018

VOLUNTEER & SERVICE WORK

Christ Redeemer Church — Lebanon, NH
Missions Trips
- Hurricane Sandy Relief: Served to rebuild homes. — 2012
- Newark, NJ: Help in an inner-city school with tutoring, mentoring, clean- up, and maintenance projects. — 2015 – 2017

Boy Scout Troop 279 — Lebanon, NH
- Assistant Scout Master — 2016 – 2017
- Scout Master — 2017 – 2019
- Fed homeless with community dinners, cleaned up various public locations.
- Eagle Scout Project: built an outdoor trail and classroom for a local elementary school.

Connor Callahan

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EDUCATION

Embry-Riddle Aeronautical University — Daytona Beach, FL
Bachelor of Science, Aerospace Engineering — May 2024
Area of Concentration: Astronautics
Minor, Business Administration
GPA 3.6/4.0

PROJECT EXPERIENCE

Design Project – CubeSat Project
Leading a 6-person team to design, budget and create a manufacturing plan to build and launch a satellite for a given mission objective. Project scope was design stage through contacting potential suppliers for observation, propulsion, and electronic systems.

Research Project – Novel UAM Vehicle
Through the Eagle Flight Research Center, under contract of a private company, researched feasibility of a novel propulsion system for a UAM vehicle. Using previous literature, created a parameterized math model to represent the system and confirmed the math model results with CFD modeling to determine feasibility.

MatLab Coding Project - Hurricane Path Prediction
Wrote MatLab code to organize one hundred years of hurricane data and create a user interface to input and alter data. Postulated and designed a mathematical method to predict the path of a hurricane based on historical norms.

WORK EXPERIENCE

Undergraduate Researcher, Eagle Flight Research Center, Daytona Beach, FL - Summer 2023, Fall 2023, Spring 2024
- Collaborated with a graduate student on creating and testing a compact, hybrid, aircraft power plant.
- Encountered and solved engineering problems focusing on testing of power plant and data collection such as designing a test article for a motor torque test along with necessary procedural and safety documentation.
- Contracted by outside company, determined feasibility of novel propulsion system and UAM vehicle.
- Solidified understanding of CAD software, CFD software and learned more about electrical wiring, metalworking, control software, system integration, and testing.

Engineering Tutor, Embry-Riddle Aeronautical University, Daytona Beach, FL - Fall 2022, Spring 2023
- Tutored students in engineering topics such as Statics, Dynamics, and Solid Mechanics and helped them understand basic physics, mathematical, and engineering concepts.

Meeting Consultant, R and T Wark, Orlando, FL - Summer 2017, 2018, and 2019
- Organized and distributed materials for large corporate conferences.
- Employed organizational skills, with an emphasis on meeting non-negotiable deadlines.

VOLUNTEER EXPERIENCE

Boy Scouts of America Eagle Scout Project – Footwear Pantry and Donation Drive
- Worked with local church and area Christian Service Center to establish a reliable, sustainable source of shoes for those in need. Organized and conducted collection efforts, including communications and mobilization of congregation, and led Boy Scout troop in constructing and installing storage for shoes.

SKILLS

Engineering Software:	CATIA V5, MATLAB, Femap, Ansys Fluent
Office Software:	Microsoft Word, Excel, PowerPoint
Technical:	Drafting, Metalworking, Wiring
Certifications:	CATIA V5 – Part Design Associate, Assembly Design Associate, Surface Design Associate, Mechanical Designer, and Mechanical Surface Designer

AWARDS

ERAU Presidential Scholarship, Fall 2019-Spring 2024
ERAU Dean's List, Fall 2019, Spring 2021, Spring 2022, Fall 2022, Spring 2023, Fall 2023
Boy Scouts of America Eagle Scout, 2019

Matthew Wolff

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EDUCATION

EMBRY RIDDLE AERONAUTICAL UNIVERISTY DAYTONA BEACH, FL

Bachelor of Science, *Aerospace Engineering, Concentration: Astronautics* *Anticipated Graduation May 2024*

RELEVANT COURSEWORK

Spacecraft Attitude Dynamics. Three-dimensional rigid-body Kinematics. Effects of energy dissipation and momentum-based spacecraft. Effects of gravity gradient, solar radiation pressure, atmospheric drag and magnetic torque on spacecraft attitude.

Space Mechanics. Vector-based solution for the position and time problem (Kepler's equations) used to analyze orbits, satellite launch, orbit transfer, interplanetary trajectories, and interception and rendezvous. Using three-dimensional vector dynamics to study the motion and stability of rigid and semi-rigid spacecraft to control orientation.

Aerospace Engineering Materials, *Aerospace Structures I* and *Aerospace Structures II*. Structure, properties and materials used in the aerospace industry and the methods of stress analysis of determinate and indeterminate aerospace structures under axial, bending, and torsion loads. Finite element modeling and computer-aided analysis of space structures, non-idealized structures, three-dimensional beam bending and plate buckling.

Incompressible Aerodynamics and *Compressible Aerodynamics* – Conservation Equations and fundamental fluid dynamic principles, governing equations for compressible flow, normal shock waves, one-dimensional flow with heat addition and friction.

Robotics Technologies for Unmanned Systems. The study of sensors, actuators, and computer control such as fly-by-wire, teleoperation, and autonomy using range finding systems, position determination systems, optical sensors, inertial guidance systems, servomotors, and safety systems, and the construction of a microprocessor-based robot.

Instrumentation and Data Acquisition. Theoretical and applied topics related to instrumentation, data acquisition, and hardware interfacing with mechatronic systems.

Space Propulsion. Basic principles of liquid, solid, and electric propulsion, comparing the performance of each in similar circumstances. Analysis of flight performance for single and multi-stage vehicles, thermo-chemistry of the combustion process, and performance enhancements of nuclear rockets.

PROJECT EXPERIENCE

AEROSPACE PRELIMINARY DESIGN PROJECT – PROJECT POLARMAP

The preliminary design of three space vehicles (rover, lander, and orbiter) to survey, obtain and analyze samples from polar ice caps on Mars to assess the feasibility of using solely Martian resources to harbor life.

ERFSEDS PROJECT PATHFINDER

Embry-Riddle Future Space Explorers and Developers Society (ERFSEDS) team to design and construct a high power, high-altitude rocket from scratch to enter and launch at the FAR 1030 Rocketry Competition, Mojave, CA.

AEROSPACE DETAIL DESIGN PROJECT – PROJECT LunOSTAR

The design of a 12U CubeSat intended for long-duration missions near cislunar space. Assisted with development of Mechanical and Structural assembly of CubeSat.

SKILLS: Solidworks (Advanced) MatLab (Advanced), Catatia, Systems Tool Kit (STK), Microsoft Office Suite

ORGANIZATIONS

Embry-Riddle Future Space Explorers and Developers Society (ERFSEDS)
National Association of Rocketry
American Institute of Astronautics and Aeronautics (AIAA)

Colby Richard Davis

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OBJECTIVE

Seeking an Aerospace Engineering position to develop career with a focus in spacecraft systems.

PROJECT EXPERIENCE

CubeSat Design – Led the comprehensive design of 12U CubeSat, conducting the trajectory analysis on **STK,** ACS performed with **SIMULINK**, vibration analysis on **SolidWorks** and thermal on **Thermal Desktop**, and designed electronic schematics all from off the shelf components. Developed **WBS**, **CONOPS**, and **REQUIREMENTS**.

Attitude Control System Project – Used equations of motion to create a state-space model in **MATLAB** for an ACS to detumble and orientate a satellite while also displaying its course in a 3D projection.

Variable Pitch Propellor– Developed and built small prototype coaxial variable pitch propellor for mars exploration. Using Arduino, motor controllers, and a state-space model to automate takeoff and landing while reaching the desired forces to do so on the conditions on mars.

3D Modeling & Printing – Designed models for **assembly**, while managing **tolerances** and optimizing printability through iterative refinement ensuring seamless integration of components and precise functionality.

EDUCATION

May 2024	**Embry-Riddle Aeronautical University** Bachelor of Science in Aerospace Engineering *Area of Concentration: Astronautics*	Daytona Beach, FL

LAB EXPERIENCE

Servo Control – Using Simulink models to do servo position and speed control, implementing PI, PIV, and other types of controllers as well as filters such as low pass. Comparing simulations vs implementation to look at step or ramp response properties such as steady-state error or sensor noise.

Strain Gage Usage and Installation – Installed strain gages and measured surface strain along an aluminum beam and a Nomex honeycomb beam reinforced with CFRP skins and compared using various loadings under different load types.

Vibration Testing and Resonance Frequencies – Using an electrodynamic shaker along with a digital stroboscope, various vibration frequencies were applied to three members where different node locations appeared at resonance.

ERPL (ERAU Rocket Propulsion Lab) – Design and hands on testing of hybrid and solid rocket motors for performance testing

Certifications

STK Level 1: Mission modeling, Simulation, Analysis and Visualization

SKILLS

Python, MATLAB, CATIA, OFFICE 365, Solidworks, FORTRAN, STK, Simulink, Nastran, FEMAP, Linux, NX, FEA, Thermal Desktop, C++