TRITONCUBED AT UCSD RESPONSE TO 2018 CUBESAT LAUNCH INITIATIVE

Proposal Contact

Name:	Jeffrey Mankey
Title:	Project Lead
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Triton Lunar Communicator (TLC)

Satellite Relay Communications Network for the Moon

CubeSat Mission Parameters								
Mission Name	Mass	Cube Size		Desired Orbit	Acceptable Orbit Range	400 km @ 51.6 degree incl. Acceptable – Yes or No	Readiness Date	Desired Mission Life
TritonComm1	2.4 kg	2U	Altitude	350 km	50 km	Yes	2022	2-3 years
			Inclination	90º	10º	Yes		

CubeSat Project Details						
Focus Area(s) (e.g., science, technology, education)	Student Involvement Yes or No	NASA Funding		Sponsoring Organization(s)	Collaborating Organization(s)	
		Yes or No	Organization		List	International – Yes or No
Science	Yes	Yes	California Space Grant Consortium	None	None	None

Points of Contact

Name: Jeffrey Mankey
Title: Project Lead
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Email: jmankey@eng.ucsd.edu

Name: Annalisa Vilaysing
Title: Project Manager
Phone: 619-530-9063
Email: vilaysing.a@gmail.com

Abstract

TLC-1 is a demonstration and proof-of-concept of a CubeSat-based Lunar Communications Relay Network. The mission of the relay communication network is to support lunar operations planned by NASA, including the Lunar Gateway. TLC-1 would be launched in 2022 along with a planned lunar mission, and would provide a communication relay during the initial phase of Lunar Gateway operations.

Once successful, additional network elements would be launched to provide full lunar coverage. This would be completed in the same timeframe that the Gateway would be operational, and would provide a vital communications network between the Gateway and the surface of the moon when the Gateway is not within a direct line of sight.

TLC-1 will be a 2U CubeSat in full compliance with CubeSat Design Specifications and testing requirements[1]. It will ideally operate in a polar orbit of approximately 400 km; however, alternative orbits are acceptable. In accordance with the Space Frequency Coordination Group standards[2], TLC-1 will offer a 15 GHz satellite relay link and 2.4 GHz surface support.

Project Details

1.0 INTRODUCTION AND BACKGROUND

Respondent organization. The collective group responding to the 2018 CubeSat Launch Initiative (CSLI) Announcement is known as, TritonCubed, a student organization located at the University of California, San Diego (UCSD). TritonCubed is a group of undergraduate students with graduate student advisors representing a range of disciplines and skill levels totaling 50 members. TritonCubed is sponsored by the California Space Grant Consortium (CaSGC). As such, the proposed CubeSat project is classified as NASA sponsored as stated in the conditions of the CSLI Announcement.

1.1 Project focus. The proposed CubeSat, Triton Lunar Communicator 1 (TLC-1) serves as a Technology Demonstration to enhance future NASA missions. It will serve as a demonstration element of a relay communications network supporting the operation of the Lunar Gateway, the cis-lunar outpost for crewed missions to the Moon that is a proposed project of NASA.[3] TLC-1 would support operations in the lunar vicinity and on the lunar surface by providing a data communications relay capability to assets without a direct line of sight to the Gateway. When proven successful, TLC-1 could serve as a low-cost blueprint for future lunar communications network.

1.2 Potential impact. TLC-1 will directly support the extension of the human presence in space, and the establishment of both manned and unmanned operations on the Moon. It will aid the general quality and availability of lunar communications, both inter-surface (LS-LS) and to a Lunar Gateway (LRS), enabling out-of-LOS datalinks in the lunar vicinity. Additionally, the CubeSat-based communications that TLC-1 represents can serve as a rapid-deployment satellite communications infrastructure in the vicinity of Earth or other planetary establishments such as Mars.

2.0 MISSION OVERVIEW

TLC-1 will ideally occupy a polar orbit at an altitude of 300 to 400 km for an expected mission life of two to three years. A circular orbit provides for an even distribution of coverage over the lunar surface, and an orbit of 400 km is more stable than higher orbits. However, many other orbits including elliptical orbits would be sufficient to demonstrate the effectiveness of this concept.

At this altitude, the resulting orbital velocity is approximately 1.5 km/s, the orbital period is between 138 and 148 minutes, the eclipsed time is a maximum of 45 minutes, and the CubeSat viewing window relative to lunar horizon is between 24 and 29 minutes.

TLC-1 will communicate with the Lunar Gateway at 15 GHz via a phased array directional antenna located on one end-face of the satellite, and will communicate with surface and other clients in the lunar vicinity over omnidirectional 2.4 GHz 3-axis dipole antennae. The satellite will be stabilized in two axes in order to maintain the 15 GHz directional antenna pointed at the Gateway.

Since Space Launch System opportunities are not offered this year, TLC-1 will need to demonstrate its capabilities in Earth orbit at 300 to 400 km or at an altitude that would provide similar orbit parameters as proposed for the Moon.

2.1 Communications Architecture

2.1.1 Lunar Satellite Relay. Assuming the Gateway operates in a Near-Rectilinear Halo Orbit[4], the maximum path length from TLC-1 to the Gateway is approximately 75,000 km. At 15 GHz, this distance results in a 213 dB path loss. Considering a data-rate-conservative modulation scheme, say QPSK, the assumed SNR requirement is 10 dB. At the maximum user data rate specified by the Space Frequency Coordination Group (SFCG) of 300 Mbps, TLC-1 will support a 75 MHz link bandwidth. Accounting for worst case system temperature in direct sunlight, antenna radiation exposure, and bandwidth, the expected noise present at the Gateway receiver is -153 dBm. Required transmission power is therefore 24 dBm. A conservative power amplifier efficiency of 25% and accompanying system circuitry yield a conservative estimate of maximum required transceiver power of 1.5 W. Closing this link requires directional antennas; accordingly, TLC-1 will implement a single-face planar phased array, which offers the adaptive beam steering necessary to maintain LRS contact despite orbital variation without sacrificing general attitude control and pointing. At 15 GHz, a single 1U face will support a 64-element planar array (64 cm2, $\lambda/2$ spacing), capable of offering a stable 30° scan angle at 23 dB gain. This link demands a similar antenna gain at the Gateway.

2.1.2 CubeSat to Lunar Surface. The SFCG recommends a 2.4 GHz link for inter-surface communication including rovers, landers, and EVA's. Because this link serves to extend the lunar horizon for surface communication, it will operate at 2.4 GHz as designated for LS-LS, rather than the bands designated for LS-LO and LO-LS, allowing operators to seamlessly shift to and from line-of-sight LS-LS and over-the-horizon LS-LS via TLC-1. Because the directional link with the Gateway will define TLC-1's orientation, and because of the much shorter range to clients on the lunar surface, TLC-1 will implement an omnidirectional antenna for 2.4 GHz communication. This frequency experiences a path loss of 161.5 dB given a 400 km TLC-1 orbit, and requires a 6.25 cm half-wave dipole antenna (for omnidirectional approximation). At the SFCG's maximum

expected data rate, 30 Mbps, the noise present in the corresponding bandwidth (QPSK) is -160 dBm. Again, allowing for 10 dB SNR, required transmission power is 11.5 dBm. This transceiver will draw on the order 50-100 mW.

2.2 Development Schedule

Year	Quarter	Stage	Detail
2018	Fall	**01: CSLI Proposal** Sep 2018 – Dec 2018	Finalized and submitted on 20 Nov 2018
2019	Winter	**02: Design** Jan 2019 – Aug 2019	• Refine mission requirements • Refine electronics architecture • Preliminary CAD/FEA modeling • Finalize design
	Spring		
	Summer		
	Fall	**03: Prototyping** Sep 2019 – Aug 2020	• Low cost representative hardware • Physical testing of prototype components • Development of communications and controls software • Early developmental testing
2020	Winter		
	Spring		
	Summer		
	Fall	**04: Manufacturing** Sep 2020 – Aug 2021	• Selection, manufacturing, and assembly of space-rated components • Software integration and debugging
2021	Winter		
	Spring		
	Summer		
	Fall	**05: Testing & Readiness** Sep 2021 – Jun 2022	• Verification testing • Mission readiness review • Final integration
2022	Winter		
	Spring		
	Summer	**Launch** Jun 2022	Lunar Orbital Platform-Gateway Power/Propulsion Module

3.0 DESIGN OVERVIEW

3.1 Hardware Design. TLC-1 will comply with Revision 13 of the CubeSat Design Specification. Its mass is approximately 2.4 kg, consisting of: the 2U CubeSat chassis, motherboard and CPU electronics, 30 Wh batteries, three reaction wheels, two transceivers, 3 dipole antennae, one phased array antenna, and solar panels. Thermal control will be achieved by one or more of the following: multi-layered insulators, thermal coating and paint, or metallic thermal straps.

Estimated peak power requirements from the transceivers, antennae, reaction wheels, and other general housekeeping requirements including motherboard, CPU and sensors totals approximately 3.9 W. The optimization framework developed for the CADRE CubeSat, also adopted in NASA's OpenMDAO, will be used to determine the optimal angle to orient the solar panels for maximum power.

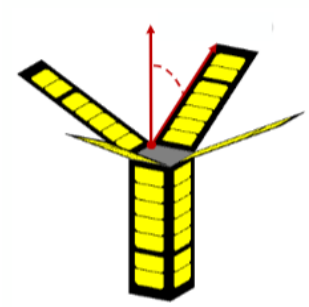

Figure 1: Solar Panel Configuration

Preliminary calculations assume the system will have a nominal EOL solar cell efficiency of 24.3%, and will have an average angle of solar incidence of 70°, which indicate that at least 327 cm^2 or 4U of solar panel faces will be required to meet power generation requirements. To achieve this required area on a 2U satellite chassis, the team will utilize the solar panel configuration illustrated in Figure 1 to the left. All four side panels will deploy and expand in accordance with the solar angle to the sun.

Lastly, for a projected maximum lifetime of 3 years, the battery will need to last for up to 64,000 cycles. Given current battery technology, this will require a depth-of-discharge limit of 10%, which necessitates a total battery capacity of 30 Wh. The battery would be configured as either two 15 W-hr cells or three 10 W-hr cells for redundancy.

The following table is a breakdown of the mass and footprint of TLC-1 required components.

Category	Component	Dimension (cm)	Weight (g)
Structure	2U Chassis Structure (including Base Plate and Cover Plates)	10x10x20	230
	Standoffs	N/A	10
	Screws	N/A	3
	Solar Panel Clips	N/A	4
Electronics	Motherboard	9.6x9.0x1.25	100
	Battery	9.5x9.0x3.9	500
	Transceiver (15 GHz)	15x10x3.3	600
	Transceiver (2.4 GHz)	9.6x9.0x1.25	100
	Dipole Antenna	N/A	30
	Phased Array	8x8	150
	Solar Panels	20x10	200
	Temperature Sensors	N/A	30
	Additional wiring	N/A	100
Mechanical Parts	Reaction Wheels (for all three)	5x5x3	360
Total			2417

3.2 Thermal Design. The recommended operating temperature of the electronics onboard TLC-1 is 300 K with a maximum survivability temperature of 350 K. Temperature drops would

occur during the 45 minute eclipse period, with worst-case scenario being the semi-annual lunar eclipse lasting 1.5 hours on average.
To survive the lunar eclipse, the best option would be to include a polyimide heater attached to the battery that would generate enough heat to stay within operating temperature range. Additional analysis would need to be performed to see if the heat radiating from Earth would be enough to help manage TLC-1's temperature.

To prevent overheating during solar exposure, there are multiple options for thermal management with the most feasible options being multi-layered insulators, thermal coating and paint, and metallic thermal straps. Other options such as sunshields, thermal louvers, deployable radiators, heat pipes, and thermal storage units were determined to be too costly, unreliable, or unable to be scaled down for the CubeSat form factor. Additionally, the satellite will be stabilized on only two axes, allowing it to rotate around the axis pointing towards the Gateway. This will even out the thermal load on the solar panels, allowing them to operate more efficiently. Further analysis will be necessary to determine whether some solar panel sections absorbing the least amount of energy may be replaced with radiators to allow for better cooling.

4.0 FEASIBILITY REVIEW SUMMARY

To conduct the feasibility review, the club chose experts in areas needing improvement, namely solar energy and power consumption. Questions that needed to be addressed were specifically: solar panel configuration, solar power optimization, and battery technology. A draft of the proposal was sent out to three UCSD professors. All three professors thoroughly studied the mission proposal and offered advice through individual, hour-long meetings to discuss its viability and feasibility. Further details of their expertise and suggestions on TLC-1 is given in the Appendix.

Professor Oscar Vazquez Mena addressed the issue of solar panel configuration and suggested introducing redundancy in the design in case of failure. Using his advice, the mechanical division modified their design to include deployable solar panels on all four sides of the body rather than just two.

Professor John T. Hwang addressed the issue of solar power optimization and made the commitment to collaborate with the club to use his research, modeling, and experience with multidisciplinary solar panel design optimization to determine the best configuration for TLC-1.

Professor Ping Liu addressed the issue of battery capacity and storage and determined that the proposed battery system was achievable using the given parameters. Additionally, Prof. Liu gave a range of temperature boundary requirements to stay within for optimal battery performance that the team has taken in to account in the analysis.

Appendix

JEFFREY D. MANKEY

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(360) 286-5561 jeffrey.mankey@gmail.com

Aerospace Engineering PhD student and veteran naval officer with policy experience

PROFESSIONAL EXPERIENCE

CALIFORNIA GOVERNOR'S OFFICE OF PLANNING AND RESEARCH

Advisor for Military and Energy, Los Angeles, CA (August 2013 – January 2015)

- Appointed by Governor Edmund G. Brown, Jr. to support national defense activities and advance alternative energy and transportation in California.
- Researched and drafted comprehensive report for the Governor's Military Council assessing California's support for national defense activities in the state, and recommending actions to state leaders.
- Led multifaceted working group with government, industry and consumer representatives to produce comprehensive guidance for residential and small commercial solar permitting.

Executive Fellow, Sacramento, CA (October 2012 – August 2013)

UNITED STATES NAVY

Submarine Communications Acquisitions Officer, San Diego, CA (2007 - 2009)

- Responsible for ensuring every aspect of any communication or network system installation on any U.S. Submarine was successfully executed, including programmatic funding, contract readiness, pre-installation testing, system installation, and post-installation verification testing. Successfully oversaw the alignment and execution of over 67 million dollars of government funds that resulted in 20 network installations, 8 Common Submarine Radio Room installations, and over 1000 discrete installations performed on 69 submarines and 2 surface ships.

Submarine Officer, USS Nevada, Bangor, WA (2004 - 2007)

- As Engineering Watch Officer (2004-2007), oversaw all daily operations of the propulsion plant, ensuring continuity of electrical and propulsion power, reactor safety, and the safe execution of all required maintenance and testing. Routinely selected as watch officer for high-profile casualty drills, evolutions and inspections.
- As Officer of the Deck (2005 - 2007), oversaw all daily operations of the ship, including navigation, ship control, maintenance, communications, and casualty response. Successfully led the ship's watch team through five major inspections with grades above average, and was designated as the watch officer for ballistic missile launches.
- As Auxiliary Division Officer (2005-2006), was responsible for operation and maintenance of all non-nuclear fluid systems onboard ship, including hydraulics, atmospheric control, ballast, trim, compressed air and waste. Oversaw ship's small valve maintenance program, contributing to ship's above-average grade on annual nuclear safety inspection.

EDUCATION AND TRAINING

UNIVERSITY OF CALIFORNIA, SAN DIEGO, San Diego, CA

Graduate Student in Aerospace Engineering (PhD objective, expected 2020)

Coursework: *Fluid dynamics · Flow instabilities · Numerical modeling · Computational fluid dynamics · Applied mathematics · Finite Element Methods · Aerospace structures · Composite materials*

Master of Science in Aerospace Engineering (2017)

Bachelor of Science in Physics with Specialization in Astrophysics (2002)

UNIVERSITY OF SAN DIEGO, San Diego, CA

Master of Arts in International Relations (2012)

SELECTED AWARDS AND ACCOMPLISHMENTS

- US Navy Nuclear Engineer Qualified (2006)
- USS Nevada Junior Officer of the Year (2006)
- Held Top Secret/SCI Clearance (expired 2009)
- MATLAB, ANSYS, SolidWorks, Python, LaTeX

ANNALISA VILAYSING

Address: 5719 Market Street, San Diego, CA 92114
Email: vilaysing.a@gmail.com
CAD Portfolio: www.coroflot.com/vilaysinga
Cell: 619.530.9063
LinkedIn: www.linkedin.com/in/vilaysinga

Teachable aerospace engineer with strong communication skills and experience in data analysis, 3D modeling and fabrication, and project management. Committed to producing professional work independently or collaboratively. Seeking an entry level position in the aerospace industry to leverage organizational, analytical, and CAD skills.

EDUCATION

Bachelor of Science, Aerospace Engineering 2018
University of California, San Diego San Diego, CA
Recipient of Chancellor's Associate Scholarship

WORK EXPERIENCE

Assistant Project Manager – California Space Grant Consortium, Jun 2018 – Sep 2018

- Managed the structural and electronics fabrication for the CubeSat Development Project at UCSD
- Performed analysis on data collected from experiments on hardware components with MATLAB
- Lead sensor development team for programming a PIC24 microcontroller in C
- Organized and wrote extensive documentation of the project's development and deliverables
- Milestones: 80,000 ft sounding balloon launch, 10 mi test of a LoRa transceiver, dual 42,000 ft super pressure balloon launch, -60 °C cold soak test of equipment, established ground station and electronic systems functionality

LEADERSHIP

Advisor and Project Manager, Triton^3 at UCSD, Sep 2018 – present

- Formed a registered student organization at UCSD following the CubeSat Development Project
- Provide continuity and project management to maintain progress towards goals
- Perform orbital mechanics analysis, mission and development planning

Lead, CubeSat Club at UCSD – Propulsion Team, Sep 2017 – Jun 2018

- Lead a team of 4 students to design and analyze a propulsion system for a 1-Unit CubeSat
- Collaborated with faculty in managing all teams totaling 40+ students
- Presented the club to local high schools and general public at the 2018 Science EXPO at Petco Park

PROJECTS

Ignitor Holder, Mar – Jun 2018

- Developed and built housing for a rocket motor ignitor for the LR-101 rocket engine with Solidworks
- Analytically solved for dimensions of the pins to withstand 50 pounds of force in MATLAB

Commercial Space Plane, Jan – Mar 2018

- Conceptualized on a team of 4, a reusable space plane capable of carrying 4 passengers to 100 km
- Created a 3D model of the space plane in SolidWorks to perform feasibility analysis

Optimization Competition, Mar – Jun 2017

- Modeled and constructed a structure to hold a 200 gram load on a group of multi-level pillars
- Analyzed the design with FEA and reduced the weight to 5 grams with SolidWorks' optimization

SKILLS

Software: SolidWorks, Autodesk Inventor, MATLAB, ANSYS, LabVIEW, Microsoft Office
Programming: MPLAB, PIC24, beginner C

Tyler Eaves

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La Jolla, CA 92092
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KM6RMH
www.linkedin.com/in/teaves/

EDUCATION

UC San Diego — *M. S. Electrical and Computer Engineering*

Sept. 2018 - Dec. 2019

Currently pursuing a master's degree focused on radio frequency circuits, systems, and wireless communications. Very interested in antennas. Exploring VLSI and RF integrated circuits.

UC Santa Cruz — *B. S. Electrical Engineering*

Oct. 2014 - Jun. 2018

GPA 3.86, Magna Cum Laude. Focused on RF hardware design.

PROJECTS

SLUGSAT — *CubeSat HF Linear Transponder*

A nano-satellite intended for LEO under development at UC Santa Cruz. The 15 meter uplink and 10 meter downlink will serve ham radio operators. RF amplifier, filter, and mixer, design and integration.

Mechatronics Competition @ UCSC — *Autonomous Robot*

A team oriented rapid prototyping of an autonomous intelligent system focused on solving a general problem without specific instructions. Ground up CAD design and chassis fabrication. Sensor design, construction, and integration. Event driven programming.

Triton Cube — *Communications Link Development*

Establishing ground station integrity, range testing, and satellite tracking automation. Developing transceiver module for flight hardware testing via high altitude balloon. Link budget using LoRa modulation scheme. Microcontroller peripheral integration and programming.

EMPLOYMENT

UC Santa Cruz — *Baskin Engineering Lab Support*

Mar. 2016 - Jun. 2018

Maintained electrical test equipment, calibrations, etc. 3D print operator. Undergraduate and faculty lab support.

SKILLS

Hardware

-Vector Network Analyzer

-Spectrum Analyzer

-Oscilloscope

-Laser Cutter

-SLA 3D Printer

-Microcontrollers and FPGA's

-SPI, I2C, UART

Software

-Cadence Schematic Capture

-Allegro PCB Layout

-Solidworks

-C Programming

-Java Programming

-MATLAB

-Windows/Linux

Organizations

-Ham Radio Operator (Technician Class)

-IEEE Member

-Tau Beta Pi Member (National Engineering Honors Society)

RIANA MENEZES

(916) 236-8210 • rianamenezes@gmail.com

EDUCATION

UC San Diego **Graduation – June 2019**

Major: Structural Engineering

Focus: Aerospace Structures

Relevant Coursework: Aerospace Structural Mechanics, Design of Composite Structures, Spacecraft Guidance, Solid and Fluid Mechanics, Structural and Finite Element Analysis, Engineering Graphics.

INTERNSHIPS AND WORK EXPERIENCE

CubeSat Development **November 2017 - Present**

Summer CubeSat Development Program

- Worked with a group of ten students to establish a permanent CubeSat club at UC San Diego
- Involved in setting up a ground station, preparing a near-space balloon launch, and got a HAM radio license.

UCSD CubeSat Club – Mechanical Lead

- Serving as the club's Mechanical Lead and guiding a group of Aerospace, Mechanical, and Structural Engineering students to build a 2 U CubeSat that would be launched in lunar orbit.

SAMPE **November 2018 - Present**

- Founding member of UCSD's Society of the Advancement of Material and Process Engineering chapter
- Collaborating with other engineering orgs on campus and helping them with composites manufacturing

Robotics Research Internship **June 2015 – August 2015**

- Conducted research in manufacturing mobile robotics at Tennessee Tech University during the summer of 2015
- Worked under Dr. Stephen Canfield to test, analyze and determine the viability of using mobile robotic systems in American dockyards to repair ships.

SMUD Solar Regatta 2015 **September 2014 – May 2015**

- Worked with civil, electrical and mechanical engineering students to build a solar powered boat from scratch and compete in SMUD's North California Solar Regatta, winning 2nd place overall.
- Served as the team's construction manager and was in charge of buying supplies, securing fabrication locations and teaching team members how to use power tools.

Student Tutor **- Cosumnes River College** **August 2013 – July 2016**

- Assisted college students in understanding important concepts in English, Math, Physics, Macroeconomics, Microeconomics, and Astronomy.

SOFTWARE AND SKILLS

- ***Engineering:*** AutoCAD, Abaqus, SAP2000 AutoDesk Inventor, SolidWorks
- ***Programming:*** C++, Python, MATLAB

- Effective Communicator
- Ability to Work Under Pressure
- Team Player
- Problem Solver

AWARDS AND EXTRA CURRICULAR

Galactic Unite Gavin Jones Prize **October 2018 - Present**

- One of seven UCSD undergrads awarded a scholarship by Virgin Orbit for making an impact in the space industry

Greenlight for Girls **August 2016**

- Facilitated an educational engineering workshop for young girls from 4 – 14 years old to inspire them to pursue an education in Science, Technology, Engineering and Mathematics.

Grid Alternatives **August 2016**

- Helped install solar panels in underprivileged communities to reduce their energy bill and transition to clean energy

TIANA MENEZES

Phone: (916) 236-8782 • Email: tmenezes@ucsd.edu • LinkedIn Profile: tiana-menezes

EDUCATION

UC San Diego — Major: Structural Engineering
Expected Graduation: June 2019 — Focus: Aerospace Structures

SOFTWARES

- SolidWorks
- AutoCAD
- AutoDesk Inventor
- MATLAB
- C++
- Python
- SAP2000
- SketchUp
- Abaqus

WORK EXPERIENCE

UC San Diego CubeSat Program – San Diego, California — Oct 2017 – Present
Position: TritonCubed President

- Worked in the 2018 Summer CubeSat Development Program to conduct research and launch a near space balloon.
- Obtained my HAM Radio Technician License from the FCC to be able to communicate with satellites and repeaters.
- Present Lead of the Operations Division which handles logistics for launches and establishing an operational ground station at UC San Diego

California Department of General Services – West Sacramento, California
Position: Mechanical Engineering Student Assistant — Dec 2015 – Dec 2016

- Worked with a team of 6 Senior Mechanical and Electrical Engineers for 1 year to design and create internal systems (HVAC, Electrical, and Plumbing) for state buildings throughout California.
- These projects included drafting floor plans and designing HVAC units on AutoCad for the following buildings:
  - San Francisco Civic Center: Edmund G. Brown State Office Building
  - Eli Hu Harris State Building, Oakland, California
  - Ione Fire Department, Ione, California
  - Employment Development Department, San Jose, California.

Cosumnes River College Tutoring Center – Sacramento, California
Position: Tutor — Aug 2013 – Nov 2015

- Tutored community college students for 3 years and proofread and edited hundreds of essays and research papers to refine their work.
- Instructed students in English, Mathematics, Economics, and Physics to help them succeed in college.

ACHIEVEMENTS

Recipient of the Galactic Unite Gavin Jones Prize — Oct 2018 – Nov 2019

- One of seven undergraduate UCSD students recognized by Virgin Galactic to make an impact on space exploration
- Award included a cash prize and a mentorship commitment from engineers at Virgin Orbit

MESA (Math, Engineering, and Science Achievement) Sacramento, California — Oct 2015 – May 2016

- Been an active member of my community college's MESA program to seek support in STEM coursework.
- Selected among all MESA students in the Sacramento region to attend the 2015 MESA Student Leadership Conference in Santa Clara, California.

SMUD 2015 Solar Regatta – Herald, California — Aug 2014 - May 2015

- Collaborated engineering students to build a boat run by solar energy and compete in the SMUD Solar Regatta.
- Served as the Lead Designer for the team and designed an 8' x 9' pontoon style boat capable of holding 1000 lbs.
- Won 5 awards including Best Design, Best Technical Drivetrain, and Judge's Choice award.

KENNY
GONZALEZ

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OBJECTIVE

Highly motivated Aerospace Structural Engineering student interested in aerospace materials development and analysis of aircraft components.

EDUCATION

Bachelor of Science, Structural Engineering – Aerospace Structures | University of California – San Diego
2016 – CURRENT

Associate of Science, Engineering | Orange Coast College
2013 – 2016

High School Diploma | Tustin High School
2009 – 2013

SKILLS

- MATLAB
- CAD Modeling
- Finite Element Analysis
- Mechanics of Materials
- Structural Analysis
- Materials Science

ACTIVITIES

UCSD CubeSat Club
2017 – CURRENT
Thermal Lead

UCSD Triton UAS
2017
Parts Fabrication and Composite Layups

Technician Class Amateur Radio License
2018
Call Sign: KM6VAV

Projects/Lab Experience
See Wordpress page listed at the header.

UNIVERSITY OF CALIFORNIA, SAN DIEGO UCSD

BERKELEY • DAVIS • IRVINE • LOS ANGELES • MERCED • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

California Space Grant CONSORTIUM

California Space Grant Consortium (CaSGC)
Department of Mechanical and Aerospace Engineering
University of California, San Diego
9500 Gilman Drive #0411
La Jolla, CA 92093-0411

November 16, 2018

The California Space Grant Consortium (CaSGC) is pleased to provide this letter of support to **TritonCubed**, a registered student-run organization at the University of California, San Diego (UCSD), located at La Jolla, CA, for their proposal entitled "Triton Comm 1: Satellite Relay Communications Network for the Moon," in response to NASA's CubeSat Launch Initiative (CSLI) opportunity.

TritonCubed's proposed project with a mission of a relay communication network is to support the Lunar Gateway that is being developed by NASA. This proposed project will engage UCSD students in hands-on interdisciplinary team activities in which students apply knowledge gained through coursework toward practical experiences preparing them for the STEM workforce. This project will involve multiple disciplines as students from various engineering and scientific backgrounds apply knowledge of their fields to provide a vital communications network between the Gateway and the surface of the moon when the Gateway is not within a direct line of sight.

In conjunction with NASA's Office of STEM Engagement, CaSGC's vision is to inspire and educate the next generation of aerospace scientists, engineers, and managers. Hence, we strongly support this proposal and look forward to a successful outcome.

Best Wishes,

John Kosmatka, PhD, PE, Director
Leah Valmidiano, Assistant Director
Rebecca Howard, Program Coordinator
California Space Grant Consortium (CaSGC)
Department of Mechanical and Aerospace Engineering
University of California, San Diego
La Jolla, CA 92093-0411
(858) 822-1597 voice
(858) 534-7840 fax

TECHNICAL RISKS AND MITIGATION PLAN

Technical Risk	Mitigation Plan
Polyimide Heater	The exact power needed to run these heaters is varied depending on the size or number of heaters needed to maintain thermal control during eclipse time.
Thermal Insulation	The amount of layer and materials used in our insulation will be determined by the amount of energy absorbed and dissipated. Our design will be tailored to keep an optimal temperature of around 300 K. https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19990047691.pdf

FEASIBILITY REVIEW PANEL MEMBERS

Oscar Vazquez Mena
Assistant Professor, NanoEngineering

Integration of graphene and nanoscale materials into nanoscale devices for photovoltaics, biosensing and two-dimensional hybrid metamaterials.

Professor Oscar Vazquez Mena's research focuses on integration and application of nanoscale nanomaterials like graphene for energy harvesting, biological applications and flexible technologies. His research experience covers the fields of two-dimensional (2-D) atomic materials, nanofabrication, photovoltaics and biophysics. He aims to exploit nanoscale physics phenomena to address challenges in energy harvesting. He also aims to develop novel biomedical microdevices by combining nano- and bio-engineering, and integrating nanoscale materials to biological structures like cell membranes and proteins to study biological processes. His research also looks into developing two-dimensional hybrid metamaterials with novel functionalities for flexible devices.

Capsule Bio:

Professor Oscar Vazquez Mena received his Ph.D. in 2010 from the Swiss Federal Institute of Technology of Lausanne (EPFL) in Switzerland. He did postdoctoral research stages at the University of California, Berkeley in the Department of Physics from 2011 to 2014, and at the Institute of Photonic Sciences in Barcelona in 2015 with a Marie Sklodowska-Curie fellowship. At UC Berkeley, Vazquez Mena founded the Indigenous Pipeline program, which aims to increase the access to UC Berkeley for children from indigenous communities in the Bay Area.

Vazquez Mena obtained his B.S. in physics engineering from the Monterrey Institute of Technology in 2000 in Mexico, and his M.S. degree in nanoscale science and engineering from Chalmers University of Technology in Sweden, realizing his thesis at Delft University of Technology. Vazquez Mena was awarded a Swiss National Science Foundation Fellowship in 2011.

John T. Hwang
Assistant Professor, Mechanical and Aerospace Engineering

Hwang develops optimization algorithms for improving the efficiency and performance of engineering vehicles and systems. He specializes in methods that efficiently optimize up to tens of thousands of parameters representing the design or control of the system. He has applied these optimization methods to the design of commercial airliners, satellites, small electric aircraft, and material systems.

Prior to coming to UCSD, Hwang worked in University of Michigan's Student Space Systems Fabrications Lab which built a 3U CubeSat called CADRE. He developed models for multidisciplinary solar panel design optimization for CubeSats in his Ph.D program. The modeled disciplines are orbit dynamics, attitude dynamics, cell illumination, temperature, solar power, energy storage, and communication.

Summary of analysis to perform for TLC-1

In order to maximize the solar power generation of the CubeSat, numerical optimization will be used to compute the optimal solar panel deployment angle, considering the altitude, orientation, orbital path around the moon, thermal management, and power required. A polar low lunar orbit, nominally less than 400 km will be adopted. Along with the solar panel angle, the satellite's orientation profile will also be optimized, subject to the constraint that the 15 GHz phased array antenna is pointed at the Lunar Gateway satellite. There will be periods during which the CubeSat will be unable to receive any sunlight, and the model used for the optimization will ensure sufficient battery charge is maintained during these periods. Further analysis will need to be performed in order to determine if it is necessary to provide controllable solar panels that can change angle to maximize solar incidence at any given time, or whether establishing a single optimal angle will supply enough energy to cover the power needs. The setup selected would also affect thermal management of the panels and will contribute to determining the proper amount of insulation needed. Additional analysis is also required to ensure that the satellite will generate sufficient power in the event of a failure of one panel to deploy, or to ensure mechanical redundancy in the deployment of the panels in order to avoid such a failure.

Ping Liu
Associate Professor, NanoEngineering

> **Materials and architectures for energy conversion and storage; solid-state actuation; nanomaterials synthesis and reaction mechanism in batteries; energy storage device architecture design.**

Professor Liu's research focuses on designing materials and architectures for electrochemical energy conversion and storage applications. One area of interest is studying the mechanical behavior of rechargeable batteries in the context of optimization as either solid-state actuators or as long- life electrochemical energy storage devices. A second area is synthesizing nanostructured materials and probing the effect of composition and size on the thermodynamics and kinetics when they are used as battery materials. A third area is designing new architectures for energy storage devices with enhanced energy density while maintain long service life. Diverse approaches including new electrolyte development, interfacial structure design, and battery cell configuration engineering are employed.

Capsule Bio:

Prior to joining the Jacobs School faculty, Professor Ping Liu has been a Program Director at the Advanced Research Projects Agency – Energy (ARPA-E) since 2012, where he initiated and managed research programs in energy storage for electric vehicles and thermal management technologies to improve building energy efficiency. He was the manager of the Energy Technology Department at HRL Laboratories and was a research staff member with the National Renewable Energy Laboratory. He received his Ph.D. in Chemistry from Fudan University in China 1995. He was a Distinguished Inventor in multiple years at HRL and won an R&D 100 award in 2009 for a battery technology developed at NREL. Liu has published over 70 peer-reviewed papers and has been issued 36 US patents in the broad areas of batteries, fuel cells, sensors and actuators.

ENDNOTES AND REFERENCES

[1] Section 3 & 4 of CubeSat Design Specifications Rev. 13, https://static1.squarespace.com/static/5418c831e4b0fa4ecac1bacd/t/56e9b62337013b6c063a655a/1458157095454/cds_rev13_final2.pdf

[2] SFCG REC 32-2R1, https://www.sfcgonline.org/Resources/Recommendations/default.aspx

[3] Information referenced on the Gateway was obtained at: http://rascal.nianet.org/

[4] Orbit Maintenance and Navigation of Human Spacecraft at Cislunar Near Rectilinear Halo Orbits, https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20170001347.pdf